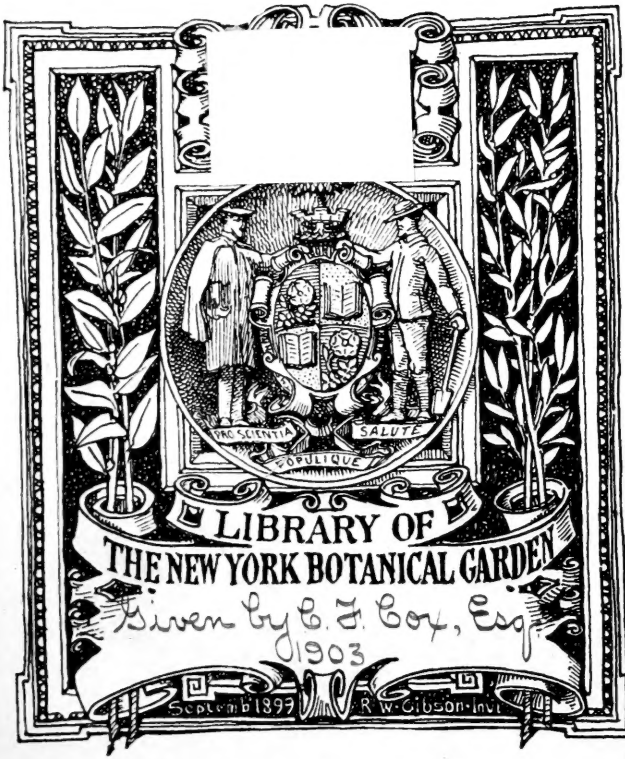
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JOURNAL

OF THE

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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GARDEN

Edited by

FRANK CRISP, LL.B., B.A.,

One of the Secretaries of the Society
and a Vice-President and Treasurer of the Linnean Society of London;

WITH THE ASSISTANCE OF THE PUBLICATION COMMITTEE AND

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CONTENTS.

SUMMARY OF CURRENT RESEARCHES, &c.—*continued.*

BOTANY.

SUMMARY OF CURRENT RESEARCHES, &c.—*continued.*

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ROYAL MICROSCOPICAL SOCIETY.

MEETINGS FOR 1883, at 8 p.m.

Wednesday, JANUARY	10	Wednesday, MAY	9
„ FEBRUARY	14	„ JUNE	13
(Annual Meeting for Election of Officers and Council.)		„ OCTOBER	10
„ MARCH	14	„ NOVEMBER	14
„ APRIL	11	„ DECEMBER	12

THE "SOCIETY" STANDARD SCREW.

The Council have made arrangements for a further supply of Gauges and Screw-tools for the "SOCIETY" STANDARD SCREW for OBJECTIVES.

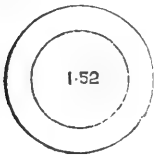
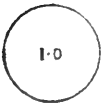
The price of the set (consisting of Gauge and pair of Screw-tools) is 12*s.* 6*d.* (post free 12*s.* 10*d.*). Applications for sets should be made to the Assistant-Secretary.

For an explanation of the intended use of the gauge, see Journal of the Society, I. (1881) pp. 548-9.

I. Numerical Aperture Table.

The "APERTURE" of an optical instrument indicates its greater or less capacity for receiving rays from the object and transmitting them to the image, and the aperture of a Microscope objective is therefore determined by the ratio between its focal length and the diameter of the emergent pencil at the plane of its emergence—that is, the utilized diameter of a single-lens objective or of the back lens of a compound objective.

This ratio is expressed for all media and in all cases by $n \sin u$, n being the refractive index of the medium and u the semi-angle of aperture. The value of $n \sin u$ for any particular case is the "*numerical aperture*" of the objective.

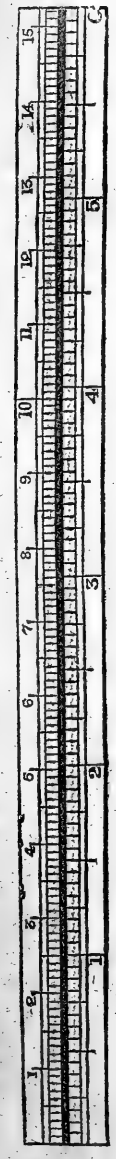
Diameters of the Back Lenses of various Dry and Immersion Objectives of the same Power (¼ in.) from 0·50 to 1·52 N. A.	Numerical Aperture. ($n \sin u = a$.)	Angle of Aperture ($= 2u$). *Dry* Objectives. ($n = 1$.)	Angle of Aperture ($= 2u$). *Water-Immersion* Objectives. ($n = 1{\cdot}33$.)	Angle of Aperture ($= 2u$). *Homogeneous-Immersion* Objectives. ($n = 1{\cdot}52$.)	Illuminating Power. (a^2.)	Theoretical Resolving Power, in Lines to an Inch. ($\lambda = 0{\cdot}5269\,\mu$ = line E.)	Penetrating Power. $\left(\frac{1}{a}\right)$
	1·52	..	..	180° 0′	2·310	146,528	·658
	1·50	..	..	161° 23′	2·250	144,600	·667
	1·48	..	..	153° 39′	2·190	142,672	·676
	1·46	..	..	147° 42′	2·132	140,744	·685
	1·44	..	..	142° 40′	2·074	138,816	·694
	1·42	..	..	138° 12′	2·016	136,888	·704
	1·40	..	..	134° 10′	1·960	134,960	·714
	1·38	..	..	130° 26′	1·904	133,032	·725
	1·36	..	..	126° 57′	1·850	131,104	·735
	1·34	..	..	123° 40′	1·796	129,176	·746
	1·33	..	180° 0′	122° 6′	1·770	128,212	·752
	1·32	..	165° 56′	120° 33	1·742	127,248	·758
	1·30	..	155° 38′	117° 34′	1·690	125,320	·769
	1·28	..	148° 28′	114° 44′	1·638	123,392	·781
	1·26	..	142° 39′	111° 59′	1·588	121,464	·794
	1·24	..	137° 36′	109° 20′	1·538	119,536	·806
	1·22	..	133° 4′	106° 45′	1·488	117,608	·820
	1·20	..	128° 55′	104° 15′	1·440	115,680	·833
	1·18	..	125° 3′	101° 50′	1·392	113,752	·847
	1·16	..	121° 26′	99° 29′	1·346	111,824	·862
	1·14	..	118° 00′	97° 11′	1·300	109,896	·877
	1·12	..	114° 44′	94° 56′	1·254	107,968	·893
	1·10	..	111° 36′	92° 43′	1·210	106,040	·909
	1·08	..	108° 36′	90° 33′	1·166	104,112	·926
	1·06	..	105° 42′	88° 26′	1·124	102,184	·943
	1·04	..	102° 53′	86° 21′	1·082	100,256	·962
	1·02	..	100° 10′	84° 18′	1·040	98,328	·980
	1·00	180° 0′	97° 31′	82° 17′	1·000	96,400	1·000
	0·98	157° 2′	94° 56′	80° 17′	·960	94,472	1·020
	0·96	147° 29′	92° 24′	78° 20′	·922	92,544	1·042
	0·94	140° 6′	89° 56′	76° 24′	·884	90,616	1·064
	0·92	133° 51′	87° 32′	74° 30′	·846	88,688	1·087
	0·90	128° 19′	85° 10′	72° 36′	·810	86,760	1·111
	0·88	123° 17′	82° 51′	70° 44′	·774	84,832	1·136
	0·86	118° 38′	80° 34′	68° 54′	·740	82,904	1·163
	0·84	114° 17′	78° 20′	67° 6′	·706	80,976	1·190
	0·82	110° 10′	76° 8′	65° 18′	·672	79,048	1·220
	0·80	106° 16′	73° 58′	63° 31′	·640	77,120	1·250
	0·78	102° 31′	71° 49′	61° 45′	·608	75,192	1·282
	0·76	98° 56′	69° 42′	60° 0′	·578	73,264	1 316
	0·74	95° 28′	67° 36′	58° 16′	·548	71,336	1·351
	0·72	92° 6′	65° 32′	56° 32′	·518	69,408	1·389
	0·70	88° 51′	63° 31′	54° 50′	·490	67,480	1·429
	0·68	85° 41′	61° 30′	53° 9′	·462	65,552	1·471
	0·66	82° 36′	59° 30′	51° 28′	·436	63,624	1·515
	0·64	79° 35′	57° 31′	49° 48′	·410	61,696	1·562
	0·62	76° 38′	55° 34′	48° 9′	·384	59,768	1·613
	0·60	73° 44′	53° 38′	46° 30′	·360	57,840	1·667
	0·58	70° 54′	51° 42′	44° 51′	·336	55,912	1·724
	0·56	68° 6′	49° 48′	43° 14′	·314	53,984	1·786
	0·54	65° 22′	47° 54′	41° 37′	·292	52,056	1·852
	0·52	62° 40′	46° 2′	40° 0′	·270	50,128	1·923
	0·50	60° 0′	44° 10′	38° 24′	·250	48,200	2·000

EXAMPLE.—The apertures of four objectives, two of which are dry, one water-immersion, and one oil-immersion, would be compared on the *angular* aperture view as follows:—106° (air), 157° (air), 142° (water), 130° (oil).
Their actual apertures are, however, as ·80 ·98 1·26 1·38 or their numerical apertures.

II. Conversion of British and Metric Measures.

(1.) Lineal.

Scale showing the relation of Millimetres, &c., to Inches.



1000 μ =1 mm.
10 mm.=1 cm.
10 cm. =1 dm.
10 dm. =1 metre.

Micromillimetres, &c., into Inches, &c.

μ	ins.	mm.	ins.	mm.	ins.
1	·000039	1	·039370	51	2·007892
2	·000079	2	·078741	52	2·047262
3	·000118	3	·118111	53	2·086633
4	·000157	4	·157482	54	2·126003
5	·000197	5	·196852	55	2·165374
6	·000236	6	·236223	56	2·204744
7	·000276	7	·275593	57	2·244115
8	·000315	8	·314963	58	2·283485
9	·000354	9	·354334	59	2·322855
10	·000394	10 (1 cm.)	·393704	60 (6 cm.)	2·362226
11	·000433	11	·433075	61	2·401596
12	·000472	12	·472445	62	2·440967
13	·000512	13	·511816	63	2·480337
14	·000551	14	·551186	64	2·519708
15	·000591	15	·590556	65	2·559078
16	·000630	16	·629927	66	2·598449
17	·000669	17	·669297	67	2·637819
18	·000709	18	·708668	68	2·677189
19	·000748	19	·748038	69	2·716560
20	·000787	20 (2 cm.)	·787409	70 (7 cm.)	2·755930
21	·000827	21	·826779	71	2·795301
22	·000866	22	·866150	72	2·834671
23	·000906	23	·905520	73	2·874042
24	·000945	24	·944890	74	2·913412
25	·000984	25	·984261	75	2·952782
26	·001024	26	1·023631	76	2·992153
27	·001063	27	1·063002	77	3·031523
28	·001102	28	1·102372	78	3·070894
29	·001142	29	1·141743	79	3·110264
30	·001181	30 (3 cm.)	1·181113	80 (8 cm.)	3·149635
31	·001220	31	1·220483	81	3·189005
32	·001260	32	1·259854	82	3·228375
33	·001299	33	1·299224	83	3·267746
34	·001339	34	1·338595	84	3·307116
35	·001378	35	1·377965	85	3·346487
36	·001417	36	1·417336	86	3·385857
37	·001457	37	1·456706	87	3·425228
38	·001496	38	1·496076	88	3·464598
39	·001535	39	1·535447	89	3·503968
40	·001575	40 (4 cm.)	1·574817	90 (9 cm.)	3·543339
41	·001614	41	1·614188	91	3·582709
42	·001654	42	1·653558	92	3·622080
43	·001693	43	1·692929	93	3·661450
44	·001732	44	1·732299	94	3·700820
45	·001772	45	1·771669	95	3·740191
46	·001811	46	1·811040	96	3·779561
47	·001850	47	1·850410	97	3·818932
48	·001890	48	1·889781	98	3·858302
49	·001929	49	1·929151	99	3·897673
50	·001969	50 (5 cm.)	1·968522	100 (10 cm.=1 decim.)	
60	·002362				
70	·002756				
80	·003150				
90	·003543				
100	·003937				
200	·007874				
300	·011811				
400	·015748				
500	·019685				
600	·023622				
700	·027559				
800	·031496				
900	·035433				
1000 (=1 mm.)					

decim.	ins.
1	3·937043
2	7·874086
3	11·811130
4	15·748173
5	19·685216
6	23·622259
7	27·559302
8	31·496346
9	35·433389
10 (1 metre)	39·370432
=	3·280869 ft.
=	1·093623 yds.

Inches, &c., into Micromillimetres, &c.

ins.	μ
$\frac{1}{25000}$	1·015991
$\frac{1}{20000}$	1·269989
$\frac{1}{15000}$	1·693318
$\frac{1}{10000}$	2·539977
$\frac{1}{9000}$	2·822197
$\frac{1}{8000}$	3·174972
$\frac{1}{7000}$	3·628539
$\frac{1}{6000}$	4·233295
$\frac{1}{5000}$	5·079954
$\frac{1}{4000}$	6·349943
$\frac{1}{3000}$	8·466591
$\frac{1}{2000}$	12·699886
$\frac{1}{1000}$	25·399772
	mm.
$\frac{1}{900}$	·028222
$\frac{1}{800}$	·031750
$\frac{1}{700}$	·036285
$\frac{1}{600}$	·042333
$\frac{1}{500}$	·050800
$\frac{1}{450}$	·056444
$\frac{1}{400}$	·063499
$\frac{1}{350}$	·072571
$\frac{1}{300}$	·084666
$\frac{1}{250}$	·101599
$\frac{1}{200}$	·126999
$\frac{1}{150}$	·169332
$\frac{1}{100}$	·253998
$\frac{1}{50}$	·507995
$\frac{1}{25}$	1·015991
$\frac{1}{20}$	1·269989
$\frac{1}{18}$	1·587486
$\frac{1}{15}$	1·693318
$\frac{1}{12}$	2·116648
$\frac{1}{10}$	2·539977
$\frac{1}{8}$	3·174972
$\frac{1}{8}$	4·233295
$\frac{3}{16}$	4·762457
$\frac{1}{5}$	5·079954
$\frac{1}{4}$	6·349943
$\frac{5}{16}$	7·937429
$\frac{3}{8}$	9·524915
	cm.
$\frac{7}{16}$	1.111240
$\frac{1}{2}$	1·269989
$\frac{9}{16}$	1·428737
$\frac{5}{8}$	1·587486
$\frac{11}{16}$	1·746234
$\frac{3}{4}$	1·904983
$\frac{13}{16}$	2·063732
$\frac{7}{8}$	2·222480
$\frac{15}{16}$	2·381229
1	2·539977
2	5·079954
3	7·619932
	decim.
4	1·015991
5	1·269989
6	1·523986
7	1·777984
8	2·031982
9	2·285979
10	2·539977
11	2·793975
1 ft.	3·047973
	metres.
1 yd. =	·914392

Conversion of British and Metric Measures—*continued.*

(2.) Capacity.

Millilitres, &c., into Cubic Inches, &c.

millilitres.		cub. ins.
1		·061025
2		·122051
3		·183076
4		·244102
5		·305127
6		·366152
7		·427178
8		·488203
9		·549228
10	(1 centil.)	·610254
20		1·220508
30		1·830762
40		2·441015
50		3·051269
60		3·661523
70		4.271777
80		4·882031
90		5·492285
100	(1 decil.)	6·102539
200		12·205077
300		18·307616
400		24·410155
500		30·512693
600		36·615232
700		42·717771
800		48·820309
900		54·922848
1000	(1 litre)	61·025387

= ·035315 cub. ft.
= 1·760724 pints.
= ·220091 galls.

Cubic Inches, &c., into Millilitres, &c.

cub. ins.	millilitres.
·1	1·638662
·2	3·277325
·3	4·915987
·4	6·554649
·5	8·193311
·6	9·831974
	centilitres.
·7	1·147064
·8	1·310930
·9	1·474796
1	1·638662
2	3·277325
3	4·915987
4	6·554649
5	8·193311
6	9·831974
	decilitres.
7	1·147064
8	1·310930
9	1·474796
10	1·638662
20	3·277325
30	4·915987
40	6·554649
50	8·193311
60	9·831974
	litres.
70	1·147064
80	1·310930
90	1·474796
100	1·638662

277·274 (1 gall.) = 4·543584 litres.

(3.) Weight.

Milligrammes, &c., into Grains, &c.

milligrammes.		grains.
1		·015432
2		·030865
3		·046297
4		·061729
5		·077162
6		·092594
7		·108026
8		·123459
9		·138891
10	(1 centigr.)	·154323
20		·308647
30		·462970
40		·617294
50		·771617
60		·925941
70		1·080264
80		1·234588
90		1·388911
100	(1 decigr.)	
decigrammes.		
1		1·543235
2		3·086470
3		4·629705
4		6·172939
5		7·716174
6		9·259409
7		10·802644
8		12·345879
9		13·889114
10	(1 gr.)	15·432349
		oz. avoir.
100	(1 decagr.)	·352739
1000	(1 hectogr.)	3·527394
		lbs. avoir.
10000	(1 kilogr.)	2·204620

Grains, &c., into Milligrammes, &c.

grains.		milligrammes.
·01		·647989
·02		1·295979
·03		1·943969
·04		2·591958
·05		3·239948
·06		3·887937
·07		4·535927
·08		5·183916
·09		5·831906
·1		6·479895
		centigrammes.
·2		1·295979
·3		1·943969
·4		2·391958
·5		3·239948
·6		3·887937
·7		4·535927
·8		5·183916
·9		5·831006
1		6·479895
		decigrammes.
2		1·295979
3		1·943969
4		2·591958
5		3·239948
6		3·887937
7		4·535927
8		5·183916
9		5·831906
10		6·479895
		grammes.
100		6·479895
	avoir.	decagrammes.
437·5	(1 oz.)	2·834954
		hectogrammes.
7000	(1 lb.)	4·535927
		= ·453593 kilogrammes.

III. Corresponding Degrees in the Fahrenheit and Centigrade Scales.

Fahr.	Cent.	Cent.	Fahr.
500	260° 0	100	212°0
450	232·22	98	208·4
400	204·44	96	204·8
350	176·67	94	201·2
300	148·89	92	197·6
250	121·11	90	194·0
212	100·0	88	190·4
210	98·89	86	186·8
205	96·11	84	183·2
200	93·33	82	179·6
195	90·56	80	176·0
190	87·78	78	172·4
185	85·0	76	168·8
180	82·22	74	165·2
175	79·44	72	161·6
170	76·67	70	158·0
165	73·89	68	154·4
160	71·11	66	150·8
155	68·33	64	147·2
150	65·56	62	143·6
145	62·78	60	140·0
140	60·0	58	136·4
135	57·22	56	132·8
130	54·44	54	129·2
125	51·67	52	125·6
120	48·89	50	122·0
115	46·11	48	118·4
110	43·33	46	114·8
105	40·56	44	111·2
100	37·78	42	107·6
95	35·0	40	104 0
90	32·22	38	100·4
85	29·44	36	96·8
80	26·67	34	93·2
75	23·89	32	89·6
70	21·11	30	86·0
65	18·33	28	82·4
60	15·56	26	78·8
55	12·78	24	75·2
50	10·0	22	71·6
45	7·22	20	68·0
40	4·44	18	64·4
35	1·67	16	60·8
32	0·0	14	57·2
30	− 1·11	12	53·6
25	− 3·89	10	50·0
20	− 6·67	8	46·4
15	− 9·44	6	42·8
10	− 12·22	4	39·2
5	− 15·0	2	35·6
0	− 17·78	0	32·0
− 5	− 20·56	− 2	28·4
− 10	− 23·33	− 4	24·8
− 15	− 26·11	− 6	21·2
− 20	− 28·89	− 8	17·6
− 25	− 31·67	− 10	14·0
− 30	− 34·44	− 12	10·4
− 35	− 37·22	− 14	6·8
− 40	− 40·0	− 16	3·2
− 45	− 42·78	− 18	− 0·4
− 50	− 45·56	− 20	− 4·0

IV. Refractive Indices, Dispersive Powers, and Polarizing Angles.

(1.) Refractive Indices.

Diamond
Phosphorus
Bisulphide of carbon
Flint glass
Crown glass
Rock salt
Canada balsam
Linseed oil (sp. gr. ·932)
Oil of turpentine (sp. gr. ·885)
Alcohol
Sea water
Pure water
Air (at 0° C. 760 *mm.*)

(2.) Dispersive Powers.

Diamond
Phosphorus
Bisulphide of carbon
Flint glass
Crown glass
Rock salt
Canada balsam
Linseed oil (sp. gr. ·932)
Oil of turpentine (sp. gr. ·885)
Alcohol
Sea water
Pure water
Air

(3.) Polarizing Angles.

Diamond
Phosphorus
Bisulphide of carbon
Flint glass
Crown glass
Rock salt
Canada balsam
Linseed oil (sp .gr. ·932)
Oil of turpentine (sp. gr. ·886)
Alcohol
Sea water
Pure water
Air

[Exact data for these tables are at present wanting.]

V. Table of Magnifying Powers.

OBJECTIVES. Focal Length.	Magnifying Power.	EYE-PIECES. Beck's 1, Powell's 1, Ross's A.	Beck's 2, Powell's 2, and Ross's B, nearly.*	Powell's 3.	Ross's C.	Beck's 3.	Beck's 4, Powell's 4, Ross's D.	Beck's 5, Ross's E.	Powell's 5.	Ross's F.
		Focal Length.								
		2 in.	$1\frac{1}{3}$ in.	1 in.	$\frac{4}{5}$ in.	$\frac{2}{3}$ in.	$\frac{1}{2}$ in.	$\frac{4}{10}$ in.	$\frac{1}{3}$ in.	$\frac{1}{4}$ in.
		Magnifying Power.								
		5	$7\frac{1}{2}$	10	$12\frac{1}{2}$	15	20	25	30	40
		Amplification of Objectives and Eye-pieces combined.								
ins. 5	2	10	15	20	25	30	40	50	60	80
4	$2\frac{1}{2}$	$12\frac{1}{2}$	$18\frac{3}{4}$	25	$31\frac{1}{4}$	$37\frac{1}{2}$	50	$62\frac{1}{2}$	75	100
3	$3\frac{1}{3}$	$16\frac{2}{3}$	25	$33\frac{1}{3}$	$41\frac{2}{3}$	50	$66\frac{2}{3}$	$83\frac{1}{3}$	100	$133\frac{1}{3}$
2	5	25	$37\frac{1}{2}$	50	$62\frac{1}{2}$	75	100	125	150	200
$1\frac{1}{2}$	$6\frac{2}{3}$	$33\frac{1}{3}$	50	$66\frac{2}{3}$	$83\frac{1}{3}$	100	$133\frac{1}{3}$	$166\frac{2}{3}$	200	$266\frac{2}{3}$
1	10	50	75	100	125	150	200	250	300	400
$\frac{8}{10}$	$12\frac{1}{2}$	$62\frac{1}{2}$	$93\frac{3}{4}$	125	$156\frac{1}{4}$	$187\frac{1}{2}$	250	$312\frac{1}{2}$	375	500
$\frac{2}{3}$	$18\frac{1}{3}$	$66\frac{2}{3}$	100	$133\frac{1}{3}$	$166\frac{2}{3}$	200	$266\frac{2}{3}$	$333\frac{1}{3}$	400	$533\frac{1}{3}$
$\frac{2}{3}$	15	75	$112\frac{1}{2}$	150	$187\frac{1}{2}$	225	300	375	450	600
$\frac{1}{2}$	20	100	150	200	250	300	400	500	600	800
$\frac{4}{10}$	25	125	$187\frac{1}{2}$	250	$312\frac{1}{2}$	375	500	625	750	1000
$\frac{1}{3}$	30	150	225	300	375	450	600	750	900	1200
$\frac{3}{10}$	$33\frac{1}{3}$	$166\frac{2}{3}$	250	$333\frac{1}{3}$	$416\frac{2}{3}$	500	$666\frac{2}{3}$	$833\frac{1}{3}$	1000	$1333\frac{1}{3}$
$\frac{1}{4}$	40	200	300	400	500	600	800	1000	1200	1600
$\frac{1}{5}$	50	250	375	500	625	750	1000	1250	1500	2000
$\frac{1}{6}$	60	300	450	600	750	900	1200	1500	1800	2400
$\frac{1}{7}$	70	350	525	700	875	1050	1400	1750	2100	2800
$\frac{1}{8}$	80	400	600	800	1000	1200	1600	2000	2400	3200
$\frac{1}{9}$	90	450	675	900	1125	1350	1800	2250	2700	3600
$\frac{1}{10}$	100	500	750	1000	1250	1500	2000	2500	3000	4000
$\frac{1}{11}$	110	550	825	1100	1375	1650	2200	2750	3300	4400
$\frac{1}{12}$	120	600	900	1200	1500	1800	2400	3000	3600	4800
$\frac{1}{13}$	130	650	975	1300	1625	1950	2600	3250	3900	5200
$\frac{1}{14}$	140	700	1050	1400	1750	2100	2800	3500	4200	5600
$\frac{1}{15}$	150	750	1125	1500	1875	2250	3000	3750	4500	6000
$\frac{1}{16}$	160	800	1200	1600	2000	2400	3200	4000	4800	6400
$\frac{1}{17}$	170	850	1275	1700	2125	2550	3400	4250	5100	6800
$\frac{1}{18}$	180	900	1350	1800	2250	2700	3600	4500	5400	7200
$\frac{1}{19}$	190	950	1425	1900	2375	2850	3800	4750	5700	7600
$\frac{1}{20}$	200	1000	1500	2000	2500	3000	4000	5000	6000	8000
$\frac{1}{25}$	250	1250	1875	2500	3125	3750	5000	6250	7500	10000
$\frac{1}{30}$	300	1500	2250	3000	3750	4500	6000	7500	9000	12000
$\frac{1}{40}$	400	2000	3000	4000	5000	6000	8000	10000	12000	16000
$\frac{1}{50}$	500	2500	3750	5000	6250	7500	10000	12500	15000	20000
$\frac{1}{60}$	600	3000	4500	6000	7500	9000	12000	15000	18000	24000
$\frac{1}{80}$	800	4000	6000	8000	10000	12000	16000	20000	24000	32000

* Powell and Lealand's No. 2 = 7·4, and Beck's No. 2 and Ross's B = 8 magnifying power, or respectively $\frac{1}{7}$ less and $\frac{1}{8}$ more than the figures given in this column.

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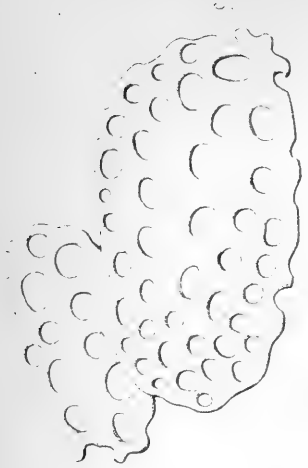

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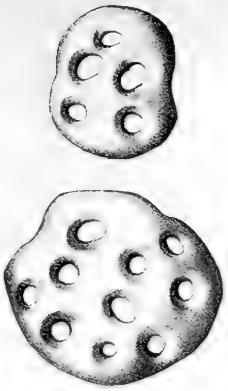

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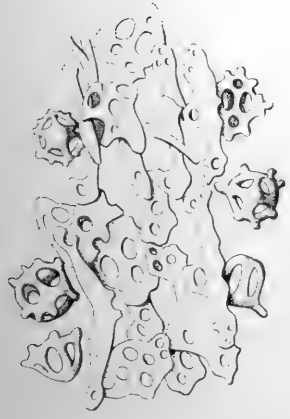

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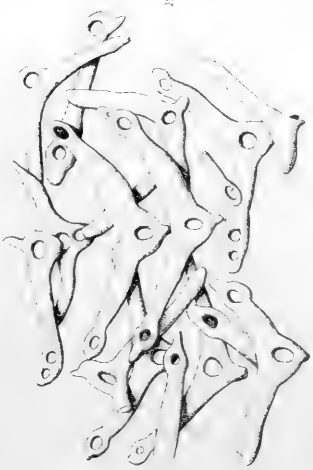


2 a

4

4

Edwin Wilson, del. et lith.

Mintern Bros. imp.

Spicules of Cucumaria hyndmanni,
C. calcigera & two allied forms.

JOURNAL

OF THE

ROYAL MICROSCOPICAL SOCIETY.

AUGUST 1883.

BOTANIC GARDEN

TRANSACTIONS OF THE SOCIETY.

X.—*On the Spicules of Cucumaria hyndmanni, C. calcigera, and two allied forms.*

By Professor F. Jeffrey Bell, M.A., Sec. R.M.S.

(*Read 13th June*, 1883.)

Plate VIII.

The descriptions given by earlier naturalists of the characters of species of Holothurians lack the precision and exactness which has been possible since the year 1844, when Düben and Koren in their classical essay laid a solid foundation for systematic discussions, by giving an account of the characters of the microscopic spicules which are found in the body-wall and the suckers of this group of Echinodermata.

No competent zoologist has since then failed to make use of the weapon which the great Scandinavian naturalists put into our hands; the only possible difficulty, indeed, that presents itself to the mind is as to whether we are not here committing the same kind of error as that which has been seen in many other departments where too much stress has been laid on a single character or set of characters.

As a matter of fact, however, we still require a very large amount of definite information with regard to a number of forms, and that even with regard to some of the best-known of the species of the Northern Seas. Among those treated of by Düben and

EXPLANATION OF PLATE VIII.

Fig. 1, 1*a*. Spicules from body-wall and suckers of *Cucumaria hyndmanni*.
„ 2, 2*a*. „ „ „ *C. calcigera*.
„ 3, 3*a*. „ „ „ *Cucumaria* sp.
„ 4, 4*a*. „ „ „ *C. montagui*.
(All × 220.)

Koren was *Cucumaria hyndmanni*, and those authors may well have thought that, with Forbes' figure of the external appearance, and their representations of the spicules, the characters and limits of that species, at least, would be placed beyond doubt.* This, however, was not to be; in 1857 Dr. Lütken described a "new species" which he dignified by an association with the name of Koren, and of which he said that its apparent resemblance to *C. hyndmanni* was opposed by the great differences in the characters of the spicules. In 1868 Professor Semper, in his great and classical work on the class, expressed the opinion that the differences in the spicules are very slight, and he proposed to unite the two species, with one of which—*C. koreni*—the earlier *C. calcigera* of the American naturalists is, in Lütken's own opinion, identical. This view has never been accepted by such investigators as have independently discussed the question since; Marenzeller, for example, enters into it at some length, and comes to the conclusion that *C. hyndmanni* and *C. koreni* are to be distinguished from one another. Our President and Mr. Sladen have some brief notes on the point in their work on Arctic Echinodermata, and though they give and are, so far as I know, the first to give figures of the spicules of *C. calcigera*, they do not in them direct attention to the characters which have most attracted my notice. Nor do Düben and Koren give a representation of so well developed a spicular plate from the integument of *C. hyndmanni* as is to be found in the accompanying drawing (plate VIII. fig. 1).

I wish to direct attention to the drawings of the spicules from the integument and from the suckers, first of all in a general way, as illustrating the characters and kind of the differences that there may be between two forms of whose specific distinctness there has been some doubt. In the next place, we may observe that the external thickness of the skin would appear to have some direct relation to the thickness of the spicules within it, the skin of *C. hyndmanni* being quite opaque; but this must not be assumed to be a truth that is to be stated without some kind of qualification; an inspection of the figures of the corresponding spicular plates of *C. calcigera* shows that the tenuity of these latter is, as in some other species, in part made up for by their being to some extent laid over one another.

While figs. 1 and 2 are representations of the plates that are found in great abundance in the general integument of the body, 1*a* and 2*a* show the supporting rods from the suckers, and bring to the mind the observation of Lütken that the rods of *C. koreni* differ more among themselves than do those of *C. hyndmanni*. It is

* It is, however, to be noted that while Düben and Koren say that Forbes' figure of *C. hyndmanni* is "bad," the specimen from which the spicules here described were taken exactly correspond to Forbes' representation.

impossible to forbear from some attempt to find an answer to a question which arises out of this remark, and which, being put generally, may be thus expressed. How is it that in two allied species a characteristic exhibits in one case constancy, and in the other variability? A closer examination of the one now in question seems to me to show us (α) that there is more variation in *C. hyndmanni* than we should have been led to expect, and (β) that *C. calcigera* (*C. koreni*) has greater opportunities for variation, thanks to the greater elaborateness of the spicules now being dealt with.

So far, I have endeavoured to direct attention to the specific differences between, and to draw such inferences as are most obvious from the plates of these two northern species. This is neither the suitable time nor place for entering upon the detailed examination or recapitulation of such other points in the external or internal anatomy, or in the "synonymy," which are important to the systematic zoologist, but have no bearing on any sort of problem that is presented to the microscopist.

Yet another form of defensive spicule is to be found in a specimen in the British Museum, which is registered as having come from the coast of Jutland; presenting several points of resemblance to the *Cucumaria tergestina* of Sars,* it is, strange as it may seem, distinguished from it by the smaller size of the plates in the integument;† while I cannot feel that we should be at present justified in uniting it with *C. elongata;* at least if it belong to that species the spicules of that "type" must vary considerably in different individuals.

The last set of spicules which I shall have to mention are those here grouped as parts of fig. 4 a–ζ; they are taken, as are the two which are marked 4*a*, from one of the specimens collected by Colonel Montagu, which was in Leach's collection, and was mentioned by Dr. Gray in the catalogue of British Radiata, under the title of *Holothuria decollata.* I had hoped by an examination of the spicules of this example to be able to set at rest the very difficult questions that surround the determination of the name of this form, which may conveniently be still called *C. montagui;* it will be seen, however, by the series of figures given, that during the seventy years or more that this specimen has been preserved it has been undergoing some slow kind of maceration, in consequence of which its spicules have become gradually broken down, and a curious "dumb-bell" shaped form becomes the most prominent, and apparently the most characteristic; a similar kind of change seems to have affected the rod-shaped spicules in the suckers (fig. 4*a*). It is difficult to understand how this very gradual

* Middelh. Fauna, p. 127.

† The largest of those here figured is nearly a quarter of a millimetre long.

change has been brought about, but it is important to notice it, for the appearances are sufficiently well marked to be very deceptive; and it is the more difficult to explain when it is known that a specimen, also from Montagu, still exhibits quite clearly and well the spiculation of *C. doliolum*, while yet another which has not been in spirit for thirty-five years has the spicules broken down beyond recognition.

Too much trust must not, therefore, be placed on the Microscope as a means of determining the specific relationship of some of the forms described by naturalists who did not themselves make use of this weapon of research; unless the greatest care is persistently taken in the preservation of specimens, the dermal and hypodermal layers with the concretions therein developed may become broken down or altered. Indeed, at present, no time could be more usefully spent by a microscopist than that which should be devoted to the careful study and description of even the spicules of the British species of Holothurians; for the worker of to-day the descriptions of Edward Forbes are found to be incomplete and unsatisfactory, in consequence of the total lack of information concerning these important structures.

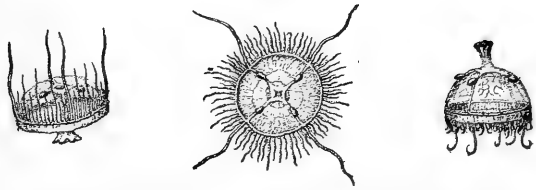
XI.—*On a Method of Preserving the Fresh-water Medusa.*

By Peter Squire, F.L.S.

(*Received 9th July*, 1883.)

The freshwater Medusa (*Limnocodium Sowerbii*) found in the Victoria Regia tank at the Botanic Gardens, Regent's Park, is a singularly beautiful object (see fig. 90). As I learnt from Mr. Sowerby that all attempts to preserve it for future observation had failed, I was induced to make some experiments in this direction. Various antiseptic media, such as Goadby's solution, and solutions of glycerine, kreosote, and many other things were tried, but in no case was the result wholly satisfactory. Before giving the matter

Fig. 90.



Whilst swimming in the tank. *When in the preserving fluid.*

up, I thought well over the structure of the animal, and its probable chemical constitution, and it occurred to me that, if albumen was chiefly concerned, bichloride of mercury would render it opalescent and less liable to change. Accordingly I plunged the creatures into very dilute solutions of this reagent (2 grains only in a pint of 20 oz. of distilled water). The result fully answered my expectations, and the animals were completely preserved, and in a form which makes them more easy of examination than when living. Their bodies being rendered opalescent, the minutest details become apparent, while during life the animals are so transparent as to be scarcely visible. In order to guard against failure I have since increased the strength of the solution to 4 grains in the pint.

To obtain good results several precautions are necessary. As the animals live in water at a temperature of 85° F. it will not do to plunge them into a cold solution of bichloride, nor into a strong solution even if warm. In either case the animals appear to sustain a shock. They shrivel up at once, and the specimens thus preserved have little resemblance to the living creatures. The solution must be previously raised to the temperature of 85° F., and its strength must not exceed 4 grains to the pint. The animals are best conveyed into it by means of a glass tube acting as a pipette. Under these

circumstances the animals continue to live for some ten or fifteen seconds in the preservative medium, making their characteristic movements, and retaining after death their normal figure.

To perform the operation described, I have used in my experiments test-tubes about 4 in. in length by ½ in. in diameter, each fitted with a new cork. Great care should be taken to use new tubes and new corks. These are filled with distilled water, and allowed to remain for a few days in a horizontal position. In all those cases in which the distilled water appeared to become coloured by caries of the cork, the corks were rejected and fresh ones substituted. One of these tubes thus prepared is a little more than half filled with the bichloride solution, and the animal is conveyed into it with the pipette. After the death of the animal, the tube is allowed to lie horizontally so that the creature may be fully exposed to the action of the whole of the solution present; in the vertical position, the specimen would remain at the bottom of the tube in contact with only a small quantity of the medium.

[Mr. Squire has sent us some test-tubes containing Medusæ treated by his method. They fully bear out the claim he makes to have discovered a process by which the animals are preserved in a most effective manner.—Ed.]

SUMMARY

OF CURRENT RESEARCHES RELATING TO

ZOOLOGY AND BOTANY

(*principally Invertebrata and Cryptogamia*),

MICROSCOPY, &c.,

INCLUDING ORIGINAL COMMUNICATIONS FROM FELLOWS AND OTHERS.*

ZOOLOGY.

A. GENERAL, including Embryology and Histology of the Vertebrata.

Early Stages of the Guinea-pig Ovum.†—Graf F. Spee has published the results of his observations on this subject. Up to the beginning or middle of the fourth day, the ova remain in the oviduct, whence they must be carefully extracted. Eggs of two days have four segmentation spheres, around and between which a coagulated mass soon appears *post mortem*. On the third day the limits of the cells are unrecognizable; but they may be more or less isolated by bursting the ovum. After the fifth day, the coagulum no longer appears around the segmentation-spheres. In all the early stages *post mortem* changes are very great and rapid. While still free, after the fourth day, the ova lie in the tip of the uterus, whence they may be driven by forcing with a syringe a current of warm 0·5 per cent. salt solution into the vagina, and out of the tip of the uterus (after cutting off the oviduct). By employing this method, Spee has obtained germ-vesicles agreeing essentially with corresponding stages as found in other mammalia, the principal difference being that the cells are relatively larger, segmentation not having progressed so far. There is an outer wall close against the zona pellucida, and composed of a single layer of cells, spindle-shaped when seen in section, polygonal when viewed from the surface. At one pole is an accumulation of cells, the *Keimhügel*, while at the opposite pole the cells at the outer layer are thickened. In a later stage the cells of the latter pole are found to have thrown out branching processes which penetrate the zona pellucida. Apparently these processes increase in size; and it is

* The Society are not to be considered responsible for the views of the authors of the papers referred to, nor for the manner in which those views may be expressed, the main object of this part of the Journal being to present a summary of the papers *as actually published*, so as to provide the Fellows with a guide to the additions made from time to time to the Library. Objections and corrections should therefore, for the most part, be addressed to the authors. (The Society are not intended to be denoted by the editorial "we.")

† Arch. f. Anat. u. Physiol., Anat. Abth., 1883, pp. 44–60 (1 pl.). Cf. Science, i. (1883) pp. 406–7.

probable that they make a hole through the zona by which the egg makes its exit. Spee has actually found, in one case, an empty ruptured zona. This is an important and interesting observation, because the fate of the zona pellucida has not been hitherto determined. Spee adds the suggestion that possibly the same protoplasmic processes which serve to free the egg, also act to fasten it to the wall of the uterus.

As a continuation of Spee's paper, V. Hensen* describes an ovum, soon after attachment to the uterine wall, found six days and twenty-three hours after copulation. The egg (0·13 × 0·08 mm. in diameter) lay in an open pit of the mucosa. It consists of a vesicle, with a mass of cells on one side, therefore agreeing in structure with the latest stage of the free ovum seen by Spee. Formerly Hensen considered the mass of cells to represent the ovum, and the wall of the vesicle to be an outgrowth of the epithelium of the uterus; but he now withdraws that interpretation, and accepts Schäfer's view that the whole is ovic. "The vesicle is therefore the single-layered primary chorion, which is derived from the ectoderm, and is separated very early from the embryo proper. In other mammals this separation does not occur until after the formation of the amnion." The ectodermal cells of the germ-mass of the embryo come to form a hollow, and this hollow Hensen homologizes with the amniotic cavity of other mammals. Of course, therefore, it is bounded by the ectoderm, and, beyond that, by the endoderm. The apparent reversal of the layers is therefore due to the early development and peculiar position of the amniotic cavity, inside the ovum. In conclusion, Hensen insists upon the importance of showing that the histological value of the germ-layers is really preserved, even in so unusual a form of development as that of the guinea-pig.

Activity of the Yolk during Impregnation.†—C. Kupffer recalls the active movement of a protoplasmatic prominence on the surface of the ovum of *Petromyzon*, observed by A. Müller, Calberla, and himself, immediately after the spermatozoon entered the yolk. He now reports a similar observation on *Bufo*. In this animal several spermatozoa enter the ovum; but those that reach the egg a few minutes after spawning are not able to pierce the egg-membrane. One then sees little protuberances arise on the surface of the yolk, and stretch up the membrane. Opposite each protuberance are one or two spermatozoa, their heads towards the yolk. It appears as if the yolk were actively striving to reach the spermatozoa. In a few minutes the protuberances sink back. In both *Bufo* and *Petromyzon* there appears this secondary act of impregnation after the male elements (or element) have penetrated the yolk.

Germ-layers and Gastrula of the Mouse.‡—In some rodents the germ-layers have apparently a position the reverse of that in other animals. This fact has led E. Selenka to investigate the early stages of

* Arch. f. Anat. u. Physiol., Anat. Abth., 1883, pp. 61–70 (1 pl.).
† SB. Akad. Wiss. München, 1882, pp. 608–18 (1 fig.).
‡ Biol. Centralbl., ii. (1883) pp. 550–8 (9 figs.). Cf. Science, i. (1883) p. 407.

white mice in the search for the explanation of the reversal. He has published a preliminary notice of his results. There is a special envelope of covering cells within which the cells of the embryo proper undergo their development. (This is perhaps the stage described by Spee—*supra*—in the guinea-pig, as a vesicle with a clump of cells at one end.) The embryo-cells lie at one end, separate into the two primitive layers, and become united with a support formed by a knob of cells attached to the uterine wall. This knob is not used in the construction of the embryo. The mass of ectoderm-cells becomes hollow, and the cavity increases in size. In the ectodermal cells limiting it, the ectodermal organs of the embryo are developed according to the typical processes in other mammalia.

Embryology of Mice.*—The observations of Selenka and Kupffer on the development of mice have been critically reviewed by V. Hensen. He does not accept their views as to the gastrulation, or that the formation of the cavity bounded by the ectoderm is the gastrula development. Selenka attributes the reversal of the germ-layers to the proliferation of the ectoderm-cells; but Hensen maintains it to be due to the invagination of the mass of cells forming the embryo-germ. The ectodermal cavity in *Arvicola* does not correspond, as would seem natural, to the amniotic cavity of the guinea-pig; for an amnion is subsequently developed in its interior. (Does not this rather indicate that Hensen's homologizing the ectodermal cavity in the guinea-pig with the amniotic cavity is erroneous, and that it is really the same as the ectodermal cavity described by Selenka and Kupffer?) Finally Hensen discusses briefly the position of the germinal disk in guinea-pigs, and compares it with that of rabbits.

Embryology of Rodents.†—J. Paladino gives the following *résumé* of his results, and, as they have a slight priority of publication over recent German papers they deserve especial attention.

The whole cylinder formed during the first developmental stages of certain rodents is the embryo, and it is implanted on the decidual new formation by the caudal extremity. This is proved especially by the fact that it is this part from which the allantois arises. The cylinder, and the vascular portion of the decidual new formation, are continuous, and so remain throughout gestation by means of the vessels falsely called omphaloid. The decidua forms not only the placenta, but also the first envelope around the embryo,—the chorion, falsely so called. (This is in direct contradiction to the latest opinions of Hensen.) Between the embryo and the decidua is a large space, filled at first with blood, which Paladino thinks is probably produced by the metamorphosis of the granulosa cells discharged from the Graafian follicle along with the ovum (!).

Origin of the Vertebrate Mesoderm.‡—G. Romiti discusses His's view that the mesoderm has a double origin, in part from the primitive streak, and in part from independent cells, which His calls para-

* Arch. f. Anat. u. Physiol., Anat. Abth., 1883, pp. 71–5. Cf. Science, i. (1883) p. 407.

† Arch. Ital. Biol., ii. (1882) pp. 363–7. Cf. Science, i. (1883) p. 525.

‡ Ibid., pp. 277–9.

blastic, and thinks derived from the yolk, and destined to form the connective and vascular tissues. Romiti admits the double origin, but maintains that the independent cells are derived from the germinal portion. The cells in the periphery of the mesoderm are derived "from the proliferation of some large cells which have emigrated from the segmented germ, and lie between the primitive layers."

Histology of the Ovary of Mammals.*—W. Harz finds in the ovary of mammals structures of an epithelial nature, which have the form of massive cords, of canals, or of groups of cells, which are all distinct from the structures of the germinal epithelium. These epithelial structures in the ovary can, however, only be derived from one of two sources; they must either be developed from the germinal epithelium or from the segmental system. It would appear to be certain that the canals and epithelial cords arise from the mesovarium and only pass at a relatively late period into the stroma of the ovary. In some cases, indeed (man, pig) remnants of the structures persist in the mesovarium or in the region of the hilus of the ovary (sheep); and this is a conclusive proof that they are not derived from the germinal epithelium. This view is supported by the statement of M. Braun, who has directly observed the passage of epithelial cords and canals from the wall of the glomeruli of the primitive kidneys into the rudiment of the genital organ. In some mammals the structures in question are not always rudimentary, but become exceedingly well developed (hare, horse, &c.); and between the two conditions, presented by the pig and the horse respectively, we have an intermediate arrangement, such as that seen in the cat or the sheep, where cords or cell-groups of epithelial nature are found extending some way into the ovary.

The author is led to doubt the accuracy of the view which ascribes to these epithelial cords any share in the formation of the membrana granulosa, and he does not believe that the segmental cells have any part in forming the corpora lutea.

With regard to the mechanism of the migration of the ova Harz believes that some attention must be given to the fact that a primordial ovum, before it sinks below the surface of the germinal epithelium, becomes overgrown by epithelial cells; this epithelial investment may perhaps exercise a pressure on the egg-cell, which is an agent in the movement. The albuginea appears to have a regulative action in this function of the germinal epithelium, for so long as primordial ova are being actively produced, it is non-existent; in connection with this we must remember that the albuginea is very poorly supplied with blood-vessels.

The segmental tubes of the calf and of the cat call to mind the ovarian tubes figured by Pflüger, and lead to the idea that this author's ovarian tube is in part a development from the segmental system. Where genital rudiments are feebly developed primordial ova may be observed in those segmental tubes which are closely connected with the germinal epithelium.

* Arch. f. Mikr. Anat., xxii. (1883) pp. 374–407 (1 pl.).

Histogenesis of Nerve-fibres.*—W. His has studied this subject on human embryos. In one only, 2·15 mm. long, it was found that the nucleated bodies of the cells of the medullary plate were already more crowded towards the central canal, early marking the central position of the ganglion-cells. The cells send out processes, most of which extend radially; hence the majority of the cells, but not all, are bipolar. Perhaps the irregular outrunners are amœboid processes. There is at this stage nothing which can properly be called nerve-fibres. In an embryo of 5 mm. in length, the number of cells in the spinal cord is greatly increased. They lie closer together, thickest centrally, and their nuclei, except in the peripheral portion, have for the most part their long axes running radially. Throughout the cord there is a system of radial fibres, many of which may be seen to be prolongations of the cells. The fibres form a more or less well-marked external layer around the cord; their external ends generally present a trumpet-like enlargement. The roots of the nerves are formed by the outgrowth of these fibres. The motor roots are first developed. They appear as processes of the ventral cells of the cord, penetrate the limiting membranes, and so enter the body-wall. The posterior roots arise later. His believes that the cells which Balfour, Sedgwick, and others have described as forming the beginning of the roots are merely those which grow out to become the ganglion cells distributed in the course of the nerves.

Olfactory Lobes in Vertebrates and Higher Arthropoda.†—Professor G. Bellonci's results are stated briefly as follows:—The olfactory lobes have the same essential characters in the above two groups of animals. The so-called olfactory glomeruli are characteristic of this region of the brain, and consist chiefly of a close nervous reticulum formed by the olfactory nerve-fibrils and the processes of the olfactory cells. The external relations of the olfactory lobes now discovered include a constant and most important connection with the optic region, as already described by the author in the higher Crustacea and with cerebral regions possessing high psychical functions, as is known to occur in Mammals also. These relations show an essential agreement to exist between the structure of the brain of Vertebrata on the one hand, and Arthropoda on the other; and this agreement depends on physiological requirements common to the two groups. Professor Bellonci concludes with some theoretical considerations having reference to the complete similarity in structure and connections which function is able to produce in the same organs of different types of animals. The animals studied were *Squilla*, *Gryllotalpa*, *Anguilla*, and *Rana*.

Colouring Matter of Egg-shells.‡—This subject has already been dealt with by Wicke, Sorby, and Liebermann. C. F. W. Krukenberg

* Arch. f. Anat. u. Physiol., Anat. Abth., 1883, pp. 163–70 (1 pl.). Cf. Science, (1883) pp. 467–8.

† Atti R. Accad. Lincei, Trans., vi. (1882) pp. 302–3.

‡ Verhandl. Phys. Med. Gesell. Würzburg, xvii. (1882) p. 109. Cf. Naturforscher, xvi. (1883) pp. 144–5.

has recently had the opportunity of examining a rich material of various coloured egg-shells and of enlarging our knowledge on the colouring matter yielded by them. He distinguishes the following colours differing chemically and spectroscopically from one another:—1. Oorhodein, already described by Sorby and Liebermann; 2. Biliverdin = Sorby's oocyan, also found by Liebermann; 3. Oochlorin and Ooxanthin, described by Sorby as yellow and red ooxanthin. The other colouring substances found by Sorby Krukenberg could not recognize.

As regards the dissemination of the different colouring substances amongst the birds, and their distribution in the egg-shells, careful examination led to the conclusion that all flesh-, olive-, or leather-coloured shells, all those which are spotted, sprinkled, or marbled with red, brown, or black, and all spotted or scribbled over with ashy-grey, contain oorhodein, but seldom unmixed with oocyan. It is doubtless universally present. Even in most pale yellowish-brown eggs the oorhodein is not absent. In all green and blue egg-shells there is oocyan.

In the shells of many closely related species, and even of one and the same species, startling examples are found of the opposing presence of both these colouring substances. In many species of birds colour is quite absent in the eggs, and a pure white egg characterizes the large family of the Psittacidæ. Of the two generally widespread colouring substances only one, oorhodein, is entirely absent in the families of the Cursores and Crypturidæ, whereas no similar case of absence has been observed with oocyan.

The representatives of a few families have colouring matters entirely specific to their shells; thus the Cursores have oochlorin and the Crypturidæ ooxanthin.

The opinion that the colouring substances in all eggs lie on the outer surface is, according to Krukenberg, incorrect. The shells of numerous species of birds are blue throughout, whilst those of some species are perfectly white outside or only coloured brown with oorhodein, but beneath the surface are coloured blue with oocyan. In those coloured with oorhodein the colour never penetrates very deep. A slight wetting of the shell with weak hydrochloric acid removes the colouring matter in many cases, and to remove very dark spots it is only necessary to wet the egg repeatedly with the acid.

That the oorhodein and oocyan originate from quite different sources, that they are separately fixed on the shell, apparently in different places, as the egg passes from the ovary to the cloaca, is verified by the fact that, besides the constant limitation of the red pigment to the upper surface, and of the blue generally to the inner substance of the shell, there is always a diffused distribution of oocyan and oochlorin in contradistinction to the oorhodein, which is, without exception, more or less circumscribed.

As typical instances of the last assertion are the pencillings on the eggs of the Fringillidæ, the red or brownish-black rings on the wide end of many shrikes', woodcocks' and gulls' eggs, and the black and red-brown spots on the eggs of the falcon and thrush. It is generally

the broad zone at the wide end of the egg, or the latter itself, which is chiefly affected by the colouring of oorhodein. Leuckhart in 1853 expressed the opinion that the colours which, according to the observations of Carus, are deposited on the shell in the oviduct, appear to be of two kinds. The one which gives a uniform appearance to the whole surface of the shell, originates apparently in certain specific pigments which combine with the separated lime; the other, which commonly appears in spots or in ramifying lines, originates from a more or less changed colouring matter of blood, which makes its way through the swollen vessels of the oviduct, and imprints itself on the egg. In the first case it is the green colour, in the others the red, with its manifold shades, which predominate over all others.

It appears, from the chemical and physical properties of the pigments, that there is a closer chemical relation between oorhodein and hæmoglobin than between the latter and oocyan.

Presence of Glycogen in Embryos of Squalidæ.*—R. Blanchard has found that in embryos of *Mustelus vulgaris*, 8½ cm. long, the yolk-sac is covered by a number of blood-vessels. On its internal surface there is a flattened epithelium, the cells of which, provided with a large nucleus, contain a certain number of large refractive granulations which are blackened by osmic acid. Some of these cells distinctly give the glycogen-reaction, but the same reaction is not to be obtained at any other point of the yolk-sac, nor in the umbilical cord.

The author points out that, in mammals, the placenta is the seat of the formation of glycogen during the earlier stages of fœtal existence, and that, inasmuch as the membrane of the yolk-sac of viviparous Squalidæ plays the same part as the placenta, we may extend the statement as to the existence of glycogen from mammals to these fishes.

Biological Studies.†—H. Eisig placed in a basin of water an *Octopus*, a *Gobius*, and a *Pagurus* with an Actinian on its shell; the *Octopus* attacked the crab, which immediately withdrew into its shell, while the attacker instantly retreated, for the stinging organs of the *Actinia* had been too much for it. The same thing happened with the goby. A *Pagurus* without a shell was afterwards placed near the *Octopus*, and the latter examined it very carefully before it dared to seize it. At the same time it is to be observed that the Actinian gets much assistance from its commensal, thanks to the locomotive and olfactory powers of the latter.

Observations on thermal conditions showed that many fishes and other marine forms were but little affected by alterations in temperature; while a study of the modes of resting of marine forms shows that much depends on what region of the sea the subjects naturally inhabit, and considerable differences are to be observed between pelagic and more deeply dwelling fishes and cephalopods.

* Bull. Soc. Zool. France, vii. (1883) p. 405.
† Biol. Centralbl., iii. (1883) pp. 142–4.

B. INVERTEBRATA.

Structure of the Nucleus.*—J. Chatin has selected as objects of his study the marginal cells of the Malpighian tubules of insects and myriopods. After describing the methods of investigation, and recommending the larvæ of Diptera and Lepidoptera, he points out that, at first, one rarely discovers all the details of the structure of the nucleus; as a rule, one only sees an enormous nucleus with from two to five nucleoli and a fine filiform plexus. The different characters presented by this last under different conditions are then described and discussed, and the nucleoli are described.

The study seems to show that in the cells examined, as in certain others, the nucleus is formed of a chief mass in which are found the nucleoli and the plexus; these one is at first inclined to regard as secondary portions, but it is possible that the converse proposition is the more exact and that the "somatic mass of the nucleus" is simply a dependent of the reticulo-nucleolar apparatus. The nucleolus, whether simple or multiple, appears to the author to be with difficulty separated from the plexus, or reticulum, and indeed the latter often exists without the former. Chatin refers to the views of Klein in which the "autonomy" of the nucleus is contested, but looks to further observations for more satisfactory conclusions.

Mollusca.

Chromatophores of Cephalopoda.†—R. Blanchard was led to study these structures from the general consideration that there was some mistake in the view which attributed colour changes in reptiles and fishes to amœboid action, and to muscular influence in the Cephalopoda. As to the general structure of these parts in the Cephalopoda, he finds no essential difference between them and the same bodies in Vertebrates. The chromatophore is, in fact, a simple connective cell, filled with pigment and possessing to a high degree the power of amœboid action; the surrounding tissues do not aid it in its activity. Those bodies are under the influence of the nervous system, but the radiating fibres supposed to be connected with it are not, as Harting has thought, nerve-fibres, but merely simple fibres of connective tissue which have a special arrangement in the region of the chromatophore, but have no connection with it. The author thinks that the anatomical and physiological "anomaly" relating to these bodies in the Cephalopoda must now be regarded as definitely denied.

Development of Chromatophores of Sepiola.‡—P. Girod, who has already described the structure of the adult, now deals with developing chromatophores in *Sepiola rondeletii*. The embryonic cells below the epidermis become differentiated into chromatophores and iridocysts. The former arise from *initial cells*, which, growing and becoming rounded, are the pigment-cells of the chromatophores. Each is surrounded by four *peripheral* cells, and forms with them a *chromato-*

* Ann. Sci. Nat. (Zool.) xiv. (1883) art. 3, 7 pp. (1 pl.).
† Bull. Soc. Zool. France, vii. (1883) pp. 492–6.
‡ Comptes Rendus, xcvi. (1883) pp. 1375–7.

phoric group. Each group touches four neighbouring ones, and every peripheral cell is in contact with one of its like. Where the four groups meet there is a separate *intermediate cell*, which serves as the centre for fresh formations.

The initial cell grows rapidly, its protoplasm becomes distinguishable from that of the neighbouring cells, and the nucleus gets a well-marked contour. A little later indications of its pigmented character are to be seen, and then become more and more abundant. The peripheral cells meanwhile divide and give rise to the 16 to 22 cells which are the *basal cells* of the adult. Each intermediate cell divides actively and gives rise to an *intermediate group*, which grows with the general growth of the integumentary surface, and so separates the chromatophoric groups. Some of the cells give rise to fresh chromatophoric groups, while others form the connective tissue of the layer in which the chromatophores are placed, while others, lastly, become fresh intermediate cells. The second set form linear series and give rise to reticula of various forms; the nuclei separate one from another, and the course of formation of the fibres may be well seen in embryos treated with Kleinenberg's solution. The history of the development of the new intermediate cells explains how it is that, in the adult, we find chromatophores in different stages of development; and, on the whole, the intermediate cells may be regarded as constituting the fundamental connective tissue of the layer, and the radial fibres which converge towards the chromatophoric groups; while, moreover, they allow of the increase in extent of the layer, by giving rise to areas in which the same phenomena are observed as in the initial embryonic formations.

Organization of Chitons.*—B. Haller has continued his investigations, and here commences with an account of the structure of the buccal muscles, to which interest has attached since Boll's discovery of larger cells lying on the muscles; these latter themselves may be regarded as consisting of an internal contractile substance, arranged in longitudinal fibres, which, however, cannot be isolated or separated from one another; their surfaces are really fused so that the longitudinal fibrillation only is apparent. This internal contractile substance is surrounded by a layer of protoplasm which contains a number of nuclei and has obviously a nutrient function; the larger cells would seem to be portions of this outer layer, which becomes compressed whenever a wave of contraction passes along the muscle.

The buccal cavity seems to be the chief seat of the sensory organs of the Chitons, otocysts and eyes being absent; among the epithelial cells of the lips there may be found the brush-cells of Flemming, of essentially the same form as in the Pulmonata, where they were first discovered. An unpaired elevation on the floor of the cavity seems to be gustatory in function, and consists of sensory and supporting cells; the goblet-cells which are so common in the buccal cavity of the Prosobranchiate Gastropoda are here completely wanting. There is a pair of feebly developed buccal glands, which are mere diverticula

* Arbeit. Zool. Inst. Wien, v. (1883) pp. 29–60 (3 pls.).

of the wall of the cavity, and their epithelial cells are exactly like those of the side-walls; they provide a mucous secretion which is very intensely tinged by carmine, but this reagent has no influence on the cells themselves. Ganglion-cells may be found scattered in the musculature of this region. The so-called subradular organ appears to be sensory; lying somewhat obliquely below the radula, its hinder portion is circular and is covered by a single layer of very high epithelial cells. More anteriorly the circle is incomplete, the groove dividing the organ into two bilaterally symmetrical halves. In the hinder and upper half of the organ we find spindle-shaped ganglia connected with one another by short commissures.

After referring to the scantiness of our present information with regard to the gills of the Placophora, the author proceeds to point out that they present a bilateral symmetry, and that the longitudinal fold lying above the so-called branchial groove is not formed by a thickening of the epithelium, but by that of the deeper lying tissue; anteriorly the longitudinal folds of either side unite above the head; they also unite posteriorly. In *Chiton lævis* there is a special epithelial layer below the gills, the cells of which are of considerable height; these, which have as yet only been observed in the females, appear to be glandular in nature, and it seems to be probable that their secretion stands in some relation to the genital products. Two types may be distinguished in the gills themselves, presenting differences of some importance in the number of the gills, and their relative size. The author is of opinion that the "gills of either side" are not the homologues of the gills of other Gastropods, but that the separate parts are each really distinct gills. A gill, when carefully examined, does not here exhibit the saccular form but is seen to consist of separate transversely disposed plates, connected together superiorly by a longitudinal ridge. The conclusion arrived at is that the Placophora are Polybranchiate Gastropods. No answer can as yet be given to the question whether *C. lævis* and *Chitonellus* with a smaller number of gills are, phylogenetically, older than *C. siculus* and others with a larger number of gills; there is no real difference in their structure, there are no signs of any rudimentary gills in *C. lævis*, and there does not appear to be any concentration of nervous elements. The key to some of the problems of the structure of the Placophora is doubtless to be found in an examination of *Chitonellus*.

Characters of Marionia.*—R. Bergh commences by pointing out that the Tritoniadæ form a group which are intermediate between those Nudibranchs with a branched liver (kladohepatic), and those in which it is not branched (holohepatic). The family contains but few forms, all of which are elongated and quadrangular; in the anterior region of the back there is a delicate semilunar growth, the edges of which are provided with simple or compound digitate processes. After noting the other special structures of the family, and the characters of its three generic groups, the author comes to the special subject of his paper.

* MT. Zool. Stat. Neap., iv. (1883) pp. 303–26 (1 pl.).

The genus *Marionia* was instituted by Vayssière in 1877, and we know of ten species. The account of the nervous system of *M. quadrilatera* shows that the central system is as small and flattened as in *Tritonia*; the cerebropleural ganglia are, especially on their lower surface, very distinctly separated. In most of its characters it agrees with what is found in the better known genus, and the same is true of many of its other parts.

M. affinis is a new species founded on a specimen found at Naples, and apparently closely allied to *M. tetraquetra*; its peculiarities are pointed out, and there are some notes on *M. tethydea* and *M. blainvillea*, but the author does not seem to have arrived at any general conclusions.

Molluscoida.

Ova of Ascidians.*—A. Sabatier finds that, in Ascidians, the ovary is first made up of an agglomeration of nuclei, derived from the mesoderm, and united together by a small quantity of clear intermediate substance. The ovary has the constitution and characters of an embryonic connective tissue, in which "the protoplasmic atmospheres" are not sharply distinguished; and this structure is to be found in such portions of the adult ovary in which there is a fresh formation of ova. The egg arises from a corpuscle of this tissue, which developes within itself one or more granules, which become nucleolar, and which is itself the nucleus of the egg. Around the nucleus there becomes arranged a layer of transparent colourless protoplasm; there then appears a very delicate amorphous capsular egg-envelope, and below this there appear on the surface of the yolk the follicular elements which become the follicular cells; they are small masses formed in the vitellus itself, and by it brought to its surface. As they increase they form a continuous layer around the egg. Below them and at their expense there is developed a second membrane which lies on the yolk; this subcapsular membrane may become more or less thick. In certain cases the follicular cells remain flattened, harden, and give rise to a thick and structureless egg-envelope. The cells which, in the author's opinion, are improperly called those of the *testa* arise from the yolk, of which they represent an eliminated element; they are imperfect cells and may be spoken of as celluloid globules. The intra-vitelline corpuscles are neither elements which have come in from without, nor capsular cells which have made their way into the yolk, but are masses of clear and finely granular protoplasm which are formed, by a process of concentration, within the yolk itself; finally making their way to the surface, they are at first "capsular" and afterwards "granular" cells.

The author has investigated a large number of forms and he points out the necessity of studying and comparing a number of species if one would seriously attempt to come to any certain conclusions as to the history of ova which *seem* to be in any points distinguished from those of other forms, and which exhibit many

* Rev. Sci. Nat., xi. (1883) pp. 348–405 (4 pls.).

remarkable and as yet unknown characters in their structure and development.

Oxycorynia, a new Synascidian Genus.*—Dr. R. von Drasche describes a remarkable form of compound Ascidian (*Oxycorynia fascicularis*) obtained from Hogolen, an island in the Caroline Archipelago. The animals are arranged in heads presenting a general resemblance to a fir-cone, and supported upon cylindrical stalks, which, in the specimen described, are about $2\frac{1}{2}$ in. long and rather more than $\frac{1}{4}$ in. thick. The oval spikes, which are sometimes pointed at the apex, attain a length of about $1\frac{1}{2}$ in. and a breadth of $\frac{3}{4}$ in. The colour of the badly preserved specimen is a dingy yellowish green. The branchial aperture is surrounded by a stellate marking; and on each side of the endostyle two or three dark lines run down from the branchial aperture; dark pigment also appears round the cloacal aperture.

The individual animals are 10 mm. long, of which about 6 mm. belong to the branchial sac. The latter is of an elongated form, narrowed before and behind; and its hinder part covers a good deal of the intestine. At the foremost part of the animal is the simple round cloacal orifice. The branchial aperture is placed in the anterior third of the branchial sac; it is comparatively large, and is surrounded by a very delicate cylindrical membrane, often cleft into four parts. Examined from within, the branchial aperture is seen to be surrounded by a frill-like ring, which appears strongly coloured by pigment-granules. Outside this there are eight tentacles, alternately large and small. The short œsophagus leads into a small smooth stomach, the intestine proceeding from which forms a loop to the left of the œsophagus, and bends forward, passing into the rectum, which is filled with fæcal masses, and may be traced nearly to the cloacal aperture. Within the loop of the intestine are placed the ovaries and the racemose testes, which consist of about six follicles, each of which opens by a small duct into the common vas deferens, which is traceable along the rectum. Posteriorly each individual animal has a filiform appendage, which passes into the common peduncle, in which it may be traced to a long distance by transverse sections. This appendage is divided by a septum into two parts. The peduncle itself consists of a dense tunic mass, in which the well known large vesicular cells with parietal nuclei are present in great quantity. The individual animals are united by an extremely delicate colourless tunic. The individuals seated upon the margin of the peduncle are short-stalked, and their stalks gradually increase in length towards the middle, thus producing the spike-like form of the colony.

The caudate larvæ lie partly in the branchial cavity itself, partly in diverticula of the body-wall. The embryo is characterized by a peculiarly formed appendage, which bears five adhesive glands. All the embryos observed showed indications of branchial hoops.

At the summit of the common peduncle, where the appendages of

* Verhandl. Zool. Bot. Gesell. Wien, xxxii. (1882) pp. 175–7 (1 pl.). See Ann. and Mag. Nat. Hist., xi. (1883) pp. 455–7.

the individual animals enter it, there are numerous much-branched diverticula of the ectodermal processes. These bud-foundations form a conical elevation in the middle of the head; and the development of the buds seems to take place as described by Kowalevsky in *Didemnum styliferum* and *Amouromium*.

Arthropoda.

a. Insecta.

Histology and Development of Insects.*—H. Viallanes finds that, in the larva, the visual apparatus consists of three principal parts: the imaginal disk of the eye, the nervous tract, and the optic ganglion. The first of these has the same structure as all other disks of the same kind, or, in other words, consists of a provisional, an ectodermal, and a mesodermal layer. Some time before the metamorphosis the most superficial cells of the ectoderm increase in size and become elongated, while at the same time they acquire the property of being coloured in a particularly intense manner under the influence of certain staining reagents; and it is at this time that they become "optogenous cells." The mesoderm of the optic disk has not the structure of the same layer in other disks. It is not formed by a fundamental homogeneous substance connecting the cells, but rather by fine nervous fibrils, with which nuclei are intermixed, and which appear to end in the basal membrane of the ectoderm, but really pass through it to become continuous with the extremity of an optogenous cell. The nervous tract is formed by fine nervous fibrils continuous with those of the mesoderm; so that, in other words, the mesoderm of the disk is only an enlargement of the nerve-tract; and thus, when differentiation is complete, we find that each optogenous cell is connected with the nervous centre.

The optic ganglion is formed by the outermost portion of the cerebral ganglion, and is invested by a neurilemma. On the lateral parts of the optic ganglion and in the grey cortex there is a very complex organ, which may well be called the rudiment of the ganglionic layer, for in this we may see all the chief parts which enter into the constitution of the definite ganglionic layer; externally there is the layer of ganglionic cells, which, as in the adult, are formed of bipolar cells united to form short rows. Just within this there is an indication of the layer of palisade-like fibres, then a layer of fibres and nuclei, the last being the rudiment of the layer of nucleated fibres. The fibres of the nervous tract arise from the surface of the layer of ganglionic cells, just as the post-retinal fibres do in the adult. The only important difference between the chief parts of the optic apparatus in the larva and in the adult would appear to be in the more compact condition which obtains in the former.

When metamorphosis occurs the provisional layer of the imaginal disk of the eye disappears, the ectoderm increases in size, and developes a membrane, while its edges become united with those of the neigh-

* Ann. Sci. Nat. (Zool.) xiv. (1882) pp. 1–348 (18 pls.).

bouring disks; its cuticle becomes the facetted cornea, and its basal membrane the posterior limiting membrane of the eye. While the neurilemma of the optic ganglion disappears, the ganglion itself grows, gets spherical in form, and becomes separated by a circular groove from the rest of the cerebroid ganglion. The ganglionic layer passes outside the optic ganglion, grows, and extends as a screen between it and the compound eye, while at the same time it becomes differentiated into its two primary layers. As the optic disk and the ganglionic layer increase in extent the fibrils of the nervous tract become separated from one another. As the former approach one another the fibres shorten, and each becomes one of the post-retinal fibres. As the ganglionic layer leaves the peripheral portion of the optic ganglion it carries with it a set of fibres; these are the pre-ganglionic fibres, and they continue to serve as a means of connection between the separated parts; they do not arise from cells placed on the surface of the grey cortical portion, but from others more deeply situated.

Before this elaborate examination of the history of the eye M. Viallanes deals with the skin, where he notes the presence of a delicate structureless layer lying beneath the hypodermis of the larva, which he looks upon as the homologue of the basal membrane found by Haeckel in the cray-fish and by Graber in adult insects.

In the larvæ studied by him there were observed between the skin and the muscles peripheral nervous ganglia, belonging neither to the ventral chain nor to the stomatogastric system; in the larva of *Tipula* they are very remarkable for their regular and symmetrical distribution, a pair being found in each segment. In *Musca*, however, they are arranged irregularly, while in *Eristalis* they are placed in the nerve-plexuses from which arise the nerves which go to special sensory organs in the anterior region of the body.

The sensory nerves in the larvæ may terminate either by putting themselves into relation with sensory hairs, or by coming into the presence of a subhypodermic plexus, whence the prolongations appear to terminate freely.

The dorsal vessel is, from a histological point of view, comparable to a capillary of a Vertebrate, but physiologically it is distinguishable from it by being contractile. This contractility is due to the development of muscular fibres in the protoplasm of its cells. The author's studies on the involuntary muscles lead him to re-enunciate the doctrine of Ranvier that organic muscles, whether striated or not, are supplied by nerves which, just before they pass into the muscles, form a ganglionic plexus.

The author believes that the fibril of the wing of an insect is the homologue of the fibril of the muscle of a Vertebrate; in *Dytiscus* the primitive fibre has no sarcolemma, and its contractile mass is reduced to a single column; in *Musca* the same fibre has no sarcolemma, but its contractile mass is made up of several columns; in the Vertebrate there is a sarcolemma.

Each primitive fibre has on its surface a certain number of projections (cones of Doyère), and each of these is provided with a nerve-

fibre; the cylinder axis of this having penetrated into the cone, divides into two chief branches, which give off the secondary ones, and these divide dichotomously a number of times; there is therefore a terminal ramification analogous to what obtains in Vertebrates; nothing like this has ever yet been suspected of Arthropods, and it has been found that just as there are differences in Vertebrates so similar differences are to be seen in insects.

M. Viallanes then treats of the phenomena of histolysis, and concludes with an account of histogenesis, discussing the integument and the muscular system as elaborately as we have reported him to deal with the eye.

Markings on Podura Scales.*—Dr. A. Y. Moore agrees that the markings on *Podura* scales are caused by spines. These are attached to the scales, not at the small end only, but by nearly the whole of their under surface. If they were attached at the end, it is highly probable, he thinks, that they would become broken or bent from their normal position by a slight rub, whereas scales are found which have been scratched and the spines still remain, but in an injured condition. A woodcut is given of spines × 7600 by a Spencer immersion 1-6th in. objective.

Mr. R. Hitchcock also refers † to some photographs by Dr. J. W. S. Arnold, made by sunlight with a 1-26th in. Wales objective, the magnification in two instances being 2470 and 2740 diameters respectively. A woodcut shows not only the appearance of the test *Podura* scale but also a portion of a scale of *Degeeria domestica* "so closely allied to *Podura* that it may be fairly assumed the structure of its scales is the same." Several detached spines of the latter are shown, separated by a fortunate accident, enabling us to see the separate spines, "thus proving that they have an existence, and disproving some views that have been advanced in the past concerning the structure of the scale."

It will be remembered that the spines of *Podura* have been separated from the scales by an electric spark, so that they could be seen in a similar manner.

β. Myriopoda.

Dermal Appendages of Polyxenus.‡—The different forms of hairs in *P. fasciculatis* are described and figured by Scudder; those upon the body-joints varying from club-shaped spines, furnished with several rows of flattened teeth, to sabre-shaped spines, serrate on the convex side. The posterior extremity of the body is provided with a pair of cylindrical fascicles, resembling those of the larva of *Anthrenus*, but composed of very curiously formed bristles, shaped like an elongated fish-hook, the shaft gently curved, and the tip recurved and apically barbed. The shaft is armed with delicate spinules, and the crook furnished on the concave side with a few spatulate, drooping appendages.

* 'The Microscope,' ii. (1883) pp. 186–8 (3 figs.).
† Amer. Mon. Micr. Journ., iv. (1883) pp. 101–2 (1 fig.).
‡ Proc. Bost. Soc. Nat. Hist., xxii. p. 67. Cf. Science, i. (1883) p. 371.

γ. Arachnida.

Pairing of Tegenaria guyonii—Organs in the Male Abdominal Sexual Region.*—Mr. F. M. Campbell describes some observations which he made on the deposition of semen by *T. guyonii*. He also gives an account, which may be taken as typical of the species, of the pairing of thirteen couples in confinement. Two cases are described in which during confinement the males killed the females after union, and an instance is also given of an attempt to impregnate an immature female, which was also destroyed by the male. In these cases hunger could not have been the cause of the attack. The author explains these occurrences, and also the accounts of females destroying males after union, by the suggestion that those instincts which are habitually practised throughout the far greater portion of the life of the species, and on which it is dependent, would scarcely be suspended for a longer period than is necessary for sexual union. Spiders frequently eat one another, and such an occurrence after pairing is only curious if considered apart from their habits. When the sexual desire is satiated their actions would be again directed by the dominant instinct of destruction which would be stronger if a general excitement be supposed to follow the union.

The external abdominal sexual region is marked by a slight convexity, in front of which is placed transversely a row of transparent spines. Two papilla-like processes are situated just above the opening of the *genital sinus*. Neither of these organs have hitherto been noticed.

The *spines* are tubular, point backwards, and project just beyond the convexity. They are generally twenty-four in number, and are placed singly or in groups of two, three, or four. A tube runs from each spine, and, after making many and sudden convolutions, ends in a gland of a pear-shaped form. The contents of the glands have a high refractive power.

The *papillæ* are erectile, and consist of pointed scales surrounding a fascicule of fibres which internally diverge, and are lost in the connective tissue lining the inferior side of the genital sinus. The points of the scales rest on one another, thus giving to the processes a conical form.

The question arises as to the function of these glands and papillæ. They are not found in the females, nor has the author yet met with them in immature males, while their position denotes some share in the primary sexual process. As to the papillæ, he would suggest that their fibres when protruded are used for arranging or supporting the triangular sheet, or for assisting the collection of semen by the palpi. It is more easy to limit the conjectures as to the purpose of the glands to two alternatives:—(1) To pour their secretion on the semen when deposited; or (2) to spin threads which would guide the semen to the silken sheet of which they might form a part.

* Journ. Linn. Soc. Lond. (Zool.) xvii. (1883) pp. 162–74 (2 pls.).

Anatomy of Pentastomum oxycephalum.*—J. Chatin describes a form found in *Alligator lucius*. In treating of the integument he animadverts on the views of those who have assimilated the hypodermis of Arthropods to an epithelial membrane, and points out that, in *Pentastomum* at any rate, the hypodermis is merely formed by a mass of protoplasm, in which a number of nuclei are scattered. The protoplasmic areas grouped around the nuclei are not arranged along one and the same horizontal line. Regularly arranged pores are to be found in the integument, each segment of the body having a row of them; they are not, as some think, to be regarded as stigmata, but are rather the orifices of canals from glandular organs. These last may be uni- or multi-cellular; in the former case they form an elongated flask-shaped sac with a large nucleus, and in the latter with small nuclei. The several portions of the intestine are not so distinctly separated as in most Arthropods; the anterior is, however, distinguished from the median portion by its smaller calibre, and, in the living example, one may see that the median region is generally distended by contents of a yellowish colour. The terminal is again narrower than the median portion of the intestine. In discussing the characters of the layers of which this part of the body is made up, Chatin refers to the views of those who would regard the epithelial zone as a layer of hepatic tissue, and directs attention to the uncertainty of the results of histochemic investigations, and the possibility, from a histological point of view, of their cells being glandular elements.

The author can find nothing in the structure of the nervous system of *Pentastomum* which would justify us in saying that it presents any aberrant arrangement. General sensibility appears to be better developed than in most parasites submitted to similar conditions of life, Linguatulidæ responding rapidly and vigorously to ordinary chemical or electrical stimuli. Unlike flat or round worms, these parasitic Arthropods appear to seek rather than avoid the light. Locomotion would seem to be effected either by the aid of the spines, and in the fashion of a mole, or by the creeping leech-like motion.

Dealing with the zoological affinities of the specimens which he has had under examination, the author refers to the work of Jeffrey Bell, who, in order to determine two individuals found in a *Boa constrictor*, thought it right to examine all the species mentioned as being found in Ophidians, and he not only approves of this mode of procedure, but says that he has himself here followed it.

Demodex phylloides.†—Professor R. Ramsay Wright having had submitted to him pieces of pork-skin largely occupied by this mite, and having found no other notice of it than that in a paper by Dr. J. Csokor of Vienna,‡ gives an abstract of that naturalist's researches.

Three forms seem to be well recognized; that of man, of the dog, and of the cat; and Csokor would also speak of *Demodex phyllosto-*

* Ann. Sci. Nat. (Zool.) xiv. (1883) art. 2, 30 pp. (1 pl.).
† Proc. Canad. Inst., i. (1883) pp. 275–81 (1 pl.).
‡ The reference is not given by Prof. Ramsay.

matis Leydig and *D. phylloides* Csokor; the latter or pig parasite is then compared with those found in man and in the dog, and its three ecdyses—(1) between the egg and the six-footed larva; (2) between the six- and eight-footed larva; (3) between the latter and the adult—are established. In the smallest tubercles in the skin 50–60 mites may be found, and in the larger 500–1000. The cast-off cuticles are found towards the centre of the tubercle, the younger stages towards the duct of the gland, and the adults towards the base and periphery of the gland. Observation convinces the student that these mites are air-breathers. From his specimens of pigs, Csokor is inclined to think that the transference of the parasite from pig to pig is more easily effected than is the case with *D. canis*.

δ. Crustacea.

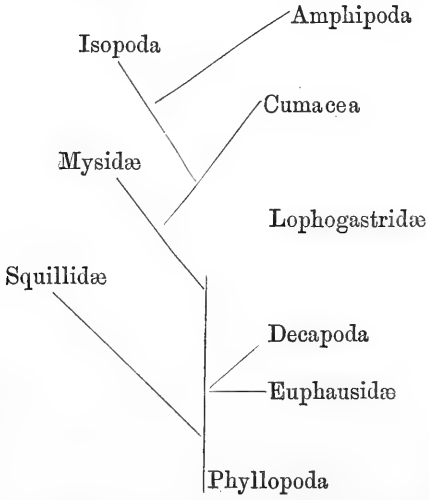
Larval Development of Phoxichilidium Plumulariæ.*—R. v. Lendenfeld gives some account of the early development of this new species of Pantopoda. Among other points he notes the characters of the pores on some of the appendages, which do not, as ordinarily, each communicate with a group of glandular cells, but from each pore there is a fine canal which leads into a well-developed primary duct, at the centripetal end of which we find the gland. These glands are large, saccular, or of an elongated pyriform shape; each is solid, and the protoplasm appears to be gradually converted into a secretion. There are two of these glands, and, centripetally to them there is a large stellate ganglion with a well-developed centripetally directed nerve, as well as nerves for the glands. As maturity is reached the hairs connected with these parts and the ganglia and nerves disappear, but the glands remain, in rudiment, as a bilobed organ. The author compares this form with others already known, and points out the difficulty of imagining how two species, both parasitic, could have arisen from one and the same non-parasitic species, and how it is that the larvæ differ so much in their mode of development, while the mature forms are almost completely unaltered.

Relationships of the Malacostraca.†—In this important and closely-argued paper J. E. V. Boas discusses the relationships one to another of the great divisions of the Malacostraca, and directs attention to the characters of the appendages. The chief result of his studies would appear to be that the Malacostraca are derived from the Phyllopoda, of which *Nebalia* is their nearest ally. The group of Malacostraca which stands nearest to the Phyllopoda is that of the Euphausidæ, and especially the genus *Thysanopus*. From a form allied to this last the group of the Decapoda has been evolved; but they, as represented by their most primitive form (Penœidæ), have become so altered that it is not possible to follow those who have placed the Euphausidæ and the Decapoda in one and the same order. The Mysidaceæ are also derived from a *Thysanopus*-like form, and their differences from the Schizopoda are so marked that it is hence-

* Zeitschr. f. Wiss. Zool., xxxviii. (1883) pp. 323-9.
† Morph. Jahrb., viii. (1883) pp. 485–579 (4 pls.).

forward impossible to place them in the same order. Of the two subdivisions of the Mysidaceæ—Mysidæ and Lophogastridæ—the latter stand nearest the starting-point. The Cumaceæ have been derived from a form which was closely allied to the Mysidæ. The Hedriophthalmata would appear to have arisen from forms intermediate between the Mysidæ and Cumaceæ; they are, therefore, not to be regarded as lowly forms, or as having only distant relations to the Podophthalmata, with which they are partly closely allied. But the Isopoda and Amphipoda differ so much from one another that it is impossible to include them in the same order. The Squillaceæ occupy a very isolated position; they are most nearly—though still distantly—allied to the Euphausidæ, but in some points they exhibit more primitive characters than any other group of the Malacostraca.

The author illustrates his view by a phylogenetic table, which it is worth while to reproduce:—



And he gives also the following systematic table:—

Sub-class Malacostraca.

Order	i. Euphausiacea.		
„	ii. Mysidacea	Sub-order	i. Lophogastridæ.
		„	ii. Mysida.
„	iii. Cumacea.		
„	iv. Isopoda.		
„	v. Amphipoda.		
„	vi. Decapoda	Sub-order	i. Natantia.
		„	ii. Reptantia.
„	vii. Squillacea.		

In his remarks on the appendages Boas points out that the same pair has often different names in different orders, while the same name

is often used for quite different pairs; thus, the third maxilliped of a Decapod corresponds to the second thoracic foot of an Amphipod, while the first thoracic foot of an Isopod is something altogether different to the first thoracic foot of a Decapod. Certain modifications in the received nomenclature are therefore proposed. All the appendages hitherto called maxillipeds and thoracic feet are grouped together under the name of trunk-feet or cormopods, and of these there are in all Malacostraca, with but very rare exceptions, eight pairs. This view is based on the considerations that in the genus *Nebalia* the body is easily divisible into head, trunk, and tail; the first, in which there are no signs of segmentation, carries the eyes, antennæ, mandibles, and maxillæ, and is distinctly separated from the trunk, which consists of eight short segments: these all carry appendages which resemble one another, and differ from those in front of or behind them; further, they correspond to what, in the Malacostraca, are spoken of as maxillipeds and thoracic feet. With the exception of the antennæ, we always find in the appendages of the Malacostraca an endopodite and an exopodite; but it is only in the cormopods that we find an epipodite developed.

The author points out the differences between the antennular and the succeeding appendages, and comes to the conclusion that they are not equivalents of those that follow them, and that it would be well not to regard them as appendages at all. He is inclined to think that, like the eyestalks, they are appendage-like sensory organs. The succeeding parts are then discussed; Boas states that the cormopods consist of a seven-jointed endopodite, an epipodite arising from the outer side of the first joint, and an exopodite from the second joint of the endopodite. One or both of these latter are frequently absent; some of the joints of the endopodite may be fused, and the basal joint is often more or less closely connected with the trunk-skeleton. After a detailed account of what is seen in the different orders, we come to the caudal feet; of these the Malacostraca have typically six pairs, and behind them there is a footless segment.

The different orders are next discussed in detail, and the whole concludes with a general review of the groups, which must be of the highest value to the scientific carcinologist.

Circulatory Organs of Stomatopoda.*—Prof. C. Claus has been making some observations on the larval stages of *Alima* and *Erichthus*, the structure of whose hearts he describes in detail. Dealing also with the circulatory vessels, he comes to the conclusion that the whole system of cerebral vessels with its numerous coils, many of which are mere capillaries, may be regarded as a large vascular loop connected with the aorta, just as the much simpler vascular loops in the ganglia of the ventral chain may be looked upon as appendages of the sternal artery. He regards as certain the homology of the anterior widened portion of the heart and its connected pair of arteries in the Stomatopoda with the heart of the Decapoda, and describes the ventral artery which has been overlooked or denied to exist as being a median

* Arbeit. Zool.-Zoot. Inst. Würzburg, v. (1883) pp. 1–12 (3 pls.).

vessel of considerable size. He finds, at the origin of all the arteries which arise from the heart or the dorsal vessel, a pair of pocket-valves, which agree in structure with those found in the Phyllopoda and the Hedriophthalmata. A sympathetic nerve accompanies the dorsal vessel, and seems to correspond to the sympathetic of the heart of the Hyperida. The absence of antennary glands would appear to be compensated for by the presence of glands connected with the rectum.

Copepoda living in Molluscs and Ascidians.*—C. W. S. Aurivillius has investigated the Copepoda inhabiting molluscs and Ascidians on the Swedish coast, and publishes the results in two papers illustrated with seven double plates. Only two species, both belonging to the Sapphirinidæ, were found inhabiting molluscs, a species of *Lichomolgus* on species of *Doris*, and a new genus and species (*Modiolicola insignis*) upon the branchiæ of *Modiola* and *Mytilus*. Twenty-one species, representing seven genera and five families, were found in the branchial sacs of Ascidians, two new species being added to those already described by Thorell and others. Nearly all the old species are redescribed, and a large part of them figured, and analytical tables of the genera and species given.

American Parasitic Copepoda.†—Prof. R. Ramsay Wright gives an account of some Copepods parasitic on fresh-water fishes; the first of these is *Ergasilus centrarchidarum* n. sp., which was found on the gills of various *Centrarchidæ;* in giving the details of this form an opportunity is taken for expressing the opinion that, when a revision of the species of *Ergasilus* is undertaken, it will probably be found that the form of the appendages offers valuable specific characters. In dealing with *Achtheres micropteri* n. sp., there are some notes on the spermatophores.

Vermes.

Development of Annelids.‡—W. Salensky describes in detail the development of *Nereis cultrifera*, the eggs of which are laid in large lobate gelatinous masses, and each has in addition to the gelatinous covering a delicate vitelline membrane, which, as in all other Annelids, is finally converted into the cuticular membrane of the larva. The author does not agree with Goette in giving to the micromeres the name of ectodermic, or to the macromeres that of endodermic cells; for the ectoderm is not only formed by the micromeres, but also at the expense of the larger cells. The cells do not definitely acquire their laminar significance until after the completion of the epiboly and the development of the ectoderm. The share in the macromeres is taken not only by the marginal, but also by the median portion of the ectoderm. Forty-eight hours after deposition epiboly has advanced so far that the macromeres, which are always four in number, are completely enveloped by the ectodermal cells; these last are not equally

* Ofvers. K. Svenska Vet. Akad. Förh., 1882, Nos. 3 and 8.
† Proc. Canad. Inst., i. (1883) pp. 243–54 (2 pls.).
‡ Arch. Biol., iii. (1882) pp. 561–604 (3 pls.).

thick throughout, being more delicate where epiboly commenced and in the region which, in time, will be the dorsal surface of the embryo, than on that which is opposite to it. On the former there are two *prostomial* pads which bound a prostomial invagination. The author cannot agree with Goette in thinking that the mesodermal elements are derived from the endoderm; he regards the mesoblasts as forming a continuous layer with the ectoderm, from the cells of which they cannot be distinguished either by their origin or their position. Other statements of the same author with regard to this layer are then canvassed, and Salensky says that, a few hours later, the prostomial buds disappear and the prostomium or blastopore becomes a small pentagonal orifice; the embryo is still spherical in form. This portion of the paper concludes by insisting on the analogy which exists between the formation of the mesoderm in *N. cultrifera* and the genesis of the same layer as described by Kleinenberg for *Lumbricus trapezoides*.

On the fourth day we note a marked advance in the organization of the embryo. The ectoderm still continues to be differentiated and the groove which forms the rudiment of the ventral ganglionic chain becomes apparent; as yet, however, the medullary plates merely consist of a single layer of cells, not yet sharply marked off from the sides of the ectoderm. The two bands of mesodermal cells now diverge much more than in the preceding stage, while they still unite towards the hinder end of the embryo. Yet again, the relation of the mesoderm to the ectoderm is still very close, and it is difficult to determine whether it grows at the expense of the ectoderm or not. In the fifth day we see various organs appear, such as the setigerous sacs and the lateral and muscular plates; the embryo now becomes a little flattened on its dorsal side, and the ectoderm undergoes delamination in the more anterior regions. The mesoderm, as may be supposed, becomes considerably modified, but the endoderm only consists of five large spheres.

The sixth day is marked by the appearance of the first rudiments of the feet, in the form of two pairs of tubercles, and herein hardly any share is taken by the ectoderm; the mesodermal segments become indicated, and each is seen to consist of the rudiments of the setigerous sacs, of the muscular, and of the lateral plates. On the next day the dorsal cavity becomes very apparent and contains amœboid cells, which are most probably of ectodermal origin. On and after the eighth day development proceeds very rapidly; the embryo becomes much larger, the cephalic region becomes separated by a crown of cilia, and the eyes appear on its margins. A post-oral circlet of cilia is developed, and the two become united on the back of the embryo. Between the cephalic ganglia and their commissure we see a cellular mass of triangular form, which is called the ocular plate, and it is this which is, in all probability, converted into the hypodermis which invests the eye. The conversion of the lateral plates into somatopleure and splanchnopleure is, as in *Euaxes* and *Scorpio*, carried on independently in each segment. The other details of development are given in full; on the ninth day the embryo escapes.

In giving an account of the post-embryonic development the author deals particularly with the digestive tract, and points out the differences between his account and that given by Goette, of *Nereis dumerilii*, in the history of which there would seem to be very considerable lacunæ, all the intermediate processes which would furnish the genetic connection between the part which that author considers as the rudiment of the digestive tube, and the tube itself, being neither described nor figured. Any conclusions based on a comparison of the mode of formation in these two species would be premature, and must be left for future observers.

Nervous System of Hirudinea.*—M. Saint-Loup finds that the arrangements of the nervous system which were thought to be peculiar to *Clepsine* are very common among the Hirudinea. Commencing with *Nephelis*, where the transparency of the tissues assists in the investigation, he saw that the ganglia of the ventral chain had on their ventral surface six capsules quite distinct and easily isolated from the rest of the nervous mass. In *Aulastomum* similar capsules are to be observed; and the same is true of the medicinal leech. The author has also been able to detect in all Hirudinea examined the intermediate or unpaired nerve which was found by Brandt in *Hirudo*, but not detected by Baudelot in *Clepsine*. Similarities in structure are also to be seen in the supra- and sub-œsophageal ganglia, and in the subcaudal mass. M. Saint-Loup hopes to be able to give a general morphological account of the nervous system of the Leeches.

Bite of the Leech.†—G. Carlet, in continuation of his previous paper,‡ states that, as soon as the leech is fixed, its anterior portion becomes sharply withdrawn, owing to the contraction of the longitudinal muscular fibres; this serves as a fixed point for the jaws. These work quite regularly backwards and forwards, and the movements may be registered as two per second. A preliminary phase in the bite is an uprising of the skin into a small mammillated process; next we find three linear incisions, which are equidistant and do not meet. Gradually they do so, and we get a triangular wound, the three planes of which correspond to the three jaws. The denticles of the jaws are not strong enough to produce at one blow a wound which gives rise to a flow of blood.

Continuing his observations,§ Carlet finds that the jaws of the leech are the essential agents in suction and deglutition; to effect the former the jaws separate from one another and allow of the entrance of the œsophagus; in deglutition the jaws approach one another, and by a kind of piston-action drive the blood in the direction of the stomach.

Development of Phoronis.||—A. Foettinger found in the morula-stage of *Phoronis* that the cavity contained a few spherical or oval

* Comptes Rendus, xcvi. (1883) pp. 1321–2.
† Ibid., pp. 1244–6.
‡ See this Journal, *ante*, p. 212.
§ Tom. cit., pp. 1439–40.
|| Arch. Biol., iii. (1882) pp. 679–86 (1 pl.).

corpuscles, sometimes surrounded by a fine granular substance filling the whole of the segmentation cavity; the important question is, are these elements, which are clearly the first rudiments of the mesoderm, derived from the endo- or the ectoderm? Kowalevsky is in favour of the latter view, while Metschnikoff holds to their endodermal origin. If the larvæ are treated with acetic acid and immediately examined evidence will be afforded as to the presence of the first mesodermic elements at a time when the ovum is still segmenting; and, indeed, indications of them were in two cases seen, where the developing ova consisted of only eight blastomeres, for there is in them a central corpuscle which appears to have a mesodermal significance. The author has no distinct opinion as to the origin of this cell, but inclines to doubt the explanation given by Metschnikoff. As to the still earlier stages it is stated that the fecundated ova are developed outside the body of the parent, but that they remain attached to the branchiæ for a certain time. After the appearance of four blastomeres two divide, and so give rise to a six-stage of two large, and four smaller cells.

Development of Sipunculus nudus.*—B. Hatschek here gives us another of his interesting and suggestive papers; in the earlier portion he deals with his observations of the phenomena of the development of *S. nudus* at different periods, and then proceeds to some theoretical considerations.

Comparing the development of *Sipunculus* with that of *Phascolosoma*, he finds a striking resemblance between the two, this point, however, being excepted, that in *Phascolosoma* there appear to be no embryonic investments. If the observations of those who have studied this form are correct, it follows that we have presented to us the problem of whether the investments in question have been comparatively rapidly acquired by *Sipunculus*, or whether they have been lost by *Phascolosoma;* the latter form must be re-examined with especial attention to this question.

Hatschek believes that the Echiuridæ completely agree with the Annelida in their development, and, in discussing the relation of *Sipunculus* to the Annelids, he brings this point into prominence. We must ask ourselves how far the differences between *Sipunculus* and the Annelids are of fundamental importance. If we take the mode of formation of the germinal layer and of the closure of the blastopore, we find a considerable agreement; in the formation of the gastrula, the development of the mesoderm from two marginal cells of the primary endoderm, the cleavage of the mesodermal bands into a visceral and a parietal layer, and further, the mode of closure of the blastopore and of the development of the œsophagus at the point at which is placed the most anterior remnant of that orifice, the two "types" present the same processes. Differences between the two are to be found in the remarkable development of embryonic investments in *Sipunculus*, but, at the same time, these seem to have appeared only after it separated from the Annelid-stock. Compared with the

* Arbeit. Zool. Inst. Wien, v. (1883) pp. 61–140 (6 pls.).

developmental history of most Annelids, that of the Gephyrean under discussion appears to be very short; examples of shortened development are, however, among Annelids to be observed in numerous Oligochæta and in the Hirudinea, though it is not of the same character as in these. At the same time it may be supposed to be a lately acquired arrangement.

Compared with the well-known trochophore-larva, that of *Sipunculus* corresponds to a stage much further developed; while there are numerous points of resemblance, we find that, in the latter, the post-oral circlet of cilia is not feebly but well developed; further, the trunk and the secondary cœlom are well developed; provisional organs appear to be absent, and the permanent retractors of the fore-body and the renal organs of the trunk are in full activity. In fact, it would seem that the trochophore stage is, in *Sipunculus*, passed through during the much shortened embryonic life, and that the provisional organs which characterize the head in that stage are completely suppressed. To what stage in the development of an Annelid does, then, the young *Sipunculus*-larva correspond? It can only be compared to some much more developed condition from which, however, it will be found to differ in important particulars, and notably in the absence of any indications of metamerism.

Points of interest are also to be observed in the history of the development of the muscular and nervous systems: compared with the Annelid we find that the layer of circular muscles is developed much earlier than that of the longitudinal, and that the latter never form a continuous layer. The very early development of the two pairs of retractors is also an important point, and may perhaps be regarded as an instance of precocious differentiation, such as is often observed with those organs which play a specially important part in the organization of any class of animals. The rudiment of the ventral medulla is median and completely unpaired, instead of, as in the Annelids, presenting two lateral cords; to this character, however, Hatschek does not attach much importance, nor does he think that it affects the homology of the structure in the two groups.

A special comparison is next made between the Sipunculida and the Echiurida, but his later observations have done nothing to shake Hatschek's view that there is a gulf between the two groups, which are so commonly united together; the latter, indeed, form a subclass of the Annelida, while the "Sipunculacea" are to be regarded as occupying the position lately held by the "Gephyrea."

In a note on the head-cavities the author states that in *Polygordius* the cœlom of the head appears to be formed by a secondary outgrowth of processes from the cœlomic sacs; in other words, it is not, as some have thought, a direct continuation of the cœlom. In another note attention is directed to the late development of the œsophageal commissure, which Hatschek, contrary to the opinion of Kleinenberg and Balfour, believes to be a cenogenetic phenomenon.

The author has made some speculations on the relation of the axis of the trochophore to that of the gastrula, and finds that the aboral end of the gastrula is directly converted into the apical area of

the trochophore; in other words, the anterior portion in front of the pre-oral circlet of cilia retains its primitive relation to the axis of the gastrula; this result, though arrived at by a different path, is the same as that reached by Kleinenberg from his speculations on the characters of the nervous system.

Sternaspis scutata.*—F. Vejdovsky has some observations on the work of other naturalists on this form, and takes the opportunity of again expressing his conviction as to the intermediate position of *Sternaspis* (between Gephyrea and Chætopoda).

Monograph of the Chætognatha.†—Dr. B. Grassi, in one of the quarto publications of the Zoological Station at Naples, gives a general account of the Chætognatha. The first part consists of three chapters, the first of which contains a definition of the group, and an account of its genera, *Spadella* and *Sagitta*, and its 20 real or nominal species. The geographical distribution is next treated of; while the third chapter deals with the anatomy and histology. A bibliographical list of 65 papers precedes the second part, which is devoted to "considerazioni." The Chætognatha seem to form a very distinct group of forms, with various resemblances to, but with no less important differences from others, which have been supposed to be their allies; the fibrils of the muscular tissue present varicosities which correspond with their dark striæ; the giant fibres appear to be homogeneous; the study of the peripheral nerve-plexuses may throw some light on the physiological value of these plexuses in other animals, while the changes undergone by the intestinal epithelium during the process of digestion seem to support the view that the secretion is the result of the action of the gland-cells.

Direct Reproduction of Tænia.‡—P. Mégnin has examined a young dog, in the intestines of which he found 3 large examples of *Tænia serrata*, and 12 small specimens. These last, only a few millimetres in length, must, the author thinks, have been derived by direct reproduction from ova set free from the larger specimens; they cannot have been more than a few days old, and for a month the dog had been under close observation, and had been fed on perfectly pure food. Mégnin has examples of similarly young forms taken from a human subject, and he looks upon these cases of direct reproduction as affording an explanation of those pathological cases in which Tænia-infection has persisted for several years.

Echinodermata.

Democrinus parfaiti.§—Mr. P. Herbert Carpenter points out that this supposed new generic type ‖ has been founded by Prof. Perrier, owing to the erroneous descriptions of the basals of *Rhizocrinus lofotensis*, which have been given by Sars and Ludwig, and his want of

* SB. Böhm. Gesell., 1882, pp. 439–50 (1 pl.).

† 'Fauna u. Flora des Golfes von Neapel. V. Die Chætognathen.' 1883. 118 pp. (13 pls.).

‡ Comptes Rendus, xcvi. (1883) pp. 1378–9.

§ Ann. and Mag. Nat. Hist., xi. (1883) pp. 334–6.

‖ See this Journal, *ante*, p. 216.

acquaintance with the observations of Pourtalès. Mr. Carpenter is convinced that *D. parfaiti* is the same as *Rhizocrinus rawsoni*. The fragmentary condition of the arms is nothing unusual, as these arms often break off at one of the syzygies; their absence, therefore, must not be taken as a proof of the feeble development of the arms.

In another note * Mr. Carpenter discusses the statements made by some observers as to the absence of the basals in certain Neocrinoids, and gives reasons, based on morphological considerations, for believing that they are really present; their absence would lead us into many grave difficulties.

Cœlenterata.

Structure of Hydroid Polyps.†—In this, his second, essay C. F. Jickeli deals with the histological structure of *Tubularia, Cordylophora*, and other Hydroids; commencing with an account of *T. mesembryanthemum*, attention is directed to the existence of two whorls of arms on the hydranths, but, as the author is as yet unable to come to any decision as to their morphological value, he speaks of the one nearest the mouth as the first, and the other as the second whorl. The number of arms presents marked individual variations. Among the ectodermal cells are those which are ganglionic; not numerous, they are generally, though not always, poorly provided with protoplasm; most of them are bipolar, and their processes are generally set parallel to the muscular fibres. A detailed account of this form is followed by some observations on *Cordylophora lacustris*, *Cladonema radiatum*, *Coryne græffii* n. sp., which was found in an aquarium of the Zoological Station at Trieste; *Gemmaria implena*, *Perigommius steinachi* n. sp., *Podocoryne carnea*, *Campanopsis* sp., *Lafoëa parasitica*, *Campanularia coliculata*, *Obelia plicata*, *Anisocola halecioides*, *A. setacea*, *Isocola frutescens*, and *Kirchenbauria* sp.

Sixteen genera have now been examined by the author. In *Hydra* he finds an ectoderm separated by a supporting lamella from the endoderm, while the gastric cavity is directly continued into the arms. This simple condition is not, as Allman has shown, to be found in any other polyp, for in all others there is a greater development of the intermediate tissues; these last may, in the Tubulariidæ at any rate, be spoken of as a third body-layer, though one cannot definitely call it a mesoderm; with regard to the development of this layer, we unfortunately know nothing certain.

In the ectoderm there are to be found investing cells which often become epithelio-muscular, and rarely supporting, glandular cells, various kinds of stinging cells, cells which go to form the capsules of the urticating cells, flagellate elements, ganglionic and sensory cells. The first of these vary considerably in size, and when they diminish in height it is often found that the boundaries between the cells disappear, and the whole fuse to form a lamella, on the lower surface of which a layer of fibrils becomes differentiated. The musculature is always best developed on the arms; the supporting cells are best

* Tom. cit., pp. 327–34.

† Morph. Jahrb., viii. (1883) pp. 580–680 (4 pls.).

developed in the parts where the ectoderm is deepest. Various forms of capsules for the urticating cells may be developed, and these may be elongated, oviform, pyriform, bean-shaped, or curved, and all kinds of intermediate conditions are to be observed; connected with these there are various forms of muscular processes. Closely allied to the urticating-capsule-cells are those which the author distinguishes as flagellate-capsule-cells, which would seem to correspond to that stage of the outer rudiment of the urticating filament (the palpocil-cells) in which the filament has become converted into a flexible continuation of the capsules. Not only can ganglionic cells be always observed, but in some cases (*Eudendrium*, *Tubularia*) localized aggregations of them are to be found at the base of the hydranth, or, as in *Campanopsis*, beneath that umbrella-like fold of the ectoderm which is found in the region of the metastome; and it is important to note that in all these three cases there was a collection of glandular cells just below the ganglionic. No connection between the two could be detected, though there were indications of it in *Campanopsis*. The author holds to his original view that the ganglionic are derived from those embryonic cells which form a part of Kleinenberg's interstitial tissue, and also give rise to the cells of the urticating capsules. Indeed, the author is convinced of the nervous nature of the last-mentioned bodies, and brings forward various facts and considerations to support his view; in particular we may note his observation that he has repeatedly found an absence of nervous elements in those parts of the ectoderm in which the urticating cells are highly developed; and we may well believe in the existence of a muscular plexus.

In the endoderm we find the ordinary nutrient cells, which are frequently provided with muscular processes. Glandular cells are found most regularly arranged in the region of the hypostome, and are, as a rule, all of one form; this layer is capable of the most marked changes in form.

The elements of the "mesoderm" are to be found in all stages of development. The axial cells of the sarcostyle seem to be the least differentiated from those of the endoderm; in other cases we observe indications of a localization of the whole tissue, and this is especially seen in the arms. In all the polyps examined it was noted that, when the arms became compressed into one whorl, there was a tendency at the base to the formation of a continuous tissue. These layers can be made out in the supporting lamella, where this is best developed, and of them the median may be regarded as embryonic, the outer as ectodermal, and the inner as endodermal. The author enters into some considerations as to the homologies of the arm-like structures, into which our space forbids us following him.

Development of Hydra.*—A. Korotneff has been chiefly studying *Hydra aurantiaca*, though he has also made some observations on *H. fusca*. The maturity of the eggs is spoken to by the appearance of two directive corpuscles, which do not seem to owe their origin to the division of a single vesicle, but to be independent formations.

* Zeitschr. f. Wiss. Zool., xxxvii. (1883) pp. 314–22 (1 pl.).

After an account of the mode of cleavage, we find that when the internal cavity of the embryo is completely filled up the earlier blastomeres take on the appearance of true cells, and divide most actively in the outer layer of the epiblast. In *H. fusca* the egg is closely attached to the parent, while in *H. aurantiaca* the ectodermal cells of the parent which are in relation to the egg, gradually become glandular in character, and give rise to a special organ which produces a kind of mucous substance, by means of which the egg is attached, and from which a special layer is developed around it. The epiblast and hypoblast become separated, and the surface of the former becomes warty, while its cells develope pseudopodioid lobate processes; and there are indications of a chitinous egg-shell. Each epithelial cell then forms a cylindrical body, at the base of which are some yolk-spheres. The egg now separates from the body of the parent, and becomes attached to various objects. The glandular cells of the disk, now developed, excrete a glairy mucous substance, after the secretion of which the special cells lose their peculiar characters.

About this period there is a histolysis of the hypoblast, the cells of which lose their distinctness, the plasma becoming concentrated around the nucleus; the epiblast and hypoblast are not now so sharply distinguished. The cells of the former undergo a retrograde metamorphosis; and we find that the primary epiblast goes to form the egg-shell, while the yolk-membrane and the mucous layers are completely used up, and take no part in the formation of the secondary epiblast.

The author points out that the doctrine that if the epiblast is cast off the nervous layer ought to be most external (and in fact the ordinary ectoderm of *Hydra* consists of an uninterrupted layer of nerve-cells), is supported by his observations. He regards the histolysis (metamorphosis) of *Hydra* as a direct result of external influences, which act in quite a special way. In the lower animals, and especially in the Cœlenterata, we cannot say that the germinal layers play so definite a part as in the higher forms. These exceptions and variations from what are regarded as general laws, which we see in the lower forms, are due to adaptations, the capacity for which in these organisms is much more considerable than in the higher animals; and thus we may understand how it is that the outer layer of the morula forms a shell.

Alternation of Generations in Hydro-medusæ.*—Mr. W. K. Brooks thinks it is hardly possible that the form of development which we now find in most of the Hydro-medusæ can bear any close resemblance to their primitive life-history; and there are many reasons for believing that alternation of generations has gradually arisen through the modification of "metamorphosis."

In *Cunina* we seem to have the ancestral form of development, a direct metamorphosis without alternation. The interesting and remarkable life-history of *Cunina* was first described by Professor M'Crady, who found inside the bell of a hydro-medusa, *Turritopsis*, a

* Johns Hopkins University Circulars, ii. (1883) p. 73.

number of hydra-like larvæ attached by short tentacles to the subumbrella, and furnished with a very long and flexible proboscis, with the oral opening in its tip. These are the larvæ of *Cunina* and are parasitic; and they obtain their food by inserting the proboscis into the mouth of the *Turritopsis*, and thus sucking from its stomach the food which it contains.

During the past summer both *Turritopsis* and *Cunina* were extremely abundant, and the author was fortunately able to trace the life-history of each of them.

The larva of *Cunina* is a hydra, with the power of asexual multiplication; but instead of giving rise to medusa-buds like an ordinary hydroid, it becomes directly converted into a medusa by a process of metamorphosis; it is a true larva and not an asexual generation, although the occurrence of asexual production renders the gap between this form of development and true alternation very slight indeed.

In *Cunina* we have a series of this kind:—

Egg,
|
Larva—Larva—Larva,
| | |
Adult—Adult—Adult.

If the larva which is produced from the egg were to remain permanently in the hydra-stage, we should have a series like this:—

Egg,
|
Hydra—Hydra—Hydra,
| |
Medusa—Medusa;

and such a history would be a true alternation.

Hydro-medusæ without Digestive Organs.* — Dr. Lendenfeld describes a new sub-family of hydroids, *Eucopellinæ*, in which the medusa has no digestive organs, and lives only a short time after its escape from the gonophore. Only one species, *Eucopella campanularia*, is known, and this is found in Australia. The larva is a campanularian whose hydranths are carried upon short, unbranched stems, which spring from a creeping root. The medusa has a veil, well-developed marginal sense-organs, radial and circular chymiferous tubes, and large reproductive organs, but it has no mouth, stomach, or tentacles. It discharges its reproductive elements within twenty-four hours after its liberation, and it lives only about thirty-six hours.

Phylogeny of the Siphonophora.†—Professor C. Claus treats of the relation of *Monophyes* to the Diphyidæ, and of the phylogenetic development of the Siphonophora. Nine years ago he pointed out that *Monophyes* might be compared to that larval stage of the Diphyidæ in which there is only one nectocalyx developed, at the

* Zool. Anzeig., vi. (1883) pp. 186–9.
† Arbeit. Zool. Inst. Wien, v. (1883) pp. 15–28.

side of which a gastric tube with filaments and a group of gemmæ is formed. After some notes of and criticisms on later studies and especially on those of Chun, the author comes to the conclusion that the Siphonophora arise from a stage in the development of the Hydroidea not unlike that represented by the Hydractinidæ; this form did not, however, become fixed, but continued to lead a free-swimming pelagic life, and so became capable of further development. It is probable that the cell-material collected at the aboral pole of the growing polypoid body formed a zone of gemmation from which, without stem or stolons being formed, polyps and medusoid buds could be given off. If the oral circlet of tentacles remained arrested in development one or another polyp-bud might, if it elongated and did not become provided with a mouth, become converted into a tentacular appendage which would take on the function of a "fishing-line" (*Fangfaden*); a medusoid bud would become converted into and be gradually set free as a sexual form, while its place as the nectocalyx would be taken by a fresh medusa formed by gemmation. It is almost certain that this sexual animal had at first the marginal filaments and eye-spots, which were only completely lost during the later processes of adaptation, in just the same way as the *Mnestra* which is attached to *Phyllirhoe* has lost the marginal organs of the medusoid body. In the course of further changes we must suppose that the first developed medusoid bodies would lose the power of developing generative elements and would persistently retain the function of the nectocalyces or of the hydrophyllia. The sterile medusæ would either become bell-shaped or have a deeply excavated swimming-sac, or cartilaginous covering pieces with atrophied subumbrella, and subumbrellar vascular apparatus.

The oldest Siphonophora must have gone through a number of changes before they became converted into the present Calycophora, while the development of a pneumatophore was necessary for forms like the Physophoridæ; it is almost certain that this divergence did not commence at a simple, but at a very advanced, stage. The appearance of the first-mentioned hydrostatic apparatus must be taken as a character of great importance, and we may group together those forms —Physophoridæ, Physalidæ, and Discoidea—which possess it under the name of the *Pneumatophora*. The organ would seem to have been developed, *phylogenetically*, at a stage much later than ontological evidence alone would lead us to expect; there are many points of affinity between *Hippopodius*, which is a Calycophore with a number of cells, and the physophorid *Apolemia*. The problem of whether the pneumatophora was a "neomorph" or a metamorphosed bud cannot yet be exactly determined, though the latter view is the more probable. The fact that this pneumatophore has an opening to the exterior explains its great importance as a hydrostatic organ, and the correlated suppression of the nectocalyces. We may pass through the simpler stage of *Rhizophysa* with an elongated stolon, to the more metamorphosed Physalidæ, which are bladder-shaped; and from them to the Velellidæ, the form of which is discoid; these are the most aberrant of the whole group.

Embryonic Tentacular Knobs of certain Physophores.*—While investigating the anatomy of the tentacular knobs of several genera of Calycophores, Mr. J. W. Fewkes was struck by their close resemblance to the "embryonic knobs" of *Agalma*.

If the terminal filament of the Calycophore knob be reduced to nothing, we have left a tentacular appendage homologous with the embryonic knob of *Agalma*, *Physophora*, *Agalmopsis* and other Physophores. This resemblance seems to the author to have a genetic significance, and to indicate a relationship between two great groups of Siphonophora, called the Physophoræ and Calycophoræ. In order to strengthen this supposition he was led to search out other resemblances in the larvæ in which these structures are found. The result was that an interesting likeness between the single ("embryonic") nectocalyx of *Monophyes* and the "primitive scale" of *Agalma* was found. The following reasons led him to regard these last-mentioned organs as homologous. Both are formed in the same way, both are embryonic and are lost in subsequent development. We have in the "primitive scale" of *Agalma* an indication of the point in the development of the Siphonophora, where the separation of the Physophoræ from the Calycophoræ, or where the separation of both groups, from a "stem-form," took place. The embryonic bell of *Monophyes* is an organ of motion; the primitive scale of the young *Agalma*, although homologous to a bell, has lost the function of motion, and is an organ of flotation; while in *Agalmopsis* (*Halistemma*) the embryonic bell is not even represented. The only structure in the larva of *Agalmopsis* (*Halistemma*), which shows the relation of this genus to the Calycophoræ is an embryonic tentacular knob, like that of the larva of *Agalma*, which is thought to be homologous to the tentacular appendage of the Calycophores. This statement of a possible genetic relationship between these two groups is not held to apply to the Pneumatophoræ ("Pneumatophoridæ" Chun), nor to the Discoideæ.

Blue Colouring Matter of Rhizostoma.†—R. Blanchard has a note on his own investigations into the blue colouring matter of *Rhizostoma cuvieri*, in which he points out the differences between his results and those lately obtained by Kleinenberg on the same body; one which the latter author distinguishes as cyanein. The French observer finds that the tissues give up the colour after death, and that the blue colour of the aqueous solution disappears when heat of from 40° to 45° is applied, and gives place to a well marked rosy hue, which, again, disappears on cooling. Spectroscopic examination reveals the presence of three absorption-bands, one in the red, one in the yellow, and one in the green region; the second of these corresponds almost exactly in position to the sodium-band. If the aqueous solution is treated with ammonia the blue colour is immediately precipitated under the form of small blue flakes which may be collected on the filter-paper and analyzed. The author hopes that further investigations will reveal the cause of the differences which obtain between his results and those of Krukenberg.

* Amer. Natural., xvii. (1883) pp. 667–8.

† Bull. Soc. Zool. France, vii. (1883) pp. 402–4.

Porifera.

Australian Aplysinidæ.*—Under the title of Cœlenterates of the Southern Seas II., R. von Lendenfeld gives an account of some new sponges.

Of these the first is *Aplysilla violacea*, the general appearance of which is first described; an examination of the skeletal structures shows that there are some striking differences between the Adriatic and the Australian species as to their modes of branching. The pores of this species are never closed, though there is a sphincter-like arrangement of contractile fibres by means of which the size of their aperture can be diminished. The histological structure is then carefully described, and in an account of the mode of digestion it is stated that if these sponges are placed for some days in water in which fine particles of carmine are suspended, it will be found that the epithelial cells not only of the afferent canals, but also of the ciliated chambers, take up these particles, and that they are also found, although in less quantity, in the epithelium of the efferent canal system of the oscular tube and of the outer surface. In other words, all the free surfaces are able to take up foreign bodies; and the same is true also of the migratory amœboid cells. If we remove the sponge from the carmine-containing water, and place it in fresh sea-water, we may follow out the fate of the carmine granules. After about six hours the epithelial flat-cells of the upper wall of the subdermal space, and the collar cells of the ciliated chambers are free from carmine, and particles of this substance will be found in the water; on the other hand, the amœboid cells underlying the epithelium of the subdermal space will be now seen to contain carmine, although before they had none at all. These observations lead to the conclusion that, in *A. violacea*, small organic bodies are taken up from the ectodermal flattened cells of the subdermal epithelium, and make their way into the subjacent amœboid cells. Here the injected matter is digested, while the amœboid cells migrate, carry the undigested remains to the ciliated chambers, and then pass them on to the collared cells, whence they are extruded. Infusoria may frequently be observed in the subdermal spaces and in the afferent canals, while diatom-valves may sometimes be seen in the migratory cells. The presence of glandular cells is also noted, and they are said to closely agree in structure with the spongoblasts. Although this sponge is hermaphrodite, self-fertilization is guarded against by the earlier (by about fourteen days) maturity of the male elements.

After an account of the characters of the generative products and of the horny fibres, Lendenfeld passes to *Dendrilla*, a new genus, distinguished by the facts that the mesodermal connective tissue contains no granules and is hyaline, as in *Aplysilla;* the ciliated chambers are large, saccular, and arranged radially; the sexes are united, and the genital products are arranged in irregularly-shaped groups; large subdermal spaces are not only developed under the

* Zeitschr. f. Wiss. Zool., xxxviii. (1883) pp. 234-313 (4 pls.).

outer integument, but also at times beneath the walls of the oscular tube; the species are not incrusting, and have a delicate stalk, while the horny fibres are tubes of spongiolin, arranged in dendritic fashion. *D. rosea* is found at Port Philip, as is also *D. aerophoba*. An elaborated and careful account is given of the external and histological characters of these forms.

The paper concludes with a tabular review of the most important characters of the *Aplysillinæ*, which with the *Aplysininæ*, are the two sub-families of the Aplysinidæ; the former contains the two genera *Aplysilla*, with three species, and *Dendrilla*, with the two described for the first time in this paper.

Protozoa.

Characters of Infusoria.*—G. Entz commences with an account of *Actinobolus radians* of Stein, which was placed by its discoverer in the family Enchelinæ; the investigations of the present author lead him to the discussion of the question of the genetic relationships between that family and the Acinetinæ, and as to which are the earlier. If we regard *Actinobolus* as an Encheline, the tentacles of which are lately acquired structures which, as more highly differentiated organs, form the sucking-tubes of the Acinetinæ, and if we regard this change as going hand-in-hand with the loss of mouth and arms and the greater loss of the cilia, we may consider that the Enchelinæ are the older forms, and *Actinobolus* intermediate between the two. It would seem, however, that any discussion of this point will be more or less barren till we can come to some more definite idea as to the genealogy of the Ciliata; we find, that is, that R. Hertwig confidently regards the primitive Ciliate as having been a unicellular organism, which was provided with a continuous investment of cilia, while Bergh looks upon the Peritricha as being the oldest Ciliata, which have been derived from the Cilioflagellata by the reduction of the flagellum and the differentiation of a cystostome and cystopyge.

Mesodinium acarus and *Didinium nasutum* are closely compared with *Urocentrum turbo*, with the object of showing that the two former differ so much from the third in all essential points that it is not possible to place all three in the same category. The author is of opinion that there are several characters which are as, if not more, important than the ciliation; such are the absence or presence of a mouth, and in the latter case the characters of the peristome, the structure of the pharynx, the position of the anus and of the contractile vacuole. A study of the ciliation alone will certainly lead to many Infusoria being placed in wrong families.

The author finds himself compelled to separate the Cyclodineæ from the Peritricha, and to regard them as nothing more than Enchelinæ in which the ciliation has become confined to two circlets of cilia. It is suggested, but by no means asserted, that the "proboscis" of *D. nasutum* is a colossal suctorial tentacle. Some points in favour of the phylogenetic views of Bergh are noted, but no definite opinion

* Zeitschr. f. Wiss. Zool., xxxviii (1883) pp. 167–89 (1 pl.).

on the genetic relationship of the Cilioflagellata and the Peritricha is at present offered.

Development and Classification of Polytoma, Ehr.*—J. Krassilstschik describes *Polytoma spicatum* which he found in the same infusion † as *P. uvella*. It is distinguished from the latter by having a body pointed behind, and it is somewhat more slender, being when full-grown 20–25 μ by 10–12 μ as against 19–23 μ by 11–13 μ.

The development of both species of *Polytoma* is as follows :—The young passing from the resting stage divide into *eight* parts. This division is at first into two, then into four, and finally into eight. It extends throughout the whole body-substance within the envelope of the mother organism. The latter, as well as its two flagella, remains uninjured during the fission and their motion is not in the least disturbed. The eight cells assume at first a round form, then elongate, and take the shape of a *Polytoma*. After the bursting of the parent envelope the eight young ones escape, and begin to grow until they attain the size of a full-grown *Polytoma*. Then they also divide in the same way as the earlier ones, but this time into *four*, and never into eight parts. The division into eight is not again met with, since each succeeding generation divides into four and only four, provided that there is no considerable alteration in the temperature, nourishment, or life-conditions of the *Polytoma*. In from four to six days most of the individuals commence to conjugate in pairs, form zygotes, assume a spherical form, and after the secretion of a tolerably thick membrane pass again into the resting condition. During the fusion of the two zoospores, the nuclei also blend together. The conjugating *Polytoma* vary very little, if at all, from the non-conjugating. The last generation are mostly distinguished by the size and bright colour of their starch-containing granules. This, however, is not always to be relied on, as with rich nourishment all have somewhat large, bluish-green corpuscles, and in unfavourable circumstances even the conjugating individuals have only small pale granules. The size also to which the latter attain is not always the same. For the most part the young do not begin to pair immediately after their exit from the parent envelope, but grow somewhat first. Moreover, when they have not the opportunity to pair whilst still small, they continue growing to the size of a full-grown *Polytoma*, and still retain their capacity for conjugating. These can pair either with each other or with quite young *Polytoma*. It is easy to understand that where a full-grown conjugates with a young one, it seems as if it was the conjugation of a macro- with a micro-zoospore, or a male with a female. Exact observations on the development of isolated examples of *Polytoma* have however shown that there are neither macro- nor micro-, male nor female zoospores to be distinguished; further, that there is no distinction between the *Polytoma* of the last and the first generation, and that in certain circumstances the

* Zool. Anzeig., v. (1882) pp. 426–9.

† The infusion was made by moistening with water the muddy sediment from a fountain basin. To this infusion rotting leaves were added and the vessel set in a warm place.

Polytoma of the last generation not only divide into eight and then into four several times, but can also produce progeny with the capacity for conjugating.

Besides conjugation, the *Polytoma* have another way of reaching the resting stage. In *P. spicatum* was observed a similar condition to that which exists in *Chlamydococcus*. After the loss of the cilia, the body-substance began to detach itself from the envelope, took the spherical form and secreted a clear membrane on its surface. After this no division of the cells took place, the membrane became somewhat thicker, but how the little ball escaped from the parent envelope, and what became of it afterwards, could not be observed.

Whether the *Polytoma* reach the resting state in one way or the other, in both cases we have globular cells. To further the transformation of the cells to the *Polytoma*, the cells, after remaining long in water, should either be dried and afterwards soaked in fresh water, or removed direct into a rich solution of organic matter (for example a 2–3 per cent. solution of gelatine in an infusion of hay). In both cases the young will during the night slip out of the cells. In the large cells a division into four first takes place, and in the small ones into two, and then the young ones appear. A *palmella* or *pleurococcus* condition was not observed. The cycle of development of a *Polytoma* lasts 3–14 days.

If we compare the development of *Polytoma* with that of the chlamydomonads, we find at once that *P. uvella* cannot be called, with Cohn, *Chlamydomonas hyalina*, and that the *Polytoma* are not to be classed with the Chlamydomonads, although, like the latter, they belong to the Volvocineæ.

Further particulars as to the structure, the variety of division, and the development of both species of *Polytoma*, as well as their deviations from normal development, will shortly appear in the memoirs of the Odessa 'Neurussische Naturforscher-Gesellschaft.'

Ophryocystis Bütschlii.* — A. Schneider has discovered in the Malpighian vessels of *Blaps* a most curious new sporozoarium. It has the form and external appearance of an *Amœba;* its body is often covered with simple or divided digitiform processes, which may equal or exceed the central mass in length. The latter, which is charged with granules, contains from one to ten spherical nuclei 3 μ in diameter, with one or two punctiform nucleoli.

The multiplication of the species is effected principally by cysts. Encystment takes place only between individuals with a single nucleus and of spherical form. The two conjugated organisms secrete around them successively several envelopes, each marked with an equatorial line of dehiscence.

The phenomena which succeed one another in the cyst are very peculiar. Each of the two nuclei divides so as to produce three nuclei in the corresponding half of the cyst. Of the six nuclei thus produced, only two take part in the constitution of the reproductive elements, represented exceptionally by two small spores, and normally by a

* Comptes Rendus, xcvi. (1883) p. 1378.

single large spore. A portion of the plasma of the cyst is implicated with the nuclei in this spore-formation. The four other nuclei and the rest of the granular mass of the cyst remain unused and become liquefied. The spore, resembling a *Navicula*, produces in its interior, besides a residuary nucleus, a certain number of falciform corpuscles, each provided with a nucleus.

Social Heliozoan.*—Prof. J. Leidy describes a singular Heliozoan from Lake Hopatcong, N.J. The animal occurred mostly in groups composed of numerous individuals; one, of irregular cylindroid shape, 0·84 mm. by 0·36 mm., contained upwards of a hundred individuals. They reminded one of a mass of tangled burs. They remained nearly stationary even for twenty-four hours, and exhibited so little activity that, without careful scrutiny, they might readily be taken for some inanimate structure. The individuals composing the groups appeared to be connected only by mutual attachment of their innumerable rays, and none were observed to be associated by cords of protoplasm extending between the bodies of the animals, as seen in *Raphidiophrys elegans*. They were of two kinds—some active and a smaller proportion which were in an encysted, quiescent condition.

The active individuals resembled the common sun-animalcule. The body measured from 0·024 to 0·036 mm. in diameter—in the encysted individuals usually about 0·02 mm. The active individuals were observed to feed on two species of minute monads, which were swallowed in the same manner as in *Actinophrys*. After some hours a few individuals appeared to have separated from the surface of one of the groups, but they were as stationary and sluggish as when in association with the others.

The species is apparently distinct from others previously noticed and may be named *Raphidiophrys socialis*.

Living Organisms in Brickwork.†—"Wherever Science looks with "close and careful eyes life appears to be found. The deepest sea-"soundings reveal the existence of cephalopods, brittle-stars, or lower "genera; the upper waters are full of invisible creatures; the dust of "the air is laden with germs and infusoria; and there is no part of "any living bodies but seems to be peopled with countless parasitical "dwellers. It is a little surprising, however, to be told that the "decaying bricks of all our buildings in London and elsewhere are "densely inhabited by special animalcula. This, however, is posi-"tively announced by M. Parize, who declares himself to have seen "with the Microscope, in every portion of crumbling, weather-worn "brickwork, minute living organisms, which are the real destroyers "of the surface and even the walls of buildings. The harder the "brick the fewer these tiny burrowing things would be; but "wherever the walls are seen to be 'weathered' there they are "declared to exist, making their invisible lodgings in the material "which would seem so impervious. We do not answer for the "accuracy of these observations, but they cannot be called ridiculous

* Proc. Acad. Nat. Sci. Philad., 1883, pp. 95-6.
† *Daily Telegraph*, 3rd April, 1883.

" when it is remembered that the sea-worm eats through stone and " shells, and that even tobacco-leaves are bored by creatures which " feed on them and dwell in them. That these odd beings can get " nourishment from a bath-brick or a cornice cannot be imagined; but " if they really inhabit our walls, as is said, one more proof is given " of the ubiquity and wonderful variety of life."

BOTANY.

A. GENERAL, including Embryology and Histology of the Phanerogamia.

Continuity of Protoplasm through the Walls of Cells.*—The existence of an open communication between certain cells of the higher plants, viz. between the different elements which make up the sieve-tubes, has been shown by the recent investigations of Wilhelm, Janczewski, Russow, Tangl, Frommann, Strasburger, and others,† and most emphatically by the observations of Gardiner ‡ on the pulvinus of *Mimosa*. W. Hillhouse adds a fresh series of observations to the same effect carried on in Prof. Strasburger's laboratory at Bonn. The preparations were made from the cortical tissue of the young stem of the laburnum, and from the cortex and base of the leaf of a number of other trees and shrubs, the best results being obtained in January.

The method pursued with the most successful results was as follows. Radial and tangential sections as thin as possible were prepared, either from fresh material with a razor covered with a layer of absolute alcohol, or from material which had lain some days in absolute alcohol. The sections were then treated with dilute, and, after some minutes, with concentrated sulphuric acid, which had been protected from the air for from 20 to 48 hours. The acid was then carefully removed by a pipette, and the preparation washed several times with distilled water; it was then inclosed in glycerin without having been once removed from the glass slide. By this means the whole of the cell-wall is removed; the intercellular substance often completely disappearing also.

The author describes in detail the preparation obtained in this way from a radial section through the base of the leaf of *Prunus laurocerasus*, where the parenchyma consists almost entirely of collenchymatous cells abundantly pitted. The connection of the protoplasmic strings of adjacent cells was here distinctly seen after the removal of the cell-wall. Similar results were obtained with a number of other plants, a very good example being furnished by the winter-buds of the sycamore. The protoplasmic threads which penetrate the cell-walls are, however, so delicate, so refringent, and appear to be so

* Bot. Centralbl., xiv. (1883) pp. 89–94, 121–4 (1 pl.).
† See this Journal, i. (1881) p. 70.
‡ Ibid., *ante*, p. 225.

slightly tinged by reagents, that no means at present exists of detecting them *in situ*.

These facts are of the greatest importance in connection with Strasburger's view of the unity of the entire plant. The author suggests that the continuity of the protoplasm from cell to cell may be an important factor in accounting for the contractility of the motile organs.

Pollination of Rulingia.* —According to J. Urban, several species of this Australian genus of Buttneriaceæ possess curious adaptations to crossing by insect aid. The flowers are small (1 cm. or less in diameter) and whitish. The pistil secretes nectar, which collects about it or in the hollowed petals. At first the stigma is closely covered by five dilated staminodia, closely inflexed over it for a time, but later separate. In *R. pannosa* there is well-marked proterandry, the staminodia not separating, nor the stigma maturing, until the stamens are all dehiscent. *R. corylifolia*, on the other hand, is synacmic, the expansion of the sepals and the dehiscence of the stamens occurring in regular succession, and being closely followed by the successive removal of the staminodia from the mature stigma. *R. parviflora* is intermediate between the two species already mentioned. Its flowers assume a rosy colour with age, like those of *Trillium grandiflorum*, *Weigelia*, &c.

Development of Chlorophyll-grains and Pigment-bodies.† —Further investigation of these bodies by A. F. W. Schimper leads him to the conclusion that the growing point always contains differentiated chlorophyll-bodies or their colourless matrix, and confirms the view that these are not formed by rejuvenescence out of the cell-protoplasm, but always by division from those previously existing, and that they are the source of all the chlorophyll-bodies and starch-generators of the tissue which developes from the apical meristem. A very favourable instance of a green growing point is afforded by the roots of *Azolla*, which contain bright green chlorophyll-grains in their apical cells. They occur also in the growing points of the aerial roots of epiphytal orchids, especially in *Dendrobrium spectabile*, and in the roots of *Lemna* and the slenderer roots of *Hydrocharis morsus-ranæ*. In the majority of cases, however, the growing point and the merismatic parts of plants contain no chlorophyll, from the absence of sufficient light; and even when exposed to the light they frequently contain only the colourless protoplasmic matrix of chlorophyll-grains, i. e. starch-generators, as in the roots of seedlings of *Zea Mays* and *Phaseolus*, and the aerial roots of *Impatiens parviflora*.

Colourless growing points contain colourless starch-generators, resulting from division, and not from rejuvenescence; these are always found in the growing point of the stem of seedlings, and give rise, by division, to all the chlorophyll-grains, starch-generators, and pigment-bodies of the entire organism, except those of the roots, which

* Ber. Deutsch. Bot. Gesell., i. (1883) pp. 53–6.

† Bot. Ztg., xli. (1883) pp. 105–11, 121–31, 137–46, 153–62 (1 pl.). Cf. this Journal, *ante*, p. 238.

are in the same way the products of the starch-generators occurring in the growing point of the radicle. A very good example of spherical leucoplastids is afforded by the transparent cells of the growing point of *Impatiens parviflora*; also by those of *Tropæolum majus* and *Dahlia variabilis*. The plastids in the growing points of monocotyledons appear as a rule to be very small; they can readily be made out in the aerial roots of *Hartwegia comosa* and in *Tradescantia*.

An exceedingly interesting point is that the plastids of seedlings are not formed during germination, but are already present in the seed, and that those found in the growing points of the radicle and plumule are the direct product of similar bodies contained in the ovum-cell, and therefore are directly derived from the parent plant. The cell-contents of the embryo are, however, far too dense for the plastids to be detected in them.

One and the same plastid may undergo many metamorphoses; the leucoplastids may become chlorophyll-grains, and subsequently again lose their colouring matter; chloroplastids and leucoplastids may become chromoplastids. It is clear that the chloroplastid must be regarded as the original form of plastid, from which the others have subsequently developed. The lowest organized plants known to contain leucoplastids or chromoplastids are the Characeæ, the former in their apical cells, the latter in their antheridia.

Leucoplastids owe their origin either to previously existing leucoplastids or to chloroplastids; this latter is the case with those flowers and fruits which change colour from green to white, as the berries of the "snowberry tree." They do not appear here to have any special function. In other cases they are the generators of starch. On the other hand, in many flowers leucoplastids become transformed into chromoplastids.

Chloroplastids (those which contain chlorophyll) are also derived either from other chloroplastids or from leucoplastids. To this class the author refers with hesitation the red and brown assimilating structures of the Florideæ and Phæosporeæ, as well as the brown pigment-bodies of *Neottia nidus-avis*.

Chromoplastids exhibit every variety of shade between pure carmine-red and greenish yellow; other colours, as blue, do not appear to occur, though vacuoles and other bodies have been mistaken for them. They are sometimes more or less regularly spherical, more often of a crystalline form, but most often fusiform, acicular, or rod-shaped. As long as they are uninjured they never contain vacuoles. They are invariably derived from leucoplastids or chloroplastids, even the form of these being sometimes not changed. Sometimes they assume regular crystalline forms. They may be classified, according to their forms, under three types:—(1) nearly or quite spherical, (2) with two or more pointed ends, and (3) rod-shaped with rounded ends. The first type occurs in the aril of the yew, the berries of *Solanum dulcamara*, and the petals of *Nuphar luteum*. Those of the second type vary greatly in form, and are found in the perianth of *Hemerocallis fulva* and *Asphodelus luteus*, the fruit of *Sorbus aucuparia* and *Euonymus europæus*, the petals of *Tropæolum majus*, &c. We find

a combination of these two types in the hip of the rose, the fruit of *Lonicera xylosteum*, the perianth of *Iris pseudacorus*, and the petals of *Cucurbita pepo*. The third type occurs in the perianth of *Tulipa Gesneriana*, the root of the carrot, and the perianth of *Maxillaria triangularis*. Chromoplastids are always developed from round leucoplastids or chloroplastids. The angular form is the result of changes in shape of the entire plastid, not of any disruption. No connection can be traced between the form of chromoplastids and the systematic position of the plant in which they occur.

The albumen of a number of plastids belonging to these three types passes over, in the living cell, partially or entirely, temporarily or permanently, from the living into the crystalline condition. In leucoplastids the albumen is comparatively rarely in the crystalline condition; the forms observed may be classified under three types:—the fusiform, rod-shaped, and spherical. The two first types are very unstable. Their chemical composition is always very nearly that of living protoplasm; they may pass over directly into it without, at least at first, losing their crystalline form. The living portion of the plastid is renewed by the direct transformation of crystallized into living protoplasm. The albumen of chloroplastids is also comparatively seldom crystalline. That of chromoplastids crystallizes more often. Except in *Cucurbita*, this takes place, in all the cases examined, before the opening of the flower or ripening of the fruit, often in the very young organ. In the act of crystallization the colouring substance is either mechanically inclosed or is less often thrown out. These crystals agree altogether in form with those of leucoplastids; they are most commonly fusiform, less often rod-shaped.

Effect of Tension of the Bark on the Formation of the Annual Rings of Wood, and on the Direction of the Medullary Rays.*—A careful series of observations on this subject by G. Krabbe leads him to the conclusion that as long as the structure of the bark has undergone no substantial change either from wounds or from other processes, its tangential tension increases with the increase in thickness of the wood. In opposition to the view of Kny, he considers that the medullary rays are diverted from their original position in consequence of the greater contraction of the bark on the side towards which they tend.

Formation and Properties of Duramen.†—J. Gannersdorfer applies the term duramen (*Kernholz*) not only to the harder wood towards the centre of stems, but also to the layer of more or less dark-coloured wood often found in the neighbourhood of wounds or adjoining dead tissue. The vessels of this duramen frequently furnish thyllæ. For the dark-coloured contents of the vessels the author adopts Hartig's term xylochrome. The following are among the more important results of his observations.

* SB. Akad. Wiss. Berlin, 1882, p. 1093. See Naturforscher, xvi. (1883) p. 53.

† SB. Akad. Wiss. Wien, lxxxv. (1882) pp. 9–41.

These formations of duramen are commonly produced in the first place by derivatives from the solid contents, especially starch, filling up all the elements of the wood. These products are formed in the affected part, as well as being conveyed from the adjoining normal parts. These products cause an increase in the mass of the duramen, so that its weight exceeds that of the alburnum. These substances must be in a fluid or half-solid state when deposited in the tracheal elements, since they reproduce perfectly the inner structure of the walls of the cells and vessels. As long as these substances are contained in the parenchymatous elements they are rich in tannin, so that they seem to constitute a link between the contents of the duramen and starch. In addition there also occur products of decomposition of a different kind, which, at least after they have been deposited for some time, considerably increase the power of resistance of the duramen. Nitric acid, or Schulze's solution, and potash or soda-lye, used in succession, remove nearly completely the contents of the duramen, except in the case of *Diospyros*; and the uninjured cell-walls are then exposed with their thickening-layers, and distinctly exhibit the cellulose-reaction. If the deposition has lasted for a very long period, the cell-walls are themselves partially destroyed, and the products of their decomposition mingle with the cell-contents. The contents of the duramen vary in their composition according to the species; in *Prunus*, for example, and the Amygdaleæ generally, they consist chiefly of gum; in the Coniferæ of resin; in *Syringa* of resinous substances. Their mode of origin is the same in all cases. The function of the duramen, especially in stumps, is the protection of the subjacent tissue from injurious external influences. The same effect is produced by the thyllæ which occur in many plants, and by deposits of calcium carbonate.

Polarization-phenomena of Vegetable and Artificial Colloid-cells.*—N. J. C. Müller gives the following as the results of a series of observations on the polarization of vegetable colloids and of gelatine:—

Hollow spheres in vegetable colloids and in gelatine have a negative tension in the marginal layer; that is, they behave as if their marginal layer were made rigid by expansion of the cavity. Solid spheres, on the other hand, such as the natural spheroids of starch and inulin, have a positive tension—that is, they exhibit a rigidity due to compression. All cell-walls in the interior of the plant behave as if they were made rigid under negative tension. Polyhedral and spherical cells are optically uniaxial; cylinders and prisms optically biaxial. Transverse sections of all correspond to the optical section of the marginal layer of a hollow sphere. The cuticular layer and cork-membrane behave in the reverse way; they correspond to a colloid mass made rigid under compression, so that a calotte cut out of an extine-intine mass of the epidermis behaves precisely like a circular section of a glass tube. All vegetable colloids adapt themselves to cylindrical cells, which correspond, in their optical properties,

* Ber. Deutsch. Bot. Gesell., i. (1883) pp. 77–83.

to the natural cylindrical or prismatic cells in the interior of the plant. The only instance of a different behaviour is in an artificial cylinder of gum-tragacanth, which resembles the stem-cell of *Caulerpa*. All the more delicate points of structure, such as pitting of the membranes, dots, or pores on the one hand, or projecting masses, ridges, or spiral bands on the other hand, can be imitated artificially in colloids rendered rigid. The former can be referred to the phenomena of hollow spheres, the latter to local compression or dilatation of the rigid mass.

Origin of "Cell-passages."*—In the annual rings of many woody plants there are visible even to the naked eye long crescent-shaped spots, which are seen on tangential section to be passages, and which have been described under various names, "Markflecke," "Zellgänge," &c. These have been examined in a number of trees, willow, birch, alder, *Pyrus*, &c., by M. Kienitz, who has determined them to be always abnormal structures; and in fact to be passages produced by larvæ, and filled up by new cells, the larvæ having devoured the cambium and other young cells at the time when the ring was being formed. The cells which break through the margin of the wound grow rapidly, and divide further by delicate septa; at the same time the cambial ring closes up completely; and from this time normal wood and normal cortex are again formed above the surface of the wound; while, quite independently of the new cambium, the cavity is closed by the growth of the cells.

Collenchyma.†—In a monograph on this subject, E. Giltay treats chiefly of the mechanical importance and properties of collenchyma.

Collenchyma occurs either at the periphery of organs, or less often in the centre; in the form either of collenchymatous bast, distinguished by the secondary sclerenchymatous elements not being lignified, as in *Polemonium reptans*, *Lycium barbarum*, *Peperomia*, *Botrychium Lunaria*, and *Ophioglossum vulgatum*, or as collenchymatously thickened medullary cells, as in *Panicum imbecille* and *Erythrina marmorata*. In the collenchyma of the vascular bundles the author includes not only the ridges in Umbelliferæ, Labiatæ, &c., but also the stereome of Aroideæ, inaccurately termed sclerenchyma by Schwendener.

Although collenchyma occurs comparatively rarely in monocotyledons, it was found in all the climbing species examined, *Asparagus scandens*, *Lapageria rosea*, *Smilax*, and *Roxburghia viridiflora*.

With regard to the power of swelling of collenchyma, the author shows by numerous measurements on various plants, *Fœniculum vulgare*, *Dipsacus ferox*, *Achillea filipendula*, *Pyrethrum multiflorum*, and *Rubia tinctorum*, that the wall of collenchymatous cells may be 32 per cent. thicker in water than in alcohol of 95 per cent.

As regards the history of its development, Giltay agrees with Haberlandt that the origin of mechanical tissue is as various as possible.

* Bot. Centralbl., xiv. (1883) pp. 21–6, 56–61 (2 pls.).

† Giltay, E., 'Het Collenchym,' 186 pp. (5 pls.) Leyden, 1882. See Bot. Centralbl., xiii. (1883) p. 409. Cf. also this Journal, i. (1881) p. 768; ii. (1882) pp. 71, 812.

Structure of the Pericarp of Orchideæ.*—J. A. Oesterberg describes the structure of the pericarp in a number of plants belonging to the order Orchideæ, with special reference to the course of the fibrovascular bundles in the flower. The pericarp he states to consist of four distinct portions; the protecting tissue, the mechanical tissue, the pneumatic and assimilating tissue, and the vascular bundles; each of which is described in detail.

Chemistry of Woody Tissues.† — N. Schuppe confirms the generally accepted chemical composition of cellulose, $C_6 H_{10} O_5$. The gum which remains after treatment with water, alcohol, and dilute soda he finds to have, in the German and American walnut wood, the composition of cellulose; in the oak and mahogany the formula $C_{14} H_{22} O_{11}$ $(2C_6 H_{10} O_5 + C_2 H_4 O)$; in the poplar and alder, $C_8 H_{14} O_6$ $(C_6 H_{10} O_5 + C_2 H_4 O)$.

The wood-fibre, after extraction of this gum, yields an approximate average composition C 45·4 per cent., H 5·9, O 48·7. The proportion of lignin in various kinds of wood he finds to average about 17·62 per cent.; that of cellulose being about 40·7. For lignin he gives an approximate formula $C_{19} H_{18} O_8$, which is also the composition of catechin; the varying properties of lignin seem to have some relation to the presence of tannic acid. The relative proportion of lignin and cellulose named above would give for the normal composition of wood a formula somewhat resembling $5C_6 H_{10} O_5 + C_{19} H_{18} O_8$.

First Products of Assimilation.‡—In opposition to the statements of Loew and Bokorny, A. Mori still maintains his view as to the formation of an aldehyde as the first product of the mutual decomposition of water and carbon dioxide. He disputes their assertion that a red tint is produced in fuchsine sulphite simply by the evaporation of sulphurous anhydride without the application of heat. No trace of coloration was produced by placing two or three drops of the reagent on various substances, such as cotton thread, cotyledons of the lupin or scarlet runner, &c.

Selective Power of Absorption of Roots.§ — Hervé Mangon records a remarkable instance of the power of plants to absorb different proportions of the constituents of the soil under different circumstances in the case of the ice-plant, *Mesembryanthemum crystallinum*. The strongly refractive glands on the surface of the leaves contain a very large amount of saline ingredients. In these he found the percentage of chlorine in the ashes to vary between 5·4 and 12·1, of potassa between 11·1 and 18·7, and of soda between 4·4 and 10·3.

* Bot. Gesell. Stockholm, March 7, 1883. See Bot. Centralbl., xiv. (1883) p. 125.

† Schuppe, N., 'Beiträge zur Chemie des Holzgewebes,' 39 pp., Dorpat, 1882. See Bot. Centralbl., xiv. (1883) p. 105.

‡ Nuov. Giorn. Bot. Ital., xv. (1883) pp. 203-5. Cf. this Journal, i. (1881) p. 906; ii. (1882) pp. 67, 361, 522; *ante*, p. 225.

§ Comptes Rendus, xcvi. (1883) p. 80.

Movements of Water in Plants.*—R. Hartig has carried on a series of experiments relating to the tissue through which the circulation of the fluids takes place in plants, and the causes which set them in motion.

In the oak he finds the duramen, notwithstanding the large amount of water it contains, quite incapable of conduction; while in the birch, on the other hand, the conduction takes place through the whole of the wood; and these may be taken as examples of two different types. The organs for the conduction of the sap are chiefly those provided with bordered pits, especially the tracheides; and at times also the true vessels.

The absorption of water by the roots is nearly altogether independent of the ascent of water through the wood. It is caused by the osmotic forces of the cells of the root, especially of the root-hairs; often called the root-pressure. It is very largely dependent on the temperature of the soil, less so on the amount of water which it contains. Hence the beech, oak, larch, and pine contain the largest quantity of water in the height of summer, the birch on the other hand about April.

The cause of the ascent of water in the wood is the difference in the density of the air in the conducting organs, by which the water is pressed upwards from cell to cell.

The proportion of water and air in the conducting organs varies with the time of year; when the cell-walls are saturated the cell-sap may occupy from one-third to two-thirds of the cavity of the cell. It rises in them by the action of capillarity.

While therefore the movements of water in trees are brought about mainly by the changes in the density of the air contained in them, the pressure of the atmospheric air exercises no or very little influence on the whole process.

Movement of Water in the Vessels.†—J. Vesque thus summarizes the results of his researches on this subject:—

1. Water is conveyed through the vessels:—(*a*) when they are full of air; (*b*) when they inclose sufficiently long columns of water, interrupted here and there by bubbles of air, local transference; but (*c*) no conveyance of water takes place when small portions of water are everywhere separated by bubbles of air.

2. When transpiration is active the vessels give up water to the surrounding elements, and become full of air.

3. When transpiration is sluggish, the air contained in the vessels diminishes in volume, and finally disappears altogether.

The vessels are therefore always reservoirs of water; and, in special circumstances, are the agents for its conveyance.

Exudation of Water from Leaves.‡—By an examination of plants in very early morning, Volkens has greatly extended the list of those

* Unters. Forstbot. Inst. München, ii. (1882); iii. (1883) pp. 47, 94. See Bot. Ztg., xli. (1883) p. 250.

† Ann. Sci. Nat. (Bot.), xv. (1883) pp. 5–15. See also this Journal, ii. (1882) p. 373.

‡ Ber. K. Bot. Gartens Berlin, 1883. See Science, i. (1883) pp. 491–2.

from which liquid water exudes. He describes the water-pores of 150 species, distributed through 91 genera and 36 families. He appears to have exercised great care to avoid errors from the possible presence of dew upon the leaves. In order to ascertain the amount of water in the stems of the plants exhibiting this phenomenon, he made use of double scissors, by which a piece about half an inch in length could be cut out at one stroke, thus diminishing the chances of affecting the relative amounts of air and water in the part at the moment of separation. By the use of this simple contrivance, he has shown that the amount of air and water in a vigorous plant varies considerably during the day, even when the specimen is kept under uniform external conditions. Most of his observations were made upon wild plants in open fields.

Hypoxanthin in the Potato.*—E. Schulze finds that in the precipitate produced in the sap of the potato by phosphor-tungstic acid after removal of the albuminoids, together with peptones, other nitrogenous substances of the nature of xanthin are present. He succeeded in obtaining a substance which gave the reactions of hypoxanthin. Approximate quantitative determinations gave an average percentage of 0·00355 gr. of hypoxanthin in 100 ccm. of the sap.

Function of Tannin in Metastasis.†—E. Kutscher thus sums up the results of a series of observations on this subject:—

1. Tannin may be an excretory product of metastasis, as in *Ricinus*, *Phaseolus*, the roots of many Cycadeæ, and in the leaf-glands of *Hypericum perforatum*. It is in this case not distributed through all the cells of the tissue, but occurs only in special excretory cells. In these it is often mixed with pigments, and disappears along with them; it appears to have no other function. It usually causes a blue reaction with iron.

2. It may be of further use in metastasis; as in *Vicia Faba*, and *Helianthus annuus* and *tuberosus*. It is then formed only during the construction of primary tissue and on its first differentiation, as in the growing point, the cambium, in young fruits, and in the formation of secondary roots. It is at first formed in all the cells of the tissue, permeating also the cell-walls and nucleus, and then passes into special tissues. A rapid consumption of tannin also takes place within the bud; this becomes afterwards slower but continuous, so that at the end of the period of growth only traces of it remain. It cannot, however, be stated with certainty that it serves directly as the formative material for primary meristem. Its chemical properties and life-history point to the conclusion that it serves as a medium for respiration; i. e. that it undergoes oxidation.

Laws which regulate the Production of Male and Female Flowers.‡—Comparing male with female maple trees, T. Meehan

* Landw. Vers.-Stat., xxviii. (1882) pp. 111–5. See Bot. Centralbl., xii. (1882) p. 257.

† Flora, lxvi. (1883) pp. 33–42, 49–64, 65–74 (2 pls.).

‡ Proc. Acad. Nat. Sci. Philad., 1882, pp. 89–92.

noted differences in their habits of growth. Taking a twig of the last season's growth, in a flowering condition, one or two blossoms might appear alongside of the leaf-bud, in trees of either sex. So far there was no difference. But in the female tree the central or leaf-bud, when it pushed into growth in the spring, made a shoot of several or many inches in length, according to the vigour of the tree or parent branch. In the male tree, on the contrary, the central growth was not more than perhaps a quarter of an inch, forming a mere tuft of leaves on the top of what was a head of male flowers. The immense amount of pollen from the early flowers, forming the great bulk of all the pollen produced by the tree, is scattered before the female flowers open, and is absolutely useless for any purpose of fertilization, or useless for any purpose of individual benefit to the tree or to the race. These later opening flowers, formed on the wood of last year, are evidently the chief reliance, if not the only reliance, of the female flower for its reproductive energy.

It may be stated in general terms that a highly vital condition is more closely allied with those attributes which characterize the female sex than with those characteristic of the male, and we may therefore reasonably look for some influence in the female direction on the male flower where these conditions exist. Therefore male flowers on a shoot characterized by a highly vitalized condition, would be likely to resist influences to which they would be otherwise subjected. In short, a male flower on a strong branch ought not to yield as readily to the excitement of heat as one growing on a weak branch. At any rate the fact that the whole of the weak spurs of the maple tree produce nothing but male flowers, and that these male flowers expand at a lower temperature than the females do, is conclusive as to the law, whatever answer the objection may receive. This law, thus demonstrated, will be of great practical value to culturists.

As regards the influence which these facts must have on questions of dichogamy, there need not necessarily be any constant rule in the production of proterandrous or proterogynous flowers. We might expect to find proterandry prevailing to a greater extent in plants growing where there was a more constant succession of warm and cool days, than in the same species growing where the climate is not what is called changeable, that is to say, where the temperature is regularly low until the regular spring season has arrived, in which there would not be much difference in time between the advance of stamens or pistils.

In conclusion, the author considers that if he may be allowed to generalize from this experience with the maple tree, the following principles are proved :—

Male flowers do not appear on female maple trees till some of its vital power has become exhausted.

Branch-buds bearing female flowers have vital power sufficient to develope into branches.

Branch-buds bearing male flowers have not vital power enough to develope into branches, but remain as spurs, which ever after produce male flowers only.

Buds producing male flowers only are more excited by heat than females, and expand at a low temperature, under which the females remain quiescent.

A few warm days, succeeded by cooler ones, will therefore make a corresponding difference in time between the opening of the male and the female flowers, and possibly in the proportionate advancement of the stamens and pistils in hermaphrodite flowers.

Selenotropism of Plants.*—Ch. Musset, struck by the heliotropic movements of plants, has made some experiments on the influence of the moon. He sowed seeds of plants known for their phototropic sensibilities, such as *Lens esculenta*, *Ervum lens*, and *Vicia sativa*. When they were some centimetres in length they were placed in the dark; the branches became delicate, long, and white, while the leaves were tinted a slight yellow. On the 22nd, 23rd, and 24th of February, when the sky was exceptionally clear, they were exposed to the direct light of the moon from 9 P.M. to 3 A.M. Almost at once the branches became curved, presenting their concavity and terminal bud towards the moon. The bud seemed to follow the moon, and when the plants were placed at a window with a western aspect a fresh movement was seen, and this continued until the moon disappeared behind the hills. The author proposes to call these movements selenotropic.

Withering of Flowers and Leafy Shoots.†—According to J. Wiesner the leaves of most plants transpire more strongly than the flowers; and in cut branches, or such as are insufficiently supplied with water from below, the leaves usually wither sooner than the flowers. Cut flowers wither less rapidly when there are no leaves attached to the shoots; and if transpiration is prevented from the leaves, the flowers remain quite fresh, showing that the transpiring leaves withdraw water from the flowers. The same is the case with plants growing in the ground when the supply of water is insufficient. The growing ends of branches and flower-stalks lose water and wither in the same way, not by direct transpiration, but by the water being withdrawn by the mature foliage.

The surface of the floral leaves and of young leaves is greatly reduced by withering and desiccation, often as much as 50 per cent., resulting partly from the cessation of tension and turgidity, partly from the loss of the water of imbibition of the cell-wall. The opening of flowers is frequently the result of transpiration.

Cut leaves which have been placed for a time under water wither more rapidly when exposed to the air than those that have not been moistened, the moistening favouring transpiration.

Leaves absorb as a rule more water through the under than through the upper surface; rain and dew do not, therefore, usually supply much water directly to the plant; but both favour transpiration after the moistening has ceased. This is of advantage to the plant only when the supply of water to the plant from the soil is insufficient.

* Comptes Rendus, xcvi. (1883) p. 663.

† Wiesner, 'Studien über das Welken von Blüthen u. Laubsprossen,' Wien, 1882.

Hence in certain circumstances dew is injurious to the plant. When plants are withering, change in position of the leaves brings their under surface under the direct influence of rain, which is of advantage to them.

Flowers which have been moistened do not usually wither more rapidly than those that have been kept dry; in consequence of secondary influences, they may even remain fresh longer.

Fatty Acids in Plants.*—E. Schmidt and H. Römer find that the oil in the nucellus and testa of the seeds of *Cocculus* consists almost entirely of free stearic acid, with small quantities of other fatty acids rich in carbon. The menispermin of commerce, obtained also from the seeds of cocculus, is also nearly pure stearic acid. Nutmeg-butter contains also from 3 to 4 per cent. of free myristic acid, and a smaller quantity of other fatty acids. When dried bay-berries are digested in hot alcohol, distilled, and the oily residue washed with hot water, the presence of a considerable quantity of free fatty acid can be proved, consisting probably partly of palmitic acid.

Influence of Mineral Substances on Germination.†—In a series of experiments on the influence of mineral substances on germination, which influence is proved by the significant increase of the ash-contents of all seedlings, P. P. Dehérain and E. Bréal, and afterwards J. Boehm, have further examined the important part lime exercises on germination. Lentils, grains of corn, and beans were soaked in distilled water or in spring water, and then left to germinate or develope in distilled water or in several solutions of salt. The development of the separate portions of the plant and their ash contents were examined, and the results gained in separate experiments are as follows:—

1. In the first stages of their development the young plants absorb a considerable portion of mineral substances.

2. They even absorb, in considerable quantity, mineral substances that exercise no favourable influence on their development.

3. Of all the mineral substances applied lime exercises the most advantageous influence. Indeed seeds which develope very badly in distilled water, when allowed to germinate in spring water, develope normally at the ordinary temperature. The favourable influence of the lime-salts is especially remarkable in the development of the roots.

4. The form in which the lime is present is not by any means immaterial; it exercises a much more favourable influence when united with ulmic acid than with nitric acid, as if the ulmic acid tended directly to the nourishment of the young plants.

5. At the same time it cannot be asserted that the addition of foreign lime is necessary for the development of the young plant; for when seeds are placed in distilled water at a temperature from 30°

* Arch. d. Pharm., xxi. (1883) pp. 34–8. See Bot. Centralbl., xiv. (1883) p. 8.

† Ann. Agronomiques, ix. (1883) pp. 58–77. Cf. Naturforscher, xvi. (1883) p. 156.

to 35° they frequently develope normally without any lime being discoverable in the newly-formed organs.

Occurrence of Iron in Plants.* — A. B. Griffiths finds that in plants (the Savoy cabbage) grown in soils without any artificial addition of iron salts, the ash contains iron, the leaves yielding a very much larger percentage than the stalk. If ferrous sulphate is added to the soil, the proportion is greatly increased. Microscopical examination showed that in the protoplasm of the chlorophyllaceous cells there were minute crystals (not crystalloids), sometimes solitary, sometimes arranged in groups round a common centre. These were easily proved by chemical tests to be crystals of some salt of iron, probably ferrous sulphate; they belonged to the monoclinic system, and their composition was probably $FeSO_4+7H_2O$. They occur in plants grown in natural soil, but are much more numerous in those grown in iron-manured soil. They were also found near to the chlorophyll corpuscles, and the author suggests that they may act as reserves for the formation of the green colouring matter of chlorophyll.

B. CRYPTOGAMIA.

Palæontological Development of Cryptogams.† — Saporta and Marion trace the fossil remains of Siphonaceous Algæ back to the Lower Silurian period. The higher algæ, they consider, do not make their appearance till comparatively modern times, partly in the Jurassic; the Characeæ, Florideæ, Phæosporeæ, and Fucaceæ in the Tertiary.

The flora of the dry land developed entirely from aquatic Protophyta. The Musci and Hepaticæ constitute a lateral branch, the main stem producing in succession the Filices, Rhizocarpeæ, Lycopodiaceæ, Gymnospermæ, and Angiospermæ. The primary and secondary strata furnish no remains of mosses, probably because they are entirely of marine or brackish origin. From a primary fern with undifferentiated sporangia, sprang the Filices, Lygodiaceæ, and Marattiaceæ. The latter have existed from the Carboniferous period; the Lygodiaceæ do not make their appearance till the end of the Cretaceous period. The Cyatheaceæ date from the commencement of the Carboniferous period, the true Polypodiaceæ only from the Rhætian. The Lycopodiaceæ with isosporous sporangia may be an independent branch from the Protophyta, and appear as early as the Devonian; the Heterosporæ are more highly differentiated Isosporæ, having their highest development in the *Lepidodendra* of the Carboniferous period, and then degenerating to the Selaginelleæ and Isoeteæ. The most highly developed Cryptogams are the Rhizocarpeæ, to which belong the Rhætian *Sagenopteris* and the Carboniferous *Sphenophyllum*.

The Cryptogams form therefore, according to these authors, a main branch of the vegetable kingdom, which has sprung directly

* Journ. Chem. Soc., xliii. (1883) pp. 195–7.

† Saporta, G. de, and Marion, A. F., 'Die palæontologische Entwicklung des Pflanzenreiches. Die Kryptogamen.' 250 pp., Leipzig, 1883. See Bot. Centralbl., xiii. (1883) p. 411.

from the Protophyta. The Gymnosperms appear in the Carboniferous period, but only to a very subordinate extent. All the groups of Cryptogams had by that time been differentiated. The highest type of Cryptogams was defeated in the struggle for existence by the Gymnosperms and Angiosperms.

Organic Unicellular Bodies in Coal.*—Further investigation of the peculiar organic bodies found in coal by P. F. Reinsch confirms him in the view that they are of two kinds totally different from one another. The smaller or *Triletes*-form bears a remarkable resemblance to the spores of *Sphagnum*, and may probably be bodies of this description. They occur in such enormous quantities in some Russian coal as to constitute from 80 to 90 per cent. of its mass. A cubic centimetre may contain 5,827,000 of them, having an average diameter of 0·033 mm. The larger of these bodies are of a totally different nature, and are probably independent organisms forming a stage of development of some very simple plant-form.

Cryptogamia Vascularia.

Fibrovascular Bundles of Vascular Cryptogams.†—According to H. Potonié the terms xylem and phloëm have neither a physiological nor a definite morphological meaning as applied to the vascular bundles of cryptogams. By phloëm nothing further is to be understood than the part of the bundle which contains sieve-elements, and by xylem that part which contains the tracheids; without associating with these ideas any definite limitation of these portions of tissue.

As respects the fibrovascular bundles themselves, everything must be regarded as belonging to the bundle which stands in an unquestionable physiological relationship to it as an anatomico-physiological unit of a high order. The mechanical adjuncts, therefore, which often inclose or accompany the bundle must be regarded as belonging to it.

The stereome which commonly surrounds the bundle in the form of strings, is sometimes found within the mestome, as in *Adiantum trapeziforma*. The tracheome is, according to the most recent observations, not the tracheal but the hydral system of the bundle, and may therefore be called the "hydrome." The function of the "amylome," or parenchymatous elements which usually contain starch, is to convey the carbohydrates. The starch-cells which often occur among the hydroids, but which are apparently not connected with one another by equivalent elements, form a continuous system. The hydrome and a portion of the amylome constitute together a system of a higher order, the "hadrome." The osmotic force of the amylome either exhausts the hydroids of water or fills them with it. This physiological relationship explains the remarkable facts that where a number of hydroids lie close together the hydrome is regularly permeated by threads of starch, and that all vascular cryptogams possess

* Flora, lxvi. (1883) pp. 187–9. Cf. this Journal, *ante*, p. 409.

† Jahrb. K. Bot. Gartens Berlin, ii. (1883) pp. 233–78 (1 pl.). See Bot. Centralbl., xiv. (1883) p. 100.

a hadrome. The "leptome" is the part of the bundle which contains albumen, and is composed therefore of sieve-tubes and cambiform, understanding by the latter term the elongated parenchymatous cells which accompany the sieve-tubes and contain nothing but albumen. The "protophloëm" or "protoleptome," consisting, in *Dicksonia antarctica*, of sieve-tubes, must apparently be included here. The "endodermis," whose function appears to be purely mechanical, and the starchy layer adjoining it on the inside, proceed from a common histogen, the "coleogen." In the young leaf-stalks of *Dicksonia antarctica* there is a gradual transition from fundamental parenchyma through the coleogen to the procambium. In many rhizome-bundles the coleogen is in immediate contact with the protohydrome.

The rhizome-bundles of the Polypodiaceæ are stated to be not concentric, but bicollateral.

The following is a table of synonymous terms.

Phloem	Sieve-tubes / (Protoleptome) / Cambiform	Leptome	Mestome.
Xylem	Hydrome / Amylome	Hadrome	Mestome.
Fundamental Tissue	Endodermis. / Stereome-sheath and adjuncts.		

Muscineæ.

Anatomical Structure of Mosses.*—G. Firtsch describes the mechanical contrivances in the anatomical structure of the following parts of the moss *Polytrichum juniperinum*:—the mechanical system of the stem and seta; the firmness of the stereids; the mechanism of the unrolling and erecting of the leaf; the contrivances for fixing the sporogonium in the stem; and the hairy covering of the calyptra.

Hybrid Moss.†—H. Philibert records a new instance of a hybrid moss, found wild, between *Orthotrichum diaphanum* and *O. Sprucei*. He considers it a true instance of a hybrid sporogonium, resulting from the fertilization of an archegonium of *O. Sprucei* by antherozoids of *O. diaphanum*. The hybrid was intermediate in its characters between the two parents, and also in the time of producing its reproductive organs.

Fungi.

Localization of the Hymenium of Fungi.‡—N. Patouillard inquires why, if all the hyphæ of a fungus are morphologically equivalent, the hymenium is as a rule localized to the under side of the pileus, where it is not unfrequently renewed after having been once destroyed. He believes the reason to be that the under side of the pileus is the best protected part of the structure, and enumerates instances

* Ber. Deutsch. Bot. Gesell., i. (1883) pp. 83–97 (1 pl.).
† Rev. Bryol., x. (1883) pp. 8–13.
‡ Rev. Mycol., v. (1883). See Bot. Centralbl., xiv. (1883) p. 130.

where the ordinary rule is departed from. The "inverse" hymenium is not uncommon in the Agaricini. *Hydnum compactum* and species of *Fistulina* may have hymenophorous tubes or projections on the upper side. The upper part of the stipes of many species of *Boletus* has reticulate structures which are a true hymenium. If the pileus does not afford sufficient protection for the development of the spores, it remains sterile, as in *Polyporus annosus*. *P. alutaceus* and *Trametes suaveolens* occasionally produce organs of fructification on the upper side. Although most Hymenomycetes require the protection of a pileus, the Clavariei do not. The *Pezizæ* seem to need the assistance of water, which the *Agarici* avoid; the Lycoperdacei surround their organs of fructification with a resisting envelope; in the Sphæriacei this envelope is hard and carbonaceous.

Chemistry of "Fairy-Rings."*—Sir J. B. Lawes, Dr. J. H. Gilbert, and R. Warington have continued their investigations as to the causes of the rings of luxuriant grass which are always more or less connected with the appearance of fungi. They consider that there is no doubt that the source of the nitrogen of the fairy-ring fungi is the organic nitrogen of the soil itself, which they assimilate, presumably, though not certainly as organic nitrogen, and eventually deposit as manure which becomes available to the associated herbage. Immediately outside the ring the turf is generally found penetrated by a white cobweb-like mycelium extending to a depth of several inches, and sometimes even to a foot or more.

Fungus-Parasites of the Aurantiaceæ.†—While previously only 34 species of fungus had been described as parasitic on the orange, lemon, citron, and allied trees, O. Penzig now brings the number up to 153, including exotic forms, 54 of which are new. Some of these, as *Rhizoctonia violacea*, *Sphærella Gibelliana*, and *Meliola Penzigi*, entirely destroy the crop; while others appear only sporadically, but are always injurious. Each species is described in detail, with Latin and Italian diagnosis, an account of its habitat, literature, synonymy, &c., with various biological and critical notices. Coloured nature-printed illustrations of 136 species are given.

"Ozonium." ‡—C. Roumeguère has investigated the connection between the old genus *Ozonium* and the filamentous mycelium of various hymenomycetous fungi. He finds that it may belong to no less than eleven species, viz. nine of *Coprinus*, one of *Lenzites*, *L. trabea*, and one of *Craterellus*, *C. muscigenus*. He is unable to confirm the statement that has been made, that "conidia" are formed on the ozonium. The white or fawn-coloured byssoid portion which forms a kind of puffiness of the base of the stipes of *Coprinus* on the surface of the ozonium is a form of sclerotium from which the *Coprinus* springs. The external layer of this sclerotium is composed of

* Journ. Chem. Soc, xliii. (1883) pp. 208–23.

† Penzig, O., 'Funghi agrumicoli. Contrib. allo studio dei funghi parassiti degli agrumi,' 124 pp. (136 pls.) Padua, 1882.

‡ Réunion des délégues des Soc. sav. à la Sorbonne, March 28, 1883. See Bot. Centralbl., xiv. (1883) p. 62.

filaments of the ozonium, cuticular filaments resembling those of ordinary sclerotia. The *Coprinus*, like the *Lenzites* and *Craterellus*, has an ozonium or not, according to its environment; just as other species of these genera have or have not sclerotia.

Harknessia.*—The genus *Harknessia* was established by M. C. Cooke from the only known species, *H. Eucalypti*, parasitic on *Eucalyptus*. G. Winter now describes a second species, *H. Molleriana*, also parasitic on *Eucalyptus* in Portugal, and which he regards as identical with Speggazini's *Melanconium uromycoide* from the Argentine Republic. Winter now proposes the following amended diagnosis for the genus:—Perithecia integra, pseudo-parenchymata, mollia; sporæ ellipticæ, unicellulares, coloratæ, pedicello articulato hyalino prædítæ, demum in cirrhis atris expulsæ.

Lophiostoma cæspitosum.†—S. Schulzer von Müggenburg has found this rare pyrenomycetous fungus on dead branches of the hawthorn. It occurred in two different forms; one had the typical form of *Lophiostoma*; the other, that of *Melogramma*, parasitic not on the wood, but on the inner bark. The fructification of the two forms is identical. It follows that the two kinds of stroma among the Pyrenomycetes, those characteristic of *Valsa* and of *Diatrype*, cannot be taken as distinguishing characters of families or even of genera.

Oidium albicans.‡—According to F. A. Kehrer this fungus consists of two elements, filaments constituting a mycelium, and small toruloid structures, the conidia. The former consists of a variable number of cylindrical cells, with lateral or terminal buds or branches; they are never composed of long unseptated tubes. The cylindrical cells are not unfrequently slightly swollen at the extremities, and somewhat constricted at the septa; they are of variable length, and about 0·025 mm. diameter. They are sharply defined, and when young the contents are quite clear; vacuoles and granules appear in them later. The buds or conidia are produced by budding either at the extremities of the filaments or near the septa, rarely at the middle of a cylindrical cell. They are globular or oval, and are formed in moniliform rows or in smaller or larger groups. At first simple, they may give rise to other buds by simple budding. They have a clearly defined outline, and the contents are slightly coloured. Instead of producing other buds, these conidia sometimes develope into cylindrical cells, giving rise to mycelia with lateral branches. The resting-spores are formed in the globular lateral buds of the mycelium, by the homogeneous strongly refractive protoplasm contracting into a central ball.

The author gives lists of nutrient fluids which are more or less favourable, injurious, and destructive to the growth of the fungus. He believes it to be both saprophytic and parasitic in its nature.

* Hedwigia, xxii. (1883) pp. 19–21.

† Oesterr. Bot. Zeitschr., xxxiii. (1883) pp. 113–5.

‡ Kehrer, F. A., 'Ueber den Soorpilz,' 71 pp., Heidelberg, 1883. See Bot. Centralbl., xiv. (1883) p. 48.

Investigation and Culture of Pathogenous Bacteria.*—Fehleisen gives a *résumé* of the methods pursued by Koch and others in the investigation of pathogenous bacteria. In the case of "panaritium" to which the fingers of servant-girls are especially liable, and which is frequently epidemic, he finds a very small micrococcus forming zooglœa colonies, which spreads over the surface as a yellow coating, which can be well cultivated on gelatin. This micrococcus appears to be almost exclusively confined to cases of panaritium.

Earthworms in Propagation of Charbon.†—M. Feltz reports that, making a preparation of earth after the method of Koch, he placed in it fourteen earthworms; some three weeks later he removed, one by one, six worms, which he washed carefully; after as carefully cutting them up he injected them into guinea-pigs. These all died in less than three days; those inoculated by the first washings of the worms likewise died rapidly, while those treated by the last resisted the action of the poison. The author agrees, therefore, with Pasteur and disagrees with Koch as to the rôle of earthworms. Some experiments on the attenuation of the poison were made by preparing slightly alkaline and sterilized infusions of chicken-broth, in which the charbon-poison was cultivated; by placing fresh cultivations in stoves heated and kept to a temperature of 42° to 43° C., Feltz was able to convince himself that the poison loses its virus in direct proportion to the time of exposure, and that it may be completely lost. The morphological expression of this is to be seen in the tenuity of the bacterian filaments, and a certain shrinking of the germs. It would seem to be certain that nature may accomplish an analogous operation in the earth, and that we may thus explain the variations in the gravity of attacks by this poison. Examination of different victims leads to the belief that the "spontaneous" cure of the poison is effected by the destruction and elimination of the bacteria by the digestive tract. The paper concludes with the account of some successful vaccination experiments.

Transmission of Bacteria from the Soil into the Air.‡—In the course of a research on the presence of bacteria in the effluvium and vapours of the fever districts, J. Brautlecht mixed baked sand, gritty earth, and tolerably loamy garden mould with liquid containing bacteria, and covered the mixture with a bell-glass according to the requisite rules of precaution. A few hours after there were, in the vapour condensed under the bell-glass, a great number of micro-organisms, of the same form invariably as those contained in the liquid used. The number of organisms raised by evaporation was great in proportion to the quality of the fluid soaking the earth; they were on the other hand fewer in number when cooled sand was sprinkled over the damp earth.

* SB. phys.-med. Gesell. Würzburg, 1882, pp. 113–21.
† Comptes Rendus, xcv. (1882) pp. 859–62.
‡ Tagebl. Deutsch. Naturf.-Vers. Eisenach, 1882. Cf. Naturforscher, xvi. (1883) p. 156.

Fresh Method of Vaccination for Symptomatic Anthrax.*—Messrs. Arloing, Cornevin, and Thomas call attention to subcutaneous injection of mitigated virus as a method of vaccination for this disease quite as efficient as venous and tracheo-bronchial injection.

The serous matter from anthrax tumours is attenuated or mitigated by exposing it to heat. It is first dried at a temperature of 32° C. in a current of air; a certain quantity is then well mixed with twice its weight of water and kept on a stove heated to from 85° to 100°, for six hours. Only small quantities should be thus treated at a time, and the stove should be so regulated as to recover its initial temperature in less than two hours from the introduction of the mixture.

In the use of the mixtures thus obtained, which are of different degrees of attenuation according to the heat employed, great care must be taken to adapt the proportions and strength of virus employed to the susceptibility of the animals exposed to its action. It is best to make two inoculations with an interval of six or eight hours between them, the first with virus mitigated by a temperature of 100°, the second with virus which has been exposed to 85°. A sheep requires ·01 gramme of each kind of virus, an ox ·02 or ·03 gramme, according to its size; this is mixed in a mortar with 100 times its weight of water, and introduced by a syringe under the skin; the side of the neck or the inside of the thigh is the place selected. The result of experiments made on sheep, calves, and a heifer was a slight local swelling in the last-named animals; this gradually disappeared; more considerable swellings were produced in the sheep. The temperature usually rises ·2° to ·7° after the first, ·5 to 1° after the second inoculation. The resistance of inoculated subjects to the disease was proved by test-experiments. Besides its great power of resisting heat, the micro-organism of symptomatic anthrax, when dried as above directed, is able to resist the action of antiseptic agents. When obtained from serous fluids it usually occurs in the sporiferous condition.

Organic Particles in the Air of Mountains.†—P. Giacosa has made a series of experiments on the nature of the organic particles found in the air at different heights on Monte Marzo, a mountain in Piedmont 2753 m. high; the observations were made in August by means of the pipette-bulbs recommended by Tyndall; and were controlled by similar observations in the plain at the foot of the mountain.

He finds the air of the mountain always to contain germs, although in different proportion to that of the plain. The Schizomycetes were very much more rare; almost the whole of the particles found belonged to the class of micrococci. The observations appear to show that the currents of air are constantly giving a circular shape to the particles suspended in it, and that such particles can then be raised to great heights, although they occur there in smaller quantities than at lower

* Comptes Rendus, xcv. (1882) pp. 189–91.

† Atti R. Accad. Sci. Torino, xviii. (1883) pp. 263–72 (1 pl.).

elevations. Insects play a certain part in this circulation of organic germs. The essential composition of the air itself appears to be the same at all heights.

New Myxomycete.*—V. Fayod describes a new myxomycete, growing on horse- or cow-dung, which may be a form of *Amœba Limax* Duj., and to which he gives the name *Guttulina protea.*

It forms yellowish-white, shining, fusiform or horn-shaped elevations from 1 to 3 mm. high, which, when immersed in water, break up into a great number of spores, which are hyaline, colourless, or slightly yellow, strongly refractive, more or less regularly elliptical, bean-shaped, or nearly triangular, with an average length of about 14 μ and breadth of about 9 μ. Their protoplasm is finely granular, and contains a comparatively large, usually central, nucleus. They do not germinate in water, but in a decoction of dung after about 20 hours. Shortly before germination a slowly pulsating vacuole makes its appearance, which disappears a few minutes before the protoplasm escapes as a myxamœba or swarmspore through a lateral orifice in the membrane of the spore, only one being formed in each spore.

The free myxamœba, after moving about for a time, takes the form of a slug and contains a nucleus, the anterior end being occupied by the denser hyaloplasm, the posterior end by the less dense granular protoplasm, where there is also a large slowly pulsating vacuole. Like other amœbæ, it has the power of taking up and digesting solid substances. No enveloping membrane can be clearly distinguished, though it probably possesses one. Their average length is from 16 to 22 μ; they move about with considerable rapidity. These myxamœbæ possess a peculiar property of a sudden rapid propulsion, to from two to four times their own length, accompanied by a temporary rounding off of their shape.

Multiplication begins some time after germination, when the myxamœba has attained a considerable size. Its motion becomes gradually slower and at length ceases; it becomes round with short blunt projections, which are soon drawn in again, the nucleus at length disappearing. It now becomes more and more elongated, then hour-glass-shaped as the protoplasm collects at the two ends, and finally divides into two. Each of the two new myxamœbæ rapidly assumes the slug-like form of the parent, and developes a nucleus. This process of division is repeated through several generations. It is well observed only in a dilute and pure nutrient fluid. They creep readily out of the nutrient fluid, and then assume indefinite, usually flattened disk-shaped forms. Although apt to collect together in great quantities, coalescence into a true plasmodium was never observed. Under favourable conditions they become transformed into spores, distinguished by their rounder form, greater refrangibility, and want of motility. It is only some time after this change that a membrane is distinctly visible. The spores germinate usually in four or five days.

* Bot. Ztg., xii. (1883) pp. 169–77 (1 pl.).

When the nutrient fluid is more concentrated or contaminated with bacteria, multiplication is greatly hindered; the myxamœbæ are larger and put out lateral pseudopodia; the proportion of hyaloplasm is smaller, and the movements slower, finally ceasing, the vacuole ceasing at the same time to pulsate. The myxamœba is then spherical, 12 to 15 μ in diameter, with a yellow or brown membrane, and may be termed a microcyst. The application of reagents shows the membrane to be double. The microcysts may remain at least a month, and even dry up without losing their power of germination.

The whole process of development resembles closely that of *Guttulina rosea* Cienk.; but the present species is distinguished by its size and absence of colour.

Lichenes.

Structure, Development, and Life-history of a Tropical Epiphyllous Lichen.*—H. M. Ward's observations led him to believe that the epiphyllous cryptogam examined by him supports the Schwendenerian theory that a lichen is a compound organism composed of an alga to which an ascomycetous fungus has become more or less intimately affixed. It is developed on the leaves of many plants, but it has been more closely watched on *Michelia furcata*. The lichen presents four types—orange-red, stellate patches, greyish-green blotches, clear grey spots, and white shining circles; but these pass imperceptibly into one another, and vary in size from a speck to 1-4th in. in diameter. The reddish spots of the earlier stages are algæ, of which the radiating filaments are in part reproductive organs, and in part barren hairs. The alga subsequently passes into the grey and green stages, and by a modification of growth the invasion of a fungus-mycelium succeeds. The white matrix of the complete lichen consists of the same algal thallus invested by dense masses of the fungus hyphæ, which produce shining black dots, viz. the fructification.

The author describes in detail the peculiarities of growth and reproduction of the alga and fungus, and the formation of the lichen. He alludes to and criticizes Dr. Cunningham's account of *Mycoidea parasitica*, which plant is evidently closely related to that described by himself. Assuming that *Mycoidea* and Ward's alga are generically the same, either Cunningham discovered a female organ of reproduction which becomes fertilized and produces zoospores, or he confounded this with "fertile hairs."

As regards the systematic position of the alga, a comparison with *Coleochæte* suggests that there is very little in common beyond the mode of growth of the disk-like thallus and the production of zoospores from certain cells. The genus *Chroolepus*, moreover, presents features which agree in several important points, viz. orange-red oily cell-contents, habitat, and production of zoospores in ovoid cells, developed terminally and laterally. The structure of the thallus, and the relative positions of the main masses of fungal and algal portions

* Trans. Linn. Soc. Lond. (Bot.) ii., 1883, pp. 87–119 (4 pls.).

agree with what occurs in heteromerous crustaceous lichens as *Graphidea*, but the perithecia indicate its angiocarpous alliance, bringing the form nearer such families as *Pertusaria* and *Verrucaria*, to the latter of which it may ultimately be referred.

Algæ.

Vegetation of Street Gutters.*—The discovery that, among the causes of epidemic diseases, microscopical organisms play an important part, is a great advance in the cause of science, which is capable of much further development. Dr. Hugo Winnacker communicates a number of observations which he made in the town of Göttingen, laying stress on the fact that scarcely any other water is subjected to greater change than that in running street gutters. Every hour produces deviations in the water-level, and from the dried edges every current of wind may carry germs which only need damp to regain active life in the habitations and breathing-places of men.

The small vegetable organisms which are now found in the running gutters of Göttingen, vary much according to the season of the year and the particular locality, and, as often happens in nature, the rapid multiplication of one checking that of another, the one supplants the other. The author notes down, according to months and particular streets, the genera and species which he found in the gutters of Göttingen from October 1877 to August 1878. There occurred partly green or black filamentous algæ (amongst which were *Oscillaria*, *Vaucheria*, *Zygnema*, and *Cladophora*), partly diatoms, and partly fungi, among which, besides *Leptothrix* and *Fusisporium* (of which a new species is described), are notably *micrococcus*, *bacillus*, *spirillum*, and *bacterium ;* the most suspicious found in the greatest quantity.

With regular plentiful rinsing through clean water, the algæ were predominant, and next to them the fungi. The vegetation is at its greatest activity from May to July. Fungi and algæ struggle against one another for existence, each prevailing as the circumstances favour the one or the other. The drought of summer and the cold of winter chiefly destroy the algæ and also a few fungi, but not *micrococcus*, *bacillus*, and *bacterium*, so that these thereby have the advantage.

Algæ are not injurious to men; but are, on the contrary, useful as regulators of vegetation. Green gutters are in no way detrimental. Among the fungi, moulds are harmless to the human organism. The only ones which are harmful as promoters of fermentation and spreaders of infection are the Schizomycetes, to which belong *micrococcus*, *bacterium*, *bacillus*, &c. The following, in the words of the author, are the principal rules to observe for the preservation of public health :—

1. By constant and abundant flushing with clean water the street

* Winnacker, H., 'Ueber die niedrigsten, in Rinnsteinen beobachteten pflanzlichen Organismen,' 4to, Elberfeld, 1883, 19 pp. and figs. Cf. Naturforscher, xvi. (1883) pp. 153–4.

gutters will contain as little organic matter as possible, so that only algæ and no fungi will be able to thrive in them.

2. But as this is only possible for a short space of time, all damming up of the stream must be avoided so as to allow moulds the opportunity of arresting the too great development of Schizomycetes.

3. As the Schizomycetes are most rapidly developed in the summer months that is the season requiring the greatest precautions.

Formation of Tetraspores.*—In the general account of the Florideæ in the first part of the second vol. of Rabenhorst's 'Cryptogamic Flora of Germany,' &c., F. Hauck states that the dense and highly coloured protoplasmic contents of the tetrasporangia may divide into the four (rarely more or fewer) tetraspores in the six following ways, viz.:—(1) Tetrasporangium undivided, only one spore being formed from its contents. (2) Bipartite; the contents divided into two equal parts by a transverse wall. (3) Divided crosswise; the contents dividing into quadrants by two successive bipartitions. (4) Tetrahedral division; the contents dividing into tetrahedra by simultaneous quadripartition. (5) Zonal division; the contents dividing into four parts by parallel walls. (6) Multipartite; when the contents divide into more than four parts.

Reproduction of Porphyra.†—The systematic position of the Porphyraceæ (*Porphyra* and *Bangia*) has long been a matter of doubt with algologists. In Rabenhorst's new 'Cryptogamic Flora of Germany,' &c., F. Hauck assigns them a definite place as the lowest family of Florideæ, and describes the cystocarps (in *Porphyra leucosticta*) as produced by fecundation by means of a rudimentary trichogyne out of female cells similar in form to the tetraspores, the protoplasm of which divides mostly into four carpospores by division-walls both parallel and vertical to the surface of the thallus. The antheridia and antherozoids are also described.

Cryptogamic Flora of Arctic Ice and Snow.‡—V. B. Wittrock describes the cryptogamic vegetation brought from a number of localities within the Arctic zone. The flora of the hard blue ice of the glaciers and of the Greenland inland ice is quite different from that of the eternal snow and of the snow-covered portions of the glaciers. The snow-flora comprises about 40 species and varieties, the ice-flora only about 10.

The plant-forms of the snow-flora belong to mosses and algæ; but the former exist only in the protonema form, and can therefore not be determined specifically. The algæ belong to 8 families and the following 25 genera:—*Chroococcus*, *Glœocapsa*, *Oscillaria*, *Scytonema*, *Stigonema*, *Navicula*, *Stauroneis* (?), *Penium*, *Cylindrocystis*, *Chionophila* n. gen., *Docidium*, *Tetmemorus*, *Cosmarium*, *Euastrum*, *Staurastrum*,

* Rabenhorst's 'Kryptogamen-Flora von Deutschland,' &c. 1882. 2er Band: Die Meeresalgen, von F. Hauck,' p. 11.

† Ibid., p. 25.

‡ "Om Snöns och Isens Flora, Särskildt i de Arktiska Trakterna." Af Veit Brecher Wittrock. Ur "A. E. Nordenskjöld, Studier och forskningar föranledda af mina resor i höga Norden." Stockholm, 1883 (2 figs. and 5 pls.). Bot. Gesell. Stockholm, March 7, 1883. See Bot. Centralbl., xiv. (1883) p. 155.

Bambusina, *Sphærella*, *Chlamydomonas* (?), *Oocystis*, *Pleurococcus*, *Glœotila*, *Ulothrix*, *Hormiscia*, *Conferva*, and *Cladophora*. Ten species and varieties are new. The mass of the snow-vegetation consists of *Sphærella nivalis*, *S. nivalis* β. *lateritia* n. var., *Chlamydomonas flavovirens* (?), *Pleurococcus vulgaris* β. *cohærens* n. var., and *Cylindrocystis Brebissonii*.

The ice-flora consists entirely of algæ belonging to 6 families and the following 8 genera:—*Glœocapsa*, *Scytonema*, *Nitzschia*, *Ancylonema*, *Cylindrocystis*, *Cosmarium*, *Zygnema*, and *Sphærella*. In both the ice and snow-flora *Sphærella nivalis* was frequently met with gamospores, usually spherical, 20–27 μ in diameter, and with blood-red contents, and unilamellar cell-wall. When the spores germinate, the contents first divide into two naked portions, each of which again divides into two, which contract into a spherical form, and clothe themselves with a thin cell-wall.

The ice- and snow-plants are mostly brightly coloured, and perform an important function in causing a not inconsiderable melting of the snow by their strong absorption of the rays of heat.

Vaucheria-Galls.*—G. Benkö has made a close examination of the galls which infest various species of *Vaucheria*, and finds them in all cases to be caused by the same parasite, *Notommata Werneckii*. The species attacked are *V. sessilis*, *geminata*, *geminata* var. *racemosa*, and *dichotoma*; but, in opposition to previous statements, he finds it not always identical in form on the same species. They have always a vertical position, and often stand very close together.

Motion of Diatoms.†—J. M. Adams suggests that, inasmuch as all efforts to find some *outside* means of movement have failed, it is very probable, if not almost certain, that the movements of diatoms are produced within the frustule. "The front view of *Naviculæ*, and of all elongated forms having a central nodule, usually shows a division of the vegetable contents into two or four parts, having a main central alley between them running both lengthwise and crosswise. Currents seem to be produced by some means through these central alleys, and water is forced out of the porous frustule at the ends or sides as through a sieve, inasmuch as the cross lines of diatoms are merely attached globules of silex with spaces between. These globules of silex, being so close together, prevent a clear vision of the interior part of the frustule, but it seems probable that vibratile cilia line the surface of the vegetable matter within, and these beating in unison cause the water to flow in one direction or another, as they more or less unite in their action." Could a fresh frustule be broken open, he believes the surface of the vegetable matter within would show this presumed ciliated arrangement.

To this the following editorial comment is made:—"Our correspondent, like many others, finding no satisfactory solution of this problem through observation, resorts to speculation concerning it.

* Magyar Növ. Lapok, vi. (1882) pp. 146–52. See Bot. Centralbl., xiv. (1883) p. 1.

† Amer. Mon. Micr. Journ., iv. (1883) p. 59.

We must caution the reader that it is not yet known whether the frustules are perforated or not, as will be seen from an article soon to be published in these columns. As for the presence of cilia within the diatoms, we have no more reason to expect to find cilia there than in any other cells in which the movement of protoplasm has been observed—as in desmids, or in the cells of higher water-plants, for example. Moreover, diatoms are not the only plants which move without visible cause. The desmids, for instance, move with vigour, and they are not inclosed in a silicious shell which obstructs examination of the interior. In young desmids especially the cyclosis can be examined with satisfaction by high powers. Looking over the algæ, we find that the *Oscillariæ* are quite as remarkable in their movements as the diatoms, and we cannot yet explain it; and in the animal kingdom the Gregarinæ also move without giving the least indication of how the motion is produced. It is a subject for still further investigation, and we have no doubt that with good objectives, supplemented by staining fluids properly applied, the cause of the movement will soon be discovered."

Fossil Diatoms of Austria-Hungary.*—A. Grunow describes the following fossil diatoms from Austria-Hungary :—(1) In the "Saugschiefer" of Dubravica, a large number of species. (2) The "Polierschiefer" of Tallya. The diatomic remains are here united together with extraordinary firmness by silicic acid, forming variously radiating microscopic masses of crystals, which renders the examination extremely difficult. (3) The argillaceous neogenous basalt-tufa of Holaikluk. The most abundant form here is *Melosira tenuis*, also closely united by silica, and often containing petrified silica in the interior of the cells. (4) The diatom-stratum of Kis-ker, of unknown age, with ordinary still existing fresh-water forms. (5) "Kieselguhre," vivianite, and "ocker" stratum of Eger and Franzensbad. Several new forms. All the new species are depicted in phototypic illustrations.

Diatom Types.—Dr. H. van Heurck is preparing a series of preparations to illustrate his synopsis of Belgian diatoms, representing the principal types and elucidating the critical species. There will be about 350 slides, containing at least 400–500 forms, and 25 will be issued monthly. M. Grunow will examine the slides to check the determinations.

MICROSCOPY.

a. Instruments, Accessories, &c.

Bausch and Lomb Optical Co.'s New Binocular.†—The Bausch and Lomb Optical Company have completed a binocular of their "Investigator" pattern, which has some variations in the construction and adaptation of the prism, and in the nose-piece in which the prism is fixed. The notices which have so far appeared of its con-

* Beitr. zur Palæont. Oesterr.-Ungarns u. d. Orients von Mojsisovics u. Neumayr, ii. (1882). See Bot. Centralbl., xiv. (1883) p. 146.

† 'The Microscope,' iii. (1883) p. 89, from the 'Odontographic Journal.'

struction and advantages are not a little perplexing both theoretically and practically, but we transcribe them as they are given:—

"1. A very large prism, with perfectly plane surfaces, cemented upon a glass disk.

2. As this combined prism and disk is fixed by the maker, it remains in place regardless of the whim of or want of skill in the observer.

3. The mounting of this combination is a brass nose-piece, which slides into the tube and is fastened by a new form of bayonet-catch, a novel feature in itself.

4. The monocular nose-piece is separate and is fastened in the tube in the same manner.

5. The effect with the prism in place is quite as good in this instrument as it is in the old forms when the prism is withdrawn, as it permits the passage of [more] light [than is] possible in objectives with the Society screw.

6. While a little more time is consumed in changing from monocular to binocular and back again than is the case in the old form, the loss is fully compensated for by the absolute accuracy of the new, which cannot get out of place.

7. As low powers only are used in binocular instruments, a given objective may be kept in the binocular nose-piece and the higher power in the monocular, an arrangement almost as convenient as in the well-known double nose-piece.

8. The bayonet-catch above mentioned may be applied, and probably will be in the near future, to objectives as a substitute for the Society screw. The fit is as good, and the time saved in changing objectives great."

The binocular is also thus referred to in the 'Amer. Mon. Micr. Journ.,' iv. (1883) p. 97:—

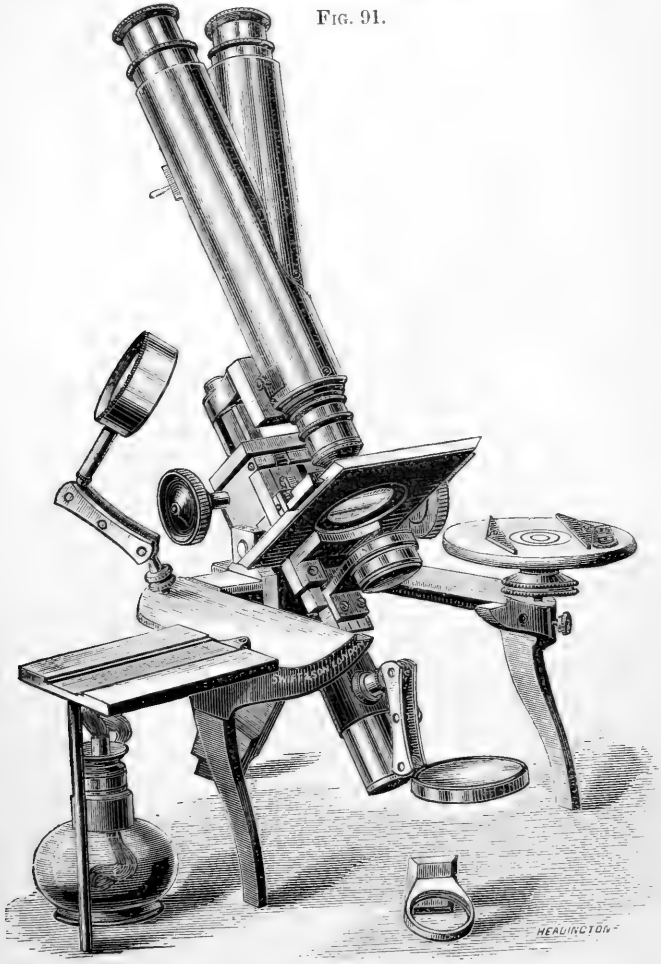
"Mr. Edward Bausch has devised a modified form of the Wenham binocular. . . Instead of mounting the prism in a metal frame which can be moved in and out, as in the ordinary form of binocular, the prism is cemented to a glass disk which is fixed in a special nose-piece. The nose-piece can be readily attached to the Microscope by a spring-catch.

In this way the prism is always secured in exactly the right place, and when a plain nose-piece is substituted, as when high-power objectives are used, there is nothing in the tube to reduce the angular aperture of the lens. The arrangement is less convenient than the ordinary plan, but if the advantages claimed for it are found not to be of sufficient practical importance to lead to its final adoption, there is no reason why the prism should not be mounted in the old way. We do not yet appreciate the advantages of the separate nose-pieces, and we understand that the makers desire to have the verdict of microscopists concerning this matter, before they adopt the plan.

The prism is a very large one, and as the face which receives the rays is fully exposed it will transmit a larger angle of aperture than the Wenham prism, which is much smaller. It is well known that the mounting of the Wenham prism cuts down the angular aperture

of some objectives.* A large prism, however, gives a correspondingly large pencil of rays, and in the instrument we examined there was a glare of light in the left ocular, which led some one who used it to think there was a defect in the fitting of the prism. On covering the right-hand half of the eye-lens of the left ocular, the glare was entirely stopped out, and the binocular effect was perfect."

FIG. 91.

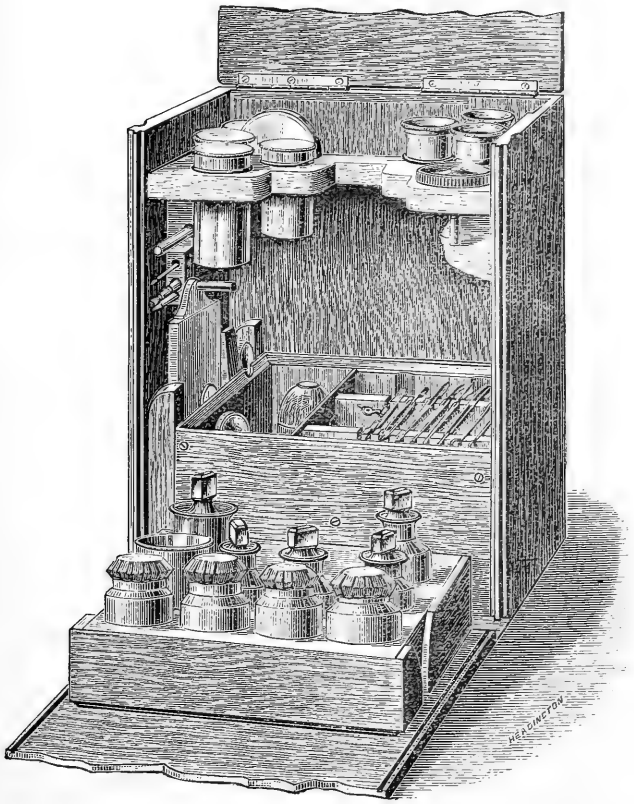


Fase's Portable Dissecting Microscope.—We regret to have omitted to state in describing this instrument at p. 415 that it was

* There is some confusion here between the mechanical cutting down of the opening of the objective caused by the setting of the prism and the optical cutting down of the aperture-angle, which with the Wenham prism is necessarily one-half, only half of the rays from the objective being directed into each tube.—[ED.]

made for the Rev. Mr. Fase by Messrs. Swift and Son. Mr. Swift, with characteristic modesty, wrote us, asking us to take care to refer to it as "Fase's Microscope" and not as "Swifts'," inasmuch as the

Fig. 92.



credit of the design was so largely due to Mr. Fase; in consequence we lost sight of the maker, to whom so much is always due, more than we should otherwise have done.

Figs. 91 and 92 give a better idea of the instrument than that at p. 416.

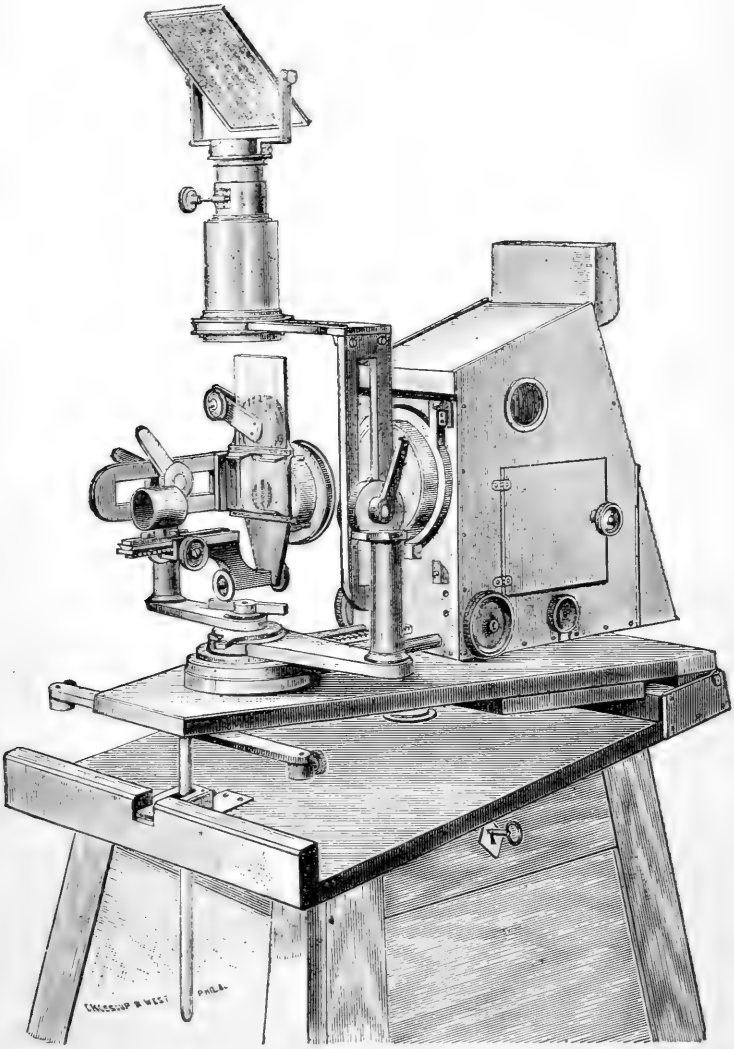
Holman Lantern Microscope.*—Mr. J. A. Ryder describes this instrument (fig. 93) as follows:—

"The instrument illustrated was recently made by Mr. Joseph Zentmayer, of Philadelphia, and presented by subscription to the Franklin Institute. It is the invention of Mr. D. S. Holman, Actuary of the Institute, and is not only adapted to show transparent photographs, but may also be converted, in a few minutes, into a pro-

* Journ. Franklin Institute, cxvi. (1883) pp. 67–9 (1 fig.).

jecting Microscope, polariscope, megascope, vertical lantern, as well as into a table Microscope. The condensers of the lantern are five

FIG. 93.



inches in diameter, and the whole apparatus is constructed in the most substantial way, and every part and accessory is of the best workmanship.

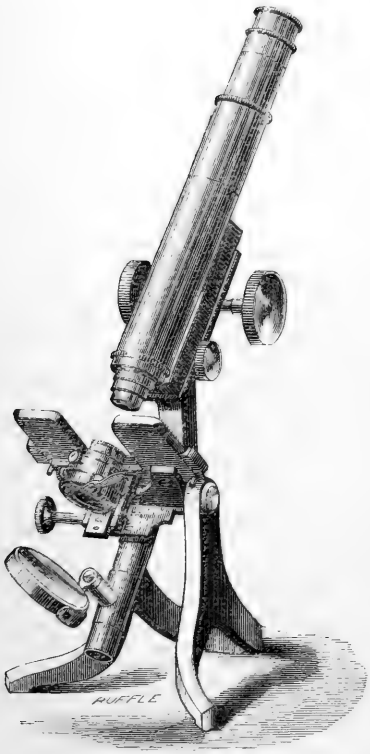
The principal and most important feature of the apparatus consists in making the object to be projected when the apparatus is to be used as a Microscope, or as a megascope, the centre of all the projecting and illuminating apparatus. The lantern-upright which carries the projecting lens or Microscope, and the upright which carries the lens and mirror for the vertical lantern, and the lantern itself, swing around a common centre, which is placed exactly below the centre of the stage on which the object rests. This enables the operator to arrange, with the greatest facility, the relative positions of each of these parts in any desirable position in respect to the object. This feature, it is claimed, has never before been accomplished, and makes the lantern more complete, especially as a megascope. The lantern and jet are movable, independently of each other, by means of racks and pinions. By this arrangement the conjugate foci of the condenser may be changed to suit low and high powers and narrow and wide angle objectives, doing away with all secondary condensers and accomplishing these adjustments better and with much greater facility. The raising and lowering of the lantern is effected by a peculiarly constructed clutch, which rigidly holds the instrument in an inclined position. The instrument is packed in a truncated pyramidal box, containing also the accessories, and forming at the same time a firm stand for the lantern, on which it may be rotated when in use.

In consideration of the fact that the instrument can be used for such a variety of purposes for lecture illustrations, it cannot be regarded as other than a marked improvement upon a similar class of instruments hitherto used for such purposes. In the illustrating and projecting of living forms alone, in conjunction with a number of ingenious devices serving as live cages, Mr. Holman has done a real service for the cause of education. While it is, perhaps, not possible to enter into an elaborate or detailed study of any organic forms of even a moderate degree of complexity, if projected only for a few moments upon a screen, it is, nevertheless, a fact that the correct likeness of such creatures so shown gives the beholder a far truer appreciation of what the things are of which he reads in books than he might possibly obtain elsewhere, provided the lecturer is able to explain in a lucid manner, and unravel the complicated life-histories of the living beings of which he displays enlarged images. In these living animal or perhaps plant-pictures we have displayed two classes of facts, namely, those of type and those of function. To the trained biologist they call to mind the occult processes of growth and reproduction by which the forms become what we see them to be. This implies that a wide range of data is to be considered: first, there is the development and evolution of the form, together with what this indicates as to its systematic relationship; second, the vital actions displayed involve the consideration of physiological processes, and these again those internal quasi-chemical and physical actions and interactions by means of which the creature is enabled to maintain its existence and individuality. If such problems are not worth elucidating, we may ask what others there are which are worthy of elucidation? The physiologist who solves the problem of the life-

actions of an amœba or a maggot has put us in a fair way of appreciating those of a man. If, therefore, better and clearer ideas of animal existence can be fostered in young minds by the aid of any optical appliance whatsoever, that appliance should be welcome as an aid in practical objective instruction. No less effective is this instrument in the illustration of many common facts in physical science. The range of its applicability seems indeed to be limited only by the resources, ingenuity, and ability of the lecturer."

Nelson's Student's Microscope.—Fig. 94 shows a medium-size Microscope, constructed by Messrs. Swift and Son, embodying some suggestions of Mr. E. M. Nelson with special reference to histological research with high powers where only a moderate outlay is allowable.

FIG. 94.

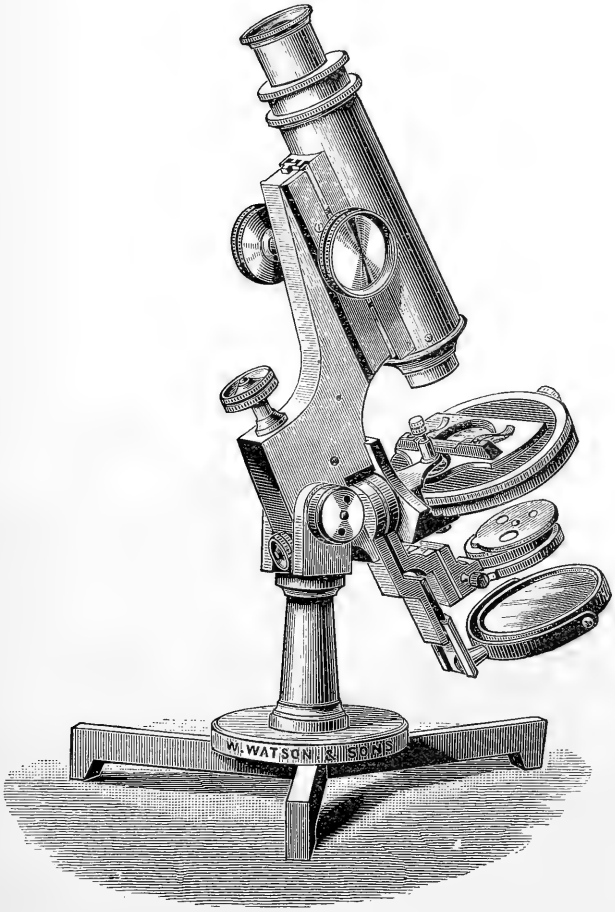


The principal point of novelty is that the front of the stage is cut away so that the position of the substage, with the diaphragms, condenser, &c., may be readily seen from above the stage, and the diaphragms rapidly changed; also permitting the finger to be placed on the upper edge of the slide for safety in focussing with high powers. Amongst other additions it may be noted that finders are applied to the stage by which the position of an object may be recorded without the use of mechanical movements, the graduations for the vertical movement being on the stage plate, and those for the lateral movement on the sliding bar carrying the object. The optical body divides in two for portability. The eye-pieces are fitted with different lengths of tubing, so that the 10-inch length is maintained with each from the diaphragm to the nose-piece, as with Powell and Lealand's Microscopes. Mr. Nelson's centering substage with lateral swinging diaphragm-carrier is also applied (for description and fig. see Vol. I., 1881, pp. 125–6).

Watson's Portable Swinging Mirror and Substage Microscope.—We have always considered Bulloch's Biological Microscope (Vol. III., 1880, p. 1078) to be one of the handiest and most practical forms of

stand made, and equally useful for biological examinations and for the more special examinations of test objects. Hitherto the instrument could only be obtained in America, which was necessarily a drawback to its use in England. Messrs. Watson have now, however, undertaken

Fig. 95.



its manufacture (with some modifications), their instrument being shown at fig. 95.

The fig. shows sufficiently the general form of the instrument: its special feature is that the substage bar and mirror bar are fixed to separate collars, so that they swing separately below and above the stage, the movement of each being independent of the

other. The feet on which the instrument stands are made to close together for portability, so that it occupies a space of $12 \times 7 \times 4\frac{1}{4}$ in.

The slides of the coarse adjustment fit on knife-edges in V-shape grooves, reducing friction, with perfect steadiness and smoothness, and working without loss of time.

The fine adjustment moves the whole of the body of the instrument (instead of the nose-piece only), so that there is no change of distance between the eye-piece and object-glass, and obviating the necessity of altering the collar-correction as the fine adjustment is used—the correction being found once for any given object, no further alteration is required.

The stage is glass and has universal motions, and by a screw-adjustment the friction can be increased or diminished; it is arranged to take off and be replaced by one with mechanical movements if desired.

Altogether the Microscope is likely to be one of the most useful forms for those who do not desire a stand of large size.

Walmsley's Photomicrographic Apparatus.—This simple and inexpensive form of camera (fig. 96), the design of Mr. W. H. Walmsley,* is intended to produce, by the aid of gelatine dry plates and ordinary lamplight, photomicrographs of a high order of excellence, and of almost all transparent objects requiring microscopical examination. It will answer equally well for photographing opaque bodies, if the latter be illuminated by the light of the sun reflected from a silvered mirror.

Any Microscope, monocular or binocular, having an axial joint whereby the body can be inclined to a horizontal position, may be employed. The Microscope is placed upon a base-board 4 feet in length and 9 inches in width, upon one end of which is constructed a platform for holding the camera, of such a height that the tube of the Microscope when inclined shall be precisely in the centre of the camera, which is firmly secured to the platform by a thumb-screw beneath.

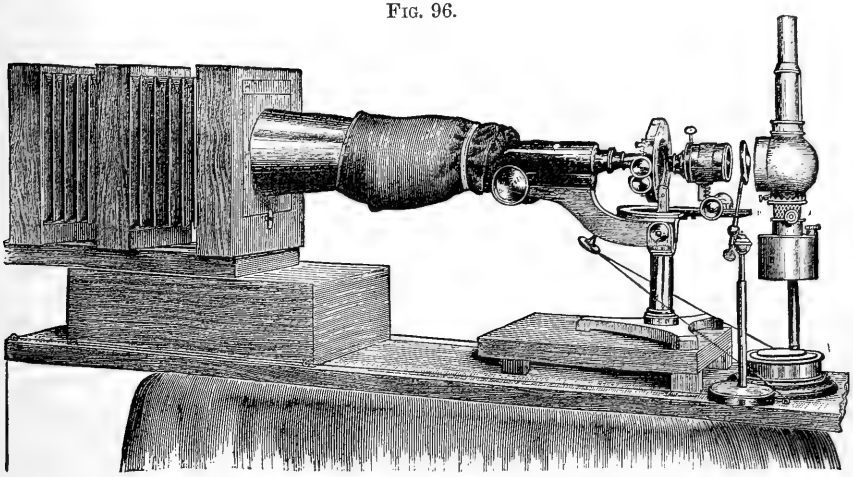
The camera box, which is square to allow a lateral turning of the plates, has a removable cone front, and bellows sliding upon a frame, with an extension of three or four feet, which has been found sufficient for all ordinary work, though it could be increased to any desired extent. A simple form of clamp holds the focussing frame tightly at any point of extension. A second front is provided to replace the one carrying the cone, to which any ordinary photographic lens may be fitted, thus providing an excellent camera for copying or other studio or laboratory purposes. The focussing screen is of glass, with an exceedingly fine ground surface, mounted in a hinged frame, which is turned aside when the plate-holder is inserted. This screen is only used, however, in adjusting and centering the object, the final and delicate focussing being done on a sheet of plate glass, as presently to be described.

* Description kindly supplied by Mr. Walmsley.

The plate-holder (single) is square, opening at the back to admit the plates, which can be placed either vertically or horizontally. The usual size of plate employed is $4\frac{1}{4}$ by $5\frac{1}{2}$ inches, but there is a "kit" furnished also, which permits the use of plates $3\frac{1}{4}$ by $4\frac{1}{4}$—the proper size for lantern positives—which can be very readily made by contact printing from the finished negatives.

Any coal oil or petroleum lamp of good illuminating power, and which can be placed at any desired height above the table, may be used. The Fiddian Illuminator (originally intended for microscopic

FIG. 96.



purposes) has been found admirably adapted to use with the camera, and is the one figured in the illustration. It gives a strong white light through the lens composing its front, all the other rays being cut off by the metallic chamber and chimney containing the flame. It can be raised to any required height, and is recommended as being the best lamp for the purpose.

Although any microscope-stand with axial inclination may be used, Mr. Walmsley finds that those of the size and general form of Beck's National and "Ideal" stands are the best adapted to this class of work. The shortness of tube of the "Ideal" renders it specially valuable, whilst the revolving stage adds greatly to the proper adjustment of the object in the centre of the focussing screen, and the substage carrying an achromatic condenser is almost indispensable. A mechanical stage will also be found to greatly facilitate the necessary manipulations, though the very simplest form of stage, with clips, will, with a little care and patience, answer every requirement.

In using this apparatus, the base-board is to be placed upon a

solid table and the camera firmly secured to the platform, as shown in the illustration. The Microscope (from which the eye-piece has been removed, and the tube, lined with a roll of dead black paper) is to be inclined to a horizontal position and firmly secured to the board by turn-buttons, with the end of the body inserted in the cone front of the camera, about the joining of which a piece of black cloth or velvet is to be wrapped to exclude all extraneous light. The lamp is now to be lighted and raised to such a height as will bring the flame exactly even with the centre of the stage, the direct light being used without the mirror, which must be removed. It is presumed that the proper object-glass has already been attached to the microscope-body, and that an achromatic condenser has likewise been inserted in the sub-stage. A Kellner eye-piece answers admirably for this purpose. A secondary condenser is sometimes necessary between the lamp and stage, as shown in the woodcut, to secure a bright and even illumination all over the focussing screen. This accomplished, the object to be photographed is placed upon the stage, secured in position by the clips or slides, and focussed, which is readily done with the coarse adjustment, for the bellows of the camera being still closed, one can observe the image on the screen and manipulate the milled head of the adjustment at the same time.

The image having been accurately centered on the screen, the bellows is to be extended until the desired magnification is reached, when it will be found that its sharpness is considerably reduced, whilst the screen has been removed so far from the object that it is impossible to readjust the focus and observe the image at the same time without some special appliance, controllable from the screen end of the camera. A very simple contrivance has been adopted in this case, which works with the utmost smoothness and delicacy. A groove is turned in the periphery of the fine adjustment screw, around which a small cord is passed, and carried through a succession of screw-eyes on either side of the base-board to the rear, where a couple of small leaden weights are attached to its ends, thus keeping the cord taut. A very slight pull on either side, whilst the eye is fixed upon the image on the screen, suffices to adjust the focus with the utmost exactness. A glance at the illustration will show the arrangement of this focussing cord, which is applicable alike to stands having the fine adjustment screw on the nose-piece or at the rear of the compound body.

Since no ground-glass has a sufficiently fine surface to admit of really sharp focussing of the image, with even moderately high powers, the final adjustment is made as follows:—The front and back of the plate-holder having been removed, a sheet of plate glass the size of the gelatine plate to be used is inserted, and the holder adjusted to the camera, when, by means of a focussing glass placed against the outer surface of the plate, a sharp and accurate adjustment can be made in a moment, after which nothing remains to be done toward securing the negative but to substitute (in the dark room) a sensitive plate for the plain glass, attach the holder to the camera, and make the exposure.

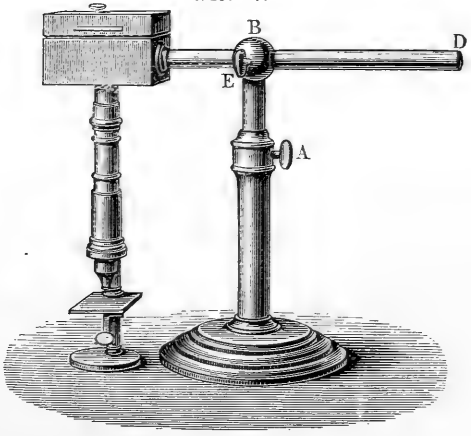
Gelatine plates, possessing the two qualities of extreme sensitiveness and great density after development, are essential for the production of the finest negatives by the foregoing process. The brands known (in America) as "Beebe," "Eastman Rapid," and "Carbutt's Special" combine these qualities in an eminent degree, and are recommended accordingly. Either ferrous-oxalate or pyro-developer may be used with equal success, but they should be strong and active, as a rapid development is necessary to the best results. If ferrous-oxalate be employed, it should be made quite acid with citric or oxalic acid.

It having been found by actual work that the chemical and visual foci of the rays from a lamp are almost exactly coincident, there is no need of employing specially corrected objectives with this apparatus. And the following table of exposures with Beck's objectives may be depended upon as an accurate basis for work with the average of objects to be photographed:—

1½ inch, 2 to 3 minutes.	1-5 inch, 8 to 12 minutes.
2-3 „ 3 „ 4 „	1-10 „ 15 „ 20 „
4-10 „ 7 „ 10 „	

For opaque objects, illuminated by sunlight, exposures of six to twenty seconds, depending upon the power employed and reflecting qualities of the specimen itself, will generally be found sufficient.

Fig. 97.



Hauer's Photomicrographic Apparatus.*—This (fig. 97) is a very simple method, devised by Max Hauer, of combining a camera with the Microscope. The standard which carries the cross-bar D slides vertically in the hollow pillar, and can thus be set (by A) at any

* Dippel's 'Das Mikroskop,' 1882, pp. 576-7 (1 fig.).

desired point in a vertical direction. The cross-bar also slides through B, so that it can be set (by E) at any point in a horizontal direction. The camera is fixed to one end of the bar. It has an opening on its lower side, to which is attached a piece of tube, into which the eye-piece end of the Microscope passes. To keep out the light, a broad indiarubber band can be passed over the point of junction.

Seibert and Krafft's Small Camera Lucida.—This (fig. 98) is but an unimportant variation of the apparatus of Nachet and others, though somewhat cheaper. Two reflecting plates at *a* and *b* are inclosed in a small box, open below, and with an aperture at *c*. A portion of the reflecting surface is removed at a point *d* concentric with the optic axis, so that the direct rays, *h*, from the object are seen through the apertures at *d* and *c* at the same time as those, *g*, from the paper. The camera is supported on the pillar *e*, and is attached by the ring *f* to the body-tube.

Fig. 98.

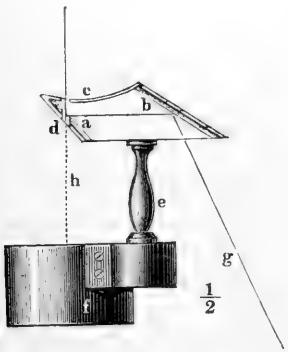
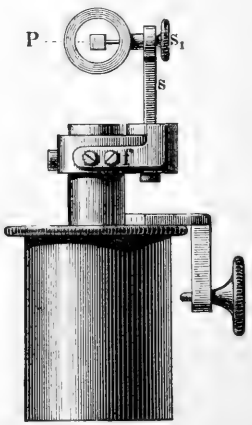


Fig. 99.



Winkel's Small Camera Lucida.—This again (fig. 99) is not distinguishable in principle from Oberhauser's apparatus.* A small right-angled prism P is protected by a ring and attached to a No. 2 eye-piece. The prism fastening can be turned on *s*, and centered by the spring *f*. It is inclined on its horizontal axis by means of s_1. The prism projects the image of the object upon the drawing-paper inclined at an angle of 45°, the pencil being viewed direct.

Correction of the Distortions produced by the Camera Lucida.†—The following is a translation, somewhat abridged, of Professor L. Malassez's paper on this subject. It was directed specially to the

* Cf. this Journal, ii. (1882) p. 680.

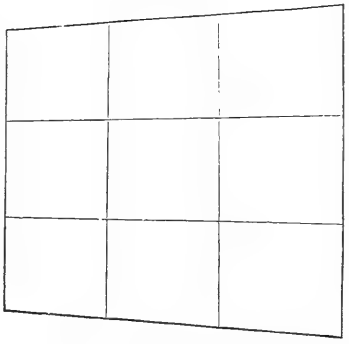
† 'Laboratoire d'Histologie du Collège de France, Travaux de l'Année 1877–8, publiés sous la direction de L. Ranvier, Professeur d'Anatomie générale' (8vo, Paris, 1879), p. 188.

camera lucida of Milne-Edwards and that of Nachet, but so far at any rate as the latter is concerned, the supposed distortion does not exist, at least it cannot be detected by the micrometer. The paper may, however, be of interest from a theoretical point of view.

"1. *Nature of the Distortions.*—These cameræ lucidæ which are so convenient and so generally employed have the grave inconvenience of giving drawings which do not exactly reproduce the form of the objects drawn, assuming, that is, that the Microscope and the paper are in their usual position—the Microscope vertical and the paper placed on the table or on any other horizontal plane.

To be assured of this fact draw, for instance, a series of parallel and equidistant lines like the divisions of an object micrometer. Then if the micrometer is placed transversely on the stage of the Microscope, so that the divisions are directed from front to back in the drawing, we shall see that the lines drawn will no longer be equidistant; they will be the wider apart according as they have been drawn at a greater distance from the foot of the Microscope. If the micrometer is placed so that the divisions are transverse in the drawing, the lines will no longer be parallel; they will diverge from the foot of the Microscope (fig. 100).

Fig. 100.



If we draw a square, we shall obtain a trapezium, a quadrilateral figure of some kind more or less irregular according to the position of the square on the stage of the Microscope, but never a perfect square. A circle will never give a circle, but always an ovoid, &c.

These distortions are little noticeable so long as the parts drawn occupy only a small portion of the field of view, and so they may be disregarded if absolute exactness is not required. But if the microscopic field is large, the distortions are considerable. A square, for instance, has given me a trapezium, the small base of which was 114 mm., and the sides 136. There were therefore differences in the drawings of equal lines (the sides of a square) amounting to 22 in 114, exceeding 19 per cent.

We see therefore to what errors we may be exposed if we use such drawings for exact measurements—measurements of the histological elements, of magnifying power, &c.

2. *Cause of these Distortions.*—The distortions are due to the fact that in these cameræ lucidæ the two surfaces at which the total reflections take place are very close to one another, so that the reflection upon the table is not made along a vertical axis. In fact, if it were so, a part of the image would be seen on the stage and foot of the Microscope, and could not be received on the paper: such an obliquity

must therefore be given to the axis of reflection, as that the microscopic image shall be brought completely outside the foot of the Microscope.

But the axis of reflection not being vertical—not being consequently perpendicular to the surface of the table, the microscopic image is formed on a plane which is obliquely inclined to the optic axis; whilst the object itself being on the stage of the Microscope, is on a plane perpendicular to the object axis. The result of this is that the relative distances which exist between the eye and the various points of the drawing are different to those which exist between the eye and the corresponding points of the object.

Consider, for instance, two points of the object equally distant from the axis. These two points will necessarily be at equal distances from the eye, whilst in the drawing the corresponding points will be at unequal distances, that on the right being further from the eye than that on the left. These differences will be produced so long as the plane of the drawing is not, like that of the object, perpendicular to the optic axis.

By comparing the position of the table with that of a plane which is perpendicular to the axis, and meeting the table near the foot of the Microscope, we can exactly determine the differences which the relative distances introduce. The table is the further from the plane according as it is further from the Microscope, and the result of this is as if the different parts of the drawing had been made on planes perpendicular to the axis, but more and more distant from the eye.

But as the amplifications of the drawings obtained by the camera lucida are larger according as they are received at greater distances from the eye, it follows that in a drawing made on the table the amplification would increase without limit in proportion as the drawing is distant from the foot of the Microscope.

This explains the results of the experiments above mentioned. If with the cameræ lucidæ of Milne-Edwards and Nachet the divisions of a micrometer are the wider apart, according as they are drawn in positions further from the Microscope; if a square gives a trapezium, a circle an ovoid, the large base of the trapezium and the large extremity of the ovoid being on the right, it is because from the construction of these cameræ lucidæ the amplification of the drawing increases from left to right in proportion as it is further off from the foot of the Microscope.

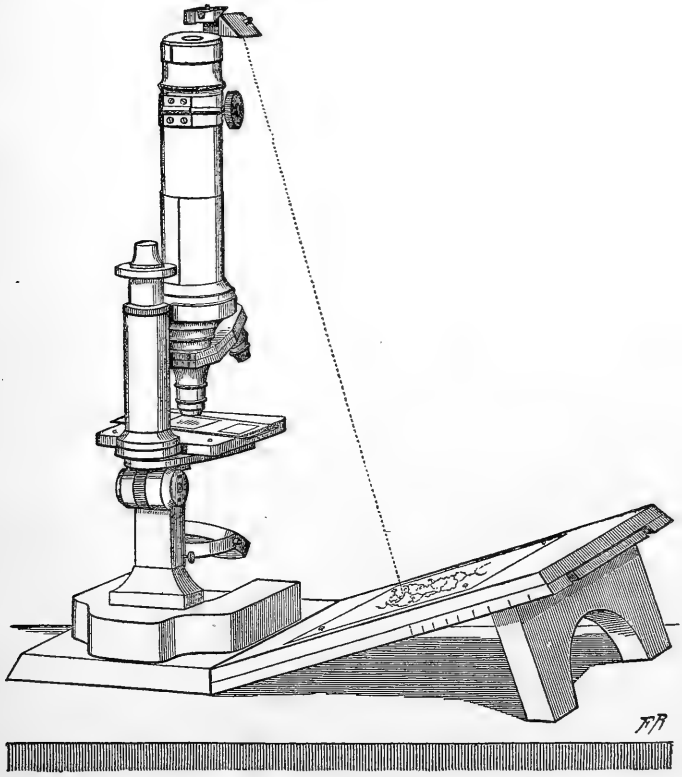
3. *Means of Correcting these Distortions.*—I assume that it is not desired to change the construction of the cameræ lucidæ. It is plain from what has been said, that to obtain a drawing like the object it is necessary that the microscopic image should be collected not on a plane oblique to the optic axis, but on one perpendicular to it.

It is easy to fulfil this condition. Two methods may be employed —(1) Either incline the Microscope so that the axis of reflection becomes vertical, or (2) leaving the Microscope in its ordinary position, draw not on the table but on an inclined plane, the inclination being such that this plane may be perpendicular to the axis of reflection.

I have tried both these methods. The first has certain advantages, in that it allows the drawing to be made on the table or other horizontal plane, and also that the eye looks in the direction of the pencil. But the inclination of the Microscope is not without practical difficulties. It requires a special arrangement in order that in this position the instrument may preserve a sufficient stability (I except, of course, Microscopes made to be inclined, which can be readily adapted to this purpose). This process, moreover, cannot be employed when it is desired to draw preparations which contain moving parts, or otherwise require to be kept horizontal.

With the second method it is necessary, it is true, to draw on a

FIG. 101.



plane which is not horizontal, and the hand is therefore outside the direction of sight, which is less convenient; but by way of compensation the process may be applied to any Microscope whatever, without its being necessary to modify its position or construction. All that is required is an inclined plane whose inclination may be varied at

pleasure, all the cameræ lucidæ not sending the image in the same direction according to the same angle. It is necessary also that this plane should be able to maintain a fixed position relatively to the Microscope, so that the agreement between the drawing and the microscopic image may be preserved during the whole process. Such a plane may be made in many different ways. The following is the one which I prefer:—

Inclined Drawing-board.—This board (fig. 101) is composed (1) of a horizontal part on which the Microscope is placed, (2) of an inclined part on which the drawing is made, and (3) of a bracket, which serves to maintain the inclination of (2).

The bracket is not fixed to the inclined part, but is carried by a slide, which, guided by grooves, may be pushed more or less under the inclined part, and so raise it. In these movements the bracket passes before a graduated scale at the margin of the board, which indicates the degree of inclination obtained. The slide may be completely drawn out of the grooves so as to allow a drawing, the outline of which has been made at the proper degree of inclination, to be completed in a horizontal and more convenient position. Moreover, if it is necessary to refer again to the cameræ lucidæ, the slide and the bracket may be replaced exactly in the same position by means of the scale.

The horizontal part of the board is fixed to the inclined part by hinges, which enables the inclination of the latter to be varied as desired, whilst at the same time keeping it in a constant relation with the Microscope so that the coincidence is maintained between the drawing and the microscopic image. The position in which the drawing was made may be easily found again by means of marks.

The different pieces of this board may be folded upon each other to make it more portable, and when folded it forms a square with sides of about 18 to 20 cm. and 3 cm. in thickness.

Modified Table of M. Künckel d'Herculais.—Where it is necessary to make the drawing at given heights above the table (for the measurement of the magnifying power, for instance), I modify slightly the excellent drawing table of M. Künckel d'Herculais (fig. 102).

This is composed of a board resting on a base formed of a double box. The box on which the board is fixed may be raised more or less from the other. Two screws keep it firmly in any given position. The board may thus be more or less elevated as desired. In order to incline the board, all that is necessary is to fix it, by hinges on one of its sides, to the box on which it rests, and then to raise more or less the opposite side by means of a movable bracket or other means.

4. *Determination of the Degree of Inclination.*—Whatever may be the apparatus employed, the important point is to give the appropriate inclination to the plane on which the drawing is made, and to determine this inclination I have employed two processes.

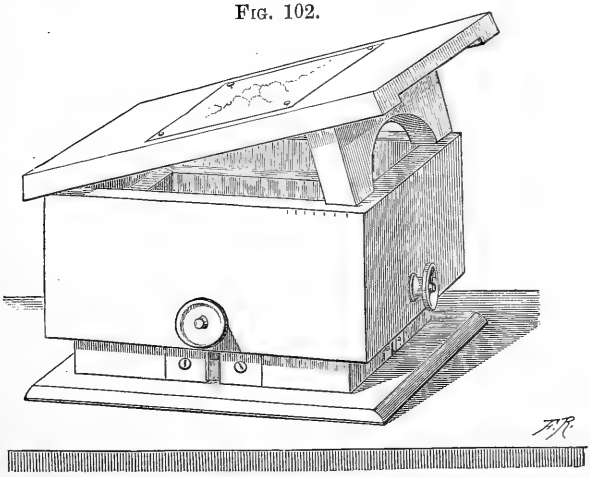
The first, entirely empirical, consists in laying down on the drawing-paper a given length, a micrometric division, for example; then to modify little by little the inclination of the inclined plane until the division being shifted about in the different points of the field of view

always gives a drawing of the same length. It is necessary in this process to use objectives thoroughly aplanatic.

In the second process we simply determine the direction of the optic axis in its path from the camera lucida to the table. This direction being known, we shall evidently know the inclination which it is necessary to give to the board so that it may be perpendicular to the optic axis.

How is the direction of the optic axis to be determined? Being a straight line, it is sufficient to know two points of its path, and this may be obtained in the following manner:—Selecting a very limited point of the field of view and as central as possible, the crossing of two lines of a micrometer in squares, for example, this point is trans-

FIG. 102.



ferred to the drawing-paper. The latter is placed successively at two different heights—on the table, for instance, and then on a box. When the paper is placed on the table, the point by virtue of the obliquity of the axis naturally falls further from the foot of the Microscope than when it is higher, on the box. We ascertain then very exactly (1) the distance between the verticals passing through the two points, and (2) the distance between the horizontals passing through these same points (the height of the box). Then we construct a right-angled triangle having for height the distance between the horizontals, and for base the distance between the verticals. The hypothenuse of this triangle will evidently give the direction of the optic axis.

To find that of the inclined plane, it is sufficient to take any given perpendicular to this hypothenuse, or, what is still simpler, to reverse the triangle, making the base the height, the inclination of the hypothenuse being then that which the board ought to have. This may be readily understood, since the angle which the inclined plane makes with the horizontal is evidently equal to that which the optic

axis makes with the vertical, for this angle is no other than that which the apex of the triangle formed before it was reversed.

The first of these methods is very easy to execute, but it requires much time and patience on account of the numerous trials which it necessitates. The second is very easy also, and much quicker, since it gives at once the result sought. I therefore prefer it, but in order to be quite sure that no error has been committed, it may be checked by the first.

When the plane of the drawing is very exactly perpendicular to the optic axis, all the distortions will disappear. Equidistant lines will remain so, squares will remain squares—in a word, the drawings will be faithful copies of the objects. This correction is very striking when we employ the drawing-board above described. If the board is horizontal, all the distortions are produced; when it is suitably inclined, they immediately disappear.

We may therefore, without changing in any respect the cameræ lucidæ of Milne-Edwards and Nachet, obtain with these instruments drawings as exact as possible.

Are these facts known? I believe so, and in a previous article* I have been content to allude to them; but having seen that they were not noticed in our classical authors, I have thought it well to direct the attention of microscopists to them."

Mr. R. Hitchcock, in a discussion on the relative merits of the Zeiss (double prism) and Grunow cameræ lucidæ, adds some remarks† concerning the distortion produced by the two forms. A stage-micrometer ruled in hundredths of an inch, and a 2-3rds in. objective were used.

The Grunow instrument was first used, the inclination of the stand being, in two different experiments, 30° and 40° from the vertical.

1. Inclination 30°, lines of the micrometer running vertically across the field.

The diameter of the field projected upon the paper was, approximately, 7 in. The distance between the lines, near the margin of the field nearest the Microscope on the paper was 1·03 in.; at the margin furthest from the stand it was 1·15 in. Hence the difference in magnification at the two extremes of the field was 12 diameters.

2. Inclination 40°. Repeating the same experiment under this inclination, the results were respectively 95 and 100 diameters; difference, 5.

Zeiss' camera lucida, inclination about 13°. As only half the field was projected on the paper, the lines had to be extended across to 7 in. to make the results comparable with those of the Grunow.

3. Lines vertical. Magnification at the extremes of a field of 7 in. diameter, respectively 104 and 113; difference, 9. This is greater than with the Grunow, but the actual distortion of vertical lines produced by this camera is only 4·5 at the greatest.

4. Lines horizontal. Owing to the small field visible, only two

* *Infra*, p. 567.

† Amer. Mon. Micr. Journ., iv. (1883) pp. 43–5 (2 figs.).

contiguous spaces were measured, showing an increase from the centre outward of 3 diameters.

The above figures should not be considered as absolutely accurate, but approximately correct—sufficiently so to illustrate the subject.

The Grunow instrument shows the entire field of view on the paper. Measuring from the middle of the surface of the prism to the margin of the field on the paper, we find the angle of view to be 16·5°, the margin nearest the Microscope being only 3° from the vertical, the centre being 17° from that margin, and 14° from the opposite side. Hence, the distortion produced diminishes slightly toward the centre from either side; but the real difference from side to side is shown by the above results.

The Zeiss instrument only gives half the field; but the centre is almost directly beneath the centre of the face of the prism, 3·5° from the vertical, hence the distortion is about equal on either side of the centre, and does not increase from one side to the other as in Grunow's instrument. Such being the facts, a camera lucida should, the author thinks, be used with great discretion in making drawings for purposes of measurement—as, for example, in drawing blood-corpuscles for microscopical expert testimony. He does not think, however, the distortion produced is of very great consequence in most cases. It is only when large objects are to be drawn or measurements to be made that it deserves serious attention.

Measurement of Microscopical Magnitudes.—The article which Professor Melassez refers to above is contained in an earlier portion of the same volume,* in which he states his view that the different processes for measuring the linear magnification of objects seen under the Microscope give only approximative and inexact results, and after describing briefly the two methods generally employed, viz. the micrometer eye-piece and the camera lucida, he proceeds to consider the causes of the want of exactness proper to the latter, and explains how, by modifying it slightly, its errors may be corrected.

In the following diagram (fig. 103) A B is the object † of unknown dimensions on the stage of the Microscope, C D the camera lucida, O the optic centre of the eye. Unite by lines the point O to each of the extremities of the object A B, and draw the visual rays which, starting from the point O, follow at first the direction of the rays O A and O B, but which, instead of going through the camera, are reflected at C and at D, and then pass out of it. We know that by interposing a sheet of paper in the path of these rays we are able to see and to draw on the paper the image of the object A B. *a b* is the drawing obtained at a distance from the eye equal to that of the eye from the object; *a′ b′* that obtained at the distance of distinct vision; *a″ b″* that obtained on the table on which the Microscope stands. As is shown in the figure, the drawings will be the larger as the paper is further from the eye, although the image in all these positions always appears of the same size to the person drawing, which is due to the fact that

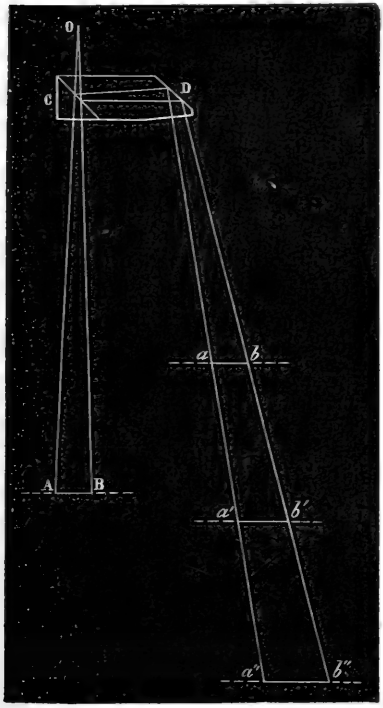
* Ranvier's Travaux, p. 114.

† Strictly speaking, A B is the *image* of the object.

it is always seen under the same angle, and corresponds to a retinal image of the same size.

Let us now suppose the image to be received at the distance of distinct vision, and let us see what, in these conditions, are the relations which exist between the dimensions of the object A B and those of the drawing $a'b'$.

Fig. 103.



Observe in the first place that A B and $a'b'$ form the base of two similar isosceles triangles, O A B and O $a'b'$; but in order that the bases may be equal, it is necessary that the altitudes should be so also, that is, that the distance of the drawing from the eye should be equal to that of the eye from the object. Is this so in practice? Certainly not, or at least very exceptionally. Indeed, if the distance of the drawing from the eye is constant (the distance of distinct vision), that of the eye from the object is very variable. It varies according as the tube of the Microscope is more or less raised above the stage, and thus varying it may be either greater or less than that of distinct vision.

If the distance of the drawing from the eye is greater than that of the eye from the object, which is the usual case with our ordinary Microscopes with short tubes, the drawing $a'b'$ will be necessarily larger than the object A B. If it is less, on the contrary, the drawing will be smaller.

A calculation may serve to give an idea of the extent of these variations. Let us suppose an object of 10 mm. in diameter at a distance of 20 cm. from the eye. Take for the distance of distinct vision 10 Paris inches, say, 27 cm., and calculate what will be the diameter of the drawing. In the similar triangles O A B and O $a'b'$ the bases being proportional to the altitude, we shall have

$$\frac{x}{10} = \frac{27}{20}; \quad \therefore x = 13{\cdot}5 \text{ mm.}$$

Suppose, on the contrary, that the distance of the eye from the

object is 30 cm., we shall have for the same object of 10 mm. in diameter a drawing having the diameter x',

$$\frac{x'}{10} = \frac{27}{30}; \quad \therefore x' = 9 \text{ mm.}$$

Thus an object of 10 mm. may, according to the arrangement of the instrument, give at the distance of distinct vision either a drawing of only 9 mm., or one of $13\frac{1}{2}$ mm. These are not exaggerated cases selected for the express purpose of making the variations greater, but are such as are habitually met with, and we may even observe still greater ones.

The following is one mode of remedying these errors. Remove the eye-piece and objective (having taken the measure of the amplification), and replace the camera lucida exactly in its original position, that is to say, at the same distance from the stage of the Microscope; then ascertain experimentally the increase or diminution produced by the image being referred to the paper, and thus by a very simple calculation we can correct the result previously obtained.

Suppose, for example, that we had found by the old method a magnification of 270 times for a given optical system, and that having applied the above method we find that 10 mm. referred to the paper gives an image of $13\frac{1}{2}$ mm. The magnifying power of the optical system having been increased 1·35 times, it is therefore in reality 1·35 times smaller than that which we obtained, i. e. $\frac{270}{1 \cdot 35}$ or 200.

This correction may be applied whatever is the distance at which the drawing is made, and it therefore becomes entirely useless to make it at the distance of distinct vision. The paper should be placed on the table which carries the Microscope, the magnification measured as usual, and then corrected in the mode above mentioned.

This method has the inconvenience of requiring two very delicate experimental operations, which have to be undertaken at each examination; but by modifying in another way the old method, we may avoid this and obtain directly the magnification produced by any given optical system.

It is obvious, in the first place, that if the eye-piece and objective are removed, and the paper is placed on the table at $a'' b''$, the drawing will be much larger than the object. Since the triangle O $a'' b''$ is of greater altitude than the triangle O A B, its base $a'' b''$ will necessarily be greater than the base A B. But if we raise the paper little by little, the drawing will diminish proportionately, and finally a point will be reached where the drawing will be exactly the same size as the object. It is the point where the two triangles O $a b$ and O A B become equal, where their altitudes being equal their bases are equal also.

The position being found in which the drawing and the object are equal in diameter, this equality continues whatever the changes in the tube of the Microscope. In raising or lowering the tube we increase or diminish by equal quantities the altitude of the triangles O A B

and O *a b*, and being equal, their bases enlarge by equal quantities. It would not be the same if the paper was in any other position.

If we now replace the eye-piece and objective, the enlargement which the drawing will have will be produced entirely by the optical system formed by the eye-piece and objective, and that will be true whatever is the length given to the tube of the Microscope.

As we see, this process consists in referring the microscopic image to paper which is no longer placed at the distance of distinct vision as in the old method, nor on the table which carries the Microscope, as in the process above indicated—positions which all require corrections—but at a distance from the eye equal to the distance of the eye from the object.

How is this position to be determined? The surest way is to find it experimentally by varying the position of the paper until the drawing and the object are of equal size (the eye-piece and objective being removed). If to refer the image to the paper we utilize the phenomenon of double sight (*double vue*), the paper must evidently be placed at the height of the stage, assuming that the sight is exactly similar in the two eyes, which is not always the case. If we employ the camera lucida, the paper must necessarily be placed higher than the stage, because the double reflection and the refraction which the visual rays undergo in the camera produce a diminution in the direct distance between the eye and the paper. With the new camera lucida of Nachet, for instance, the loss being about 3 cm., the paper must be placed 3 cm. above the stage of the Microscope. For greater exactness the paper must, of course, be raised on one side, as previously described.

Simple and Cheap Eye-piece Micrometer.*—Mr. W. M. Bale points out how a simple but efficient eye-piece micrometer for ordinary work may be constructed without any expense, except of a little time and patience. The material is fine silk, a single fibre of which is not perceptibly thicker than a cobweb, and is far less difficult to manipulate. It may be ravelled out of a ribbon; a corded ribbon, in which the transverse threads are straight, and woven over by two series of longitudinal threads, is better than an ordinary one, in which the threads of the warp and woof have acquired a series of "kinks" which are difficult to get rid of. The best eye-piece for the purpose is a C or D. The method of procedure is as follows:—

Unscrew the field-lens, and at two opposite points on the under side of the diaphragm (not close to the edge) apply minute spots of rather stiff balsam. Cut a piece of the silk fibre about as long as the diameter of the eye-piece, and with the forceps place one end of it in contact with one of the spots of balsam, to which it will adhere, after which the other end is similarly attached to the opposite spot of balsam. With a pointed but blunt penknife the two ends are pressed well into the balsam and drawn apart till the line is "taut,"

* Southern Science Record, iii. (1883) pp. 13–16.

the balsam being at the same time spread out and made drier and stiffer. The field-lens is now screwed in, and the eye-piece held to the light and examined, to see if the thread is straight; and if it be found to have in it a number of small flexures due to the weaving, it is best to replace it by another. So far there is no particular difficulty, but the next step, which is to attach another fibre parallel with the first and very close to it, is rather a delicate operation, as it must be done without disturbing the first, and the distance apart of the two must be regulated with the utmost nicety. This distance will of course depend on the space to be measured; assuming that it is desired to measure 1-1000th in. with a C eye-piece and a 1-4th in. objective, it will be about 1-30th in. The field-lens having been replaced, the eye-piece is inserted in its proper position, and a stage-micrometer laid on the stage, with the thousandth divisions in the field (under the 1-4th in.); the eye-piece being now placed so that the silk lines are parallel with the ruled lines on the stage-micrometer, it can at once be seen whether the fibres are too close or too distant. If either is the case the field-lens must be removed and one of the fibres shifted, which may be done without much difficulty with the blunt-pointed penknife, pressing down the ends in the balsam and at the same time gently rolling them almost imperceptibly to one side. The field-lens is again replaced and the eye-piece placed in position and examined, and if necessary the operation repeated till the two fibres are exactly coincident with two of the lines on the stage-micrometer, when the space between them, as seen on the magnified image, will represent 1-1000th in. I have fixed a third line at the same distance as the second from the central one, or 1-100th in. from each other. These last two threads are near the opposite sides of the diaphragm, their actual distance apart being about 7-16ths in.

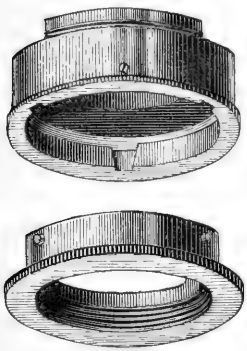
Finding the balsam scarcely sufficient to keep the fibres tight I cut very small narrow slips of postage-stamp paper, moistened them, and fastened down the ends of the fibres with them, at the same time pulling them "taut," with a slight pressure, but taking care not to move them laterally; there is a good deal of risk, however, of the latter, and as the mucilage dries immediately, it will be necessary, should the fibres prove on examination to be displaced, to remove the paper forcibly, most likely breaking the fibre, and necessitating its renewal. The dots of balsam being placed well back from the margin of the diaphragm, there is room for the attachment of the slips of paper between them and the edge. If a transverse line is desired crossing the others, it is best to fix two fragments of the paper on the opposite sides of the diaphragm, and mount the ends of the thread *upon* them (fastening them down with other pieces), so that the fibre is clear of the others, and there is no risk of dragging them out of place in attaching it.

The eye-piece, as described, gives direct measurements of 1, 2, 4, 5, 6, and 10 thousandths of an inch. The lines on an ordinary stage-micrometer appear with the 1-4th in. fully six or eight times as thick

as the silk fibres, and the latter should therefore be made to coincide with the centres or corresponding edges of the ruled lines; it is, however, impossible to attain perfect accuracy unless the stage-micrometer be much more truly divided than those in ordinary use.

Nelson's New Nose-piece Adapter.—Mr. E. M. Nelson has devised a new form of adapter (fig. 104), for rapidly changing objectives, founded on the principle of the bayonet-joint. A collar is screwed upon the objective furnished with three radially disposed projecting pins placed at equal distances apart. The adapter, which screws into the nose-piece, is provided with three internal annular slightly sloping grooves and three vertical notches. The pins are slipped up the notches and a partial turn given to the objective secures it firmly in place.

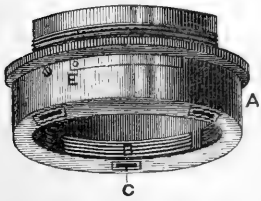
Fig. 104.



Curties' Nose-piece Adapter.—Fig. 105 shows the first rough model of this device, which is designed as an improvement on Pease's "Facility" nose-piece (*ante*, pp. 425–6).

The nose-piece screws on the Microscope by the usual "Society" screw shown at the top, and may remain there permanently. A is a box, or cap, fitting over three equal segments B of a ring having the "Society" screw on the inner surface. Each segment has on its upper edge a grooved tooth working against a flat spiral, and on its lower edge a guide-piece C passing through a slot on the edge of A. The rotation of A acting on the guide-pieces forces the segments to travel in the spiral, in one direction moving them towards the periphery, consequently expanding their circle, so that the objective may be slid in, and in the other direction causing them to move towards the centre when they grip on the threads of the objective. E is a fixed pin to limit the rotary motion of A.

Fig. 105.



With this device no alteration is required to the usual brass-work of the objectives. Any objective having the "Society" screw can be slid into the nose-piece at once, when one-sixth of a turn of A to the left will cause the segments to grip it in place, whilst the reverse movement will release it.

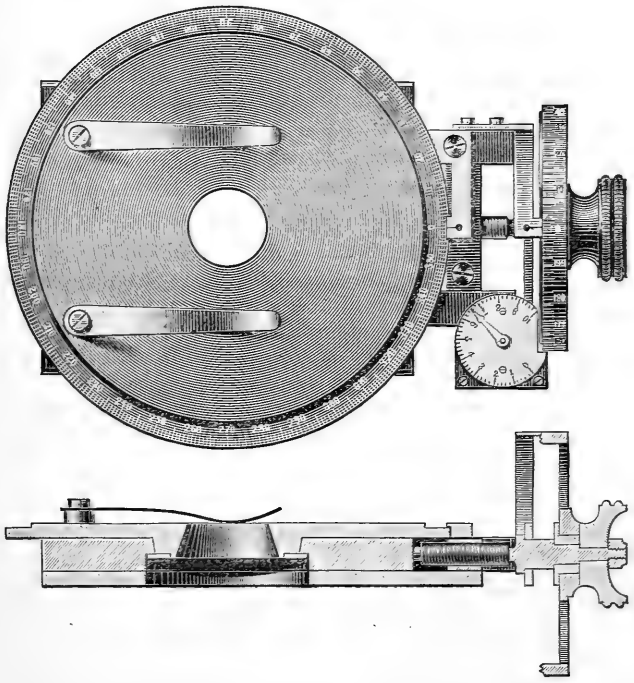
The objections to the nose-piece appear to us to be, 1st, the difficulty of centering,—the segments have to be made so loose, that there can be no good centering; and, 2ndly, the liability to injure the thread of the objective through there being no provision to insure

the position of exact correspondence of the outer and inner threads. This is apart from the objection common to all these forms of adapter, that they are liable to let the objective drop off when the adjustment-collar is turned, especially if it moves somewhat tightly.

Zeiss's Stage-Micrometer.—This micrometer (fig. 106) is intended more particularly for the measurement of objects, the whole of which cannot be seen in one field of view.

The upper plate is graduated, and rotates on the middle plate.

FIG. 106.

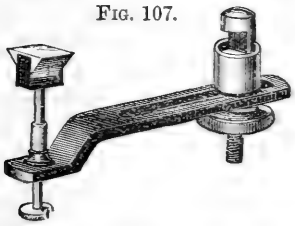


The latter is moved laterally on the lower fixed plate by the screw shown on the right. The number of whole turns of the screw is registered on the small dial with index, by means of an endless thread on the periphery of the drum, working on a toothed wheel on the same axis as the index, while parts of turns are shown by the graduations on the drum of the screw.

Queen's Holder for Woodward's Prism.—Fig. 107 shows an arrangement issued by J. W. Queen and Co., of Philadelphia, for readily applying the Woodward prism. The prism is mounted between jaws

attached to a sliding and rotating rod carried at one end of a bent arm. The other end of the arm has a slot $1\frac{1}{2}$ in. long fitting on a clamping arrangement, which can be attached to the stage. The clamp consists of a bar with a notch cut in its upper end, and with a short piece of tube fitting over it. The bar is pushed up by a spiral spring, but when the milled head beneath is turned, it is drawn down within the tube, thus shortening the length of the notch correspondingly with the thickness of the stage. The slot enables the arm to be moved so that the prism may be adjusted in the optic axis with varying diameters of stage.

FIG. 107.



The hemispherical lens might be substituted for the prism, which, indeed, we think, would be found more generally useful.

Impromptu Condenser.*—Prof. Rindfleisch suggests that the absence of a condenser may, on emergency, be supplied by a drop of distilled water placed on the lower surface of the slide, where it will act as a convex lens.

Illumination by Sunlight.†—Dr. J. Edwards Smith says that "in the study of very minute and delicate structures requiring the utmost separating or resolving power of the objective, remarkable effects are to be secured by condensing sunlight *on the top* of the object by means of the concave mirror, the object being mounted with a cover in the usual way. The objective used should, of course, have wide aperture. The mirror being posed slightly above the level of the stage, the sunlight is thrown on the surface of the cover, and making a very acute angle therewith. Although not absolutely necessary for this purpose, those stands furnished with swinging substages, allowing the mirror to rise above the level of the stage, are extremely handy and convenient. By the employment of this illumination in conjunction with object-glasses of wide apertures, the most difficult diatoms, such as *Amphipleura pellucida, Frustulia saxonica,* &c., are easily and forcibly displayed."

Monochromatic sunlight is procured most easily as follows: cut with a diamond, or a point of a file, a small piece of blue glass roughly to fit the *cap* of the eye-piece, so that when the cap is restored to its place the blue glass shall be between the eye and the eye-lens of the eye-piece, and the light is thus modified before it reaches the eye. This is the handiest method of obtaining monochromatic light he has ever tried, and the resolutions are quite as strong and effective as when the cupro-ammonia cell is used in the usual manner. In working with sunlight care should be taken to exclude the full strength of the solar beam; that is, if the sun be clear and bright.

* 'Berliner Klinische Wochenschrift,' 1883, p. 183, but the above noted from Bizzozero's 'Manuel de Microscopie Clinique,' French transl. by Dr. C. Firket, 1883, p. 333.

† 'How to See with the Microscope,' 1880, pp. 186–7, 191–2.

Too much light, supposing the manipulations are tolerably well attended to, will be manifest by the appearance of a multitude of diffraction lines, and these, as a rule, may be recognized by their extending beyond the objects observed. Under very high amplifications, involving the use of powerful eye-pieces, we can, of course, make use of a little more of the solar beam.

Another method of sunlight illumination will be found useful at times—the "reflex" illuminator with direct sunlight. In this case the solar beam can be received through the closed window and reflected from the plane mirror. "This illumination is only suitable for work with wide apertures, and over the most minute objects, and the mount must be free from surrounding objects of a coarse character, else, from the extremely oblique character of the illumination, these stronger and coarser objects will project their strong shadows across the field, causing nothing but confusion and chaos. With the genuine form of the Wenham 'reflex' an epithelial scale would hardly be recognized were there several in the field. The principal advantage in the use of the 'reflex' with sunlight is in arriving at a knowledge of surface markings, and for this purpose it is indeed very valuable." "The mirror may be substituted for the hand-lamp when working in the evening, but the most favourable results are obtained with the light direct. This reflex and sunlight illumination is especially desirable when one wishes to trace out structure situated in one particular plane, to the exclusion of that lying in adjacent planes. In the general squabble to produce the so-called penetration, this very important item has been lost sight of."

Blue-tinted Lamp Chimneys, Light Moderators, &c.*—Dr. J. E. Smith, referring to the attempts made to modify artificial illumination by the introduction of blue-tinted chimneys, white-ground illuminators, &c., says that he has patiently tried the entire list and rejects them all, from the fact that there is no real advantage secured by their adoption, which cannot be obtained in a simpler way without them. The neutral tint "light moderator," so-called, is a pleasant thing enough for use with moderate amplifications; yet there is nothing seen with it that cannot be as well shown without it.

The blue-tinted chimney cuts down seriously the intensity of the lamp illumination to an extent which will defeat the resolution of any severe test, while, on the contrary, any and all work with the lower powers can be as well accomplished without its aid.

Thompson's Polarizing Prism.†—Neither the polarizing prism of Nicol nor that of Foucault can be regarded as perfect. The latter especially has so small an angular aperture available, as to be very inconvenient for any but narrow beams of parallel light. Prof. S. P. Thompson has sought to improve upon the existing forms of polarizing prism; and his investigations into the cause of their defects have led him to produce prisms having a considerably wider effective angular aperture.

* 'How to See with the Microscope,' 1880, pp. 189–90.
† Lond., Edin., and Dubl. Phil. Mag., xii. (1881) pp. 349–51.

In the text-books it is usual to tell students that in the Nicol prism the ordinary ray is suppressed by total reflection, because the ordinary index of refraction is greater than that of balsam, and that the extraordinary ray is transmitted because the extraordinary index of refraction is less than that of balsam. Neither of these statements is completely true. All that its inventor claimed for the Nicol prism, and all that it actually performs, is as follows:—The critical angle of total reflection being different for ordinary and extraordinary rays, the ordinary ray is totally reflected and thrown out of the field at an incidence at which the extraordinary ray is still transmitted, the available field of polarized light being the region between the points where the extraordinary ray itself vanishes by total reflection and the ordinary ray enters by lack of total reflection. The former limit is in all ordinary Nicol prisms marked by a broad blue iris or band of colour, the latter is delimited by a curved band at the opposite side of the field, in which, amidst a prevailing line of red and orange, a system of interference-bands can be seen. The existence of these interference-fringes was examined by the author in 1877, in a paper which appeared in the 'Proceedings of the Physical Society of London,' vol. ii. p. 157. In the Foucault prism a similar limitation of the field occurs, interference-fringes being visible at both limits.

The refractive index of balsam for light of mean refrangibility may be taken at 1·54, that of the ordinary ray in calc-spar as 1·66, that of the extraordinary ray as 1·487. The reciprocals of these are very nearly in the respective proportions of 65, 67, 60. The extraordinary index, however, is 1·487 only for rays at right angles to the crystallographic axis, having there a minimum, and increasing up to 1·66 for rays whose direction coincides with that of the axis. The ellipsoidal wave-surface of the sheet of extraordinary waves lies partly without and partly within the spherical wave-surface for Canada balsam, while the spherical wave-surface of the sheet of ordinary waves lies wholly within. Hence total reflection may occur for the extraordinary as well as the ordinary rays, but of the extraordinary rays only those can suffer total reflection which are situated in such a direction with respect to the optic axis that their corresponding portion of the ellipsoidal wave-surface lies within the spherical wave-surface for balsam. As the Nicol prism is usually constructed, this limit of possible extraordinary total reflection occurs for rays (in a principal plane of section) inclined at about 10° to the balsam film, giving rise to the limit of the polarized field marked off by the blue iris before mentioned.

Prof. Thompson has succeeded in widening the available field of polarized light by constructing polarizing prisms in which this blue iris, and the total reflection of the extraordinary ray which produces it, are got rid of. This can be done by cutting the crystal so that (1) the balsam film lies in a principal plane of section, and (2) the crystallographic axis is at right angles to the axis of the prism.

The result of this mode of orientation of the axis and film is to gain 9° of angular aperture at this side of the "field," supposing the

angles respectively made by the film and by the terminal planes with the axis of the prism to be the same as in the Nicol prism.

It is possible to produce a further increase in width of available aperture at the other side of the field by reflecting back the ordinary ray more than in the Nicol prism by making the terminal faces more oblique; but there is then more loss of light by reflection at the surfaces.

Besides the advantage of a wider angular aperture, this new form of polarizing prism has the advantage of producing a field in which the rectilinear polarization approximates more uniformly and symmetrically to a polarization in one plane than is the case in the ordinary Nicol. There is, however, more waste in cutting the spar, with proportionate increase in cost.

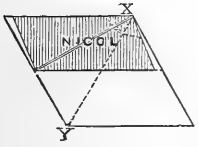
Prof. Thompson has been good enough to supplement his original paper by the following additional remarks and diagrams.

Fig. 108 is the ordinary Nicol prism, as cut from a symmetrical rhomb of spar. (Such a rhomb might be split so as to give four ordinary Nicols.)

Fig. 109 is the Hartnack prism, so cut that the film lies at right angles to the optic axis.

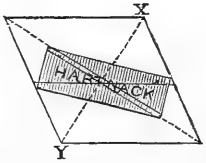
Fig. 110 is the Thompson wide-angled prism, cut so that the film of balsam is in a principal plane of section, and the longitudinal axis at right angles to the optic axis of the crystal.

Fig. 108.



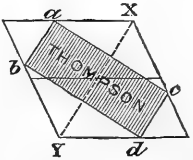
Film inclined about 23° to long axis of prism. End faces mostly make 68° with the long axis. Optic axis inclined at about 43° to planes of end faces. (X Y optical axis).

Fig. 109.



Film perpendicular to optic axis. Longitudinal axis of prism does not lie at right angles to the optic axis of the crystal.

Fig. 110.



Film runs from front edge *a b* to the back edge behind *c d*, and therefore it is in a principal plane of section and contains the optic axis, and the optic axis is at right angles to the longitudinal axis of the prism.

The reason why the new method of cutting secures a wider angle to the field of the extraordinary ray may be further elucidated by the diagrams figs. 111 and 112.

Fig. 111 is to demonstrate the point that in the ordinary Nicol, although the maximum refractive index of extraordinary rays is less than the refractive index of Canada balsam, yet that at certain angles of incidence the extraordinary ray does not pass through the balsam film, but suffers total internal reflection. In this figure

the dotted line X Y represents the optical or crystallographic axis of the spar, inclined obliquely to the plane of the film of balsam. Following out Ampère's modification of Huygens's construction for the wave-surfaces, the smaller circle represents the wave-surface of ordinary rays (with which we are not dealing here), and the ellipse the wave-surface (much exaggerated in ellipticity) of extraordinary rays. The wave-surface of the ray in the balsam film will be then represented by the dotted circle whose radius has a certain value

Fig. 111.

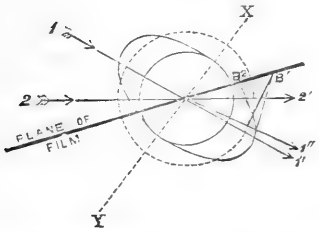
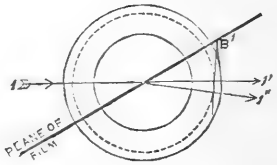


Fig. 112.



intermediate between the major and minor semi-axes of the ellipse. Suppose a ray 1, 1′, to strike through the spar obliquely upon the film, its path will be found by producing it till it cuts the further side of the ellipse; there drawing a tangent to the ellipse meeting the bounding surface at B^1, and thence drawing a tangent to the dotted circle, giving as a radius through the point of contact the direction marked 1″, which is the direction of this ray through the film. This may be taken as the typical case of all the rays in the useful polarized field of the Nicol. But now consider another ray 2, 2′, which traverses the spar in a direction making a greater angle of incidence with the film. A tangent drawn at its point of emergence from the ellipse meets the limiting surface at B^2, *which falls inside the dotted circle.* In this case it is impossible to draw a tangent back to the dotted circle: signifying that total reflection takes place internally. Rays then whose directions through the spar are at very small angles with the balsam film, are in the ordinary Nicol cut off totally, and the limit of their transmission is in the ordinary Nicol marked by the well-known blue band.

Fig. 112 shows the wave-surfaces in the new prism, the ellipsoid here appearing as a circle whose radius is equal to the semi-major axis of the ellipse of fig. 111, since the optical axis is in this case in the plane of the film and at right angles to the longitudinal axis of the prism. Take, as before, a ray of 1, 1′, draw a tangent at the point of emergence, meeting the plane of the balsam surface at B^1, the tangent drawn from B^1 back to the dotted circle gives the direction 1″, of the transmitted ray; and since it is obvious that in no case can the point B^1 at any incidence fall within the outer circle, much less within the dotted circle, it is clear that in *all* cases, and at every incidence, the extraordinary ray is transmitted. Hence the greater width of the field.

Mr. R. T. Glazebrook also describes * a polarizing prism designed to obviate the lateral displacement in the image produced by the Nicol prisms and to give a field in which the plane polarization should be as nearly as possible complete. It was not, however, designed for microscopical work.

Depth of Vision in Photomicrography.†—Mr. G. E. Davis, in an article on "Penetration in Objectives," calls attention to the difference that must necessarily exist between the appearance of a solid object seen by the eye through the Microscope and the same object in a photomicrograph. What is seen through the Microscope is the result of the combined effects of the accommodation of the eye and the focal depth of the objective, but when a picture is thrown upon a sensitive plate it is evident that the first element is nearly eliminated, and the only depth of vision attainable is that which the objective itself possesses.

The following table shows the focal depth of the objective, the accommodation depth of the eye, and the total depth of vision for objectives from 4 in. to 1-20th in. (A eye-piece.)

Objective.	N.A.	Focal Depth of Objective.	Accommodation Depth of Eye.	Total Depth of Vision in Air.
in.		μ	μ	μ
4	0·07	522	2080	2602
4	0·14	262	2080	2342
$1\frac{1}{2}$	0·14	86	230	316
$1\frac{1}{2}$	0·17	69	230	299
$1\frac{1}{2}$	0·21	57	230	287
$\frac{1}{2}$	0·34	10·6	20	30·6
$\frac{1}{2}$	0·57	6·3	20	26·3
$\frac{1}{2}$	0·82	4·4	20	24·4
$\frac{1}{6}$	0·60	1·99	2·3	4·29
$\frac{1}{6}$	0·76	1·57	2·3	3·87
$\frac{1}{6}$	1·20	0·99	2·3	3·29
$\frac{1}{12}$	0·83	0·72	0·58	1·30
$\frac{1}{12}$	0·97	0·61	0·58	1·19
$\frac{1}{12}$	1·10	0·54	0·58	1·12
$\frac{1}{20}$	0·98	0·37	0·21	0·58
$\frac{1}{20}$	1·10	0·33	0·21	0·54

From this table it will be seen that large objects cannot possibly be penetrated even with objectives of low angle and medium power. The seeds of *Betula alba* measure 1100 μ across, and require therefore 550 μ of penetration to see the whole of one of them under one focussing.‡ This cannot be obtained from a $1\frac{1}{2}$ in. objective of 0·14 N.A., even allowing the 230 μ which the accommodation of the eye affords, and if we wish to photograph such an object, the 4 in. of 0·07 N.A. will not have sufficient focal depth.

* Proc. Phys. Soc. Lond., v. (1883) pp. 204–16 (6 figs.).
† Micr. News, iii. (1883) pp. 172–6.
‡ i. e. half the depth—diameter in the case of a spherical object.

The spherical Foraminifer *Orbulina universa* is 600 μ in diameter, consequently a depth of vision of 300 μ is necessary to see the whole under one focussing. The 1½ objective and A eye-piece magnifying together 30 diameters, will just suit this, provided it does not possess an aperture exceeding 0·17, but if we wish to photograph this spherical body a much lower objective than the 1½ in. must be employed, as the focal depth of this objective is not higher than 86 μ. *O. universa* affords a good proof of the accuracy of Prof. Abbe's figures. Under the 1½ in. objective of 0·14 N.A. the spheres are splendidly seen, and the same may be said of the 2 in. of 0·14 N.A. and B ocular, but when the picture is thrown upon a ground-glass screen the want of penetration is soon apparent, for it is only when the amplification of the picture has been reduced to rather less than 10 diameters that a satisfactory result is obtained.

Similar illustrations may be offered of the higher power objectives. The larger species of Polycistina require a depth of 75 μ to show them distinctly, whereas a 1-2 in. objective of 0·34 N.A. in air, when used with the A eye-piece, to produce 100 diameters of amplification, possesses but 10·6 micras.

A 1-6th objective, magnifying 300 diameters, loses exactly 1 μ in depth between 0·60 N.A. and 1·2 N.A., so that while the spores of *Penicillium glaucum* (diameter of spores 3 μ) could be photographed with the former, it would be impossible to obtain perfect sharpness with the latter.

The figures in the table for the 1-12th in. and 1-20th in. objectives are equally confirmed by the results obtained in practice. The short diameter of *Bacterium termo* may be taken as 0·8 μ, requiring a penetration 0·4 μ to yield a clear picture, and this is obtainable by using a homogeneous 1-12th in. of 1·10 N.A. to produce an amplification of 600 diameters. A 1-20th in. objective, magnifying 1000 diameters, although producing a fairly sharp picture to the observer's eye, cannot produce an equally sharp image on a prepared plate, as the focal depth of such an objective will only approximate to 0·37 μ, and this statement is borne out by the photographs published by Dr. Sternberg, in his translation of Magnin's 'Treatise on the Bacteria,' wherein those pictures taken with a Beck's 1-5th in. are much clearer, though smaller, than the plate taken with Zeiss' 1-18th. There is more detail in the latter, and here comes in the value of amplification and aperture.

Reference is also made to the increase in the depth of vision in direct proportion with the refractive index of the mounting medium. The great gain in stereoscopic effect, on objects mounted in a medium of high refractive index, has led Mr. E. Ward, of Manchester, to mount opaque objects in balsam, with extremely good results.

Value of Photography in Microscopical Investigations.*— R. Hitchcock discusses the question whether photography affords a means of illustration or demonstration in any wise equal or superior to drawing by hand. On the one side it may be said that a photo-

* Amer. Mon. Micr. Journ., iv. (1883) pp. 33–4.

graph is necessarily a faithful and absolutely correct representation of the object. This may be true and it may not be true. Ordinarily it is so. But somewhat depends upon the nature of the object. A transparent object does not appear the same as an object shown by reflected light, and it will not be produced the same upon a photographic plate. The colour of the parts influences unequally the actinic power of the transmitted light. Thus, in an insect preparation, the yellow chitinous portions obstruct the most active rays of light. In order that the detail observed in these parts by the eye shall be impressed upon the sensitive plate, a rather longer exposure is necessary than for the other parts. The dry plates, however, are far more sensitive to rays of yellow light than the wet plates heretofore commonly used, and they will give better pictures than the latter. Still, there is a loss of detail in many preparations because of the absorption of actinic rays by certain portions of the objects.

On the other hand, it may be said that the photograph only clearly represents what is in focus at one time, while the observer studies and gets the relation between different planes by moving the focussing screw backward and forward. Hence a pencil drawing more truthfully represents an object as it appears to the mind of the observer. This is undoubtedly a fact; and for this reason there can be no doubt of the superior value of the drawing. Yet drawings require a much longer time for execution, and their excellence partly depends upon the skill of the artist, and partly upon his familiarity with the use of the Microscope.

Both the photographic and free-hand methods have, in fact, advantages of their own, the photographic, however, furnishing evidence of the accuracy of the observations which it is relied upon to sustain.

Abbe's Refractometer.*—Since the introduction of homogeneous-immersion objectives it has become a matter of increasing importance to be able to readily determine the refractive index and dispersive power of a fluid, without having to resort to the old cumbrous methods by hollow prisms, &c. The refractometer devised by Professor Abbe enables this to be done with a facility and accuracy that leaves nothing to be desired.

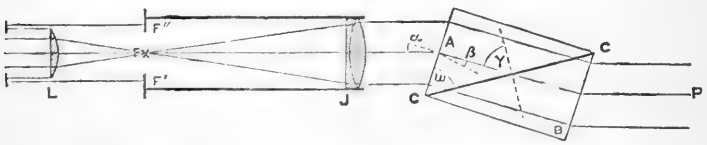
The leading principle of the apparatus depends upon the obstruction of the rays by total reflection at the surface of the fluid under examination. Wollaston and others have previously adopted the method of observing the *maximum* intensity of the reflected ray, but a great advantage is gained by observing instead the *minimum* intensity, so to say, of the transmitted ray. In the former case there is a difficulty in ascertaining the precise point when the light reaches its maximum, whilst in the latter a very small amount of light is easily detected in the darkened field.

The principle will be better understood by reference to fig. 113. Two similar prisms A and B of highly refracting flint glass, with

* Abbe, E., 'Neue Apparate zur Bestimmung des Brechungs und Zerstreuungs-vermögens fester und flüssiger Körper,' 8vo, Jena, 1874, 79 pp. (1 pl. and 7 figs.).

their hypothenuse surfaces contiguous so as to form a parallel plate, are placed in front of a telescope having an object-glass at J, with crossed threads in its focus at F, and a second (eye-piece) lens at L. Suppose that any fluid, or semi-fluid, of *less* refractive index than the prisms, is spread in a thin layer between them, and they are rotated on an axis at right angles to the plane of the paper. When the telescope, with the prisms in front of its objective, is now directed to any bright object, a given point P of the latter will send a pencil of parallel rays through the prisms in a direction parallel to the axis of the telescope. These rays will therefore be collected by the objective J to the centre of the ocular-field, at F, and the eye behind the ocular will see that point of the field illuminated. This, however, will only be so as long as the angle γ, under which the parallel rays reach the internal surface of the prisms, is less than the critical angle corresponding to the difference in the refractive indices of the flint and the fluid between the prisms. If, according to the position

FIG. 113.

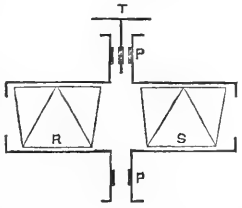


of the prisms, this angle should exceed the critical angle for the rays which are directed to F, no ray can reach this point of the ocular field, nor any other point F′ of the *lower* half of the field (as the diagram is drawn). For the rays which could be collected by the objective J to such a point F′, must of necessity enter the objective as a parallel pencil inclined *upwards* in front of J, and (as will be readily seen by considering the refraction of the prisms) must meet the surface C under *greater* obliquity than the axial pencil just considered; consequently they will undergo total reflection if the axial pencils are totally reflected. Under the condition assumed above, the points of the *upper* half of the field only could possibly receive light through the prisms, because the parallel pencil which is directed to such a point (F″) is inclined downwards, and is therefore transmitted through the surface C under a smaller obliquity. If now, by rotating the prisms, the angle γ for the rays directed to the central point F of the field, should *just* be equal to the critical angle, *all* points of the field above F will receive light through the prisms, whilst all points below F will remain dark, provided monochromatic light is used; the observer will therefore see through the ocular one half of the field bright and the other half dark, the intersecting line of both halves just coinciding with the crossed threads at F. By noting the angle α at which this occurs the refractive index of the fluid is readily obtained. For $\sin \beta = \frac{1}{v} \sin \alpha$ (v being the refractive index of the glass prisms) $\gamma = \beta + w$ and $n = v \sin \gamma$.

With white light the boundary line between the dark and bright parts of the field of view is coloured on account of the difference between the refractive indices of the differently coloured rays, a fact which is made use of to determine the dispersive power of the fluid.

For this purpose a "compensator" is added consisting of two direct vision (or Amici) prisms, R and S fig. 114, so constructed that rays of a given colour D will pass through each without deflection, whilst rays of a different colour will be deflected towards the former, and make with it an angle k in the direction of the principal section. By turning the screw head T of the pinion acting on a circular rack at P the prisms simultaneously revolve in *opposite* directions, and starting from the position shown in the figure (the "primitive plane") in which the two principal sections are parallel, and the refracting edges directed to the same side, they pass through *equal* angles in opposite directions, so that the two principal sections remain always symmetrically inclined to the primitive plane. The principal sections will again coincide after revolving 90°, 180°, &c., with this difference, however, that at 90° the refracting edges will lie in reversed directions, whilst at 180° both will be in the same direction, the opposite of that which they occupied in the original position.

Fig. 114.



It follows, therefore, that the rays corresponding to the line D will pass through the prisms (provided they can pass at all, i. e. are not totally reflected) without deflection, whatever their relative position, and that all other colours will undergo deflection only in that plane in which the two prisms coincide, i. e. the principal plane. During the revolution the extent and direction of the dispersion within that plane varies for any two colours as the diagonal of a parallelogram whose sides are proportional to the dispersion k of the single prisms, and correspond with the direction, whatever it may be, of the principal sections.

Hence the "compensator" acts as a single direct-vision prism for the colour D, with a *constant* principal section, but variable dispersion within that section; and in every position of the prisms, by their revolution (either way) through an angle z, the amount of their dispersion for the assumed colour, and for all others proportionately, is

$$\kappa = 2\,k \cos z.$$

Consequently this amount may have all values from $2\,k$ to $+\,2\,k$.

If we look through such a combination of prisms at a luminous line perpendicular to the central plane of the principal section, it will be seen to extend into a spectrum constantly lengthening as the prisms revolve, becoming contracted again, as the revolution is continued, to a colourless image, and again expanding into a spectrum with the colours in reversed order.

By means of this device any desired amount of dispersion between the limits $-\,2\,k$ and $+\,2\,k$ may be introduced into the pencils

of rays transmitted through the film of fluid at C; and by properly regulating this amount, the relative dispersion of the fluid and the flint-glass of the prisms may be exactly compensated for, or balanced, and the dividing line of the ocular field made to appear *colourless* even with white light. At the same time the position of the compensating Amici prisms (the angle z with which the compensation is obtained) affords all necessary elements for computing the dispersion of the fluid under investigation, provided the refraction and the dispersion of the glass-prism A is exactly known from previous measurement. The author shows that the dispersion of the fluid (for any definite interval of the spectrum) may be obtained by means of the formula

$$\delta n = A + B\,\sigma,$$

where A and B are co-efficients which depend on the refractive index of the prism A and of the fluid, and the dispersive power of the prism A at the same time, whilst σ depends on the angle z of the compensating prisms only. The co-efficients A and B may be easily computed for every instrument and arranged in a tabular form, a definite interval of the spectrum (e. g. from D to F) being assumed for δn.

Fig. 115.

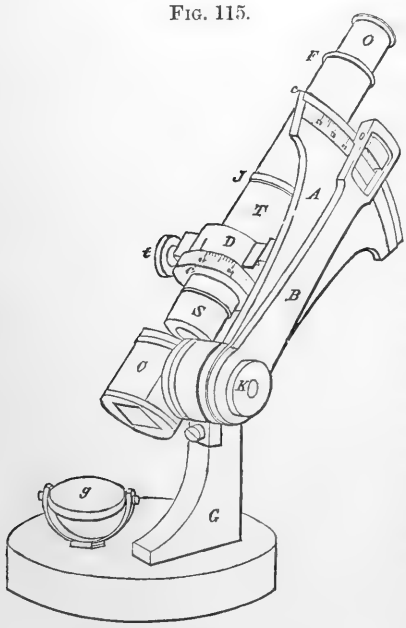


Fig. 115 shows the instrument complete. F J is the small telescope magnifying two or three times. In the focus F of the object-glass are the double cross threads. At the upper end the telescope is attached to a tube, in which the eye-piece O (consisting of a convex lens) slides. At its lower end the telescope is screwed to T D S, containing the two prisms of the compensator; D again is fixed to the sector A. The two prisms between which the fluid is placed are at C. One of these is fixed to an axis which passes through the support G, and has also attached to it at K an alhidade or movable index-arm B. The refracting edge of the prism is at right angles to the plane of the sector and the axis of the telescope. The second prism is simply ledged on the former, being held in place by a spring. The graduation on the sector is arranged so as to give the refractive index directly, and shows thousandths, so that with the naked eye the refractive index to three

places of decimals is readily obtained, and with a lens an approximation to the fourth place is possible. The prisms of the compensator are revolved by a pinion acting on circular racks, the milled head of the pinion being shown at *t*. A drum *e* moving with the lower prism is graduated from 0 to 60, and back to 0, the graduations showing the angle *z* for every 3 degrees.

The instrument is attached to a metal base, and has a concave mirror *g*. In its normal position for observation it is inclined as shown in fig. 115, but in order to insert the fluid between the prisms, the telescope, sector, &c., can be turned completely away from the observer so that the upper end *c* of the sector nearly touches the table, the hypothenuse surface of the lower prism being then horizontal. This is accomplished by the sector not being fixed to the support G, but to an axis passing through it, the prisms with the alhidade being on another axis within the former. Thus the prisms and index can be moved together on the inner axis, or the whole sector, together with the telescope, can be moved on the inner axis, carrying with them the prisms and index.

The following are the directions for use issued with the instrument by Dr. Zeiss, of Jena, by whom it is made:—

"On removing the instrument from its box (taking hold of it by the foot and support G only) it should be placed so that the sector with the telescope is turned away from the observer, the prisms C being towards him. After taking out the small wood, or cork, wedge (used for security in transit) the movable prism should be slipped off by slightly pressing down the spring and drawing it backwards; the surfaces of the two prisms which come into contact are thus free.

After the prisms have been thoroughly cleaned, and the hypothenuse surface of the fixed prism brought into a horizontal position by turning the alhidade, a drop of the fluid to be examined is to be placed in the centre of the prism by a glass rod, the movable prism being replaced by pressing the spring down with the finger.

The sector with the telescope is now to be turned up so that the eye-piece is towards the observer, and the alhidade brought to the beginning of the scale.

Looking through the telescope, the mirror is adjusted so that the whole field of view is uniformly illuminated, and the eye-piece drawn out till the cross threads are seen sharply defined.

The alhidade is then moved forwards till the lower half of the field of view is obscured, and the screw turned until the boundary between light and dark becomes a line *as colourless as possible*. By again turning the alhidade this line is adjusted to lie along the two adjacent points of intersection of the double cross threads.

The position of the alhidade-index on the graduated arc, and the position of the drum, are then to be read off on the respective scales, a lens being preferably used for the former. After further turning the screw till the boundary line a *second time* becomes colourless, it is again adjusted on the cross threads, and the sector and drum read off.

The *mean* of the two readings on the sector gives, direct, the refractive index of the fluid (to the third decimal place), for the then temperature of the instrument and for the Fraunhofer line D. By estimating the fraction of the intervals the fourth decimal may be obtained.

The mean of the drum-readings gives the value of z from which the dispersion of the fluid for the colour interval between D and F may be obtained from the dispersion table which accompanies the instrument, and gives the value of the quantities A, B, and σ of the formula at p. 584, for every reading of the sector and the drum. The elements on which the figures of the table have been computed are taken in such a way, that the formula

$$\delta n = \mathrm{A} + \mathrm{B}\,\sigma$$

gives the dispersion of the fluid for the interval from D to F of the spectrum, i. e. *the difference of the refractive indices* for the Fraunhofer lines F and D. The value of the factor σ corresponding to z is to be taken with a negative sign when z *exceeds* 30.

The index of the alhidade is properly corrected if pure water at about 18° C. gives as the mean of the two readings $n = 1{\cdot}3330$. If the index should have been displaced it can be adjusted by loosening the two screws at the back of the alhidade, by which the index is attached to it, and shifting the latter until the proper reading with water is obtained."

It is also pointed out that it is imperatively necessary that in cleaning the prisms (with water or alcohol) only *soft* and very *clean* linen should be used, and that, as the prisms are made of heavy and therefore easily injured flint-glass, they should be cleaned *immediately* after use.*

Two simplifications of this instrument are also described by Professor Abbe, enabling the refractive index only to be determined. They are both intended to be held in the hand. One has the sector and scale, with a direct vision prism over the eye-glass, and has the full range of scale. In the other the sector is replaced by an eye-piece scale, and is limited to fluids of refractive indices between $1{\cdot}30$ and $1{\cdot}43$. It is a very handy instrument for use with aqueous or saline solutions. All the forms can be made use of for readily determining whether substances have been adulterated or are pure, or the degree of concentration of solutions such as sugar.

As, however, these two forms are of more limited use, and in particular do not admit of the determination of the dispersive powers, it is unnecessary to give here any more detailed description.

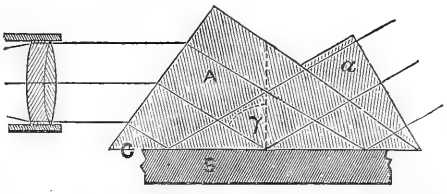
The paper contains very full descriptions of all the three instruments, with directions for use, and elaborate discussions on the principles and limits of exactness of the methods, and on the influence of the errors of observation on the results. It also con-

* Formerly strips of paper were placed between the prisms to keep them a little apart, but recently the movable prism has been ground slightly concave so that the paper is not necessary.

tains a description of a new form of "spectrometer," for the exact measurement of the refractive indices and dispersive powers of *prisms*, which, however, is mainly of interest to physicists.

Professor Abbe subsequently suggested * an addition to the refractometer, in order to enable the refractive indices of *solid* bodies to be determined. For this purpose a small part of the metal back of the fixed prism is removed and a small prism is cemented on. A piece of the substance to be examined is then attached to one of the faces of the large prism by a fluid of high refractive index. In fig. 116, A is the prism of the refractometer, S the solid substance —a plate with one surface polished and cemented to the face C of the large prism by means of a drop of cassia-oil, or monobromide of naphthaline; *a*, the small prism cemented to A, in order to admit rays *from above* to the face C. If the angle γ of the incident rays at C, on rotating the prism A, becomes equal to the critical angle for the substance S —relatively to the flint-glass of A—*total* reflection begins, and the *under* half of the ocular-field appears *brightly* illuminated, the upper half *less* so. The line of intersection being brought just upon the cross-wires and made colourless by means of the compensator, we have again the same conditions as in the case of transmitted light.

Fig. 116.



In order that the total reflection shall be obtained from the solid substance S, and not from the fluid film by which it is cemented to A, the refractive index of this fluid must of course *exceed* that of the solid under investigation.

Refractive Indices and Dispersive Powers of Solids and Fluids.† —Professor L. Matthiessen of Rostock gives a table of refractive indices and dispersive powers, prefaced by the following observations:—

"It is well known that recently in practical optics the theory and technic of microscope objectives have attained special interest. Important advances in the perfecting of the Microscope are connected with the names of Helmholtz, Abbe, Amici, and Stephenson. The problem of eliminating spherical and chromatic aberration in objectives has through them (in different directions) been brought nearer a solution, although in the optical properties of transparent solid and fluid bodies there are still many obstacles to further perfection to be overcome. In the substances hitherto observed the dispersive power generally increases with the refractive index, and substances are wanted which combine small dispersion with a high refractive power or *vice versâ*. Moreover the fluids hitherto observed all have a propor-

* "Ueber die Bestimmung der Brechungs-Verhältnisse fester Körper mittelst des Refractometers," SB. Jenaisch. Gesell. f. Med. u. Naturwiss., 1879, pp. 35–44.

† Centr. Ztg. f. Opt. u. Mech., iii. (1882) pp. 73–4.

tionately larger dispersion than solids of equal refractive index. For the homogeneous-immersion method, however, fluids are required which agree in refraction and dispersion with the glass of the objectives. Finally, it is found that with an increasing total dispersion

Refracting Substances.	Observer.	^nD.	$^nH - {}^nB$.
Fluor spar	St.	1·43390	0·01004
Distilled water, 22° C.	v. W.	1·33292	0·01305
Sulphuric acid—(hydr.) 4·5 per cent.	„	1·33862	0·01350
Sugar candy—sol. 10 per cent.	v. O.	1·34756	0·01351
Alcohol, 38·8 per cent.	v. W.	1·35686	0·01368
„ 86·8 „	„	1·36343	0·01376
Calcspar (*e*) Hofm. III.	„	1·48639	0·01381
Chloride of sodium—sol. 8·6 per cent.	„	1·34702	0·01428
Sugar candy—sol. 30 per cent.	v. O.	1·38080	0·01451
Chloride of ammonium—sol. 9·7 per cent.	v. W.	1·35098	0·01466
Arragonite (γ)	R.	1·53013	0·01477
Glycerine, 49·7 per cent.	v. W.	1·39242	0·01493
Acetic acid, 97·6 per cent.	„	1·37455	0·01501
Chloride of zinc—sol. 18 per cent.	„	1·36719	0·01559
Chloride of calcium—sol. 16·7 per cent.	„	1·37392	0·01599
Topaz (β)	R.	1·61375	0·01691
Quartz (*o*) Hofm. I.	v. W.	1·54417	0·01711
Glycerine, 100 per cent.	„	1·46196	0·01712
Chloride of sodium—sol. 26·6 per cent.	„	1·37963	0·01715
Topaz (*a*)	R.	1·62109	0·01715
Chloride of ammonium—sol. 24·8 per cent.	v. W.	1·37947	0·01720
Chloride of zinc—sol. 31·0 per cent.	„	1·39169	0·01757
Quartz (*e*) Hofm. III. R.	„	1·55323	0·01777
Crown glass	Lo.	1·50867	0·01867
Heavy spar (γ)	H.	1·63630	0·02043
Chloride of calcium—sol. 40·6 per cent.	v. W.	1·44313	0·02106
Heavy spar (*a*)	H.	1·64797	0·02145
Crown glass (Merz IV.)	v. W.	1·53032	0·02194
Turpentine	„	1·47212	0·02311
Rock salt, 22° C.	St.	1·54400	0·02904
Arragonite (*a*)	R.	1·68589	0·02950
Calcspar (*o*) Hofm. III.	v. W.	1·65844	0·03032
Flint glass	Lo.	1·56945	0·03086
Naphthaline in Benzol	Ve.	1·49513	0·03815
Benzine, A.	v. W.	1·49721	0·03853
Benzole, pure	Ve.	1·49947	0·03893
Sassafras oil	B.P.	1·53215	0·04360
Oil of anise	„	1·55725	0·05977
Thallium glass	Ve.	1·75303	0·06709
Flint glass (Merz II.)	v. W.	1·75139	0·07008
Monobromide of naphthaline	Ve.	1·65815	0·08369
Bisulphide of carbon	v. W.	1·62403	0·08411
„ „ 13·7	„	1·63307	0·08576
Oil of cassia	v. W.	1·61883	0·11270

there is generally a larger partial dispersion in the blue. It is to this point, as it seems to me, that the opticians will in future have to direct their attention in the correction of the chromatic aberration.

A comparison of the above three conditions can, however, only be made by means of a tabular statement of the measurements hitherto

carried out. These measurements, which were extended to the whole spectrum, are scattered here and there in books, and moreover are not all of equal value, being affected partly by personal and partly by instrumental errors. For the purpose of forming a normal table for the partial dispersions, I have collected about 200 of the best and most authentic series of refractive indices, which embrace the Fraunhofer lines A, *a*, B, C, D, E, *b*, F, G, H_1 or at least the seven lines B, C, D, E, F, G, H_1. From this series the accompanying table has been compiled for optical purposes, in which the substances with the index D or ^{n}D are arranged according to the total dispersions $H_1 - B$ or $^nH - {}^nB$."

[We have not thought it necessary to print the whole table of 173 data but have selected 44.] The observers were Fraunhofer (F.), van der Willigen (v. W.), Baden-Powell (B. P.), Rudberg (R.), Mascart (Ma.), Dutiron (Du.), Heusser (H.), Ditscheiner (D.), Stefan (St.), Verdet (V.), Veress (Ve.), von Obermayr (v. O.), Swan (Sw.), Lohse (Lo.)."

"**The Genus Microscopista.**"*—The Annual Address for 1882 to the Microscopical Society of Victoria was delivered in November last by the Vice-President, the Rev. J. J. Halley.

After referring to the small number of members and the still smaller number who contributed papers, the address continued as follows:—"In such circumstances, perhaps, this Annual Address may properly take the form of what would in theology be called apologetic. We must defend our position, and show the *raison d'être* of our existence. Looking, then, at our Society as we are accustomed to look at the various divisions of sentient life as they come under our investigation, we will proceed to examine the various species of what we may call the genus *Microscopista*, the generic characteristics of which are, that they examine minute objects with artificial aid more or less elaborate and that they do this with a more or less useful end in view.

Of this great genus, whose habitat is the civilized world, the first species is the *M. delectata* (*sic*), or the playing microscopist. This is the lowest species in the scale of development, and some observers consider that the other species are all derived from this one, while a few who have no love for the genus affirm that this is the one and only species, the others so-called being only transient varieties. But *M. delectata*, though often despised, is by no means to be set aside. We will grant that in his hands the instrument is a plaything and nothing more,—that he looks at the wondrous beauties revealed merely to please the eye,—that he peers into quaint and curious forms merely to satisfy curiosity,—that the valve of a diatom is interesting to him merely as it is strange, and that the organs of an insect or the home of a Bryozoon only allure as they are novel. In this there is nothing to be despised. The great order of the Bimana must be amused, and the more rational the amusement the better; and surely it is not less rational to find amusement in examining the wonders of

* 'Southern Science Record,' ii. (1882) pp. 285-9.

Nature,—her painting of marvellous beauty,—her sculpturing of unrivalled forms,—than in turning over the prints of man, or spending time examining and collecting his effigies; surely as reasonable as counting the pips on a card, as cannoning ivory balls, or bouncing indiarubber ones over a net. We will not, then, push out of existence the playing microscopist, for my own part I have for him a very tender regard, being perhaps myself but little removed, if at all, from this species. In your name I will welcome all such to our gatherings, assuring them that they will find here much to amuse them if they do not care to learn; but we will hope that in consorting with higher forms they will imperceptibly, perhaps, yet surely, by the force of association, put on new features, lose obsolete and useless organs, and develop into higher and higher forms, and this not in descendants yet to be, but in a conscious life-history. Again I say we are delighted to find, and would gladly have more in our midst of, *M. delectata*.

We advance next to *M. evocationes* (*sic*), or the collecting microscopist. This is only one of the somewhat despised forms:—'Only a collector,' with an elevated head and a righteous shrug, is a phrase often heard. But in great economical systems 'mere collectors' play a most important part. This solid world, with its fertile plains, is just a vast collection gathered together by collectors, organic and inorganic. And collectors provide the material for others to work on and work up. The higher workers not infrequently have neither the time nor the opportunity to collect, and, so far as the preparation of microscopic mounts is concerned, have often not the manual skill and delicacy of touch to be successful. Such must depend for their mental pabulum in its raw state on others. And there is work of immense importance to be done by the 'mere collector.' If such cannot add to our knowledge by their own investigations, if from their brains can come no world-shaking theories that shall make their name and our Society's name familiar as household words, they can add to the treasures of our cabinet, their quick-seeing eye can pick out new forms, their diligent feet can take them to unexplored parts, and their delicate hands can mount their finds in such a way that the true investigator will be able to read with his glass, as in a glass, natural riddles, adding to the world's store of knowledge. Our Society cannot afford to despise the collector. Far from it; we will thankfully receive from any quarter, and ardently welcome, genuine specimens of *M. evocationes*.

M. tabernarius, or the tradesman microscopist. A large and growing species, every day producing novel varieties, and one that in these days must be treated with no little respect. Utilitarianism has invaded the old halls of science, and in these modern days not one but many a philosopher's stone has been found in the crucible of the chemist and the jar of the electrician; and mean homes have turned palaces, and common delf silver-plated, at least, through fortunate discovery. Yes, gold in abundance has followed in the track of the scientists. All this is but *vero verius*, nothing more true. In saying the scientific plaything of yesterday is the mighty

machine of to-day—the toy of an enthusiast one day, the necessity of life to thousands the next—it would be but a work of supererogation to remind you of the giant strides made in the development of electric science and practice. In our own line we can perhaps look for no startling discoveries that shall revolutionize the world of daily life, but there is yet room for the *Microscopista tabernarius*. I do not mean the man who makes the instruments, for him there undoubtedly is ample room, and almost every month we have to hail improvements that make our work more easy. But the Microscope is a tool of trade for some. We have heard that the intricate and charming markings of diatoms and Foraminifera have been used by pattern designers, and in some trades the Microscope is daily used. About a year ago I was at the Italian National Exhibition at Milan. Among the most interesting of the exhibits was the process of silk producing and manufacture. At that exhibition the results were not merely shown, but all the details from the beginning to the end, and a row of microscopists with persistent care examined the silkworm eggs, picking out and rejecting every egg that showed any symptom of disease. But why go to Milan? Has not the *greatest* of your legislators declared that by the aid of a powerful Microscope he was enabled to determine on the spot the magnificent character and splendid suitability of the Stawell stone for our new halls of legislature? In this Society it would be of thrilling interest to hear what was the powerful instrument he used—how he used it in the trying circumstances of the Parliamentary picnic—what he learned—and how he learned it by looking at a lump of sandstone? But this is perhaps too much to expect; let us be content that the value of your instrument has been acknowledged in those halls of wit and wisdom. I think I must place this new-caught specimen in a unique sub-species of his own, and label him *M. ludificatio*. I hardly dare translate this title, but its English synonym is not far off 'humbug.'

Under *M. tabernarius*, as a sub-species, we will place *M. detergitata (sic)*, or the detective microscopist. Here we come to a class directly useful to mankind. By the aid of the Microscope we discover largely what it is that we eat and drink, how sometimes very widely the real differs from the apparent, and how true it is that "things are not what they seem"—a wide field, that has hitherto not been taken up to any extent by our Society. Under this species I had intended to have ranged myself during the past year, and to have done something worthy of your attention for this meeting: but, alas, it has been but a good resolution, and gone, I fear, where many other good resolutions have gone before it. This I have done: prepared a series of test starches for comparison, some eighteen or twenty slides of which I had the pleasure of placing in the Society's cabinet. I have also made a preliminary examination of some of our ordinary articles of food, not sufficiently exact to go into detail, but enough to give to you a hint as to what may be done, and to indicate a useful line of work. For example, I have found arrowroot adulterated with sago, and arrowroot, tapioca, and sago all showing more or less of the well-known form of potato-starch. Cocoa has exhibited potato-starch, sago-starch, in one case

the beautiful grain of *tous-les-mois*, besides sugar crystals and inorganic matter, that may be colouring matter, or may be dirt—in one case, I suspect, plaster-of-paris. Mustard showed pea-flour, potato-starch, and wheat-flour, as well as inorganic matter, probably plaster-of-paris. Oatmeal showed wheat-flour, and maizena potato-starch.

I give these just as examples of what is and of what may be done. It is not our province to do with legislative action, yet we have, I think, a right to know what it is that we eat and drink. Many of the adulterations are in themselves harmless to the public health, though not to the public morals. This species of microscopist is much needed, and I regret that, so far as our Society goes, we have no member that has given himself up to this work in a systematic and careful manner; but certain it is that such a work needs doing, and doing well. I can only bid you hope that our energetic Secretary will secure for us numerous specimens of *M. detergitata.*

M. medicus is the medical microscopist. Our learned and much honoured President comes, of course, under this title. One would say that specimens of this species would be found in abundance about our rooms, making themselves heard above the more subdued voices of other species; for surely the Microscope must be a necessity for medical men, and one would certainly have predicated that our Society's literature would have been enriched by their contributions many and learned; but, with the one exception of our President, I do not think that for years a solitary specimen of the *M. medicus* has been heard in our gatherings. I cannot altogether account for this: I do not know if the class is an exceptionally shy one—shrinking from publicity—in no case courting profane gaze, and with a modest dislike to uttering opinions in gas-light, and never on any occasion advancing thoughts that are not well matured and tested. It may be the *M. medicus* has a difficulty in consorting with other species of the same genus, and prefers buzzing only where his more immediate kin are found. I do not know what bait must be prepared to catch this remarkable shy form: possibly our President may give our Secretary a few hints on the subject.

My last species is the *M. germanus*, a true genuine microscopist. Of this species we have some admirable examples, men who patiently and perseveringly take up some section of the wide world of science, and work on and on till they have worked out some beautiful system, or worked up the whole life-history of a race. It is those men who add to the sum of the world's knowledge, and so add to the sum of its happiness. The discovery of truth in any one line cannot but be beneficial, for every discovery of truth helps in the discovery of other truth, and sometimes in lines remote enough from the first. The story of the world of science is full of instances of this. And every man who lays a stone may know that he is doing something for the completion of that grand temple of truth that shall fill the world with its radiance.

Gentlemen, we exist that we may bring together these various classes, all interested, though in different ways, with microscopy. Men of kindred pursuits naturally desire to meet each other, or should do

so, that there may be mutual help and the interchange of ideas, and that by such help knowledge may 'grow from more to more.'

I think I have shown that we have a right to exist, that by our existence we may not only amuse and profit each other, but do good in the community in which we are placed, and perchance do something to help in the advance of knowledge in the mighty world of science.

May I trust that next year will be far more prosperous than any preceding ones have been?"

ADY, J. E.—The Methods of Microscopical Research. Part I. Introduction. Part II. On Instruments and their Uses. Chapter I. The Microscope, pp. i.–vi. 8vo, London, 1883.

AYLWARD'S (H. P.) Camera Lucida.

["Very cheap camera lucida which can be used with the eye-pieces of any maker without requiring an adapter. The reflecting surface is a thin cover-glass, which is made adjustable in order that the instrument may be used with either deep or shallow eye-pieces."]

Micr. News, III. (1883) p. 208.

BAUSCH'S (E.) New Binocular. [*Supra*, p. 548.]

Amer. Mon. Micr. Journ., IV. (1883) p. 97.

The Microscope, III. (1883) p. 89 (from *Odontographic Journal*).

BEHRENS, W.—Bericht über einige, während des Jahres 1882 publicirte Verbesserungen etc. von Mikroskopen und mikroskopischen Apparaten. (Report on improvements, &c., in Microscopes and Microscopical Apparatus published during 1882.) [Abstracted from this Journal.]

["Wir wenigstens glauben nicht, dass ein deutscher Mikroskopiker je zu 'Wenham's universal inclining and rotating Microscope' greifen wird. (Sollten dieses und ähnliche englische Instrumente sich nicht noch dahin vervollkomnen lassen, dass der Beobachter auf dem Kopfe stehend hindurch sehen kann?)"]

Bot. Centralbl., XIV. (1883) pp. 253–5, 350–1 (5 figs.).

BIZZOZERO, G.—Manuel de Microscopie Clinique avec des instructions sur l'emploi du Microscope en Médecine légale, &c. (Manual of Clinical Microscopy with instructions for the employment of the Microscope in medical jurisprudence.) Translated from the 2nd Italian edition with notes and several additional chapters, by Dr. C. Firket (*infra*, p. 613). xii. and 359 pp., 45 figs. and 7 pls. 8vo, Bruxelles, 1883.

[Chap. I. Description and Use of the Microscope, pp. 1–19 (3 figs.).]

BLES, E. J.—Germination of Fungus Spores under the Microscope.

[Describes Dallinger's Damp Chamber and the author's device.]

Sci.-Gossip, 1883, p. 137.

BRADBURY, W.—The Achromatic Object Glass, XX., XXI., XXII., XXIII., XXIV., XXV.

Engl. Mech., XXXVII. (1883) pp. 305–6, 329–30, 356–7, 377–8, 405, 451.

COHEN, E., and J. GRIMM.—Sammlung von Mikrophotographien zur Veranschaulichung der mikroskopischen Structur von Mineralien und Gesteinen. (Collection of microphotographs for the demonstration of the microscopical structure of minerals and rocks.) Part VIII., 8 microphotographs. 4to, Stuttgart, 1883.

CURTIES' (T.) Nose-piece Adapter. [*Supra*, p. 572.]

Engl. Mech., XXXVII. (1883) pp. 333, 365, 385.

CURTIS, R. J.—The Clinical Use of the Microscope.

[Considers that "the following list will comprise a battery of objectives which will most satisfactorily cover the whole ground of microscopy:—3 in. 10°, 1 in. 25°, 1-2 in. 45°, 1-8 in. 180°," with a set of eye-pieces of 2 in., 1 in., 1-2 in., 1-3 in., 1-5 in.]

The Microscope, III. (1883) pp. 71–6, from *Peoria Medical Monthly*.

DAVIS, G. E.—Penetration in Objectives. [*Supra*, p. 579.]

Micr. News, III. (1883) pp. 172–6.

DAVIS, G. E.—"To our Subscribers."—"Our Free List."
Micr. News, III. (1883) p. 182.

GLAZEBROOK, R. T.—On Polarizing Prisms. [*Supra*, p. 579.]
Proc. Phys. Soc. Lond., V. (1883), pp. 204–16 (6 figs.).

GOVI.—Intorno allo scopritore di una singolare illusione ottica. (On the discoverer of a singular optical illusion.) [*Post.*]
[With remarks by Sig. Respighi.]
Atti R. Accad. Linc. Trans., VII. (1883) pp. 183–8.

GRATTAROLA, G.—Su un possibile errore nelle misurazioni micropetrografiche. (On a possible error in micropetrographic measurements.)
[In measuring, by means of the fine adjustment screw, the vertical dimensions of an object inclosed in a transparent medium, such as a microlith in quartz or felspar, or the vertical distances between two points in such a medium—in short differences of level—the true difference is equal to that shown by the direct reading of the screw multiplied by the refractive index of the medium.]
Atti Soc. Tosc. Sci. Nat., Proc. Verb., III. (1883) pp. 244–6 (1 fig.).

GRIMM, J.—See Cohen, E.

HAILES, H. F.—Adapters for Microscopes.
[Note on letter of J. A. Ollard *infra* as to Nelson's and Curties' Adapters.]
Engl. Mech., XXXVII. (1883) p. 385.

HARDY, J. D.—Gas lamp for microscopic use.
[Exhibition — An adaptation of the albo-carbon burner to a table lamp-stand.] *Journ. Quek. Micr. Club*, I. (1883) p. 197.

HITCHCOCK, R.—Instructions in Dry-plate Photography (in part).
["The object of these articles is to enable the reader to make good photographs with the Microscope, and to prepare lantern-transparencies for use in illustrating articles read before Societies or public lectures," with "full instructions for developing and finishing negatives, glass positives, and paper prints."]
Amer. Mon. Micr. Journ., IV. (1883) pp. 84–8, 106–9.

Homogeneous-immersion Lenses.
[The cement of Möller's slides shows no signs of deterioration from cedar oil. Hollis' glue appears to be quite proof against the oil. Ward's brown cement seems to be equally efficacious.]
Micr. News, III. (1883) p. 208.

JADANZA, N.—Sopra alcuni sistemi diottrici composti di due lenti. (On some dioptric systems composed of two lenses.)
Atti R. Accad. Sci. Torino, XVIII. (1883) pp. 601–18 (5 figs.).

JOHNSON, G. C.—Photo-micrography.
["Since the introduction of rapid gelatine dry plates he showed that good pictures might be obtained by the use of objectives of high power, such as the 1-16th in., even with ordinary gaslight."]
Rep. and Proc. Manch. Sci. Stud. Assoc. for 1882, p. 17.

JUNG, H.—Neuer Zeichenapparat (Embryograph) für schwache Vergrösserungen. (New Drawing Apparatus—Embryograph—for low amplifications.) [*Post.*]
Zeitschr. f. Instrumentenk., III. (1883) pp. 165–7 (2 figs.).

M'INTOSH, D.—United States Patent for a Microscope, No. 273752, 18th June, 1882 (title only). *Zeitschr. f. Instrumentenk.*, III. (1883) Mai, Wrapper.

Manufacturers, Hints to.
[Recommendation to "make stands that are adapted to the wants of students rather than to attempt to reform or educate the Harvard Medical College professors"—where Hartnack Microscopes are almost universally employed—"up to an appreciation of the excellency of American stands and costly objectives."]
Amer. Mon. Micr. Journ., IV. (1883) pp. 97–8.

MONOYER.—Formules générales des systèmes dioptriques centrés. (General formulæ for centred dioptric systems.)
[Intended to show that for the formulæ of analytical geometry employed by Gauss those of elementary algebra may be substituted without at all diminishing the exactness of the results.]
Comptes Rendus, XCVII. (1883) pp. 88–91.

Moore, A. Y.—*Amphipleura pellucida* by central light.

[Considers the real explanation of the resolution when the mirror is central to be that the edge of the front cell of the objective radiates the light, and all light reaching the bottom of the slide at a greater incidence than the critical angle is reflected upwards, and enters the lens after having passed through the diatom.]

The Microscope, III. (1883) pp. 49–51 (1 fig.).

Nelson, E. M.—On a quick-acting Adapter for Microscopical Objectives. [*Ante*, p. 858.]

Journ. Quek. Micr. Club, I. (1883) pp. 152–3.

„ „ New Nose-piece Adapter. [*Supra*, p. 572.]

Engl. Mech., XXXVII. (1883) pp. 333, 365, 385.

Ollard, J. A.—Adapters for Microscopes.

[Note on Nelson's and Curties', *supra*, p. 572.]

Engl. Mech., XXXVII. (1883) p. 365.

Ottawa Microscopical Society.

[Note on the formation of the Society and their offer of exchange of microscopic material.]

Sci.-Gossip, 1883, p. 138. See also *Amer. Mon. Micr. Journ.*, IV. (1883) p. 99.

[Pease's] "Facility" Nose-piece. [*Ante*, p. 425.]

Amer. Mon. Micr. Journ., IV. (1883) p. 103 (1 fig.).

Peragallo, H.—Considérations élémentaires sur l'ouverture des objectifs microscopiques et les moyens de la mesurer. (Elementary considerations on the aperture of microscopic objectives and the methods of measuring it.)

Journ. de Microgr., VII. (1883) pp. 326–36 (7 figs.), from *Bull. Soc. d'Hist. Nat. Toulouse.*

Prado, P.—United States Patent for a Photo-micrographic Camera, No. 274515, 18th October, 1882. [Title only.]

Zeitschr. f. Instrumentenk., III. (1883) Mai, Wrapper.

"Prismatique."—Object-glass working, VI., VII.

Engl. Mech., XXXVII. (1883) pp. 283 (1 fig.), 473–4.

Prisms *v.* Mirrors.

["It has long been an opinion among microscopists that the best and strongest light for the illumination of microscopic objects is obtained by substituting a prism for the ordinary mirror. The advantages offered by the prism are more theoretical than practical, while the quantity of light reflected by a silvered mirror is far greater than can be obtained from a prism of equal size. The only advantage of the prism is the reflection from the single plane surface, while the mirror gives a reflection from both the outer and inner surfaces of the glass. But practically this is of absolutely no consequence. A well-silvered mirror reflects 95 per cent. of the light incident upon it. We will soon give a process for silvering glass which yields perfect results and is readily applied by any person."]

Amer. Mon. Micr. Journ., IV. (1883) p. 119.

[Queen & Co.'s] "Acme" No. 3 Improved [Microscope].

Amer. Mon. Micr. Journ., IV. (1883) pp. 110–1 (1 fig.).

Respighi.—See Govi.

Rindfleisch.—[Impromptu Condenser. *Supra*, p. 574.]

Berliner Klinische Wochenschrift, 1883, p. 183.

Ryder, J. A.—The Holman Lantern Microscope. [*Supra*, p. 552.]

Journ. Franklin Institute, CXVI. (1883) pp. 67–9 (1 fig.).

Schrenck.—Exhibition (New York Microscopical Society) of a new form of Microscope-table.

["The particular feature of the table was a revolving centre upon which the Microscope is intended to be placed."]

Amer. Mon. Micr. Journ., IV. (1883) p. 100.

Smith, G.—Apparatus for Photomicrography. [*Post.*]

Amer. Mon. Micr. Journ., IV. (1883) p. 118. from *British Journal of Photography.*

Stowell, C. H.—Projecting Lanterns. [*Post.*]

The Microscope, III. (1883) pp. 51–3.

Stowell, C. H.—Microscopy in the University of Michigan.
[Description of the nature and extent of the microscopical work in the University.]
The Microscope, III. (1883) pp. 63–8.
„ „ and L. R.—[Suggestions for early publication of the proceedings of the American Society of Microscopists.] *The Microscope*, III. (1883) p. 69.
Thomas, C.—A new form of "Life-slide" ("Thomas's Vivarium").
[See Vol. II. (1882) p. 688.] *Trans. Essex Field Club*, III., pp. xlix.–l. (2 figs.).
Van Heurck, H.—La Lumière électrique appliquée aux recherches de la Micrographie. (The electric light applied to microscopical researches.)
[I. Production of Electricity (Méritens' and Reynier's Dynamos; Tommasi and Reynier's Batteries.) II. Storage (Kabath's and Tommasi's Accumulators.) III. Lamps (Reynier, Swan, and Stearn.) IV. Illumination of the Microscope (Stearn's method, *ante*, p. 29.) V. Photo-micrography. Additional Note (Reynier's new Accumulators).]
Journ. de Microgr., VII. (1883) pp. 244–60 (13 figs.).
Watson's New Microscope-stand. [*Supra*, p. 555.] *Micr. News*, III. (1883) p. 205.
Wright, L.—Optical Combinations of Crystalline Films.
[Describes easily-made combinations of mica-films put together with canada balsam dissolved in benzol. Contains also a reference to an apparatus made by Swift and Son by which all the preparations and crystals requiring highly convergent light can be shown on the stage of any Microscope provided with a draw-tube.]
Proc. Phys. Soc. Lond., V. (1883) pp. 186–95 (1 pl.).
Zeiss, C.—On the method of using Abbe's test-plate.
[The directions issued by Dr. Zeiss with the test-plates and printed *ante*, p. 281.]
Journ. Quek. Micr. Club, I. (1883) pp. 154–6.
„ „ Dissecting Microscope.
[Exhibition and discussion; also on Stephenson's Binocular.]
Journ. Quek. Micr. Club, I. (1883) pp. 200–1.
Zenger, K. W.—Berechnung des Endomersions-Objectives für Fernrohr- und Mikroskopobjective. (Computation of the Endomersion Objective for Telescope and Microscope Objectives.) [*Post.*]
SB. K. Böhm. Gesell. Wiss. Prag, 1881 (1882) pp. 467–79.
„ „ Dioptrische Studien. (Dioptric Studies.)
[On "Endomersion objectives." *Post.*]
SB. K. Böhm. Gesell. Wiss. Prag, pp. 479–92.

β. Collecting, Mounting and Examining Objects, &c.

Water Collecting-Apparatus.*—Mr. C. F. George has used the following in searching for Hydrachnidæ, and has found no other piece of apparatus so efficient:—

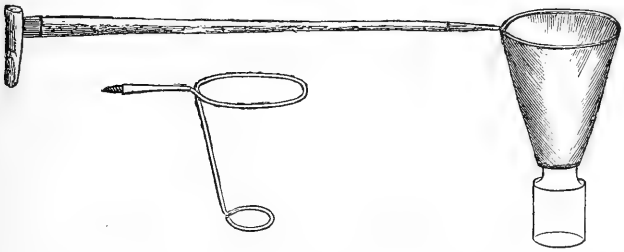
A piece of thick brass wire (fig. 117), is bent at about 6 in. from one end into a ring 4 or 5 in. in diameter. After connecting with some finer wire the two extremities of the ring, bend the stout wire at right angles to the ring, and continue it for about 4 in. Then make another ring about 1½ in. in diameter, and there terminate the wire, leaving the small ring, however, not quite complete. The two rings will thus be parallel to each other. On the upper ring stitch a piece of tape, and to this sew a piece of muslin, made to the shape of a conical bag, and having its wider end affixed to the tape. Into the lower opening of this bag a small, wide-mouthed glass bottle, of about two ounces capacity, should be fastened by a piece of thread or fine string, and the lower ring is then sprung round the neck of the bottle. The other end of the brass wire, which was left

* Journ. Post. Micr. Soc., i. (1882) pp. 158–9 (1 fig.).

projecting for about 6 in., is now to be firmly lashed to a light cane or stick, and the apparatus is complete.

In order to use the apparatus, move it gently backwards and forwards on the surface of the water, under the surface, or just above the bottom of the pond, and among the weeds; the muslin will allow the water to pass through it, whilst any living organisms will be retained by the bottle. This can from time to time be examined with

Fig. 117.



a pocket lens, and when it is found to contain anything, the lower ring of wire can be slipped off, and the neck of the bottle pushed up through the upper ring, inverting the net. The contents may thus be poured off into another bottle, and after rearranging the apparatus, fishing may go on again. The object of the piece of wire connecting the two ends of the net is to keep all stiff, so that the bottle can be turned in any direction, and yet both the upper and lower mouths of the net will remain open.

Preparations of Coal.*—P. F. Reinsch's preparations of coal from the carboniferous strata, the Dyas and Trias (the material being very difficult to reduce to thin and sufficiently transparent sections), are made by using the finest emery employed in polishing mirrors. Powdered chalk obtained by levigation, and carbonate of lime precipitated from lime-water by soda, are also used. A small piece of cork serves as a rubber. During the process the preparation is moistened with glycerine.

Cathcart's Ether Microtome.†—C. W. Cathcart's object in venturing to add another to the many forms of freezing microtome was:—(1) to obtain a simple ether spray-producer which would not allow any ether to escape unevaporated; (2) to have an efficient microtome for use with the ether spray, which would be so simple in its mechanism as to admit of manufacture and production at a comparatively low cost. The microtome can be sold at 17*s.* 6*d.*, including the spray-producer, and it freezes 1-4th in. of tissue in 1½ or 2 minutes, using in the process about 2 drachms of ether, which cost something less than a farthing.

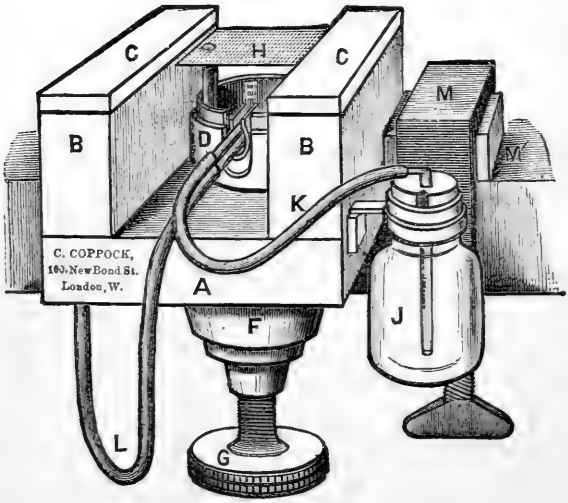
The instrument is thus described by the author:—"The spray-producer works on the same principle as the scent sprays which have

* Bull. Soc. Belg. Micr., ix. (1883) pp. 87–8.

† Journ. Anat. and Physiol., xvii. (1883) pp. 401–3 (2 figs.).

been in use for a long time, where a jet of air playing across the top of a tube draws up the fluid from its interior by tending to make a vacuum in it. The bellows used are the ordinary hand ones sold for carbolic and other spray-producers, these being as cheap and efficient as any that can be got. In working at the spray points, I began by selecting the size of air-hole that these bellows could easily feed with a continuous blast of air, and then, experimenting with various sizes of vaccine tubes, I found at last, that with the smallest size I could produce a spray which, at about 1-2 in. distance from any object, contained just as much ether as the given blast of air could evaporate. There was then of course no running of the ether to waste, while at the same time an intense cold was very rapidly produced. The method of adapting the spray points to one another is a modification of the ordinary one, and is adopted from a German model. It is as

FIG. 118.



follows:—Two fine brass tubes are taken—one is brought to the requisitely fine point for the ether, and the other, being closed at the end, has the air-hole bored at the side a little below the closure. The point of the ether tube is then placed over the middle of the air-hole, and the tubes, laid one over the other, are soldered together in this position; the free ends of the tubes are then connected with the air bellows and the ether bottle respectively by means of indiarubber tubing, and this part of the apparatus is complete.

The microtome (fig. 118) consists of the framework, and the mechanism for raising the section. The framework is of 1-2 in. mahogany, and is in the form of a base with two upright parallel pieces screwed on to it. The base A, which is about $2\frac{1}{2}$ by 4 in., is bored to allow the tubes for raising the section to pass up between the parallel pieces, and has a projecting part at one side to allow of

its being clamped to the table M'. The two parallel parts BB, which are of the same 1-2 in. mahogany, stand about $1\frac{1}{4}$ in. apart; they are 4 in. long, and, rising to 1 in. high, each carries on the upper surface a piece of quarter-in. plate glass CC, of the same length and breadth as itself. This is to support and steady the knife as it is pushed across the tissue to be cut, while the fact of the tissue coming up between the plates allows that part of the knife which is to cut the specimen to be kept free of contact until it touches the tissue.

The method of raising the section plate H is as follows:—About 2 in. of accurately fitting double brass tubing are taken, and into the outer one D the nut F of a fine screw is firmly soldered at what is to be its lower end. The inner tube E has the section plate fixed to its upper end by two screws, with, however, two small pieces of vulcanite intervening between the plate and the tube, so as to disconnect them as much as possible, and into the lower end of the inner tube a transverse bar is fitted, against which the screw coming through the outer tube presses when it is desired to raise the section plate to which the inner tube is attached. By means of a small screw-nail fixing the outer screw to the bar in question, the inner tube can be withdrawn, as well as pushed up whenever that movement is required. A milled head G has been substituted for the ordinary capstan arms, for turning the main screw round.

The spray points are introduced at the requisite distance below the section plate by cutting a narrow slot through both tubes, and fixing to the inner one a piece of bent brass, into which the spray points can be pushed and held firmly, while a small shoulder on the latter prevents them from passing beyond the centre of the under surface of the plate.

Finally, the ether bottle J (with the tubes K and L) is fastened to the side of one of the upright pieces of the framework by a simple hook and eye, the hook being fixed to a collar round the neck of the ether bottle, and the eye to the side of the framework in question. It will be seen, I think, from this description, that with the exception of the fine screw for raising the tissue, the details of the mechanism are very simple, hence the low price at which it can be sold; and in practice it has been found to work admirably."

The instrument is to be obtained from Mr. C. Coppock.

Glycerine Mounting.*—For vegetable sections glycerine is one of the best preservatives, but the difficulty of confining it within the cell has been deemed insuperable. A method invented by Professor Hillhouse enables this end, it is said, to be perfectly attained. The mode of operation is as follows:—

No cell is used, the object being merely placed in a drop of glycerine of sufficient size to reach the edge of the cover-glass when it is dropped in. Canada balsam, dissolved in turpentine, is then applied round the edge so as to close the cell, by means of a small glass rod drawn out to a point, but terminating in a little knob. If a little of the glycerine should exude beyond the cover-glass, it need not be

* Midl. Natural., vi. (1883) p. 166.

removed; it can be covered with the Canada balsam as easily as if it were under the cover-glass, and without interfering with the security of the cell. The Canada balsam is, of course, best if of such a consistence as not easily to become hard and brittle. Professor Hill-house mentions as one of the advantages of this method, that if the section should slip from beneath the cover-glass on the application of pressure, as the thinnest and therefore best sections are apt to do, they would still be visible through the transparent balsam, if its upper surface were made parallel to the slide. It was jocularly suggested at the meeting at which the process was explained that the next step in advance would be to dispense with the cover-glass altogether, and encase the object in a layer of glycerine, protected by a horizontal film of balsam.

Mounting Sections in Series.*—Referring to Dr. J. Frenzel's method of mounting,† Mr. R. Threlfall says that it was pointed out to him by Mr. W. H. Caldwell that the use of hot absolute alcohol in the method has many practical disadvantages. He therefore made some experiments in order to find a better solvent, and after a little consideration came to the conclusion that paraffin of low boiling point would probably dissolve the paraffin in which the sections are imbedded more quickly than the guttapercha film to which they are attached. This proved to be the case to a certain extent; the guttapercha was, however, appreciably soluble. He therefore tried a solution of raw caoutchouc in benzine, instead of guttapercha, with perfectly satisfactory results.

A thin solution of caoutchouc in benzine or chloroform is prepared and poured over the slide so as to form a film in the same way that collodion is poured on a photographic plate. When the film is dry the sections are arranged on it, and the temperature of the slide raised to the melting point of the paraffin; the sections then fall on to the indiarubber film which has become sufficiently sticky to adhere to them perfectly. When the slide is cold it is treated with naphtha or any light paraffin oil, the solvent action being the more rapid the lower the boiling point of the oil used. Absolute alcohol is readily miscible with the naphtha or light paraffin, so that the solvent is readily removed. The slide can now be placed in successive alcohols, stained and returned to absolute alcohol. It is now to be cleared with kreasote or oil of cloves and mounted in the ordinary way. Apart from the great advantage of being able to stain on the slide, this indiarubber method seems to possess some points of superiority over the shellac method of Giesbrecht. This depends on the fact that sections can be mounted in balsam direct from the naphtha. The following are some of the advantages over Giesbrecht's method:—

1. The indiarubber is more uniform and therefore safer for small objects.

2. The indiarubber is dry and thus allows a more minute arrangement of the sections on the slide.

* Zool. Anzeig., vi. (1883) pp. 300–7.

† See this Journal, *ante*, p. 307.

3. The naphtha solves the solid paraffin quicker than turpentine does.

4. No traces of indiarubber are visible after mounting, since indiarubber becomes perfectly transparent in balsam.

These methods have been put to a rigorous test by Mr. Caldwell and are now in use in the Morphological Laboratory of Cambridge University.

Sealing up Preparations.*—Dr. C. Nörner, of the Veterinary Institute of Vienna, describes a method adopted there by Prof. Csokor for the above purpose.

Take the ordinary commercial resinous turpentine, break it into small pieces, and dissolve them in a water-bath, then pour the liquid into another vessel and let it cool. A hard, dark-brown, brittle mass is thus formed upon which the pressure of the finger makes no impression. A little of the resinated oil of turpentine may be added to the liquid, but the whole must be heated for several hours in the water-bath in order to obtain the requisite degree of hardness on cooling.

The turpentine thus prepared is placed on the cover-glass by means of a heated knitting-needle (fixed on a piece of wood), the other end being bent at right angles for about 15–18 mm. to correspond with the width of the cover-glass. The bent end being pressed into the turpentine and withdrawn, the turpentine adhering to it is spread out on the margin of the cover-glass, and this repeated until it is completely surrounded with turpentine, which is finally drawn a little over the edge. Care, however, must be taken not to overheat the needle so that the glass cracks. If the cover-glass should not be sufficiently firm, or if any glycerine still remains on the edge, a combination of gold size and turpentine may be used. The gold size has the advantage of agreeing well with the glycerine, so that it is not necessary to remove the latter completely. When the gold size is dry a second layer of turpentine may be put on. The author generally uses this combination to inclose worms, when the cover-glass cannot be completely closed on all sides in consequence of the thickness of the object. The ring of turpentine may be laid over the gold size without detriment.

The method of sealing glycerine preparations by turpentine has, the author says, the great advantage of extraordinary durability. The object so prepared can also be cleaned at any time with a piece of wash-leather without the fear of injuring it by too much pressure. An additional layer of varnish, which is absolutely necessary for gold-size and other preparations, is dispensed with by this method of treating glycerine preparations with turpentine. It has the disadvantage of being more tedious than in the case of gold size, but practice soon brings dexterity.

Opaque Dry Mounts.†—Mr. J. E. Fawcett prepares opaque dry mounts by building up on the turntable a cell with hot wax partly on

* Arch. f. Mikr. Anat., xxi. (1882) pp. 351–4.

† Micr. News., iii. (1883) pp. 153–4.

the disk of black paper forming the background, and partly on the glass slide. There is thus no untidiness of the paper not fitting the bottom of the ordinary vulcanite cell, or if it is placed on the under side of it, being scratched off. Then again, if the background is put at the back of the glass slip, it is invariably bright, instead of dull. When the slide is dry and ready for sealing up, all that is necessary is to place the cover on it and put it once more on the turntable, when one turn, with the application of the wax-brush, is sufficient to make it a permanent mount. It can then be finished with the usual varnishes. The wax must be kept very hot, and the brush should be left in it when not in use.

Mr. Fawcett also commends cells built up with wax for transparent dry mounts, and the use of wax to help to fill up the sides of balsam cell mounts, between the closing cement and the finishing varnish, though for the latter purpose shellac in spirit would be much more convenient. Wax is also a remedy, he considers, for the running in of the cement used for sealing, and for dampness in the case of "dry" preparations, but as to this see the discussion on the subject in vols. iii. (1880) and i. (1881) of this Journal.

Examining Live Aphides.*—Mr. H. J. Slack says that when we want live aphides to examine under the Microscope in a vigorous condition, we must handle them with extreme gentleness, or their soft and delicate bodies will be injured and the creature killed. Their slightness of structure is, however, accompanied with great endurance of conditions that would be quickly fatal to many stouter organisms. Most insects would be rapidly killed by immersion in paraffin oil; but young and vigorous aphides will often live for some time, and occasionally for hours in this fluid, such as is burnt in lamps. If two or three of the insects are very carefully placed in a little cork cell,† filled with paraffin oil, and covered with thin glass, they are in a handy condition for examination. The result of numerous experiments made with the best American petroleum oil, commonly called crystal oil in the lamp-shops, is that the survivals are very uncertain, but sufficiently frequent for the process to be well worth trying. They keep pretty quiet in the fluid, and it enables higher powers to be used with convenience. A 1-2 inch objective, magnifying about 100 linear, with a full-sized instrument, is very handy. The illumination should be varied; but one of the best ways is to use both an achromatic condenser and a lieberkuhn, or little silver reflector, at the end of the objective. The largest hole and central stop of the condenser will give a fine dark-ground illumination. When used in combination with the lieberkuhn, it lights up the inside of the object, while the less transparent parts receive reflected rays from the silver surface. The student will find a great many cases in which this mode of treating a refractive and reflective object produces the best results. The eyes of the *Aphis* seen in this way are like half mulberries, and the little eye

* Knowledge, iii. (1883) p. 246.

† A phial cork 5-8ths inch in diameter cut across so as to make a disk 1-16th inch thick with an oblong hole in the centre and gummed on a slide. The gum is not dissolved by paraffin oil.

projecting from the corner of the larger group is well displayed. Where the view of the compound eyes is a full-face one, the darker pigment is seen so strongly that its true position is concealed. A profile view shows the little lenses to be clear, like glass, and the pigment to be behind them.

Microscopical Examinations of Articles of Commerce.*—A. Tomaschek points out the value of microscopical examination in the determination of the purity of many articles of commerce, and gives the following illustrations:—

Tea-leaves are readily recognized by their peculiar idioblasts.

Barley-meal is very well characterized by the beautiful tabular cells with thick wavy margins belonging to the paleæ which are always found in the meal in consequence of the close adherence of the paleæ to the fruit. The following method is recommended for their detection:—A drop of concentrated hydrochloric acid is thrown on to the meal and rolled in it. A piece of the dough thus obtained is placed on the slide, and another drop of hydrochloric acid run on to it before covering with the cover-glass, and the cover-glass then pushed lightly backwards and forwards. The tabular cells are not only not attacked by the acid, but are coloured by it a bright sulphur-yellow colour. They may be detected even after the baking of the barley-meal.

The microscopical appearance of wheat-meal is distinguished by the peculiar properties of the paste, which can be best demonstrated in the following way:—A thin layer of meal is placed on the slide, carefully covered with a cover-glass, and then moistened by a drop of water placed on its margin. The cover-glass is then lightly pressed, and pushed backwards and forwards, the gelatinous substance being thus separated from the starch-grains, and appearing in the form of dense clouds. If glycerin is used it solidifies into bluntly angular granules, averaging 0·08–0·01 mm. in length. In order to obtain the iodine reaction characteristic of a nitrogenous substance, a comparatively large quantity of the reagent must be used, as the golden-yellow reaction of the proteinaceous substance does not appear until the starch-grains have absorbed what iodine they require. This gelatinous substance is especially well recognized by its reaction with cochineal. If cochineal-powder is scattered over the wheat-meal, and moistened merely by breathing on it, the proteinaceous masses at once take a beautiful carmine-red colour, the starch-grains remaining quite colourless.

Microscopical Separation of Wheat- and Rye-Meal.†—L. Wittmack records the following observations on the microscopical distinctions between wheat-meal and rye-meal. The amount of starch gives no certain character, and the size of the starch-grains is not in itself sufficient; the maximum size of the starch-grains of rye is 42–52 μ;

* Verhandl. Naturf. Ver. Brünn, xix. (1881) p. 15. See Bot. Centralbl., xi. (1882) p. 318.

† SB. Bot. Ver. Prov. Brandenburg, xxiv. (1882). See Bot. Centralbl., xiii. (1883) p. 91.

of wheat 28–35 μ. Better characters are obtained from the grains themselves.

The denseness of the pitting in the transverse cells of wheat gives them a chaplet-like appearance. The shell or pericarp is often difficult to meet with in the finer kinds of meal.

	Wheat.	Rye.
	μ	μ
Skin, average thickness	43–50	31–40
Epidermal cells of the skin or pericarp—length	116–160	136–400
,, ,, ,, breadth	20–28	26–62
,, ,, porous pitting	very close	less close
Sub-epidermal transverse-cells—length	114–192	72–90
,, ,, breadth	14–17	11–14
,, ,, thickness of walls	5·8–8·7	3·3–5·0
,, ,, pitting ..	very dense and conspicuous	less dense, inconspicuous
Starch-cells—average larger diameter	56–72	40–64
,, shorter diameter	32–40	24–40
Iso-diametrical starch-cells—diameter	40–48	32–36

Good characters are also obtained from the hairs. Before grinding, both ends are removed from the grain; the embryo-end on account of the oil which it contains; the opposite apex on account of its hairs; but a few hairs are still to be found in the meal, which give the following characteristics:—

	Wheat.	Rye.
	μ	μ
Length of hairs	120–742	50–420
Diameter of the largest	15–21	9–17
,, at the bulbous base ..	28	23
,, of the smallest	9–10	8
,, at the bulbous base ..	14	11–14
Thickness of wall of the hair ..	7	3–4
Breadth of cell-cavity	1·4–2 (rarely 5)	7

Wheat has therefore thick-walled hairs with narrow cell-cavity; rye thin-walled hairs with wide cell-cavity.

V. Berthold * confirms in the main Wittmack's statement. He finds the gum-cells of wheat to be decidedly larger than those of rye; the former measuring 3, the latter 1·5–2 μ. The thickness of the wall of the hairs of wheat he states at 5–8, of rye 3–6 μ; the diameter of the cavity of the former 1·5–4, of the latter 4–12 μ.

Hunting for Lost Glaciers with a Microscope.†—Considerable work has been done in this direction in Germany and elsewhere by various observers, work with which geologists are more or less

* Zeitschr. f. Landwirthsch. Gew., &c., 1883, pp. 1–3. See Bot. Centralbl., xiv. (1883) p. 247.

† Nova Acta Acad. Leop.-Carol., xlv. p. 35. See Science, i. (1883) p. 177.

familiar, and Dr. E. Geinitz gives the results of an extended study of the plagioclase rocks and phonolites of the Mecklenburg drift.

The method consists in examining thin sections of the rocks found in the drift, and comparing them with the descriptions given by the Scandinavian lithologists of rocks known *in situ* in that peninsula. In this way various basalts, diabases, gabbros, diorites, and phonolites are referred to certain localities in Sweden, whence they are supposed to have been derived. Interesting results can be obtained by such methods; but they are often uncertain, since it cannot be predicated that rocks of the same character do not exist, or have not existed, in the intermediate drift or water-covered areas.

Microscopical Analysis of the Structure of Iron and Steel.*—The first step, writes Mr. J. C. Bayles, to be taken in practical microscopy is the training of the eye to observe what may be seen without the aid of a lens. This is accomplished by the patient examination of characteristic fractures, and noting similarities and differences. After the naked eye has become familiarized with all it can see, the student should continue his investigations assisted by a hand lens with a power of from two to three diameters, and absolutely achromatic. Specimens to be studied with a view to determining their internal structures should be surfaced in a planer, and smoothed by draw-filing in the direction of the fibre. The surface thus obtained is treated with slightly diluted nitric acid, which gives a rapid and wide development of the structure, which may be studied with advantage while it lasts, and will prepare the student for finer work. For fine development more care and time are needed. After planing, the surface of the metal is ground with fine emery or under a metallic mirror-grinder. It is then treated with acid. A thorough development with weak acid requires from twenty-four hours to six days, according to the composition of the metal. Small specimens are prepared by planing down from the back to a thickness of 1-32nd to 1-16 in. The planed face is then ground and surfaced on a fine whetstone, developed with weak acid, and mounted between glasses with Canada balsam. In selecting a Microscope, care should be taken that the lenses give a good definition, that there is no "shake" or lateral motion in the adjustments for focus, and then the table should admit of inclination at any angle found most convenient for observation.

Concerning the results to be expected from the microscopical analysis of metals, Mr. Bayles expresses the belief that it opens a vast field of knowledge not yet reached by either chemical analysis or physical test. There are many conditions, the result of changes produced by mechanical treatment, to which chemical analysis gives no clue and which are detected, but not explained, by the test of the physical laboratory. The Microscope will, no doubt, explain many of the mysterious changes which occur in metals of given chemical composition under different conditions, and will give the metallurgist an opportunity of studying the anatomy and physiology of iron and steel, which, in a most important sense, will supplement

* Science, i. (1883) p. 101.

analysis and mechanical test, which have thus far, to some extent, run in parallel lines. When, between the report of analysis and the fracture of the broken test-piece, we can place a polished longitudinal or cross-section of the material, its internal structure developed by acid and admitting of careful microscopical study, we are furnished with the missing link in the chain of evidence required for a correct conclusion as to the nature of the material under investigation.

Microchemical Reaction Methods.*—A. Tschirch describes the great advantages of the Microscope in technical chemistry, especially in the examination of foods, and expresses regret that many chemists consider their laboratories complete without such an instrument: he enumerates many examples of its usefulness, such as starches, textile materials, &c.; even in the domain of pure chemistry, its application is necessary in the hæmatin reaction for the detection of blood-stains, the composition of urinary deposits, the search for strychnine, atropine, &c.

These advantages led to its more extensive employment in pure chemistry, and the name of microchemistry was given to it by Döbereiner. The author thinks that microchemistry must always be distinguished by a series of colour reactions, that in the same manner as the changes of colour, &c., in experiments on the large scale are examined in the test-tube, so must they be similarly observed on the slide of the Microscope. The actual process is simple; the objects to be examined must be either in thin sections, fine powder, or as fibres; a drop of the reagent is placed on a slide and allowed to flow slowly towards the object, the operator observing through the instrument: many physical as well as chemical changes may be thus detected; expansion or contraction, refractive changes, commencement of coloration, evolution of gas bubbles, solution, &c. The iodine starch reaction of Stromeyer was the first to be employed with the Microscope; from it is learned the topography and division of starch in plants, the way it is stored up, and the process of its conversion; this reaction has also taught the difference between pure cellulose and woody fibre, and the nature of intercellular substance. The reactions with zinc chloride and iodine, and with sulphuric acid and iodine, are also striking instances of the value of microchemistry, affording an easy method of distinguishing vegetable from animal fibres, the first colouring pure cellulose violet, and the second dissolving it with an intensely blue colour, the lignin incrusting the fibres having been previously moved by maceration in nitric acid, alkalis, or Schultze's maceration fluid. Thus sulphuric acid and iodine stain cork dark yellow, thereby affording a trustworthy test for all membranes or sections containing suberin. The solubility of pure cellulose in "cuoxam," discovered by Schweitzer, is also credited to microchemistry: the reagent may be prepared by digesting copper turnings in concentrated ammonia, or by decomposing a concentrated solution of copper sulphate with ammonia until the precipitated hydroxide is redissolved.

* Arch. Pharm., xx. (1882) pp. 801–12. See Journ. Chem. Soc.—Abstr., xliii. (1882) pp. 376–8.

The maceration process of Schultze is a valuable aid to operations in microchemistry; the substance is treated with nitric acid and potassium chlorate either in the cold, or in cases of obstinate samples, is boiled for a short time, when the cells are isolated by the solution of the intermediate lamellæ. Amongst the instances given of its utility in food analysis is the separation of those peculiar cells of radiating branchial form which exist in the tea-leaf, and are not found in other leaves used for its adulteration (they are, however, found in some of the *Camellia* family).

This treatment has also the advantage of dissolving the coloured incrustations of cinnamon, roasted coffee, &c., and leaving the substances ready for further examination. Potash plays an important part in microchemistry, as it renders many objects transparent which are not made so by other reagents; it was by successive treatment with potash solution, acetic acid, and iodine that Böhm was able to perceive in chlorophyll the small particles of starch which had hitherto escaped observation. The most striking success in the science is that of Sachs with Trommer's sugar-test, which, with slight modifications, enables the microscopist to identify, and even estimate quantitatively, cane- and grape-sugar, dextrin, gums, and albuminous substances in single cells.

The author alludes to the tinctorial methods which are employed in the examination of microbes, but which do not come under the strict domain of chemistry; he urges more extensive use of the Microscope, together with the micropolariscope and spectroscope, and the study of botany and physics among chemists.

Dr. T. Schuchardt, of Görlitz (Silesia), has issued a special list of chemical reagents supplied by him for the use of botanical-physiological Institutes, arranged after Poulsen's 'Botanische Microchemie.'

Microscopical Examination of Dyed Silks.*—In an article by M. Marius Moyret, it is pointed out that if the silk fibre is seen lengthwise, it appears uniformly dyed; but in transverse sections it is found that the dye forms a concentric ring, the depth of which ordinarily diminishes gradually from the circumference towards the centre.

The observations made by M. Lembert establish, also, that if we dye silk with a simple colour, such as cochineal, the colour penetrates in time more and more towards the centre of the silk, becoming at the same time deeper and deeper; so that, if we take successive specimens from a lot of yarn during dyeing, they will exhibit under the Microscope rings of colour which become broader and broader, until they reach the centre.

If a silk dyed a light shade of one colour is plunged into a bath of a second colour, and dyed to saturation, the section will show under the Microscope an outer ring, the colour of which is a result of the two dyes employed, and an inner part having the pure tone of the second dye. Or if we plunge a silk dyed to saturation with one

* Chem. Review, xi. (1882) p. 203, from 'Teinturier Pratique.'

colour into a second colour, but without saturating it, with the Microscope we see an outer ring, which is the result of the two colours, and a central part of the primitive shades.

Apparent Motions of Objects.*—Prof. F. C. Van Dyck considers that the familiar fact that objects viewed through the Microscope seem to move when the position of the mirror is slightly changed, has not been discussed in its optical bearings.

"The phenomenon is easily observed by using nearly parallel rays to illuminate the object, and placing the mirror approximately central under the stage. If daylight is used, set the Microscope at a considerable distance from the window, and use the plane mirror. If lamplight is used, set the lamp at the focus of the concave mirror, or use a lens to make the rays parallel and reflect them from the plane mirror.

If the object be so thin as to be sensibly in one plane, it will maintain its location in the field whatever change be made in the position of the mirror, so long as it is accurately focussed. But if the tube of the Microscope be raised or lowered, so as to throw the object slightly out of focus, a shifting of the mirror on its bearings will cause an apparent motion of the object to one side or the other.

If an object of considerable thickness be used and the focus obtained for a central plane, rocking the mirror will cause the lower parts of the object to move to one side, while the upper parts move to the other side. I have an insect's foot with claws, which, treated in this way, seems to work the claws like scissors. Minute details of an object may be made to disappear under spots on the cover-glass, and various similar effects can be produced.

Let us suppose that the illumination is received from the left of the observer, and that a micrometer is inserted in the eye-piece to facilitate observation. Take three points A, B, and C, in the optical axis, A beyond the focus of the objective, B at the focus, and C a little above the focal plane. Suppose a pencil sent from the mirror along the axis, passing A, B, and C, and the centre of the objective. The images of A, B, and C, will fall with their centres on the axis. If the edge of the mirror toward the observer's right be tilted up, the point A, beyond the focus, will appear to be displaced toward the right of the field of view, the point B will remain stationary, and C which is above the plane focussed upon, will move toward the left. Now it can be shown that if the spherical aberration of an objective could be corrected for a series of points and their images, all the images must remain stationary.

The necessity for correction consists essentially in the fact that the margins of lenses with spherical surfaces are too strong relatively to their centres. Hence, with an uncorrected lens, the image of the point B, made by the central portion of the lens, would fall on the axis; but an image of the same point, produced by rays entering the left-hand margin, would fall to the left of the axis, as well as nearer to the lens. The essence of correction is to relatively weaken the

* Amer. Mon. Micr. Journ., iii. (1882) pp. 72-3.

action of the margin, so that the image shall fall on the axis and at the same distance from the lens as the image formed by its central portion. Suppose this correction to be made for the point B. Let the mirror be tilted as described, so that a pencil of rays passes through A to the left margin of the objective. This pencil makes a smaller angle with the front surface than a pencil coming from B and entering at the same place. Hence, the pencil from A will reach the back surface of the lens at a point nearer the axis than would be reached by the pencil from B. If then the pencil from B comes to a focus on the axis, the pencil from A would cross the axis before coming to a focus. This explains the displacement of the image *a* to the right under the conditions given above. The image *b* of the point B will not be affected, because the objective is corrected for a cone of rays from B, and any pencil passing through B must coincide with some element of the cone. It is not necessary to discuss the image *c*, for it will be seen that it must be formed on the side of the axis opposite to *a*."

Phenomena of Motion.*—C. Nägeli and S. Schwendener deal with this subject as follows:—

"The observation of the phenomena of motion under the Microscope has led to many false views as to the nature of these movements. If, for instance, swarm-spores are seen to traverse the field of view in one second, it might be thought that they race through the water at the speed of an arrow, whereas they in reality traverse in that time only a third part of a millimetre, which is somewhat more than a metre in an hour. It must not, therefore, be forgotten that the rapidity of motion of microscopical objects is only an apparent one, and that its accurate estimation is only possible by taking as our standard the actual ratio between time and space. If we wish, for the sake of exact comparison, to estimate the magnitude of the moving bodies, we may always do so; the ascertainment of the real rapidity remains, however, with each successive motion, the principal matter.

If a screw-shaped spiral object, of slight thickness, revolves on its axis in the focal plane, at the same time moving forward, it presents the deceptive appearance of a serpentine motion. Thus it is that the horizontal projections of an object of this kind, corresponding to the successive moments of time, appear exactly as if the movement were a true serpentine one. As an example of an appearance of this nature we may mention the alleged serpentine motion of *Spirillum* and *Vibrio*.

Similar illusions are also produced by swarm-spores and spermatozoa; they appear to describe serpentine lines, while in reality they move in a spiral. It was formerly thought that a number of different appearances of motion must be distinguished, whereas modern observers have recognized most of them as consisting of a forward movement combined with rotation, where the revolution takes place sometimes round a central, and sometimes round an eccentric, axis.†

* 'Das Mikroskop,' English translation (in the press) pp. 258–60 (1 fig.).

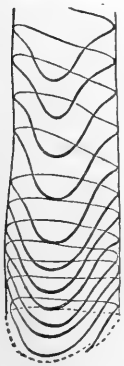
† Cf. on this point Nägeli, 'Beiträge,' ii. p. 88.

To this category belong, for instance, the supposed oscillations of the *Oscillarieæ*, whose changes of level, when thus in motion, were formerly unnoticed.

In addition to these characteristics of a spiral motion it must, of course, be ascertained whether it is right- or left-handed. To distinguish this in spherical or cylindrical bodies which revolve round a central axis is by no means easy, and in many cases, if the object is very small and the contents homogeneous, it is quite impossible. The slight variations from cylindrical or spherical form, as they occur in each cell, are therefore just sufficient to admit of our perceiving whether any rotation does take place. The discovery of the *direction* of the rotation is only possible when fixed points, whose position to the axis of the spiral is known, can be followed in their motion round the axis. The same holds good also, *mutatis mutandis*, of spirally wound threads, spiral vessels, &c.; we must be able to distinguish clearly which are the sides of the windings turned towards or turned away from us.

If the course of the windings is very irregular, as in fig. 119, a little practice and care is needed to distinguish a spiral line, as such, in small objects. The microscopical image might easily lead us to the conclusion that we were examining a cylindrical body composed of bells or funnels inserted one in another. The spirally thickened threads, for instance, as they originate from the epidermis cells of many seeds, were thus interpreted, although here and there by the side of the irregular spirals, quite regular ones are also observed.

FIG. 119.



Moreover, it must not be forgotten that in the microscopical image a spiral line always appears wound in the same manner as when seen with the naked eye, while in a mirror (the inversion being only a half one) a right-handed screw is obviously represented as left-handed, and conversely. If, therefore, the microscopical image is observed in a mirror, as in drawing with the Sömmerring mirror, or if the image-forming pencils are anywhere turned aside by a single reflection, a similar inversion takes place from right-handed to left-handed, and this inversion is again cancelled by a second reflection, as in Oberhäuser's camera lucida, and in many multocular Microscopes. All this is, of course, well known, and to the practised observer self-evident; nevertheless, many microscopists have shown that they are still entirely in the dark about matters of this kind."

Brownian or Pedetic Motion.*—The skipping motion of extremely small particles has been for long a subject of curiosity, but in the view of Prof. Ramsay has as yet remained without explanation. The following is an attempt on his part to ascertain its cause.

1. It is not dependent on the life of the particle. This would

* Proc. Bristol Naturalists' Soc., iii. (1882) pp. 299-302.

seem an absurd notion, but it was a theory first advanced to account for the phenomenon. And as it was first observed by Robert Brown, when examining the pollen of plants, he had some ground for his supposition. Buffon attributed it to this cause, and Spallanzani termed the dancing particles "animaletti d'ultimo ordine." It occurs, however, with particles strictly mineral in their constitution, such as quartz, cinnabar, finely divided gold, &c.

2. Nor does it depend on the material of which the particles are composed, for all substances, if in a sufficiently fine state of division, manifest this motion. (*a*) They may be conductors, e. g. gold, silver, platinum. (*b*) They may be non-conductors, e. g. sulphur, gamboge, quartz. (*c*) They may be absolutely insoluble in water. (*d*) They may be slowly attacked by water, e. g. quartz, silicates, barium sulphate. (*e*) They may be good conductors of heat, e. g. the metals above mentioned. (*f*) Or bad conductors, e. g. sulphur, gamboge. (*g*) They may be transparent, or (*h*) opaque.

3. The motion does not depend on the form of the particles. The question of pedesis is very closely connected with that of the settling of finely divided powders in different menstrua. In a paper communicated to the Geological Society of London in 1876, on the settling of mud, the author showed: (1) that finely divided matter does not quickly settle in pure water. (2) That it settles more quickly in hot than in cold water. (2) That the rate of settling does not depend on the density of the solution, for mud settles more quickly in strong than in weak solutions. (4) It does not depend on the chemical action of the liquid on the solid, for sulphur follows the same rule as other substances. (5) It follows the same order as the absorption of heat, when the salt is dissolved, in the solution of which the suspended particles settle. (6) It depends on the agglomeration of the particles: when the particles acquire sufficient size to have no motion, or a very slow one, they settle quickly. This phenomenon is evidently closely allied to pedetic motion, and is to be explained by it.

Pedetic motion depends on, that is, is affected by:—

1. *The size of the particles.* Particles more than 1-5000th of an inch in diameter do not jerk about suddenly, but are sometimes seen to oscillate slightly.

2. *The specific gravity of the particles.* Metals, or particles of vermilion, of similar size to particles of silica or gamboge, move much more slowly and less frequently.

3. *The nature of the liquid.* No liquid stops pedesis; but liquids which have a chemical action on the substance do. This action may be very slow, still it tends to agglomerate the particles. For instance, barium sulphate, when precipitated from the cold solution, takes a long time to settle; whereas, when warm and in presence of hydrochloric acid, agglomeration soon occurs. Iron precipitated as hydrate in presence of salts of ammonium, and mud in salt water, are other instances. The motion does not cease, but the particles adhere together and move very slowly.

The moving particles may be either liquid or solid; but the

motion of one liquid in another has a character of its own. Thus if a little olive oil be shaken to an emulsion with a large quantity of water, the minute drops move, but slowly and not with a jerky motion. Similarly a few drops of water mixed with a large volume of oil, display the same character of motion.

This motion cannot be attributed to currents in the liquid, for its nature is such as to preclude this explanation. It is in no sense regular, or in one direction.

The author thought it worth while to compare the relative size of such particles with those estimated for molecules, and likewise the amplitude of their motion with that of molecular vibration.

The diameter of a molecule, according to Sir W. Thomson, lies between the millionth and ten-millionth of a millimetre. The diameter of an active particle is about or below the two-thousandth of a millimetre. With this size the pedetic motion is slow and infrequent. If we take the larger diameter for the molecule, then the diameter of the molecule is greater than that of the particle as 1 is to 500, and the mass, supposing them to be of equal specific gravity, as 1 to 125 millions.

If molecules do not coalesce and move as a whole, then they would appear to have no possible power of giving motion to a mass so much larger than themselves, but that molecules have arrangement is probable, owing to the power which some liquids possess of rotating the plane of polarized light.

Clerk-Maxwell supposed for some time that the attraction of two molecules varies inversely as the fifth power of the distance. If attraction at distance 2 is 1, attraction at distance 1 would be 64. Why do not all molecules therefore coalesce? probably, because their own proper motion, of which heat represents the high harmonies, causes them to fly apart again. The wave-length of that motion is not so minute, and although we have no means of ascertaining the amplitude of such vibrations, still their rate is so prodigious as to give rise to an almost incredibly forcible impact.

Ady, J. E.—Exhibition of some Microscopical Preparations of Bone.
Proc. Zool. Soc. Lond., 1883, p. 74.

Bell, F. J.—Exhibition of and remarks upon some Microscopical Preparations obtained from the Zoological Station at Naples.
Proc. Zool. Soc. Lond., 1883, p. 47.

Calderon y Arana.—Nota sobre la extraccion y coleccion de las conchas microscópicas de moluscos y foraminiferos. (Note on the extraction and collection of the microscopic shells of mollusca and foraminifera.) In part.
An. Soc. Esp. Hist. Nat., XII. (1883), Actas, pp. 33–6.

Carter, H. J.—On the Microscopic Structure of thin slices of Fossil Calcispongiæ.
[Contains directions for grinding down a slice of a calcareous fossil. *Post.*]
Ann. & Mag. Nat. Hist., XII. (1883) pp. 26–30.

Cathcart, C. W.—New form of Ether Microtome. [*Supra*, p. 597.]
Journ. Anat. & Physiol., XVII. (1883) pp. 401–3.

Chabry, L.—Note sur quelques propriétés du Bleu de Prusse. (Note on some properties of prussian blue.)
Journ. de l'Anat. et de la Physiol., XVIII. (1882) pp. 503–9.

COLE, A. C.—Studies in Microscopical Science.
Vol. II. No. 1. Section I. Animal Histology. Chap. I. The Morphology of the Cell. pp. 1–2.
No. 2. Section II. Botanical Histology. Chap. I. The Morphology of the Cell. pp. 1–4.

COWEN, A.—The Application of the Microscope to Geological Research.
[Principally historical (Nicol to Lévy and Fouquet), with a description of a few of the most important minerals which enter into the composition of the eruptive rocks.]
Journ. Post. Micr. Soc., II. (1883) pp. 65–72.

DIPPEL, L.—Das neue Mikrotom von Dr. C. Zeiss. (The new Microtome of Dr. C. Zeiss.)
[Described Vol. I. (1881) p. 699.]
Bot. Centralbl., XIII. (1883) pp. 388–9 (1 fig.).

Evenings with the Microscope. I.
["Articles especially intended for the beginner in the use of the Microscope." Describes two methods of preparing and mounting the eye of common house-fly.]
Amer. Mon. Micr. Journ., IV. (1883) pp. 116–7.

FIRKET, C.—Recherche et diagnostic des microbes parasitaires. (Investigation and diagnosis of parasitic microbia.)
[Forms pp. 277–333 of G. Bizzozero's 'Manuel de Microscopie Clinique,' *supra*. Contains:—I. Examination of microbia in liquids. A. Collection of the liquids. B. Examination of the liquids without reagents, and with reagents. II. Examination of microbia in the interior of the tissues; Cutting sections and hardening; Reagents. III. Special processes for certain pathogenous microbia. IV. Illumination of preparations for the examination of microbia. (Abbe condenser—"truly indispensable for most microbiological researches.")]

FOL, H.—Beiträge zur histologischen Technik. (Contributions to histological technics.) [*Post.*]
Zeitschr. f. Wiss. Zool., XXXVIII. (1883) pp. 491–5.

GIBBES, H.—Practical Histology and Pathology. 2nd ed., viii. and 154 pp. 8vo, London, 1883.
„ „ A rapid method of demonstrating the tubercle bacillus without the use of nitric acid. [*Post.*]
Lancet, I. (1883) p. 771.

GROVE, W. B.—New methods of mounting for the Microscope.
[1. Exhibition of two slides of objects mounted in spirits of wine 64 over proof in 1881 and still perfectly intact. Cement used in closing the cell not described. 2. Description of Prof. Hillhouse's method, *supra*, p. 599.]
Midl. Natural., VI. (1883) p. 166.

GROVES, J. W.—The History of a Stained Section of an Animal Structure.
[Report of demonstration.] *Journ. Quek. Micr. Club*, IV. (1883) pp. 205–8.

HAZELWOOD, J. F.—Histological Work. [*Post.*]
Amer. Mon. Micr. Journ., IV. (1883) pp. 109–10.

HITCHCOCK, R.—The Podura Scale. [*Supra*, p. 501.]
Amer. Mon. Micr. Journ., IV. (1883) pp. 101–2 (1 fig.).

KAROP, G. C.—On a specimen of *Bacillus tuberculosis* prepared by Dr. Gibbes' method. *Journ. Quek. Micr. Club*, I. (1883) pp. 157–60.

LOVETT, E.—A day's microscopic shore-hunting among the low-tide pools of Jersey. *Journ. Post. Micr. Soc.*, II. (1882) pp. 75–9.

MEYER, R.—Microscopical Investigation of Dyed Cotton Fabrics. [*Post.*]
Journ. Chem. Soc.—Abstr., XLIV. (1883) p. 751, from *Ber.*, XVI. pp. 455–7.

Mounting the Eye of common House-fly. See 'Evenings with the Microscope,' I.

Notes on Collecting and Preserving Natural History Objects. New ed., 216 pp., 12mo, London, 1883.

PIFFARD's (B.) Series of mounted objects illustrating Botanical Structures.—"Micro-slides for Science Classes."

[3, 4, 5 or 9 objects on each slide—"a true botanical *multum in parvo*, and their neatness and high finish render them almost artistic objects."]

Sci.-Gossip, 1883, p. 158.

REEVES, H. A.—How to fix Aniline Dyes. [*Post.*]

The Microscope, III. (1883) pp. 53–4, from *British Medical Journal*.

SINEL & Co.'s Embryological Specimens for the Microscope.

[Description and recommendation.] *Sci.-Gossip*, 1883, pp. 137–8.

SLACK, H. J.—Pleasant Hours with the Microscope.

[*Bacillus tuberculosis*, &c.; Rotifers; Infusoria.]

Knowledge, III. (1883) pp. 322–3 (9 figs.), 358–9 (3 figs.), 383–4; IV. pp. 17–18 (6 figs.).

THOMPSON, J. C.—On the Classification, Arrangement, and Labelling of Microscopic Objects.

[Report only of paper read before Liverpool Microscopical Society. Suggests labels printed in red, green, and black, according to whether the specimen belongs to the Animal, Vegetable, or Mineral kingdom.]

Micr. News, III. (1883) p. 206.

THRELFALL, R.—A new method of Mounting Sections. [*Supra*, p. 600.]

Zool. Anzeig., VI. (1883) pp. 300–1.

VAN ERMENGEM, E.—Sur les méthodes de culture des micro-organismes pathogènes. (On the methods of culture of pathogenous micro-organisms.)

[Résumé of paper to appear in the 'Annals.']

Bull. Soc. Belg. Micr., IX. (1883) pp. 105–19.

WARD, E.—Mounting objects "opaque" in balsam. [*Post.*]

Micr. News, III. (1883) pp. 197–8.

WHITMAN, C. O.—The Hertwigs' Macerating Fluid. [*Post.*]

Amer. Natural., XVII. (1883) pp. 806–7.

WHITTELL, H. T.—On mounting in glycerine, and on making cells of thin glass. [*Post.*] *Journ. Quek. Micr. Club*, I. (1883) pp. 191–3. See also pp. 210–1.

WILDER, H. M.—Microscopical Examination of Drugs.

The Microscope, III. (1883) pp. 81–4, from *American Journal of Pharmacy*.

PROCEEDINGS OF THE SOCIETY.

Meeting of 13th June, 1883, at King's College, Strand, W.C., The President (Prof. P. Martin Duncan, F.R.S.), in the Chair.

The Minutes of the meeting of 9th May last were read and confirmed, and were signed by the President.

The List of Donations (exclusive of exchanges and reprints) received since the last meeting was submitted, and the thanks of the Society given to the donors.

	From
Van Heurck, H.—Synopsis des Diatomées de Belgique. Fasc. 6. Crypto-Rhaphidées, 2e partie. 40 pp. and 34 pls. (8vo, Anvers, 1883)	*The Author.*
Wright, L.—Light: a Course of Experimental Optics chiefly with the Lantern. xxiv. and 367 pp., 190 figs. and 8 pls. (8vo, London, 1882)	*The Publishers.*
Claus, C.—Beiträge zur Kenntniss der Entomostraken. I. 28 pp. and 4 pls. (4to, Marburg, 1860)	*Mr. Crisp.*
Behrens, H.—Mikroskopische Untersuchungen über die Opale. 48 pp., 2 figs. and 2 pls. (8vo, Vienna, 1871.)	
Penhallow, D. P.—Tables for the Use of Students and Beginners in Vegetable Histology. 39 pp. (8vo, Boston, 1882.)	
(Also Bentley's 'Botany,' Carpenter's 'Zoology,' Foster and Balfour's 'Elements of Embryology,' Jones' 'Natural History,' Beale's 'Protoplasm,' De Quatrefages' 'Metamorphoses of Man and the Lower Animals,' and Watson's 'Reasoning Power in Animals.')	
Three slides of *Bacillus tuberculosis* in human lung, *Bacillus anthracis* in cow's lung, and *Eozoon canadense* from Sutherlandshire	*Mr. Coppock.*

The President, in reference to the specimen of *Eozoon canadense*, suggested to be the first which had been found in the British Islands, said that a great deal would depend upon the proper identification of the rocks and the specimens found in them, and he might say that without having seen and examined the specimen referred to, he had some little doubt on the matter. The true *Eozoon canadense* had hitherto only been found in the Laurentian rocks of Canada, which were believed to be the oldest in the world, and though there was no difficulty in identifying good specimens, there was very great difficulty in the identification of bad ones, and it would be found that most of the troubles which had arisen in connection with this subject had been from bad specimens. One of the burning questions of the present day amongst geologists was the age of the rocks in the North-West of Scotland. The Geological Survey had considered them to be of late Palæozoic age, but there were other observers who thought them as old in origin as the Laurentian of Canada. Years ago Sir

Roderick Murchison detected in the Western Islands what he called "fundamental gneiss," but its age was never determined, and the existence of this *Eozoon*, if it could be satisfactorily made out, would no doubt go far towards settling the question of age. What he had seen, however, of specimens which had at times been produced, did not carry conviction to his mind. He thought it was not sufficiently remembered that these rocks were not in their natural condition, but that they had been metamorphosed, and it was quite possible that during this process, by the action of water or steam, blow-holes might be produced which would cause appearances which strongly simulated organic forms. There were many instances in which biologists had confused the two things, and without throwing any doubt upon the genuineness of the specimen now produced, he thought the case was one for careful consideration.

Mr. Crisp exhibited a new Portable Microscope by Mr. J. W. Bailey, and Messrs. Swift's newer form of Wale's Working Microscope (III. (1880) p. 1045, and I. (1881) p. 296).

Mr. Hitchcock called attention to a collection of freshwater sponges by Mr. E. Potts, which he had brought to the meeting. Each slide was prepared in three different ways—opaque, transparent section, and spicules. He said that the collection contained some very interesting examples of different species of *Spongillæ*. If any Fellows of the Society would like to examine these or other specimens now being exhibited in the American Department of the Fisheries Exhibition they would be able to do so on making the request.

A Letter was read from Mr. A. M'Calla, President of the American Society of Microscopists, in acknowledgment of the election of the Society under the Bye-law relating to Ex-Officio Fellows.

The President read a note on some Calcareous Stellates from off deep-sea organisms, illustrating his remarks by a drawing on the blackboard.

"Some months since I found some small highly refractive white patches upon *Lophotelia prolifera*, a coral from deep water in the North Atlantic; and lately, whilst investigating some corals from the Caribbean, I again noticed these filmy structures. At first sight the films, which may be a centimetre in length, and of the same breadth, resemble a Geodic sponge; but on removing the mass carefully with a sharp scalpel from the surface of the coral, and mounting in Canada balsam, a totally different appearance is presented to that of any siliceous sponge.

An exceedingly delicate homogeneous membrane forms the base of the film, and adheres to the supporting body. On it may be one layer of crowded stelliform bodies very unequal in size, the diameters

being from 1-2000th to 1-1000th in. Each consists of about 24 rays united centrally by simple contact, and not by any visible medium, and free peripherally and at their sides. Each ray is longer than broad, pointed externally rather bluntly, and less so towards the centre of the star. The shape is that of a blunt scalenohedron, and as the free terminations project as the ends of radii on all sides, the mineral not being very transparent and its faces being highly refractive, the stars are by no means easy to define.

Under a power of 200, with a black spot lens beneath, the appearance presented is very beautiful; and a still higher power, with the careful employment of the achromatic condenser and diaphragm, shows the outlines of the crystals very distinctly. Here and there a star may be seen to be incomplete, and two or three rays only may be in apposition by their thicker end. The shape of the ray is then observed to resemble a long obliquely placed rhombohedric crystal of calcite. Polarized light developes an object of great beauty, each ray showing a play of colours as the Nicol is revolved, but not developing a definite cross.

In some specimens, layer on layer of the stellates exists, and foreign objects such as half-dissolved siliceous sponge-spicules may be intermixed.

No trace of organization can be seen in the thin basal film.

That these stellates are of calcic carbonate there is little doubt; and from what can be made out, I do not feel disposed to connect them with any organism with which I am acquainted. I therefore seek for information at the hands of any of the Fellows."

Mr. Stewart thought from the description given by the President, as well as from looking at the specimens exhibited under the Microscope in the room, that the objects referred to were not spicules but rather modified groups of crystals such as were found in the bodies of some of the Ascidians. On examining a portion of a large mass of crystals by polarized light it would be found that each one of the processes had its own special optic axis which corresponded with the optic axis of the crystallized body, whereas in the case of the ordinary spicule this was not so, but rather as if the spicule was carved out of a piece of calcite. He thought those which the President had described were probably derived from a species of *Botrillus* which formed an extremely thin film over various bodies, and when dried up had the appearance of a portion of a visiting card of extreme whiteness, the whiteness being due almost entirely to the groups of these crystals.

Prof. F. Jeffrey Bell read his paper "On the Spicules of *Cucumaria hyndmanni*, *C. calcigera*, and two allied forms" (p. 481).

The President said that if any one wanted to work at this subject, materials were very easy to obtain, and he should be very glad to supply some sea-cucumbers to begin with, which had been sent to him some time ago, but which he had almost thought of returning for want of time to devote to them.

Mr. Conrad Beck read a paper "On some new Cladocera of the English Lakes."

The President expressed the great interest with which he had listened to the paper, and his appreciation of the perseverance with which Mr. Beck had devoted himself to the subject.

Mr. Crisp said it might have been supposed that the subject of the paper had long been worked out by English naturalists, but as a matter of fact it did not appear that hitherto it had occurred to any one to undertake such an examination of the English Lakes as Mr. Beck had initiated.

Mr. Stewart and Prof. Bell also referred in complimentary terms to the paper; and further remarks were made by Mr. Hardy and Mr. J. Beck.

Dr. F. C. Kiaer's paper "On Microphotography by Lamplight" was read, the subject being illustrated by a number of microphotographs, all taken by lamplight, with Nachet objectives Nos. 0, 1, and 5. These demonstrate, in the author's opinion, that with these objectives just as good results are to be obtained by lamplight as by sunlight. The lamplight, besides being inexpensive and readily accessible at any time (the time for exposure being easily fixed and with absolute certainty), allows microphotographs to be taken of objects with dark colours. It requires no correction for the chemical focus, nor produces in an objectionable degree phenomena of interference or heat.

The President said that the photographs appeared to be very excellently done, and it was of great interest to know that so much could be done with such simple methods.

The paper was also discussed by Mr. Mayall, Dr. Maddox, and Mr. Stewart.

Dr. Flögel's paper "On Cutting Sections of Diatoms" was explained by Mr. Crisp, and the drawings accompanying the paper exhibited.

Mr. Beck asked if Dr. Flögel claimed that he had determined the internal structure of the diatoms by means of his sections?

Mr. Crisp said that Dr. Flögel claimed that many years ago, in a paper which he published in 1873. His present paper was written in reply to a communication to him from Mr. Mayall, and was intended to supplement the previous one by new proofs, and to refute some of the objections which had been made to the previous one.

Mr. Curties inquired if there were any specimens of diatoms in sections, or were there only drawings?

Mr. J. Mayall, jun., said that mounted specimens, in further illustration of the paper, had been forwarded, but had not yet arrived. They would be exhibited at the October meeting.

Mr. Beck said that the subject was one of surpassing interest to microscopists, and he thought it would be very desirable that the earlier paper of the author should be translated and published.

Mr. J. Mayall, jun., described Dr. Schröder's new polarizing apparatus.

The President inquired if the apparatus had been worked out theoretically only, or whether it had been attempted in practice?

Mr. Mayall said the analyser had really been cut and prepared according to the formula described, although it had not yet been applied to the Microscope. There could be no doubt as to its practicability, as the images were certainly most fully separated.

Prof. W. A. Rogers' note to Mr. Crisp, accompanying one of his standard micrometers, was read as follows:—

"Will you please present to the Society on my behalf the combined English and Metric Standard Micrometer which I have forwarded to your address. It consists of 1001 lines in 1 centimetre, 1001 lines with the interlinear space 1-2500th in., and of a repetition of these bands with finer lines for high powers.

The process of graduation was conducted in the following way:— The error of the screw for one decimetre at 62° Fahr. was first determined by a comparison with the first decimetre of a standard metre upon a bar of glass presented to me by Mr. Chaney, the Warden of the Imperial Standards.

The amount of this correction was then introduced into the setting of the magnet-arm which governs the required part of a revolution of the screw. If therefore no error was introduced through the screw itself, the resulting centimetre should be really Standard at 62° Fahr.

The band of lines 1001 to the centimetre was first ruled, the time required being a little over an hour. The ruling carriage was then set back to the starting-point and moved forward upon the ways such a distance that the beginning of the first line of the next band should fall upon a point near the end of the first line of the preceding series. This operation was repeated with each band ruled.

It will be seen that the first lines of the bands form one and the same line, that is, this line is made up of four lines ruled independently, and at different times. By measuring the distance between the end lines of the first two adjacent bands it will be easy to determine the relation between the yard and the metre which was employed in the graduation.

I have recently subjected the centimetre of this plate to a test which will add much to the value of the unit employed. The U.S. Bureau of Weights and Measures has prepared a standard centimetre upon a platinum-iridium surface. The lines upon this surface are of the most beautiful character, and admit great precision in measurement. This plate has recently come into my possession for examination, as a member of the committee for whom it was made. I have compared it both with my bronze and glass standard centimetres. The results are not yet fully reduced, but it is safe to say that this centimetre is a very small fraction of a mikron too long at 62° Fahr.

A comparison of the centimetre of the plate marked No. 1 with the centimetre of the plate marked A, gives the following results:—

		At 62° Fahr.	
1883.	May 23.	No. 1.	$\cdot 04\,\mu = \text{A}$.
	May 24.	No. 1.	$\cdot 29\,\mu = \text{A}$.
	May 25.	No. 1.	$\cdot 09\,\mu = \text{A}$.

When the definitive value of A is determined the relations given above will be sufficient for the exact determination of the error of the centimetre of plate No. 1. The amount of this correction will, however, be found to be so small that it will be of no practical importance.

It is proper to add that the glass plate was ruled nearly two years in advance of the preparation of the platinum-iridium plate."

Mr. H. G. Madan's note on a modification of Darker's Selenite-holder was read.

Dr. Hudson's letter was read, identifying the orange-coloured rotifers found by the Rev. E. J. Holloway (*ante*, p. 474) as *Philodina roseola*.

The following Instruments, Objects, &c., were exhibited:—

Mr. Coppock:—*Eozoon canadense* from Sutherlandshire.

Mr. Crisp:—(1) Bailey's Portable Microscope. (2) Swift's new form of Wale's Working Microscope.

Mr. Hitchcock:—American Fresh-water Sponges.

Dr. F. C. Kiaer:—Photomicrographs taken by lamplight.

Mr. J. Mayall, jun.:—Dr. Schröder's Polarizing Apparatus.

New Fellows;—The following were elected *Ordinary* Fellows:—Messrs. H. F. Atwood, H. P. Aylward, Frank R. Cheshire, Rev. W. E. Codling, Ezra H. Griffith, George Hunt, F.R.A.S., Wm. J. Lewis, M.D., John M. Offord, Robert Peach, and B. W. Thomas.

WALTER W. REEVES,
Assist.-Secretary.

The Journal is issued on the second Wednesday of February, April, June, August, October, and December.

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JOURNAL

OF THE

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.

Edited by

FRANK CRISP, LL.B., B.A.,

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and a Vice-President and Treasurer of the Linnean Society of London;

WITH THE ASSISTANCE OF THE PUBLICATION COMMITTEE AND

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F. JEFFREY BELL, M.A., *Professor of Comparative Anatomy in King's College,*

S. O. RIDLEY, M.A., *of the British Museum,* AND **JOHN MAYALL, JUN.,**

FELLOWS OF THE SOCIETY.

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(OCTOBER, 1883.)

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Wednesday, JANUARY	10	Wednesday, MAY	9
„ FEBRUARY	14	„ JUNE	13
(*Annual Meeting for Election of Officers and Council.*)		„ OCTOBER	10
„ MARCH	14	„ NOVEMBER	14
„ APRIL	11	„ DECEMBER	12

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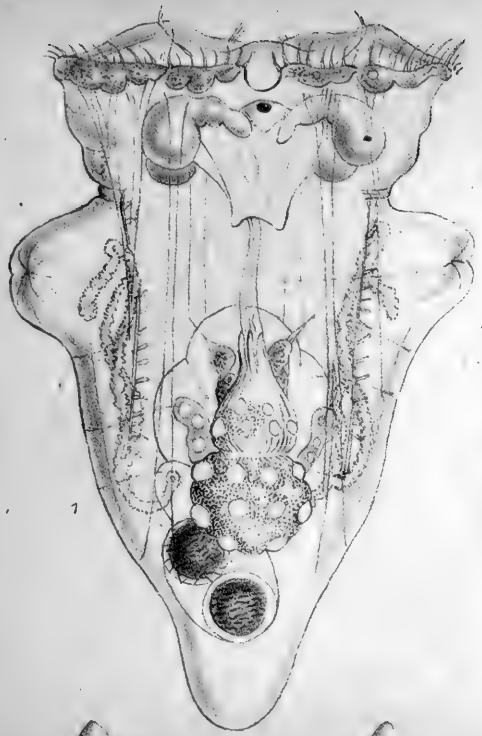

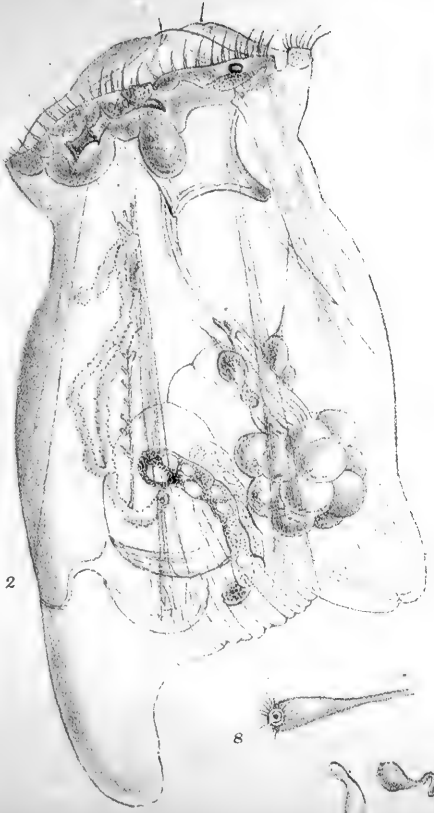

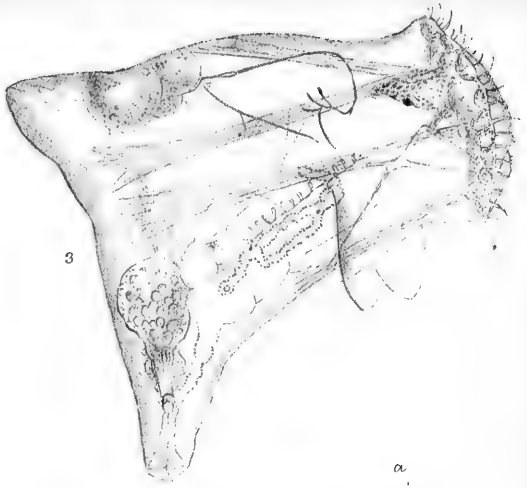

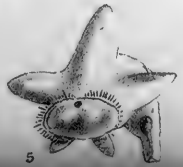

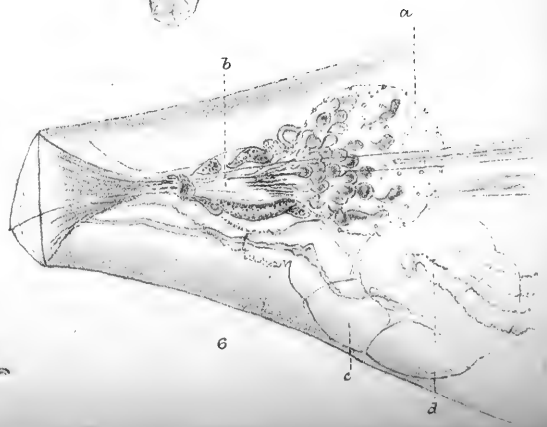

Asplanchna Ebbesbornii

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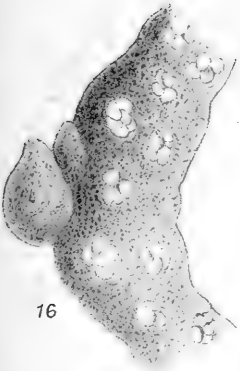

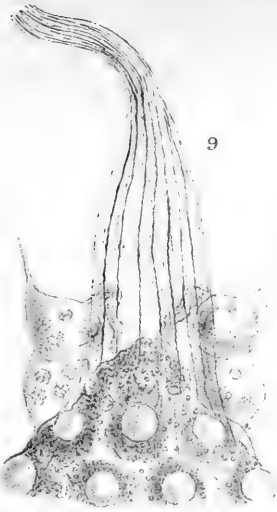

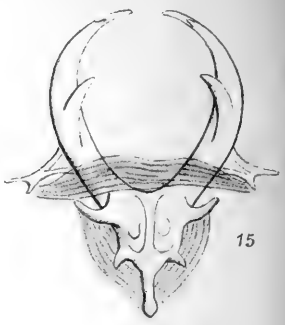

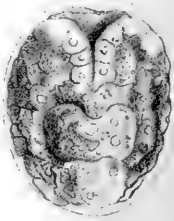

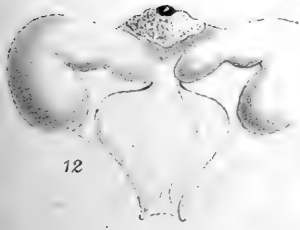

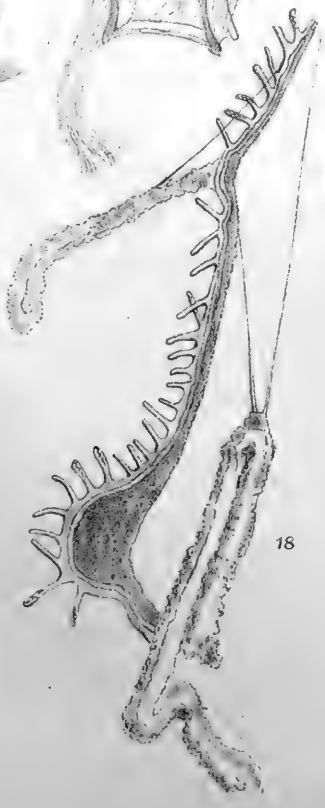

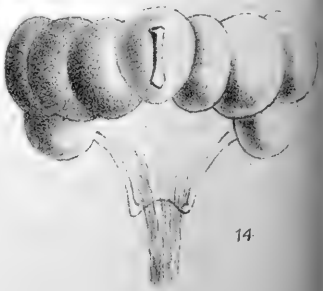

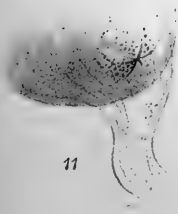

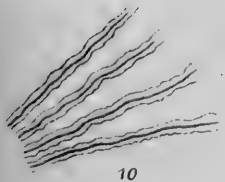

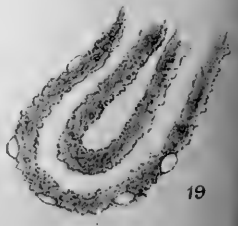

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Asplanchna Ebbesbornii.

JOURNAL

OF THE

ROYAL MICROSCOPICAL SOCIETY.

OCTOBER 1883.

TRANSACTIONS OF THE SOCIETY.

XII.—*On Asplanchna Ebbesbornii* nov. sp.

By C. T. Hudson, LL.D., F.R.M.S.

(*Received* 14*th September*, 1883.)

Plates IX and X.

This fine new species was discovered about three years ago by Mrs. Tupper Carey in a duck-pond in the vicarage grounds at Ebbesborne Wake. I first became acquainted with it this August, when Mr. Thomas Bolton supplied me with several specimens of both sexes.

The female differs from the other species of the genus *Asplanchna* in having one dorsal and two lateral humps, as well as

EXPLANATION OF PLATES IX. and X.

Plate IX.

Fig. 1.—Female of *Asplanchna Ebbesbornii*, dorsal view.
„ 2.— „ „ lateral view.
„ 3.—Male of *A. Ebbesbornii*, lateral view.
„ 4, 5.—Males of *A. Ebbesbornii*, different views.
„ 6.—(*a*) Penis, (*b*) sperm-bag, (*c*) contractile vesicle, (*d*) end of tortuous thread.
„ 7.—Spermatozoa.
„ 8.—One of the lateral antennæ.

Plate X.

Fig. 9.—Œsophagus, gastric glands, and head of stomach.
„ 10.—Muscular threads of œsophagus.
„ 11.—Orifice and duct of gastric gland.
„ 12.—Pharynx, dorsal view; showing eye and nervous ganglion.
„ 13.— „ lateral view; showing top of œsophagus.
„ 14.— „ ventral view.
„ 15.—Jaws.
„ 16.—Central portion of ovary, with maturing germs.
„ 17.—Ovum.
„ 18.—Tortuous threads and vibratile tags.
„ 19.—A loop of fig. 18, more highly magnified.

in ending posteriorly in a blunt rounded cone curving up towards the dorsal surface.

These humps are mere prolongations of the thin cuticle, and both the dorsal and lateral ones are only fully extended when the creature withdraws its head into the folds of the body. Each time that it does this the three humps are seen to fly out to a great length, making the animal from one point of view look like an equilateral triangle, and from another like a pyramid. The humps are quite empty, save that delicate muscular threads pass from their apices to various parts of the body. The dorsal hump of the male has as many as four of these, while one fine fibre actually passes right through the centre of the body from the apex of one lateral hump to that of the other. When either the male or female is swimming quietly, the lateral humps lie empty, wrinkled, and inconspicuous on the surface of the body; and the dorsal hump has only half its possible elevation. Behind the latter the cuticle lies in a multitude of concentric wrinkles encircling its base, so as to hinder the distinct view of the organs beneath; they can however be easily seen through the ventral surface. The male has two cuticular processes that are lacking in the female. These lie on the ventral surface beneath the neck, and are smaller than the other three. I did not detect any muscular threads in them, and they do not seem to fill and empty as the others do. The whole range of the Rotifera does not contain a more curious or more beautifully transparent creature than this male. Though often 1-30th of an inch in size, and but a slow swimmer, it is scarcely perceptible to the naked eye; and through the Microscope it looks like a many-pointed bubble of blown glass.

The female also is very transparent, and is a still slower swimmer. It is fond of grubbing at the bottom of the live-trough among the sediment; and it every now and then contracts the circumference of its wide trochal disk, and lashes more vigorously with its cilia, so as to drive some tempting morsel towards its mouth. It is almost colourless, with the exceptions of the eye and stomach; the former a very dark crimson, and the latter a yellow ochre. Occasionally the ovary is also tinged with the same yellow about its middle, and I have seen the ephippial eggs of the same tint. The animal feeds on other rotifers, whatever else it may eat, for I have seen *Brachionus angularis* still alive in its stomach, the victim's cilia and jaws yet feebly moving. But *A. Ebbesbornii* is not particular as to what rotifer it catches. In the stomach of one I detected the jaws of one of its own species, and on watching the animal I saw these jaws rejected, through the mouth, with other undigested food. It was a curious sight. The long, thin œsophagus, with the stomach (fig. 9), was drawn up towards the pharynx (fig. 14), and at the same time shortened and widened so

as to be as broad as the base of the pharynx itself. Then the contents of the stomach were thrust up through the pharynx so as to come within reach of the curved jaws. These seized the yellow mass, and slowly dragged it up right out of the pharynx, and jerked it away through the mouth. It did not add to my respect for the rotifer, that, not content with this uncomfortable method of getting rid of indigestible material, it repeatedly swallowed the yellow ball, to have it again dragged out by the teeth and again engulfed in the pharynx.

The Female.

Nutritive System.—The structure of the female closely resembles that of the other species of *Asplanchna*. The jaws (fig. 15) are like those of *A. Brightwellii* and *A. Sieboldii;* and as in the latter, two sets of muscles that work the jaws can be easily seen in the living animal. First there are the muscles that are attached to the free end of the fulcrum, and to the processes at the base of either jaw. These clearly open the jaws. Next there is a large muscle, which crosses the jaws transversely, and is attached at either end to a Y-shaped process on each jaw. This evidently shuts the jaws. The whole apparatus is imbedded in a stout horseshoe-shaped ring (figs. 12, 13, 14) that is much denser than any part of the body except the jaws themselves: it dissolves however under the action of caustic potash. The jaws lie on a sort of shelf which floors the closed half of the horseshoe, and in front of them is the rectangular opening of the mouth. The head consists mainly of two low conical protuberances, whose bases are in the ciliated rim of the trochal disk. They are confluent at the dorsal surface, and on the ventral they unite together so as to form a funnel leading to the mouth, which is pretty nearly in the centre of the disk; the funnel—the "proventricular canal" as Gosse has well named it—sloping backwards and downwards from the ventral surface towards the mouth.

The ciliated rim dips down on either side of the ventral surface so as to form a V; and just behind it, guarding the entrance to the funnel, are two papillæ armed with large vibrating setæ. The trochal disk is interrupted in no less than six places by notches, in which are placed similar large vibrating setæ. Two of these are on the dorsal surface, two on the ventral, and one on each side.

Below the horseshoe-shaped ring inclosing the jaws, and just under the mouth, lies the pharynx. It is a very delicate membrane, capable of great expansion, and seems to be kept in the shape of a roughly cubical box by a kind of framework of four slender curved rods which dip down from the head, and are united two and two on each side by curved transverse pieces so as to make the base of the crop rectangular. The whole apparatus resembles a waste-paper

basket which has been squeezed so as to have a rectangular transverse section, or the silk-well of a lady's work-table. There appear to me to be thin rods keeping the membrane stretched, as I have described; but I have not been able to satisfy myself that they resist the action of caustic potash, and they have not apparently been observed either by Dalrymple, Leydig, or Gosse. Possibly the membrane may be kept stretched by fine muscular threads at the four corners; but I have not been able to see any. The dorsal view of the apparatus (fig. 12) moreover, shows two strongly marked curved lines—two of my supposed rods—from which the membrane falls inwards towards the centre of the pharynx so that its dorsal wall becomes a kind of cup. This can be readily seen with dark-field illumination, when the line of sight passes through one of the dorsal edges of the pharynx. The appearance so presented seems to require the existence of some stiff kind of support down the four pharyngeal edges. This strange contrivance, which is common to all the species, can be suddenly dilated so as to cause a partial vacuum, and thus engulf the creature's prey; and that it is very effective is clear from my finding in the stomach the teeth of a young *Asplanchna*, an animal nearly half the size of that which devoured it. I have repeatedly seen the larger specimens attack the smaller ones, nibbling at them with their jaws, but without success; for the smaller *Asplanchna* drew in its head, and distended its skin to the utmost, so that the jaws of its enemy slipped over the smooth, taut, yet yielding surface; as unable to penetrate it as a man would be to bite a blown-out bladder. When the *Asplanchna* falls a prey to its bigger brother, it is doubtless swallowed whole.

The pharyngeal membrane is produced from the dorsal surface of the pharynx into a long slender and very extensile œsophagus (figs. 13, 14, 9), down which run long ribbon-like muscular threads (fig. 10). Not unfrequently the œsophagus becomes loaded with food for which there is no room in the stomach, and sometimes so much so as to make the stomach look twice its proper size.

The two gastric glands placed where the œsophagus joins the true stomach are, under dark-field illumination, quite pellucid; except in one bluish-white spot which has a granulated appearance. By transmitted light each is seen as in fig. 11, showing an opening embraced by the end of a winding duct leading to the stomach. The gastric glands have clusters of cells imbedded in them, with about four or five cells in each cluster (fig. 9). The stomach has thick walls studded with clear round cells which (Dalrymple suggests) may secrete the yellow-brown fluid that colours the food after it has been swallowed.

There is not a trace of intestine or anus: the stomach has but one opening, and is kept in its place by two muscular threads, one

on each side, which are attached to the dorsal surface near its hinder extremity.

The Nervous System.—There is a nervous ganglion of a rectangular shape, just under the surface of the trochal disk, touching the mouth on its dorsal side and carrying the crimson eye. From its four corners spring nervous threads; two of these pass to the setigerous antennæ on the trochal disk, and two to similar antennæ, one on each side of the dorsal surface. One of these latter is well seen in fig. 3, and its magnified rocket-like extremity is shown at fig. 8. The trochal disk has however four setigerous antennæ, one at the top of each of its cones, and one on the inner side of each towards the mouth. The four are nearly in a line, and the nervous thread on each side of the body swells out into a kind of ganglion, when underneath the antennæ, and sends off a branch to supply each.

Leydig has drawn nervous threads from each of the four antennæ of the trochal disk, but figures them as passing separately to the main ganglion. Of course this may be the case in *A. Sieboldii*, which he was describing; but in *A. Ebbesbornii* there is only one principal nerve-thread on each side of the body passing to the antennæ, and it supplies the two antennæ on the same side by branching just under the inner one. So much I think can be distinctly made out; but such a network of muscles and fibres crosses the trochal disk, and so restless is the animal when held down for observation, that I strove in vain to make out any further details with certainty.

Reproductive System.—The female has a horseshoe-shaped ovary; of a cylindrical shape in the middle, but flattened out at the ends, so as to remind one of the merrythought of a chicken. It is hung by fine muscular threads between the stomach and contractile vesicle, which latter it appears to clasp round. The germs of the future ova are seen imbedded in its slightly granular substance, and appear to consist of several cells each. The ova appear always to be developed at the arched end of the ovary; and, when they have attained some size, they drop off into the ovisac, which is a funnel-shaped pocket, with its broad base attached to the hinder end of the contractile vesicle. The ovisac ends in an oviduct, which opens on the ventral surface by a rather long transverse slit. This apparatus can be best seen by dark-field illumination, as its walls are of extreme delicacy. Occasionally I have met with specimens that had as many as three or four ephippial eggs in the ovisac at once; but generally there is only one maturing ovum (fig. 17), or a young animal that has already left the egg, and lies across the parent with its head presented to the opening of the oviduct. The birth of the young is almost instantaneous, but the force used to expel so large a fœtus is sometimes fatal to the young; for I have seen it issue

with its own stomach driven right through its mouth, so that its own trochal disk appeared half-way down its body. In fact the poor creature had almost been turned inside out in being suddenly thrust through the vagina.

The ephippial eggs are often of a yellow colour, and their outmost covering is corrugated very similarly to the ephippial eggs in *A. Sieboldii*.

Muscular and Vascular Systems.—These in the female are very similar to those in the male, but are much better seen in the latter, owing to the absence of the stomach and to its greater transparency.

The Male.

The male is rather more than half the size of the female, and when full grown is about 1-33rd in. in length. The largest female I have seen was rather less than 1-20th in. The teeth and mouth, with their inclosing ring, the pharynx, œsophagus, gastric glands, and stomach are all entirely wanting in the male, which has as it were in lieu of them three or four rounded masses adhering to the dorsal surface in front of the dorsal hump. These are structureless, faintly opaque and granular, and their use is unknown. Possibly they may be a kind of stored-up material to compensate in some degree for the male's inability to take nourishment.

Reproductive System.—The penis and sperm-bag are shown *in situ* in fig. 3, and much enlarged in fig. 6. The former is a canal with delicate longitudinal furrows, and lying sheathed in soft granular masses. Its obliquely cut opening is ciliated.

It can be drawn backward by two pairs of muscles that are attached by their broader ends to the dorsal surface near the bases of the dorsal muscles; and by their other extremities to the posterior end of the penis. Short muscular threads help to draw the penis forward, but I think that this motion is mainly caused by the vigorous compression of the whole body by its transverse muscles. The spermatozoa can be distinctly seen in motion within the sperm-bag, and they are of the two forms drawn in fig. 7.

I attempted on several occasions to see the union of the sexes, but without success. The male would play round a female, and thrust the penis backwards and forwards, but I never observed any copulation. Once I found the male adhering by the tip of the penis to the female; but it was on the outside of the centre of the ventral surface, and not at the opening of the oviduct.

Vascular System.—*A. Brightwellii*, *A. Sieboldii*, and *A. Ebbesbornii* all differ from *A. priodonta* in the large size of the contractile vesicle. In the female of *A. Ebbesbornii* this sometimes swells till it appears to occupy nearly two-thirds of the body-cavity. In the male it is much smaller, but in both sexes it is covered with a fine

muscular network which is constantly compressing it into ever-varying and graceful shapes.

In the female the contractile vesicle appears to empty itself into the broad end of the oviduct, but of this I am not certain; in the male there is a distinct narrow duct which opens into the same cavity as does the penis. Moreover in the male there is obviously a sphincter muscle between the vesicle and its duct; it is too delicate to be seen, but the frequent contraction of the duct at that spot reveals its presence.

The tortuous threads and vibratile tags that are so constantly present in the rotifers are in this creature unusually large and distinct. Fig. 18 gives an accurate drawing of one side of the vascular system as seen in a male. The vibrating tags are often as many as forty in number; and they are evidently attached to a delicate canal, which is itself supported by a twisted tube, whose walls are delicately granulated and sometimes carry clear cells in them, as seen in fig. 19. The posterior end of the tube on each side opens on the contractile vesicle. I believe that the system is a depuratory one, and that the effete perivisceral fluid is drawn in through the ciliated tags, and poured by the twisted tubes into the contractile vesicle, to be by it expelled from the body.

As to the structure of the tags themselves, it is clear from their different appearances under different aspects that there cannot be merely *one* large cilium waving in each tag. Dr. Moxon is probably right in considering the tags as having their inner surfaces lined with extremely minute cilia, whose united action under certain aspects produces the effect of one large vibrating cilium. But the tags of *A. Ebbesbornii* are too small for such investigations, and the subject is too long a one for further discussion in this paper.

Muscular System.—The arrangement of the muscles is very similar to that of the majority of rotifers. Two large dorsal muscles run nearly the whole length of the body, as do two corresponding ventral ones; while a third pair that may be called lateral, lie close under the dorsal ones. All of these are attached to the lobes of the head, and are branched there, having several points of attachment. At their bases they are attached to the surface of the cuticle by broad ends split into several fibres.

Smaller muscular threads run from the head and are attached half-way down to the dorsal and ventral surfaces; while, from a spot close to the mouth on the trochal disk, at least four pairs of transverse muscles run to the edge of the trochal disk, and enable the creature to rapidly draw it all together.

The united pull of the six longitudinal muscles permits the animal to withdraw its head with great rapidity, while the action of these is counteracted by some half-dozen transverse muscles, which

encircle the body at regular distances from the side humps downwards.

There are also fine muscular threads which contract the dorsal and lateral humps, but these I have already described.

There are five known species of *Asplanchna*, viz. *A. Brightwellii*, *A. Sieboldii*, *A. priodonta*, *A. Ebbesbornii*, *A. Bowesii*. The last, *A. Bowesii*, was described by Gosse, but so very briefly that I prefer at present to pass it over. The other four are related to one another as follows.

*

With serrated jaws, round ovary, small spherical contractile vesicle, vibratile tags in a cluster on a twisted thread.

A. priodonta.

**

With branched jaws, horseshoe-shaped ovary, large-lobed contractile vesicle, vibratile tags in a row on a long straight thread.

Female without humps ..	Male humpless ..	*A. Brightwellii.*
	Male with humps	*A. Sieboldii.*
Female with humps	Male with humps	*A. Ebbesbornii.*

SUMMARY

OF CURRENT RESEARCHES RELATING TO

ZOOLOGY AND BOTANY

(*principally Invertebrata and Cryptogamia*),

MICROSCOPY, &c.,

INCLUDING ORIGINAL COMMUNICATIONS FROM FELLOWS AND OTHERS.*

ZOOLOGY.

A. GENERAL, including Embryology and Histology of the Vertebrata.

Aspects of the Body in Vertebrates and Invertebrates.†—Under the above title Prof. R. Owen has republished in a separate form his essays on the conario-hypophysial tract, and on the cerebral homologies in Vertebrates and Invertebrates, which have already been noticed in this Journal.‡ Having had the opportunity of making some additions, he now directs attention to the work, among others, of Cadiat on the development of the branchial clefts and arches. In this paper is figured the extension of the fore part of the alimentary canal in the direction of that region of the brain which, at a later period, is occupied by the conario-hypophysial relics. "The branchial chamber, with the pulsating vesicle and first rudiments of gills, here repeat the branchial sac which receives the oral aperture of the alimentary canal in the Ascidians, a structure which is the condition of the deviation, in a higher step of the Life Series, of the œsophagus from its primary course, and of its communication with the precocious gill-chamber, which then becomes the vertebrate mouth, retaining the closer resemblance to the Ascidian branchial sac in the lowest (piscine) forms of the Vertebrata (*Amphioxus*)."

Ancestral Form of the Chordata.§—The great difficulty that is encountered in any attempt to point out a definite group amongst Invertebrates most closely allied to the primitive Vertebrata is the total absence of anything resembling so important and so early-formed an organ as the Vertebrate *chorda dorsalis*.

* The Society are not to be considered responsible for the views of the authors of the papers referred to, nor for the manner in which those views may be expressed, the main object of this part of the Journal being to present a summary of the papers *as actually published*, so as to provide the Fellows with a guide to the additions made from time to time to the Library. Objections and corrections should therefore, for the most part, be addressed to the authors. (The Society are not intended to be denoted by the editorial "we.")

† 8vo, London, 1883, iv. and 48 pp. (11 figs.).

‡ See this Journal, *ante*, p. 349.

§ Quart. Journ. Micr. Sci., xxiii. (1883) pp. 349–68 (1 pl.).

Prof. A. A. W. Hubrecht considers that in one group we do find an organ ranking equal to the vertebrate notochord, and thus supplying the much desired transitional form by which the Chordata are allied to the lower Metazoa, and in fact to such forms as have neither the much specialized organization of the segmental animals (Arthropods and Annelids) nor require to be turned upside down before their homology with the lowest Vertebrate is admissible. The proboscis of the Nemerteans, which arises as an invaginable structure (entirely derived, both phylo- and ontogenetically, from the epiblast), and which passes through a part of the cerebral ganglion, is homologous with the rudimentary organ which is found in the whole series of Vertebrates without exception—the hypophysis cerebri. The proboscidean sheath of the Nemerteans is comparable in situation (and development?) with the *chorda dorsalis* of Vertebrates.

Hypophysis cerebri in Vertebrata and Tunicata.*—Prof. W. A. Herdman states that in two specimens of *Ascidia mammillata* which he has lately had an opportunity of examining, the neural gland was connected with the cloacal part of the peribranchial cavity only; this is just the position in which one would expect to find it, if the gland had a renal function, and it appears possible that some arrangement of this kind obtained in the primitive Chordata, previously to the divergence of the Urochorda. "There may have been a renal gland placed ventrally to the nervous system, not necessarily at the anterior end only, and opening on the surface of the body by one or more laterally-placed apertures, this gland being represented in the Tunicata by the neural gland, and in the Vertebrata by the glandular portion of the pituitary body."

It is suggested that the connection of the so-called dorsal tubercle with the neural gland is due to the enlargement of the pharynx into a branchial sac, and the development of the peribranchial chamber. It has been shown by Ussow and Julin that the dorsal tubercle is not merely a sense-organ, while its complex structure indicates that it is not merely the aperture of a duct. Further evidence must prove what present evidence suggests, that it is a sense-organ into which the duct of the gland has come to open.

Origin of the Follicular Cells.†—H. Fol has observed the process of the endogenous formation of the cells of the ovarian follicle in the ovum of Ascidians, and in some Vertebrates. The author's earlier observations have been noted by various writers, and, of late, especially by Roule and Sabatier. He now describes what he has seen in *Ciona intestinalis* and *Ascidia mammillata;* in the former the endogenous production commences by a thickening of part of the nuclear envelope; the nucleolus is generally found in the immediate neighbourhood of this small diverticulum, and seems to give up a small portion of its substance. The nucleolus is then carried to another region of the nucleus, and the diverticulum becomes a solid bud, which grows without losing its connection with the nuclear envelope;

* Nature, xxviii. (1883) pp. 284–6.
† Comptes Rendus, xcvi. (1883) pp. 1591–4.

the peduncle which attaches it to this membrane does not divide until it has attained its definite size; the corpuscle then commences to traverse the yolk. The first cells which leave the yolk become arranged in a delicate and continuous layer, formed of flattened cells, each provided with a small nucleus; this is the follicular envelope. The cells of the next set are thicker, and form a layer internal to the first; this is the papillary layer. Finally, the ovum, the yolk of which is beginning to be charged with granules of lecithin, gives rise to a third endogenous generation; these, however, are only homogeneous globules, which have no relation to the germinal vesicle; they form the testa. Fol regards the follicular cells as being genetically the exact homologues of the spermatoblasts or mother-cells of spermatozoa, while the ovule itself corresponds to the polyblast, or male ovule of Duval.

Cells of the Ovarian Follicle.*—A. Sabatier discusses the views of Fol and of Roule on the follicular cells; dealing with those of the former, who believes that the bodies in question are the result of a local budding from the nuclear envelope and the nucleus itself, he states that an attentive microscopic study has always convinced him of the presence of a surface of separation between the so-called bud and the nucleus. The differences between the statements of Fol and Roule are sufficient to justify a doubt as to the correctness of either's views as to the function of the nucleus or nucleolus, and Sabatier remains firm to his opinion that the follicular cells arise endogenously in the vitellus. Similar observations may be made on Vertebrates of various groups, and this widely observed elimination of cellular elements is very striking; they lead, indeed, to certain generalizations as to the nature and origin of the sexuality of the reproductive elements. These are already known to the readers of this Journal,† but attention is to be directed to the present communication, as it no doubt affords some of the "further evidence" which the author promised in his essay on spermatogenesis in the Nemertinea.

Bizzozero's New Blood-corpuscle and Norris's Third Corpuscular Element.‡—G. Hayem insists that the elements of the blood to which he gave the name of hematoblasts are identical with the objects which have since been described by G. Bizzozero § as "plaquettes." Norris's third corpuscular element || he considers to be a red corpuscle decolorized as the result of the manipulation to which the blood is subjected.

Colour-Markings of Mammals.¶—Professor Eimer has continued his studies in regard to the colour-markings of vertebrates.

As the result of his observations, he has laid down certain general

* Comptes Rendus, xcvi. (1883) p. 1804–6.
† *Ante*, pp. 212–3.
‡ Comptes Rendus, xcvii. (1883) pp. 458–61.
§ See this Journal, ii. (1882) p. 480.
|| Ibid., iii. (1880) p. 229.
¶ Jahresb. Verein Vaterl. Naturk. Württ., xxxix. (1883) p. 56. Science, ii. (1883) pp. 144–5.

principles, which he applies to the different groups, notably to the mammals.

The following general statements are elaborated: 1. That the colour-markings of mammals may be reduced to longitudinal stripes, spots, and transverse stripes. 2. That the longitudinal stripes are the oldest form, and that the two follow in course. 3. That the primitive mammalian fauna was a longitudinally striped one. 4. That the males have been first to take on the new forms of markings, while the females hold longer to the older form. 5. That the effects of the law by which the development of the markings takes place from the posterior part of the body toward the anterior part are not so easily traced in mammals as in the case of other groups, such as the Saurians. 6. That in mammals the development of markings follows a regular course, that is, the longitudinal markings are followed by spots which, in turn, run together, and finally form the transverse or tiger stripes. 7. That the position of the smallest spot on a mammal is not accidental, but due to the action of generic and philogenetic laws, from which it follows that markings are an available means for the determination of species. 8. That the regularity of the development of markings shows that they arise from constitutional causes.

The author takes the Viverridæ as the original types of the Carnivores, and believes that in the hyena, cats, dogs, bears, and weasels, he can trace the form and position of markings possessed by the former. He acknowledges several difficulties, however, in the case of the leopard, jaguar, and other peculiarly spotted cats. He believes that the Ungulates follow the same law in regard to markings as the Carnivores.

Retina of Ganoids.*—A. Dogiel distinguishes twelve layers in the retina of Ganoids. These are: (1) Pigment layer; (2) Layer of rods and cones; (3) Granular layer; (4) Membrana limitans externa; (5) Outer subepithelial ganglionic layer; (6) Layer of nervous deposits; (7) Layer of stellate cells; (8) Median ganglionic layer; (9) Layer of the Neurospongium; (10) Internal ganglionic layer; (11) Layer of nerve-fibres; (12) Membrana limitans interna. These elements may be arranged in three groups: (α) Catoptro-dioptric, viz. 1 and 2; (β) nervous, viz. 5, 6, 8, 10, and 11; and (γ) the supporting apparatus. The author describes in detail the various parts.

Influence of Sea Water on Fresh-water Animals, and of Fresh Water on Marine Animals.†—H. de Varigny records the results of his experiments on the influence of the saline principles contained in sea water. The ova of frogs and tadpoles were employed.

Sulphate of magnesia (2·20 gr. of which is contained in each litre of sea water), chloride of potassium (0·7 gr. per litre) and chloride of magnesium (3·5 gr. per litre) were not found to exercise any injurious influence either on the ova or the tadpoles when the same proportions were separately dissolved in fresh water. Chloride of sodium, however, 20 or 25 gr. of which exists in each litre of sea water, is decidedly hurtful. No ova could be hatched in a solution of 20 gr.,

* Arch. f. Mikr. Anat., xxii. (1883) pp. 419–72 (3 pls.).
† Comptes Rendus, xcvii. (1883) pp. 54–5, 133–6.

and only tadpoles in an advanced stage of development (without feet, but 4 or 5 cm. long) could be kept alive in a mixture of 2 litres of sea water and 2 litres of fresh water. Tadpoles of 10 or 20 days could not live in a solution of more than 10 to 12 gr. per litre.

P. Bert subsequently directed attention to the results of his investigations made some ten years ago, in which he demonstrated that it is the chloride of sodium in sea water which causes the death of fresh-water forms immersed in it. Bert was able to make out the whole of the process, for he found that the action is due to exosmosis in the region of the gills, the epithelium of which becomes opaque, and the circulation of blood arrested; while this obtains in animals whose body is covered with a mucous secretion, we find that, where (as in frogs and toads) this secretion is absent, the exosmotic action gives rise to desiccation, in consequence of which the animal dies, after having lost from a quarter to a third of its weight. Indeed, a toad may be killed by simply plunging one of its legs into sea-water. On the other hand an eel, unless we remove the mucus from some portion of its body, will live for a long time in sea-water.

Animals gradually accustomed to the action of sea-water—such as *Daphnia*—present a very interesting phenomenon; when the fresh water in which they live has been gradually brought to a degree of salinity equal to one-third of that of the sea, they die quite rapidly; but, a few days later, fresh *Daphniæ* appear, which have been developed from the ova of those that are dead. Here, then, we have acclimatization, not of the individual, but of the species. This phenomenon was first observed by Plateau, but Bert independently convinced himself of its truth.

Infusoria—such as *Paramœcia*—and diatoms of fresh water resist perfectly a degree of salinity which kills fish and Crustacea.

Dealing with the opposite case, the author found that marine animals were killed by fresh water, owing to the absence of chloride of sodium; for the fresh water has a kind of exaggerated endosmotic action, swelling out the gills of fishes, in which the circulation becomes arrested, rendering opaque the transparent epithelial layers, and destroying the contractility of the chromatophores of Cephalopods, and the muscles of worms.

Acclimatization experiments led here to similar results; in other words, the animals die rapidly when the salinity of the water is reduced by one-third. Further experiments are being made on a subject which is of great interest, not only as bearing on the physiology of the epithelium, but on the general history of aquatic forms.*

B. INVERTEBRATA.

Radial and Bilateral Symmetry in Animals.†—H. W. Conn points out that the relation of radial to bilateral symmetry among animals is a question in regard to which there has been considerable

* F. Plateau (tom. cit., pp. 467–9) also subsequently wrote claiming priority over M. de Varigny's results by an article published in 1870 (Mém. Couronnés Acad. R. Belg., xxxvi. 1870), in which he described the effect of sea water on fresh-water Articulates and of fresh water on marine Crustacea.

† Johns Hopkins University Circulars, ii. (1883) pp. 73–4.

discussion. It is however to-day pretty generally acknowledged that the type of radial symmetry must have preceded that of bilateral symmetry. Two important views are current as to the origin of a bilateral form of symmetry, such as is presented by the group Vermes, from a radial symmetry such as we find in the Cœlenterata. The simplest view, of which Ray Lankester is an exponent, is as follows:—

Starting with a radially symmetrical larva, this view supposes that the two forms of symmetry arose with reference to the stationary or locomotive life of the animal. On the one hand, the stationary animal retains its primitive radial symmetry, and grows into a radial adult. On the other hand, the locomotive larva is modified by its free life. Its growth, in order to give greater freedom of motion, results in an elongation of the body in a direction parallel with its axis. Such a long cylindrical body would of necessity soon develope swimming organs; and these swimming organs, in order to give greater steadiness of motion, and prevent an inconvenient revolution of the body, would appear in such a position as to give the animal an upper and an under surface, and consequently a bilateral symmetry. With the continued elongation of the body the digestive tract, which at first ended blindly, would also elongate, and finally acquire a posterior opening at a position directly opposite the mouth. This view, then, supposes the body of the radiate animal to elongate in the direction of its long axis, and a bilateral symmetry to arise in reference to the organs of locomotion.

A second view, advanced by Balfour, while based on the same fundamental principle of stationary and free life, supposes the change to take place in a different fashion. This view supposes that the growth of the free living radiate form resulted in an elongation, not in the direction of the axis of the animal, but rather at right angles to this axis. This places the mouth of the animal, from the first, not at one extremity, but on one side, which therefore becomes very early the ventral side. The swimming organs afterwards arose in reference to the already indicated bilateral symmetry.

These two views are fundamentally different. Besides affecting our belief as to the manner in which bilateral symmetry arose, the acceptance of one or the other is the foundation of our understanding of the homologies which are to be found in the two groups.

Evidence for the one or the other of the views is to be looked for in embryology; but very few animals give an opportunity for such research, owing to secondary changes which have acted upon the ova and the embryos. For this reason no direct evidence has been hitherto obtained. At Beaufort, during the last summer, some work was done upon *Thalassema*, a species of worm which possesses a very primitive development, and enables a direct study of the origin of bilateral symmetry from radial symmetry to be made. The results of the observations were satisfactory upon the point in question, and showed that, as far as this group of animals is concerned, the second of the above views, viz. that of Balfour, is in all essential respects correct. The radially symmetrical gastrula elongates nearly at right angles to its long axis, and gives rise to a bilateral larva, of which

the ventral surface has been from the first indicated by the position of the mouth. The acquisition of a direct motion occurs some time after the animal is truly bilateral, an indirect revolutionary motion being gradually changed into a direct motion with its anterior extremity in advance.

Symbiosis of Bryozoa and Actiniæ.*—W. A. Haswell dredged specimens of a branching species of *Cellepora*, which was dotted over with small red specks, and on examining these more minutely, he found each to consist of a minute Actinid lodged in a cylindrical pit excavated in the substance of the polyzoarium, and projecting, when expanded, about a quarter of an inch from the surface of the latter. Each of the pores was about 1-20th in. in diameter; they are cylindrical and tolerably smooth, and in most cases the orifices are furnished with a low projecting rim. When they are traced backwards into the substance of the *Cellepora*, two are frequently found to unite, and very often they eventually open into the cavity occupying the centre of the thicker branches. They very often extend in this way through a distance many times greater than the length of the Actinid itself, and as the latter is provided with no means by which it can retract itself into the interior, this long canal must be the result of the simultaneous growth of the little anemone and the *Cellepora* in which it is lodged.

This singular phenomenon is specially interesting, on account of the light which it throws on the structure of some very problematical-looking species of Bryozoa, one of which Mr. Haswell recently described as *Sphæropora fossa* (*Cellepora fossa*). In this species the bryozoarium is spherical, slightly compressed, one pole being always characterized by the presence of the deep cylindrical pore running in the direction of the axis, but not quite reaching to the opposite pole. This pit is always well defined and uniformly cylindrical, and it is difficult to explain its nature unless we suppose that it was occupied by a minute Actinid similar to those already described. None of the specimens seen exceeded 1-8th in. in diameter, and most of them, from their worn appearance, must have been dead when dredged, so that there would seem to be a tendency in this species to arrest of growth and death at a certain definite stage of growth. This species, it is to be remarked, differs entirely in the nature of its zoœcia from the branching species already mentioned, which is a normal *Cellepora*.

A species very nearly related in the peculiar form of the cells to *C. fossa* was dredged off Port Stephens. The form of the bryozoarium in this case is usually that of an elongated cone, 1-3rd in. to 1-2 in. in length, with a pit exactly like that occurring in *C. fossa*, in the centre of the base; but sometimes it has the form of a circular plano-convex disk 1-3rd in. in diameter, with cells on both sides and without a pit, while in other cases the shape is more irregular, subhemispherical or the like, but never larger than a pea.

It seems very likely that the first-mentioned species starts from an early stage, resembling *C. fossa* or its ally, a group of cells surround-

* Proc. Linn. Soc. N. S. Wales, vii. (1883) pp. 608–10.

ing a single young Actinid; as the zoarium increases, and the cells grow round the mouth of the cavity occupied by the latter, the canal is constantly being elongated, as the sea anemone remains at its orifice, and thus prevents it from being encroached upon by the multiplying cells. Sometimes the sea anemone gives off a lateral bud, and at this point the canal is seen to branch, and by degrees, by the simultaneous growth of the Bryozoon and the sea anemone, such a complex organism as the author has described is produced.

Mollusca.

Digestive Processes in Cephalopoda.*—E. Bourquelot finds that the secretion of the salivary glands of Cephalopods has no action on raw or on hydrated starch; the hepatic secretion converts the latter into sugar, and the pancreatic juice has a similar action; in other words, we may say that the ferment produced by the liver and pancreas is identical with the salivary ferment of higher animals.

The author is of opinion that the action of the ferment ought to be considered separately from that of hydration. If in any animal raw starch becomes saccharified, we must suppose that it has been previously hydrated under conditions which are, as yet, unknown to us.

There is at present no evidence which would lead us to think that the liver of Cephalopods forms glycogen; the so-called liver is then, from a physiological point of view, a pancreas, for it contains a peptic and a diastatic ferment. The author concludes by merely adverting to the difficulty of explaining the presence of this last ferment in carnivorous animals.

Suckers of Cephalopods.†—P. Girod describes the suckers of *Octopus vulgaris* and *Sepia officinalis*, which are, at first, to be distinguished from one another by their sessile condition in the former, and their pedunculated character in the latter; in the Decapod there is, further, a horny ring developed, but there is not, as in the Octopod, any elastic cup or constriction, the cavity of the sucker forming a single chamber.

In the Octopod the suckers act thus: the animal contracts the extrinsic infundibular muscles, the sphincter of the orifice, and the inferior muscular envelope, and the form of the sucker becomes perfectly plane. Then the infundibulum or upper portion of the sucker becomes conical, the acetabular chamber enlarges, and its orifice dilates slightly; a vacuum is thus formed, and any pulling on the sucker only tends to separate the orifice from the base of the sucker, and so to increase the vacuum. In the Decapod there is a piston-like arrangement which becomes withdrawn by the action of lateral muscles, while the horny ring becomes more firmly attached. As the author justly points out, his results will be more completely displayed when he gives an account of the minute structure of the parts which he here mentions.

* Arch. Zool. Expér. et Gén., x. (1882) pp. 385–421.

† Comptes Rendus, xcvii. (1883) pp. 195–7.

Development of Gastropoda.*—F. Blochmann first reports on the development of *Aplysia limacina*, the ova of which are so transparent as to need no special preparation; their rate of development is very slow. But, owing to his repeated references to his figures, and to the account given by Ray Lankester, this portion of the essay does not, without illustrations, admit of being condensed. The author states that the most important result of his observations is the demonstration of the agreement of *A. limacina* with the leading points in the developmental stages of other Gastropods.

Dealing, next, with the fate of the blastopore in *Paludina vivipara* we find Blochmann disagreeing with Rabl, and agreeing with Lankester and Bütschli in believing that the blastopore is directly converted into the anus. Though among the Gastropoda the blastopore and the mouth have generally a close relation, the doctrine here supported finds analogous results in the history of the Annelids *Serpula* and *Salmacina dysteri*.

When we come to seek for an explanation of the varied fate of the blastopore, we have to note that, in *Aplysia*, this orifice is elongated, and that its hinder edge is, at a very early stage, brought into close relation with the two anal cells, which mark the point of the future anal orifice; at the same time, the anterior end of the slit is close to the œsophageal invagination; in other words, it extends over the whole of the ventral surface, just as is the case in *Peripatus* (Balfour). The author thinks that Bütschli's idea, that the blastopore corresponds morphologically to the oral and anal orifices of the Metazoa, is necessary to the Gastræa-theory; it is, at least, to be noted that, not only does the blastopore occasionally in all groups correspond to the anus, but in one great division—that of the Echinodermata—it always does so correspond. In the Entomostraca we have the Cladocera in which the blastopore and mouth correspond in position, and the Copepoda in which the anus and blastopore so correspond; insects have a slit-shaped blastopore occupying the ventral surface, and even in the lower Vertebrates we find, as Balfour and Hatschek have especially shown, that the blastopore is, in many cases, an opening of an elongated form.

Liver of Gastropoda.†—The researches of D. Barfurth have led him to the following conclusions: In *Arion* and *Helix* the liver is a compound acinous gland, the parenchyma of which is surrounded by a lacunar serous layer, a muscular layer, and a circular tunica propria. The unilaminate epithelial investment of the follicles consists of ferment, hepatic, and calcareous cells. The liver is nourished by the hepatic artery, the final branches of which terminate in the spaces in the connective tissue, and these communicate with the blood-sinus which surrounds the liver. The epithelial investment of the gall-ducts consists of ciliated and mucous cells; but at some points cylindrical epithelial cells are alone developed. Special nervous structures are to be observed in the liver, where they have the forms of large cells,

* Zeitschr. f. Wiss. Zool., xxxviii. (1883) pp. 392–410 (1 pl.).

† Arch. f. Mikr. Anat., xxii. (1883) pp. 473–524 (1 pl.).

with granular contents, some of which may be seen to be connected with nerves, while others are lost in the surrounding tissue; these cells agree in character with those which are to be found in the supra-œsophageal ganglion. The ferment-cells of the liver form vesicles containing brown ferment-spheres, and the ferment itself is digested in acid, neutral, or alkaline solutions. The liver-cells excrete small vesicles which have yellowish contents, and which are evacuated with the fæces. The calcareous cells are distinguished by the presence of refractive spherules formed of phosphate of calcium. During the summer phosphate of calcium is stored up in the liver, and carbonate of calcium in the walls of the vessels and other regions of connective tissue; in winter this is used by *Helix* to form the winter operculum, and in *Arion*, probably, as a means for strengthening the integuments. It is also used by *Helix* to repair the shell, and by *Arion* to replace the excreted calcareous dermal mucus. All the constituents found in the liver are always found in the same relative proportions, so that though the absolute weight of the ash varies, the percentage of its constituents is always the same. We see, therefore, that the liver of the Gastropod performs a number of functions which, in higher animals, are undertaken by various separate organs.

For the purposes of his microscopical investigations Dr. Barfurth places a small piece of liver for ten minutes in a 1 per cent. solution of osmic acid, and then makes sections.

Sensory Organs of Gastropoda.*—P. B. Sarasin describes the tentacular ganglion of the fresh-water Pulmonata, and finds, as in higher animals, that in the young the nervous system is proportionately better developed than in the adult; at first the two tentacular ganglia are placed quite close to the cerebral, and they appear to arise from the sensory plate.

The so-called organ of Semper is an organ consisting of several lobules, which lies round the mouth, and is richly provided with nerves. In *Helix pomatia* Sarasin finds that the outer edge of the lobule is covered by a strong cuticle, beneath which there is an epithelial layer of elongated and a mass of ganglionic cells; connected with this nervous mass is a well-developed nerve, and the whole structure calls to mind the arrangement of a tentacular ganglion; both these organs are absent from the Prosobranchiata.

The olfactory ganglion has been examined in a number of species, and the cells which compose it have been found to be large and very distinct, though in the Stylommatophora it is, as compared with the Basommatophora, in a rudimentary condition.

The author concludes with some observations on the glands of the foot, and states his conviction that the Basommatophora and Stylommatophora have many points in common.

Pedal Nerves of Haliotis.†—H. Wegmann, bearing in mind the opposing statements of Lacaze-Duthiers and Spengel, finds that, in

* Arbeit. Zool.-Zoot. Inst. Würzburg, vi. (1883) pp. 91-108 (1 pl.).
† Comptes Rendus, xcvii. (1883) pp. 274–6.

the foot of *Haliotis*, there are two large nerve-cords which arise from the lower surface of the ganglionic mass which contains the pedal and the asymmetrical (Lacaze-Duthiers) ganglia. Extending to the hinder edge of the foot, they there terminate without undergoing any anastomosis; the two trunks are connected by several commissures and give off a number of nerves; the former arise from the ventral portion of the cords, some of the peripheral nerves arise from the outer edge, some from the dorsal portion, and some from the inner face of the dorsal portion. These results, just as much as those gained from a study of sections of the nervous trunks, prove that there are two nerves in each of the pedal nerve-trunks, as Lacaze-Duthiers had indicated.

To this note Prof. Lacaze-Duthiers* added the following remarks; he pointed out that he had employed methods altogether different to those of Spengel; he had not been content with a few dissections or sections; he had made researches based on comparative studies, and on the relations, which have been clearly established, between, on the one hand, the nerves and the trunks from which they arise, and, on the other hand, between the nerves and the parts to which they are distributed. All methods, howsoever excellent, ought always to be controlled by comparisons, and by *à posteriori* confirmations. Any method employed absolutely and by itself may lead to error, for morphology only furnishes certain results when we base ourselves on anatomical facts which are incontestably true, and on relations, well established by a series of comparisons leading to a knowledge of the connections of different parts. In regarding the epipodium as a structure connected with the mantle, he had in mind the fact that no nerve from the pedal ganglion of a Gastropod ever passes into the mantle, and that a nerve from the asymmetrical centre never passes into the foot; as we have here to do with two kinds of nerves, it follows that we have two sets of parts or organs. He looks upon the results of Spengel as being erroneous because they have not been controlled by morphology.

Pedal Glands of Mollusca.†—J. Carrière thinks that the openings in the feet of Gastropods or Lamellibranchs are the orifices of various glands; water does not seem to be taken into the blood directly, either by their pores or by the kidney; nor is a quantity of water necessary for the erection of the foot, for the blood alone can bring that about. The renal cleft is not used as the means for introducing water into the blood, but rather as a passage by means of which the fluid which passes into the pericardium from the blood can make its way into the kidneys. There are no indications of a water-vascular system in either Gastropods or Lamellibranchs.

In pursuing his investigations the author found great assistance from the air-pump, the use of which he learnt at the Naples Station; the thickest and largest pieces of the feet, which would otherwise have required several days' treatment, were rendered easy of section after a few hours.

* Tom. cit., p. 277.

† Arch. f. Mikr. Anat., xxi. (1882) pp. 387–467 (3 pls.).

Glands of Aplysia and allied Forms.*—F. Blochmann deals with the glands found at the edge of the mantle in *Aplysia* and some of its allies, attracted to the study by the presence, in *A. limacina*, of gigantic unicellular glands, which may be as much as 1 mm. in length. The basis of the edge of the mantle, like the whole of the body-wall, is formed by the peculiar laminar tissue which is so widely distributed among the Mollusca. Externally this is limited by a unilaminate cylindrical epithelium, the cells of which are pigmented.

The glands now to be mentioned are imbedded in the connective tissue, and they may be regarded as (1) simple, (2) as more complicated purple-glands, and (3) as the analogous glands which produce a milky secretion. They are all unicellular, and the simple have the form of the so-called goblet cells. These are filled by a clear mucous secretion, such as is also found in some pyriform glands, which are most common on the upper side of the mantle. Another form of unicellular gland, which is seen in *A. depilans*, is greatly elongated, and the contained protoplasm has a large number of secretion-granules. The narrower end serves as an efferent duct, and appears to be provided with a membrane. This kind of cell was found to be, in all cases, limited to the lower side of the mantle, and placed between the large purple-glands; they were best developed in *A. punctata*, where the purple-glands are considerably diminished in size and number. In *Dolabella dolabrifera* we find, in addition to the unicellular glands, multicellular ones, which are remarkable for consisting of two continuous layers of cells, of which those lying next to the efferent ducts are smaller, and contain clearer protoplasm than those of the outer layer.

The glands which secrete the purple-colouring and milk-like substance are particularly interesting, inasmuch as we have here to do with comparatively complicated organs, which are essentially unicellular in structure. Not only is the secretory function performed by a single giant-cell, but the ectodermal invagination gives rise to a multicellular efferent duct. The structure of these bodies is investigated, and their development is reported to be of the following character; the glands arise from epithelial cells, which, suddenly increasing in size, push their way into the connective tissue, without, however, losing their connection with the outer world; a cavity is only gradually developed in their interior, and they seem, at first, to be provided with a membrane, no indications of which are to be seen in the adult. An investment of connective tissue cells is gradually formed around the gland-cells.

Sexual Characters of Oysters.†—J. A. Ryder treats of the microscopic sexual characters of the American, Portuguese, and common edible oyster of Europe, pointing out that, until recently, he had "maintained with reservation that the sexes in the European oyster were probably separate, as in the American"; a greater refinement of method has shown the author that he was in error.

* Zeitschr. f. Wiss. Zool., xxxviii. (1883) pp. 411–8 (1 pl.).
† Ann. and Mag. Nat. Hist., xii. (1883) pp. 37–48.

The following method of investigation was adopted; after removal from the shell, the animal was thrown into a chromic acid solution of from one to two per cent., and was so allowed to remain for several days. After hardening satisfactorily, it was thoroughly washed and soaked in water for two days, and finally put into alcohol. Thick slices or blocks of the body should then be cut in a transverse direction, and it is as well to take several individuals, inasmuch as in any two the sexual glands will hardly be found to have attained the same state of maturity. After the blocks had been soaked in water for a day, they were dried, and then placed in a solution of gum arabic for from 24 to 48 hours; again covered with strong alcohol, they are, after a day, hard enough to cut. The sections were found to be most conveniently stained with the following reagent: equal parts of dense alcoholic solutions of safranin red and methyl green are poured together, and diluted with about eight times their combined volumes of water. Being now too deeply stained to be at once mounted, the sections must be transferred to 95 per cent. or absolute alcohol, and stirred about in it; as soon as the sections are of a rosy red hue, they should be removed and placed in oil of cloves. If the process of the extraction of the colour has been allowed to go on too long, the staining effect of the safranin is lost; while it will stain the eggs, the methyl green only affects the spermatozoa and the cells from which they are derived. "It is one of the most astounding facts known to histological chemistry, that although both of these dyes, to begin with, are intimately mixed together in the staining fluid, the different histological elements of the section exert some kind of selective power by which they absorb and hold mainly the one colour only."

This elaborate method of investigation is only necessary for *Ostrea edulis*, where the spermatozoa are packed together in oblong clusters, which are often of about the size of the ovarian ova; and this species is essentially hermaphrodite, while *O. virginica* and *O. angulata* are unisexual. It is further to be noted that, in the first, the calibre of the generative tubules appears to be relatively greater than in the other two species.

The author enters into a detailed account of the results of his observations, and concludes by discussing the evidence which we have as to the annual regeneration and final abortion of the reproductive organs of the oyster. Together with the changes in the glands, there are remarkable changes in the solidity and consistence of the animal; "the shrinkage of a spawn-spent oyster in alcohol is excessive, and may reduce the animal to one-tenth of its living bulk; this is, of course, due to the absorption of the water with which the loose tissue of the exhausted animal is distended." It would seem, therefore, to be clear that, in consequence of the enormous fertility of the oyster, a vast amount of stored material in the shape of connective tissue must be annually converted into germs, and annually replaced by nutritive processes.

The author thinks that there is, as yet, no conclusive proof of the alternate activity of the generative organs in producing ova and spermatozoa; and though he recognizes that his view is in opposition

to the generally received doctrine as to the provision of nature against continuous interbreeding, he feels that, as yet, there is nothing to show that self-fertilization cannot obtain in the case of the oyster.

Molluscoida.

Development of Salpæ and Pyrosomata.*—L. Joliet supports the doctrines of Kowalevsky, as against the adverse views of Salensky, Brooks, and Todaro. He finds that the gemmation of *Salpæ* is a true gemmation, but one which is particularly complex from the fact that "organs already differentiated take part in it, each on its own behalf." To prevent ambiguity, the author proposes to define the stock organic form as "that which, produced sexually and possessing sexual tissue, either not yet differentiated, and simply in potentiality, or already differentiated and recognizable, but being incapable of conducting it to the term of its evolution, confides it for this purpose to one or more successive forms, the last of which at least is sexual."

The author thinks that a definition of this kind will be found to apply to the *Salpæ*, to the *Pyrosomata* (in which the third bud is alone capable of reproduction), to the *Doliola*, to the compound *Ascidia*, and several other animal forms.

Structure of Anchinia.†—A. Kowalevsky and J. Barrois have made some observations on this little-known Tunicate, a species of which, *A. rubra*, is to be found at Villefranche, but it would seem to be rare. *Anchinia*, like *Pyrosoma* and *Doliolum*, has the incurrent and excurrent apertures directly opposite to each other, but it differs from the former in having the lateral, and from the latter the median portions of the cloaca rudimentary.

On the whole *Anchinia* is the most complete transition form known between the *Salpæ* and the *Ascidiæ*. After a detailed account of the general structure, the authors pass to the mode of gemmation; in the earliest observed stage the endostyle was found to be enormous, but there was no cloaca, nor any means by which the bud could communicate with the outer world. The bud, which is at first rounded, soon becomes clavate, and there are indications of a division into body and peduncle. The pharyngeal and cloacal orifices become open to the exterior, and the endostyle is proportionately smaller. After describing the succeeding stages, the authors deal with the question of the affinities of this interesting form.

The arrangement of the organs of the adult bears the closest resemblance to what is found in *Doliolum*, and the resemblance of the buds of the former is still more remarkable, and leads to the supposition that the *Anchiniæ* are *Doliola* which retain throughout life the embryonic form of the buds of the latter; there they separate from the stolon, and becoming free, alter their organization so as to adapt it to the fresh conditions of their existence. In *Anchinia*, on the other hand, the buds remain fixed, and in that condition become sexually mature.

* Comptes Rendus, xcvi. (1883) pp. 1676–9.
† Journ. Anat. et Physiol., xix. (1883) pp. 1–23 (3 pls.).

In *Anchinia* the buds and the stolon appear to be two distinct structures, and call to mind the relations which obtain between the mammalian embryo and the walls of its containing uterus. This arrangement would be very difficult to explain but for the discovery by Oulianine that the buds of *Doliolum* arise at the end of the endostyle, and pass to the stolon, to which they become attached, and on which they develope.

The individuals of a colony of *Anchinia* appear to function sometimes all as males, and sometimes all as females; but as yet nothing is known as to the characters of the form developed from fertilized ova; in other words, the organic generation which produces the stolon and gives rise to the sexual buds is as yet unknown. Like the *Salpæ*, the *Anchiniæ* would appear to be very short-lived, inasmuch as they are not provided with any organs adapted for pelagic life.

Development of Brachiopods.*—Led by numerous requests, M. Lacaze-Duthiers publishes an analysis (by MM. Oehlert and Deniker) of the important essay, written in Russian, which has been published by Kowalevsky. Observations were made on *Argiope neapolitana*, *Thecidium mediterraneum*, *Terebratula minor*, and *Terebratulina caput-serpentis*. In all these four types we find that the larvæ are formed of a cephalic, a thoracic, and a caudal segment. The second of these is alone devoid of vibratile cilia, and it is the one which gives rise to the fold which produces the mantle, the margin of which is alone ciliated. With the exception of *Thecidium*, the larvæ are very active.

In the Brachiopoda there are two modes of development—in one (*Argiope*, *Terebratula*) the endoderm is formed by the invagination of the ectoderm, while in *Thecidium* there is delamination. We find in both types much the same history for the mesoderm and the early stages of embryonic development. The author is inclined to think that in *Thecidium* the dorsal valve of the shell is alone formed by the mantle, while the ventral valve is largely developed from the wall of the caudal segment; should this be correct, it would follow that the ventral valve of *Thecidium* does not correspond morphologically to the similarly named part of the shell in the stalked Brachiopods.

The larvæ of Brachiopods have nothing in common with those of Molluscs, though they offer a great resemblance to what is seen in the Chætopoda; like them, they have neither velum, foot, nor shell, while they are segmented. The sole difference would appear that in the Brachiopoda segmentation is very early arrested, while in Worms new segments are continually intercalated. The bundles of setæ are similarly arranged in the two kinds of larvæ, while their absence in *Thecidium* is to be explained by the feeble development of the ventral surface, which again is due to the absence of a peduncle. The existence of setæ during the larval stages of the Brachiopods is looked upon as a fact of capital importance, for they are not found in Molluscs, Echinoderms, or in any other worms save the Chætopods. Nor is the

* Arch. Zool. Expér. et Gén., i. (1883) pp. 57–76.

resemblance between Brachiopods and Chætopods confined to external characters; in both the intestinal canal has the same direct relation to the dorsal wall of the body, and in the adult the canal is attached by two mesenteries. Notwithstanding certain points of disagreement, the muscular system of the two sets of forms offers some striking characters of resemblance. So, again, the ovaries are in both suspended by a mesentery, and the oviducal glands of the Brachiopod are very similar to the segmental organs of worms. As the gills of Brachiopods are always found on the dorsal side of the mantle, they may perhaps be homologized with the dorsal gills of such forms as *Eunice* and *Nerine;* on the other hand, the cephalic segment may, as in *Thecidium*, enter into the formation of the gills, which might, therefore, be homologized with the gills of the Cephalobranchiate Annelids. The greatest difficulty is to be found in a comparison of the shells, which are not the same as the tubes of some Worms; on the other hand, the prolongations of the mantle which fill the tubules of the shells present a great resemblance to the prominences which are found in the gelatinous subcutaneous layer of the Chloræmina. On the whole, Kowalevsky is inclined to regard the Brachiopoda as merely an order of the Annelids, for he thinks that they present as many resemblances to the Chætopods as do, for example, the Discophora.

Arthropoda.

Eyes of Arthropoda.*—B. T. Lowne points out that three distinct forms of eye are to be found in the Arthropoda, the compound eye, the simple ocellus, and the compound ocellus, described by Landois as being found in larval insects. The author believes that the relationship of the first two is very distant, but that there is a much closer relation between the compound eye and the compound ocellus, the former being merely an aggregation of a great number of these ocelli, variously modified in different forms. There is, further, a fourth kind of eye, which may be regarded as forming an intermediate link between these two, and which may be well spoken of as the "aggregate eye"; it is to be found in Isopods.

In the compound eye we find that there is a membrane which separates the crystalline cones and great rods from the more deeply lying nervous structures; this is now called the *membrana basilaris.* It is usually attached to the cornea by an inflected ring of integument —the *scleral* ring—so that the crystalline cones and great rods are entirely inclosed in a case; all these structures receive the name of the *dioptron*, and they apparently correspond to the cornea, vitreous and fibrous membrane of the simple ocellus. Beneath the dioptron is a structure now called the *neuron*, which consists of a retina, an optic nerve, and an optic ganglion.

Lowne states that for several years he has regarded as inadequate all the theories that have been put forward to explain the mode of action of the compound eye; he has lately observed in the fresh eye of a *Pterophorus* that the spindles are, during life, large ovoid bodies,

* Proc. Roy. Soc., xxxv. (1883) pp. 140–5.

filled with transparent, highly refractive fluid. "The slightest injury gave rise to the escape of the fluid, and left the spindles in a shrivelled condition, the usual appearance of these bodies." Further investigations have shown that all compound eyes, when uninjured, have similar ovoid spindles; these appear to act as magnifying and erecting lenses.

Four distinct modifications of the cornea have been observed; simple continuous, facetted, kistoid, and lenticular. It has been found that, during the process of ecdysis, the segregate retina of many larvæ is finally replaced by a newly formed retina, which is continuous; it would seem, therefore, that a kind of internal ecdysis affects the epithelial elements of the nervous system concurrently with the general integumental ecdysis.

Results of Decapitation in Insects and Myriopoda.*—Taking advantage of the large numbers of insects driven out of their hiding places by the last autumn's floods in Italy, R. Canestrini carried out some experiments in this direction, in order to ascertain how long movements would continue in the heads and bodies. He commonly employed very thin-bladed forceps for the purpose, and had recourse to artificial irritation when spontaneous movements ceased (e. g. pricking, squeezing, blowing tobacco smoke over the insect). *Coleoptera*, he finds, at once showed signs of having undergone a serious operation. Many of the more active *Hymenoptera* and *Orthoptera*, as the ants, bees, *Bombus*, *Harpalus*, &c., remained as if unaffected, while others seemed only to recover their senses long after the operation; *Lepidoptera* do not seem much discomposed, and *Diptera* (horse-flies, house-flies) show even less annoyance. Indeed several female flies which had been decapitated coupled with uninjured males directly after the operation and remained in this condition for 1 to 2½ hours and made movements indicative of no great discomfort afterwards; in one case the female coupled twice during the 9 hours following decapitation.

Statistical tables show the duration of movements in the following (among other) insects to be as follows:—

	Body.	Head.
Geotrupes stercorarius ..	5 days ..	16 hours
Cetonia aurata	9½ „ ..	4 „
Harpalus	60 hours ..	10 „
Various Butterflies	18 days ..	few „
Formica rufa	30 hours ..	30 „
Wasps	5 days ..	24 „
Flies	36 hours ..	6 „
Forficula	11 days ..	6 „
Gryllotalpa	9 days ..	78 „

Most of the results were obtained at a temperature of 10° C. The duration appears to be unaffected by the exudation or retention of liquid at the wound; a temperature as low as 5° to 10° C. is favourable to it, a hot, dry atmosphere soon renders the parts stiff and

* Bull. Soc. Venet.-Trent. Sci. Nat., ii. (1883) pp. 119–25.

insensible. The last parts to move before death are usually the second or third pair of legs, more usually the third than the second, and the most mobile joint is the last of the tarsus.

From a few observations which he has made, Canestrini finds that with *Myriopoda*, as with insects, drought is unfavourable, whilst damp earth promotes the duration of movement. *Geophilus* shows no signs of inconvenience on being deprived of its head, and many specimens walked vigorously about for some days with the anterior end of the body elevated; in 10 days all movement had ceased. *Scolopendra* has considerable vitality if kept in damp earth; both the body and head have been found to move 8 days after the operation. *Julus*, under the same conditions, moves its legs, and especially the terminal joints, after 7 days, and the antennæ move for upwards of 48 hours.

Use of an adhesive substance by Arthropoda in jumping.*—H. Dewitz has already † shown the application of this principle to *walking*. But a *Cicada* in a closed glass tube is able to jump from the bottom on to the cover and from one vertical side to the other, turning in the air; the contingency of having to jump on to vertical surfaces or the under side of horizontal surfaces, occurs also in nature, viz. in the case of stems and leaves, which are, moreover, smooth, so that claws are ineffectual to support the insect, and sucking-disks would probably not act with sufficient rapidity. Now, the leaping spiders possess a well-developed pedal adhesive apparatus, by the aid of which they can remain attached to the surfaces on which they alight; the glands which secrete the liquid open all over the balls of the feet, and are especially numerous at their bases.

a. Insecta.

Relation of Light to Colour in Evolution of Species.‡—G. Lewis is disposed to attribute the origin of the colours of insects to the sun's rays rather than to sexual selection. He supposes a process "by which the various rays or wave-movements from the sun impress living organisms with the structure necessary for colour," and terms it "photoplasticity," basing his supposition on the alleged sufficiency of this mechanical theory of the action of light to explain the phenomena of colour. After giving many instances from the Insecta of protective coloration, he turns to examples, e.g. *Carabus*, where the coloration is not protective, and states his belief that the latter are due to the sun's action.

Constancy and Methodic Habits of Insects in their Visits to Flowers.§—A. W. Bennett finds that the different classes of insects show very great differences in this respect. Butterflies show but little constancy, except in a few instances; but they would appear to be guided to a certain extent by a preference for particular colours. The Diptera exhibit greater constancy, though by no means absolute.

* Zool. Anzeig., vi. (1883) pp. 273–4.
† See this Journal, *ante*, p. 363.
‡ Trans. Entomol. Soc. Lond., 1882, pp. 503–30.
§ Journ. Linn. Soc. (Zool.) xvii. (1883) pp. 175–85.

A much greater degree of constancy is manifested by the Apidæ; and this becomes all but absolute in the hive-bee. It is an interesting circumstance that this constancy appears to increase in proportion to the part performed by the insects in carrying pollen from flower to flower. A much larger number of observations is, however, needed in order to determine with certainty any general law, and especially a careful microscopic examination of the pollen attached to the proboscis, mandibles, legs, and under side of the abdomen and thorax. As respects preference for particular colours, the Lepidoptera paid, while under observation, 70 visits to red or pink flowers, 5 to blue, 15 to yellow, 5 to white; the Diptera, 9 to red or pink, 8 to yellow, 20 to white; the Hymenoptera, 203 to red or pink, 126 to blue, 11 to yellow, 17 to white.

R. M. Christy also records* in detail the movements of 76 insects while engaged in visiting 2400 flowers. He tabulates the results, and concludes that insects do possess a decided preference for a number of successive visits to the same species of flower, although this is not invariably the case. Most of the observations were made on bees, which seem to perform the fertilization of at least one-half of all the flowers fertilized by insects in this country. Butterflies, as a rule, seem to wander purposelessly in their flight; nevertheless some species, including the Fritillaries, are fairly methodic. The author believes that it is not by colour alone that insects are guided from one flower to another of the same species, and the sense of smell is suggested. Bees, he avers, have but poor sight for long distances, but good sight for short distances; of 55 humble bees watched, 26 visited blue flowers, 12 of the bees were methodic in their visits and 5 not so; 13 visited white flowers, 5 were methodic and 8 not at all; 11 visited yellow flowers, of which 5 were methodic and 6 not; 28 visited red flowers, 7 were methodic, 9 nearly so, while 12 were not. Mr. Christy inclines to the opinion (though admitting paucity of data) that bees, in a flight from their nest, confine their visits exclusively or principally to one species of plant.

Rudimentary Wings in the Coleoptera.†—Dr. H. Dewitz points out that the hind-wings of the Coleoptera show most distinctly how an organ may gradually become aborted by disuse, and how a transformation of the whole habit of the animal may be connected with this. The membranous hind-wings of beetles, which serve for flight, lie, as is well known, concealed beneath the firm horny fore-wings, the so-called elytra. For the purpose of flight the elytra are raised, and the folded hind-wings extended, so as often to exceed the former in length. But many beetles do not fly at all. In these we find the hind wings more or less aborted or entirely deficient. This phenomenon occurs with especial frequency among the Carabidæ, Melasomata, and Curculionidæ, and also, although less frequently, among the Ptinidæ.

As the wings are already indicated in the larva, Dr. Dewitz was inclined to think that, in one or other of the species entirely destitute

* Journ. Linn. Soc. (Zool.) xvii (1883) pp. 186–94.

† Zool. Anzeig., vi. (1883) p. 315. Ann. and Mag. Nat. Hist., xii. (1883) pp. 108–11.

of wings, traces of these organs would occur, at least in the larval or the pupal stage. For four years his labours were in vain, and it is only quite recently that he succeeded in demonstrating the rudimentary hind-wings in the larvæ and pupæ of *Niptus hololeucus* Cam., in which both sexes are apterous, i. e. destitute of hind-wings. The fore-wing occurs in the half-grown larva, but the rudiment of the hind-wing only shows itself much later when the animal is already on the point of terminating the larval stage.

We have in these rudiments of hind-wings an organ which is either advancing or has retrograded. That it is not an advancing organ, but one in course of disappearance, is shown most decidedly by the circumstance that this, like all retrogressive organs, does not, like those in full function, increase with the development of the individual, but, on the contrary, diminishes. We are therefore justified in assuming that *Niptus hololeucus* once bore well-developed hind-wings, and that these gradually became aborted in consequence of disuse, until they were finally thrown back into the young stages, and some day will disappear even from these stages. In other wingless beetles this period may have already occurred.

This abortion of an organ brings after it other transformations of the body. Without the hind-wings the beetles cannot fly. It is therefore not necessary for them to be able to spread out the elytra, the latter rather remain permanently lying upon the back. What is the consequence? The two elytra grow together to form a firm dorsal shield, such as we find in nearly all beetles which are entirely destitute of hind-wings. At the same time the elytra become convex, and bend round at the sides, so that they embrace the abdomen. In consequence of the disappearance of the wing-muscles, the thorax becomes altered. The body acquires quite a different form; new forms are produced which we call species.

Clasping Organs, accessory to generation, in Lepidoptera.*—P. H. Gosse's observations relate primarily to the Papilionid Butterflies, of which he describes the accessory male organs in sixty-nine species, belonging to two genera, from study of dry specimens. He finds the greatest divergence in the form of these parts between species which appear otherwise closely related, but hesitates to apply their characters to the classification of the group. The manipulation employed was as follows:—One of the anal valves is detached by making incisions along its hinge and then prising it off; the valve is examined, and the attached harpe sometimes detached; the organs still remaining in the abdomen are usually examined *in situ*, either dry or after introduction of a drop of water to swell the soft parts.

The parts described are:—1. *Valves* (De Haan), characteristic of the males in *Papilio*, more or less aborted in a few genera. 2. *Harpes* (lateral appendages? De Haan), one placed in the concavity of each valve; they are chitinous, transparent plates, varying from colourlessness to a very dark brown hue; the margins are usually thickened,

* Trans. Linn. Soc. (Zool.), ii. (1883) pp. 265–345 (8 pls.).

and these and other ridges are usually more or less beset with hooks or points. The form of the organs varies immensely, e. g. from that of claws, hooks, pikes, and swords, to mere knobs or combinations of these. The base is always expanded and disk-like. The muscles which work them are probably attached to two short, thick, chitinous processes placed at the bottom of the abdominal cavity. The function is certainly to grasp the female during impregnation, the teeth being frequently found clogged with scales. 3. *Uncus* (tegumen, Buchanan White). This name is applied to the hinder margin of the 8th abdominal segment, which is drawn out into a point in *Ornithoptera* and *Papilio*; and this point is usually armed with a strong horny spine. The form of the point varies much, being spoon-like in *Papilio Rhodifer*, bifid in *P. Agamemnon*, trifid in others, curved upwards in *Agamemnon*, downwards in other species, short and thick in *P. Antenor*, &c., slender and bowed in *Ornithoptera Arruana*, &c.; the margins are turned strongly up in *P. Machaon*, &c. The dorsal surface of the segment may be marked with depressions, or may have a median ridge of long hairs which project horizontally, so as to cover the generative cavity (*P. Agamemnon*, &c.), or the hairs are erect (*P. Erechtheus*, &c.). The uncus is absent in *P. Hector* and *Podalirius*. To the annular part of the 8th segment Mr. Gosse confines Buchanan White's term, *tegumen*. When the valves are fully developed, the uncus lies directly below the line of their dorsal point of opposition; from its lower surface two laminæ usually extend downwards, commencing near the point. The uncus combines with the harpes to grasp the female's abdomen. 4. *Scaphium* (lateral plates? De Haan) originates from the lower surface of the uncus near its base, whence it descends, dilating, and sends angular lobes back towards the abdomen. In *Papilio Machaon* and others the distal part resembles a mammalian lower jaw, in *P. Mayo* and *Pammon* a boat, a median cutwater and keel being readily distinguishable from the bulging sides in *P. Mayo*. In any case, the upper surface has two dilated margins, between which the uncus sometimes lies; these margins bear teeth resembling the mammalian double molar, the outer cusps being usually the larger, and having the form of a blunt peg, or a canine tooth, or one horizontal and recurvate or decurvate; or the two sets may form two equal, smooth cones; a third part is occasionally present; both are absent in *Ornithoptera Arruana*. In *P. Merope* the stout broad teeth are especially richly beset with notches and bristles. The double teeth are sometimes replaced (*Ornithoptera* spp.), occasionally accompanied (*Papilio Erectheus*) by a sharp ridge, cut into parallel erect teeth, by which the margins of the scaphium are produced upwards. The connections of the lower part of the scaphium are obscure, but its descending rami sometimes embrace, though they are apparently not in organic connection with the penis. It is usually opaque white, smooth and shining, and then must be mainly muscular, probably working not only its own teeth, but also the uncus, and perhaps in part the valves and harpes also; but in *P. Podalirius*, &c., it is more or less brown, and contains chitin. 5. The *Penis*, though not "auxiliary," is fully treated of, and its varia-

tions in shape and position described: it may not extend beyond the 8th segment, or it may (*P. Rhodifer*) project like a fine wire far beyond the end of the abdomen. The normally upper side consists of a cylinder of dense smooth chitin, lined by a soft pulpy white substance with shining surface. Occasionally the organ is connected with the scaphium or with the floor of the generative cavity by bands of tissue: in a few species it has a conical sheath, in one it traverses an aperture in a horny wall. It appears that the accessory organs grasp the exterior of the female abdomen, except the harpes, which perhaps grasp the vulva-valves, but their various forms in different species do not seem to be represented by corresponding modifications of the abdomen in the female.

Although he finds that the characters given by the shapes of these organs would arrange the species quite otherwise than the usual classificatory characters, Mr. Gosse finds them very constant in the same species, and even employs them to support his opinion as to the identity of nearly allied forms: thus he would unite *Papilio Agenor* Wallace and *Androgeos* Cramer with *P. Memnon* Linn., and *P. Androgeos*, *Thersites*, *Polycaon* and *Lycophron* with each other: in the case of *P. Nireus* and *Bromius* he is inclined to consider these very similar species as distinct creations, on the ground of the great differences between them in the whole of the external male generative apparatus.

In some other Butterflies examined, chiefly *Pieridæ*, these organs exhibit gradual disappearance. In *Pieris* the harpes are absent or delicate, and the scaphium may be absent. In *Callidryas* the valve is elaborate. *Gonopteryx* has no, or but a small scaphium, and the proper harpes may be absent. *Terias* seems to have no harpes, and the uncus is minute. *Colias* has no valves or harpes. *Morpho* seems to have no harpes or scaphium. *Dynastor* has its valves modified into formidable harpe-like organs, already foreshadowed in *Morpho*.

Mr. Gosse claims almost absolute novelty for the observations made by him.

Colour Preferences in Nocturnal Lepidoptera.*—L. P. Gratacap writes:—"For two seasons past (1881 and 1882) I have made fruitless attempts to reach some definite conclusions as to the relative importance of a few primary colours as attracting signals to night-flying insects. I do not know whether the plan adopted is original or not, and as it may yield some useful or interesting results in the hands of others, I briefly describe it. I made four or five sleeves, or cylinders open at both ends, of variously coloured tissue papers, and drew them over common kerosene lamps with glass chimneys, the familiar illuminating agents of all country homes, thus improvising a very serviceable and inexpensive Chinese lantern. The advantage of this arrangement consists in the ease with which the coloured sleeves can be changed, any combination of colours being secured without removing the light, and so a uniformity of light-power maintained at the several stations and for the several colours during one experiment.

* Amer. Natural., xvii. (1883) pp. 791–2.

The method also permits a very easy adjustment of lights in their intensity, by raising or lowering the wicks, and thus allows the observer to test the strength of mere illumination against attractiveness of colour as a hue for the insects. The planting of the lights seems important. I started by placing them in a row at long distances from each other. The defect of this arrangement appeared to be that the brilliancy of the first light, encountered by the insects coming upon it from its side or portion of the row, interfered with the visitor's freedom of choice as between that colour and another when the light from the others reached it in a dim and imperfect manner. The lanterns were then arranged in a square (four colours), whose dimensions were determined by the intensity of the several lights. The distance between the lanterns was such as to allow the limital circle of illumination of each at first to touch, and subsequently to intersect those of its neighbours. This distance was reduced until the separation between the lanterns was less than the radius of the circle of light which each threw around itself, the lights being of equal intensity. This proved unsatisfactory, and having devised no means of exhibiting a number of coloured lights so that the chances were equalized completely for insects coming from all sides, to choose according to any constitutional preference for one colour over another, I used only two colours at a time. The arrangement might be found useful to place four lanterns in two pairs, each pair of one colour, and in a diamond pattern, so that each colour appears equally prominent, no matter from what side the dazzled insect may approach the group. The apparent necessity for allowing the insect to choose instantly between the colours before it reaches either arises from the infatuation produced in the insects by the light, which, once reached, seems to obliterate all capability in the creature to free itself from its enticement, except in an irregular and accidental manner. My experiments proved nothing except the absence of any marked preferences for certain colours over others, and the almost invariably greater charm exerted by the white lanterns, which, on account of their translucency, appeared more brilliant than the coloured lamps."

β. Myriopoda.

Scolopendrella.*—J. Wood-Mason has some observations on this remarkable Myriopod, which he thinks to be more nearly related to the Chilognatha, though in the form of the body it resembles the Chilopoda. It would appear to be the descendant of a group of Myriopods, which have given rise to the Campodeæ, Thysanura, and Collembola. The form in question presents two of the most remarkable features of *Peripatus*—two-clawed feet and segmental openings; these last are the apertures which Ryder described as stigmata. The tracheal tubes themselves are all devoid from their very origin of the spiral thickenings in the walls, which are so characteristic of the trachea of insects; in the body the author has not been able to make out any tracheæ, except those which are meta-

* Ann. and Mag. Nat. Hist., xii. (1883) pp. 53–63.

merically arranged; these form arches, and do not seem to give off any tufts of tubes. The stigmata are very minute.

The fresh somites as developed appear to be intercalated by two at each moult between the antepenultimate and the penultimate sterna, as in the Chilognatha and some of the Chilopoda.

γ. Arachnida.

Auditory Hairs of Arachnida.*—F. Dahl has convinced himself by experiment of the existence of a sense of hearing in these Arthropods. A constantly repeated sound, produced without any manifestation perceptible to the eyes of the animal, near a spider moving slowly forwards, was followed each time by a sudden pause. Two kinds of hairs placed on the legs and palps appear to Dahl to be instrumental in receiving the sensations of sound: (*a*) a hair of equal thickness throughout, fringed with a short fine pile towards the apex; it is implanted in a cup-shaped depression and is extremely mobile; a nerve is connected with the base; (*b*) a hair set in rows and projecting outwards more than the ordinary protective hair. There are objections to the theories according to which these hairs might receive sensations of vibrations of the web or of the motions of the air, but the idea that they are sensitive to waves of sound is supported by direct observation, under a high magnifying power, of their vibration when a note was being sounded and of the cessation of the movement when it stopped. The gradual transition in the length of the hairs appears to the author to indicate adaptation to different notes, especially as their regularity in those which he calls *Kreuzpinnen*, which are decidedly fond of music, is marked; here they are short as if for perceiving high notes; they show great regularity in *Cœlotes atropos* also. From their constancy in the arrangement of the hairs Dahl is able to classify the German spiders as follows:—

1. *Epeiridæ* and *Theridiidæ*. Tibia provided with two rows of auditory hairs; metatarsus with a single hair; tarsus with a depressive but no projecting hair.

2. *Saltidæ*, *Thomsidæ*, *Lycosidæ*. Tibia, metatarsus, and tarsus all with two rows of hairs.

Among the Tubitelarian forms occur transitional stages, but most belong to the second division. The hairs of the legs occur on the upper side and are confined to the three terminal joints; the palps carry two irregular rows, on the penultimate joints only. The hairs found by Henking on the back of *Trombidium* have the same mobility as those just described, and Dahl has found them on the claw joints of the palps of *Chernetidæ* and of scorpions; the pits found by Haller in *Ixodes* very possibly come under the same category.

δ. Crustacea.

Integument of Decapod Crustacea.†—A. N. Vitzou, by a study of decapod crustaceans shortly after moulting, has been able to

* Zool. Anzeig., vi. (1883) pp. 267–70 (2 figs.).

† Arch. Zool. Expér. et Gén., x. (1882) pp. 451–576 (6 pls.).

demonstrate the constant possession of a chitinogenous layer, and the homology between the integuments of Crustacea and those of higher animals; there is a definite separation into dermis and epidermis. He has also been enabled to detect a close connection between the formation of fresh integuments and an abundance of glycogen.

The "first part of the epidermis" consists of a cuticle, a pigmented layer formed of parallel lamellæ traversed by canaliculi, a calcified layer, which forms by far the greater part of the carapace, and a non-calcified layer formed of very small lamellæ; the "second part" is represented by the cylindrical epithelium, which is the representative of the Malpighian layer of higher forms.

At the moment of ecdysis the new coverings of the crustacean are not completely formed, though one may distinguish all the different layers of chitine which can be made out in a well-formed integument; in the crayfish, at this moment, we may see, in sections, the old carapace, the new carapace, the chitinogenous epithelium, and the layer of connective tissue. The most remarkable character appears to be the constant presence of the third or chitinogenous layer, which is formed of large, more or less cylindrical cells; in the underlying tissue vessels and nerves are to be detected, and it, therefore, is truly a *dermis*, while all that lies outside it is *epidermal*. In the ecdysis it is only the outer layers of the epidermis that are cast off.

The author then proceeds to an account of the chitinous lining of the digestive tract, which presents a similar history to the external investment. As Max Braun was the first to point out, glands, which, from their position may be called salivary, are really present in the higher crustacea; glands of exactly similar structure to those of the œsophagus are to be found in the intestine, and the author has consequently some difficulty in forming an hypothesis as to their function.

The chitinous layers have a cellular origin, and this stratum of cells becomes of great size during the ecdysis, and diminishes again after the formation of the chitinous layers; but the diminution in length is not proportional to the thickness of the new layers, for it is compensated for by the using up of the glycogenic material which is contained in the large cells of the connective tissue. The process of growth in the integument is not due to the secretion of a chitinous material from the cells of the chitinogenous epithelium, but to the successive thickening of the superior portion of the cells which separates from the body of the cell; herein we find the explanation of the constitution of the integument by parallel lamellæ. Growth of the individual appears to take place before and not during the ecdysis.

The presence of glycogen and its origin is discussed, and it is finally regarded as being a reserve of organic material primarily due to a slowing of the processes of nutrition during winter and early spring; the term of "reserve of inorganic material" is applied to such calcareous concretions as the gastroliths of the crayfish. The author has borrowed many of the excellent illustrations which adorn Prof. Huxley's book on the crayfish.

Sense of Colour among some of the Lower Animals.*—Some years ago M. Paul Bert made a series of interesting experiments with the common *Daphnia*, exposing them to light of different colours, and he thought himself justified in concluding from his observations that their limits of vision at both ends of the spectrum are the same as our own, being limited by the red at one end and the violet at the other. In a previous communication † Sir John Lubbock has shown that on the contrary they are not insensible to the ultra violet rays, and that at that end of the spectrum their eyes were affected by light which we were unable to perceive. These experiments have recently been repeated by Mereschkowski who maintains that though the Daphnias prefer the yellow rays which are the brightest of the spectrum they are in fact attracted not by the colour but by the brightness; that, while conscious of the intensity of the light, they have no power to distinguish colours.

Given an animal which prefers the brightest rays, it may seem difficult to distinguish between a mere preference for light itself rather than for any particular colour. To test this, however, Sir John Lubbock took porcelain troughs about 1 in. deep, $7\frac{1}{2}$ in. long, and $2\frac{1}{2}$ in. broad. In these he put fifty Daphnias, and then in a darkened chamber threw upon them an electric spectrum arranged so that on each side of a given line the light was equal, and he found that an immense majority of the Daphnias preferred the green to the red end of the spectrum. Again, to select one out of many experiments, he took four troughs and covered one half of the first with a yellow solution, one-half of the second with a green solution, one-half of the third with an opaque plate, and he threw over one half of the fourth a certain amount of extra light by means of a mirror. He then found that in the first trough a large majority of the Daphnias preferred being under the yellow liquid rather than in the exposed half; that in the second a large majority preferred being under the green liquid rather than in the exposed half; that in the third a large majority preferred the exposed half to that which was shaded; and in the fourth, that a large majority preferred the half on which the extra amount of light was thrown. It is evident, then, that in the first and second troughs the Daphnias did not go under the solution for the sake of the shade, because others placed by their side under similar conditions preferred a somewhat brighter light. It seems clear, therefore, that they were able to distinguish the yellow and green light, and that they preferred it to white light. No such result was given with blue or red solutions. In such cases the Daphnias always preferred the uncovered half of the trough.

It is of course impossible absolutely to prove that they perceive colours, but these experiments certainly show that rays of various wave-lengths produce distinct impressions on their eyes; that they prefer rays of light of such wave-lengths as produce upon our eyes the impression of green and yellow. It is of course possible that rays of different wave-lengths produce different impressions upon their

* Journ. Linn. Soc. (Zool.) xvii. (1883) pp. 205–14.
† Ibid., xvi. (1882) p. 121.

eyes, but yet that such impressions differ in a manner of which we have no conception. This, however, seems improbable, and on the whole therefore it certainly does appear that Daphnias can distinguish not only different degrees of brightness but also differences of colour.

Vermes.

Anatomy and Histology of Polyophthalmus pictus.*—E. Meyer gives a detailed account of the structure of this Polychætous Annelid. The nervous system is described as consisting of (1) a cerebrum made up of several pairs of ganglia, and appearing externally not to be composed of two lateral symmetrical lobes, but as compact and smooth; (2) of two long œsophageal commissures, and (3) of a ventral cord which presents distinct swellings in its anterior portion only. In dealing with the sensory apparatus, attention is directed to the ciliated organs which lie just behind the cephalic lobes. These do not appear to be, as Quatrefages has thought, organs comparable to the "wheels" of the Rotatoria, but rather as something analogous to the olfactory organs of higher forms. The species in question has twelve pairs of lateral eyes, which seem to have the same typical structure as the eyes of other Annelids.

The body-cavity is divided into three chambers; the largest of these is perivisceral, and contains the digestive tract; the other two are smaller, and are placed at the sides. There is not, for the greater part of the cœlom, any metameric cameration; some of the segmental organs appear to function as efferent ducts for the generative products.

Annelids from Thau.†—H. A. Robin gives some account of *Pionosyllis pulligera* and *Grubea limbata;* with regard to the former, he points out that Claparède had noted the presence, in those segments of the adult male that lie in front of the testicular segments, of a number of cæcal tubes, which seemed to be segmental organs in a greatly modified condition, and possibly of testicular function. The author has been able to convince himself that the structures in question are pedal glands, and that they cannot be considered as testicular, inasmuch as they are often found in the same segment as a well-developed testicle. In both the species examined the young appear under the chætopodous form, and do not pass through a larval stage; on escaping from the egg, the young has a well-developed head, although this is not distinct from the buccal segment; there then succeeds an apodal, then three setigerous segments with feet, and then an anal joint. The head is provided with antennæ and eyes, but has no pigment-spots; behind the eyes the young may be seen to be provided with ciliated pits analogous to those found in the Nemertinea, but they do not seem, as is the case with *G. fusifera*, to be carried on into the adult stage.

Observations on Phreoryctes and Nais.‡—R. Timm finds that the cuticle of *Phreoryctes* is not only much better developed, but that its

* Arch. f. Mikr. Anat., xxi. (1882) pp. 769–823 (2 pls.).
† Bull. Soc. Philom. Paris, 23rd December, 1882, 7 pp.
‡ Arbeit. Zool.-Zoot. Inst. Würzb., vi. (1883) pp. 109–57 (2 pls.).

elements are larger than in other Oligochæta; in transverse sections one may observe a distinct striation, and in surface views a system of intercrossing bands, formed of fibres. The setal follicles are provided with large orifices which are set in the long axis of the body, and, in addition to these, there are the openings (macropores) of the canals of the dermal glands, and a large number of "micropores." Similar observations on the structure of the annelid cuticle have been made, and will shortly be published by Voigt, who has especially busied himself with *Branchiobdella*. After describing the setæ, the author passes to the *epidermis*, and then to the *musculature*, the different parts of which are fully described. The blood-vascular system is stated to have the closest relation to the intestine, and the account of Leydig is, on the whole, confirmed.

The nervous system displays, from the third segment backwards, the arrangement of a double ganglionic swelling in each segment; these two parts are connected together by the ordinary œsophageal commissures. Notwithstanding their distinct separation, these double ganglia must be regarded as the enlargements of a single ganglion, inasmuch as the investment of ganglionic cells is not broken in the intermediate space, although it is reduced in the longitudinal commissure which traverses the dissepiment to a median and ventral row of cells; and, further, the number and distribution of the primary nerve-branches in each segment of *Phreoryctes* correspond to the relations found in other Oligochæta. After describing the general distribution of the nerve-trunks, the author points out that the nervous connection with the epidermis is distinguished by a distinctly dotted striation, such as is characteristic of fine nerve-fibrils. In the head the elements of the nervous system are of considerable size.

The well-developed septa consist of two membranes of connective tissue, which are separated off from the general peritoneum which covers the longitudinal system of muscles; owing to the great development of the fat-bodies in the neighbourhood of the segmental organs, the perivisceral fluid occupies a proportionately small space.

By the aid of high powers, Timm was led to think that the cuticle of *Nais* was characterized by the presence of a number of extremely fine holes, but he was not able to absolutely convince himself of this. Among the remarkable forms of setæ in this genus the author detected one which, as he thinks, has not been yet described, and the species in which it is found being apparently new, their form justifies the application of the specific term *hamata*.

The ventral medulla is not so distinctly segmented as in the other Oligochæta, a fact which is probably to be explained by the rich development of the cells on the ventral surface, for these frequently cover the whole of the under side of the longitudinal commissures. The author confirms the observation of Semper that, at the end of the body, the ventral medulla (at least in all asexual forms) passes directly into the epidermis. The supra-œsophageal ganglion consists of two fairly separated halves, the ganglionic investment of which passes directly into the layer of cells which invests the cæcum connected with the œsophagus.

A few free-cells (corpuscles) are to be found in the blood. The paper concludes with some comparisons between sexual and asexual forms, and the descriptions of the two new species *N. hamata* and *N. lurida*. Many of the author's observations will be found to confirm the accounts of those who have preceded him.

Glands of Morren in the Earthworm.*—C. Robinet finds that if the secretion from the glands of Morren is allowed to dry, experiments prove that we have in it a mineral body; further observation shows that this is formed of carbonate of calcium, and its function would appear to be:—

1. To neutralize the acids of the humus, and to convert an acid nutrient medium into a neutral one, a condition which is indispensable for the digestion of the quaternary substances of the humus by the digestive fluid of the hepatic glands.
2. To transform part of the carbonate into soluble bicarbonate.
3. The soluble bicarbonate acts on the humus, and forms soluble salts from the insoluble acids of the humus. The ulmate of calcium which is formed by the action of the ulmic acid on the carbonate of calcium becomes soluble in the presence of an excess of carbonic acid.
4. The soluble ulmate thus obtained is more easily absorbed in the intestine.

Processes of Division and Regeneration in Earthworms.†—G. Bülow has directed his studies especially to *Lumbriculus variegatus*, and he finds that, in addition to the usual sexual method, reproduction may be effected by simple transverse division, when either the head or the tail, or both, may be redeveloped. No zone of gemmation is first formed, as in *Nais*, nor is the process of reproduction from behind forwards, as Bonnet thought, but in the opposite direction. The result of the process quickly acquires individuality, two days being sufficient for the appearance of all the essential characters. Among other experiments, he relates one in which a worm was cut into fourteen pieces, and of these thirteen became complete individuals; in some cases the effects of the experiment were hardly satisfactory, inasmuch as a worm that had been operated upon gave rise to two equal caudal ends. The author's observations gain in value from the exact and careful manner in which his results have been registered.

Excretory Organs of Hirudinea.‡—O. Schultze has examined the excretory apparatus of *Clepsine complanata*, *C. bioculata*, *Nephelis vulgaris*, *Aulostomum gulo*, and *Hirudo medicinalis*. He finds that there is a continuous connection between the narrowest and the widest lumen of the ducts, and that as the lumina become wider the ducts become less elaborately branched and the cells diminish in number; a gradation in the ramification and coiling of the lumina may be seen, as we pass from *Clepsine* and *Nephelis* to *Aulostomum* and *Hirudo*. The study of the development of the segmental canals gives indications of a marked agreement in the typical structure of the excretory organ,

* Comptes Rendus, xcvii. (1883) pp. 192–4.
† Arch. f. Naturg., xlix. (1883) pp. 1–96.
‡ Arch. f. Mikr. Anat., xxii. (1883) pp. 78–92 (1 pl.).

while the absence of the ciliated funnels in certain species may be regarded as a retrogression comparable to what obtains in the renal organs of higher animals.

A comparison is instituted between the excretory organs of the leeches and of the earthworm, which deserves study, but is not to be explained without the aid of a number of figures.

Nervous System of Solenophorus.*—H. Griesbach, who is, in a number of points, enabled to confirm the results of Roboz on *Solenophorus megalocephalus*, describes the ganglia of the scolex as consisting of four ganglia arranged in cruciform fashion, but in two planes; their substance consists of unipolar and bipolar cells, but the processes are often altogether absent, and the cells then appear to be rounded; the ganglia are connected by more or less delicate commissures, and they give off peripheral nerve-branches. From the more deeply lying median ganglia a well-developed nerve is given off on each side, which appears to embrace the adjacent sucker. There are signs of these nerves breaking up into fine branches. In the strobila there are two longitudinal nervous trunks, which take their origin from the median ganglia of the scolex, and pass along the margins of the proglottids. The author inclines to the view that we have here to do with an undifferentiated ventral medulla.

Development of Planaria polychroa.† — E. Metschnikoff was directed to a study of this form in the hope of being able to find an explanation of the intracellular mode of digestion, and of being able to solve the question as to how far that method is a primitive one. The effort has, however, been vain.

The author finds that, at an early stage, the embryonic cells enter into so close a relation with the mass of the yolk-cells, that it is for a long time impossible to find any boundary between them; in certain stages of embryonic development two constituents could be distinguished; there were a number of fused yolk-cells, and a much smaller number of embryonic cells which had already become differentiated into an epidermis, a pharynx, and into more indifferent subepidermic cells. Although these are quantitatively more unimportant, they are qualitatively much more important, for the fused yolk-cells serve exclusively as nutrient and supporting material for the active embryonic cells.

Each stage in the further development of the embryo is marked by the presence of a large number of yolk-cells within the body of the larva; during the third day the last remains of the free yolk-cells are absorbed by the larva, which now becomes considerably altered in form.

Notwithstanding this change of form, these larvæ still retain some of their most marked characteristics; they appear to be radially arranged animals, in which the cortical layer of embryonic cells surrounds a considerable mass of yolk-cells. From the third to the fifth day a marked increase is to be observed in the number and size of the

* Arch. f. Mikr. Anat., xxii. (1883) pp. 365–8.

† Zeitschr. f. Wiss. Zool., xxxviii. (1883) pp. 331–54 (3 pls.).

epidermal cells; the nutrient material for this activity is clearly afforded by the fused mass of yolk-cells, the nuclei of which may be observed to be undergoing retrogressive metamorphosis. No evidence, however, could be obtained as to the direct conversion of the yolk-cells into endodermal elements; we seem rather to have here to do with a remarkable substitution of organs. The yolk-cells appear to be vicarious endodermal cells, which have undertaken their duty in consequence of a shortening of the process of development. Primitively a true primary endoderm must have been developed, and then the yolk-cells served as nothing more than nutrient material. Indications of the remains of a primary endoderm are to be sought for in a small group of cells which lies below the pharynx, the early development of which organ clearly stands in relation to the important part played by the yolk-cells. It has not till yet been known that a rudimentary organ could become differentiated before the formation of the germinal layers or the body-wall; here, however, we have an example of a pharynx being developed before the definite differentiation of the ectoderm and mesoderm. This being so, we must not wonder if the central nervous system of the fresh-water Triclades shall be shown to be formed from the mesoderm. It would hardly be so remarkable an example of cenogeny.

Remarkable as are the embryonic adaptations presented by these forms, they are not without their like in the animal kingdom; thus, in the Tunicata, the atrial cavity may be developed in very different ways, and by modes which can hardly be supposed to be the primitive ones. The mesodermal origin of the rudiment of the cerebrum has been noted in some Mollusca, and there are, in fine, quite a series of embryonic adaptations which affect most intimately the differentiations of the germinal layers. Indeed the Tunicata, where, as Salensky has shown, the blastomeres of the embryos of *Salpa* disappear to be replaced by follicular cells, afford even better than *Planaria polychroa*, the most striking examples of cenogeny.

Echinodermata.

Physiology of Echinodermata.*—Dr. G. J. Romanes has already shown † that the ocelli at the end of the rays in starfish, and occupying the homologous position in Echini, perform a visual function—inducing the animal to seek the light so long as the ocelli are intact, and the animals ceasing to be affected by light when the ocelli are removed. He has now tried whether these organs might not have an olfactory as well as a visual function. Having procured some fresh starfish, he dropped little pieces of limpet and crab in their vicinity. None of them, however, approached the food. Supposing it possible that the starfish, having been freshly caught, might not be in want of food, he left them in a tank for a couple of days, and then repeated the experiment. The result was now quite different, for the starfish began actively to crawl in the direction of the food. Selecting, therefore,

* Journ. Linn. Soc. Lond. (Zool.) xvii. (1883) pp. 131–7.
† Croonian Lecture, Phil. Trans., 1881, pp. 829–85.

one individual, and putting it in a large dish which was filled with sea-water, he found that he could at pleasure lead the starfish in any direction by holding a morsel of crab an inch or two from the end of one of its rays, and continuously withdrawing the food as the starfish approached it. Moreover, he could at any time reverse the direction of advance by transferring the food to the opposite side of the animal, and holding it for a short time near the tip of a ray. Thus he could entertain no doubt that starfish have a well-developed sense of smell.

With the view of ascertaining whether or not this sense is localized in the ocelli, he removed the latter from all the rays of the same starfish, and then repeated the experiment. The result was the same, thus showing that the ocelli are not specially concerned in the sense of smell. Nor was there any change produced when the rays were progressively truncated further and further down: the olfactory sense was found to be distributed throughout their length, and as the author considers, as the result of other experiments, over the lower surface, while not extending to the upper surface.

Confirmation is also given to the view that one function of the pedicellariæ, at all events, is that of assisting locomotion by seizing fronds of seaweed, to hold them steady until the pedicels have time to gain attachment by their adhesive disks.

When an *Echinus* is inverted on a flat surface under water, so that it rests upon its aboral pole, it will quickly right itself by using two or more adjacent rows of pedicels; and in his earlier paper the author discussed the question whether the execution of such a manœuvre was to be considered due to the co-ordinating influence of a nerve-centre having a dim sense of gravity, and feeling, as it were, this sense disturbed by the unusual position in which the animal is placed; or whether the manœuvre was to be considered due merely to the serial action of the pedicels themselves, sundry experiments tending to show that the manœuvre must at least in part be due to the co-ordinating influence of a nerve-centre. Mr. F. Darwin, having read the account of these experiments, suggested an additional one, which Dr. Romanes has tried, with the result of definitely settling the question. This experiment and its results are as follows:—

An *Echinus* is inverted with its aboral pole resting on the bottom of a large bottle filled to the brim with sea-water. The mouth of the bottle is then corked (no air-bubbles being included), and placed upon the rotating apparatus which Mr. Darwin and his father used for investigating the geometrism of plants, so that the *Echinus* was continuously rotated in a vertical plane. So long as the rotation was continued, whether rapid or slow, the *Echinus* did not attempt to right itself; but, when the rotation was allowed to cease, it began to do so after two or three minutes. Moreover, if allowed to do so until it had raised itself into the equatorial, or any other intermediate position, and the rotation were then resumed, the position gained was permanently retained so long as the rotation was continued. Therefore no doubt could be entertained that the effect of the rotation was that of confusing, as it were, the co-ordinating influence of a nerve-centre,

the stimulus to the operation of which, in the absence of rotation, is gravity.

A short account is given of the effects of nerve-poisons on the Echinodermata, the poisons tried being chloroform, caffein, nitrite of amyl, chloral hydrate, alcohol, strychnia, nicotin, curare, digitalis, and cyanide of potassium.

Organization of Echinoderms.*—E. Perrier states that the studies of several years have led him to very different results as to the structure of the arms of Comatulids, as compared with those obtained by Dr. Carpenter, and since discussed and variously interpreted by P. H. Carpenter, Ludwig, and others. Perrier's observations have been chiefly made on young or re-developing arms, while those of the writers just named have been made on fully formed arms.

Ludwig has described, in Comatulids, a complicated circulating apparatus, the centre of which is formed by a remarkable organ, which is variously known as the heart or the dorsal organ, and which has been thought to correspond to the so-called heart of the Echinozoa. Perrier believes that he has demonstrated that this organ in Asteroids and Echinoids is of a glandular nature, and he finds that in Crinoids it has the same structure as in other Echinoderms, and should, as in them, be spoken of as the *ovoid gland*. As seen in the pentacrinoid stage of a Comatulid it forms a fusiform body, continuous with the axial cord of the stalk; in an adult Comatulid it is set on one of the horizontal lamellæ of the chambered organ, the nervous nature of which has been insisted on by the Carpenters. Perrier finds that, not only do the fibro-cellular cords which are given off from it present the appearance of true nerves, but that, wherever muscles are found, these muscles are in close connection with the ramifications from it. These ramifications divide into a large number of cords, the final branches of which terminate in stellate cells, each of which is continued into a muscular fibre. The ramifications are also connected with the fibres contained in the ambulacral tentacles.

The author thinks that the connection of the axial cords of the arms and cirri with the organs of sensation and of movement confirm the doctrine of Carpenter. So close is the connection between the various tissues of the animal that the nervous system remains in a remarkably non-differentiated condition; however this may be, the chambered organ ought to be considered as the central part of this system in Crinoids.

From his studies on the development of the pinnules Perrier finds that, in structure, the arms and pinnules are at first identical. "If a pinnule continues to be developed it becomes a ramification of the arms." Further details with regard to the points here noted in abstract are promised.

'Challenger' Ophiuroids.†—T. Lyman's beautifully illustrated volume will be of the greatest service to the student of the specific characters of the Ophiuroidea. In addition to a detailed and technical

* Comptes Rendus, xcvii. (1883) pp. 187–9.

† Zoology, H.M.S. 'Challenger,' xiv. (1882) 386 pp. (48 pls.).

description of the new forms, already described in the Bulletins of the Museum of Comparative Zoology at Cambridge, U.S.A., the author has included the names and distribution of, with references to some of the literature on, previously described species. Keys of the specific characters are given with most of the genera, and geographical and bathymetrical lists complete the work. Anatomical observations have been made on some species, and are incorporated as occasion offers. There are, however, no general remarks on the arrangement of the genera, and the introduction is chiefly remarkable for its attack on two principles dear to most modern zoologists; one is the application of the doctrine of descent, and the other the necessity of applying definite technical terms to definite characters and conceptions. Mr. Lyman, in genial but strongly expressed paragraphs, expresses his views on these questions.

New Ophiuroids.*—T. Lyman remarks that the West Indies are the hotbed of Echinodermata; more than a quarter of the known Ophiuroids are from that region, and nearly all genera are found within it. As in other groups of animals, some genera are very rich in species, *Ophioglypha*, *Amphiura*, *Ophiacantha*, and *Ophiothrix* containing two-thirds as many species as do all the remaining 68 genera in the family. A peculiar structure does not, as *Ophiomyxa* bears witness, necessarily entail abundance of species. The author gives a technical account of a number of new species, one of which, *Ophiocreas spinulosus*, lives, like some other forms, in great colonies. The tangles often came so clogged with hundreds of specimens that it was necessary to cut them off and throw the mass into alcohol.

New Crinoid from the Southern Sea.†—P. H. Carpenter describes a small *Comatula* which was dredged by the 'Challenger' at the depth of 1800 fathoms in the Southern Sea. Although it is unusually small, the diameter of the calyx being only 2 mm., the characters presented by this form are such as to render it by far the most remarkable among all the types of recent Crinoids, whether stalked or free. The name proposed for it is *Thaumatocrinus renovatus*. It is distinguished by four striking peculiarities:—

1. The presence of a closed ring of basals upon the exterior of the calyx.

2. The persistence of the oral plates of the larva, as in *Hyocrinus* and *Rhizocrinus*.

3. The separation of the primary radials by interradials which rest on the basals.

4. The presence of an arm-like appendage on the interradial plate of the anal side.

Taking these in order—

1. No adult *Comatula*, except the recent *Atelecrinus* and some little-known fossils, has a closed ring of basals, and even in *Atelecrinus* they are quite small and insignificant.

2. In all recent *Comatulæ*, in the *Pentacrinidæ*, and in *Bathy-*

* Bull. Mus. Comp. Zool. Camb., x. (1883) pp. 227–87 (8 pls.).
† Proc. Roy. Soc., xxxv. (1883) pp. 138–40.

crinus, the oral plates of the larva become resorbed as maturity is approached. In *Thaumatocrinus*, however, they are retained, as in *Hyocrinus*, *Rhizocrinus*, and *Holopus*, representatives of three different families of Neocrinoids.

3. There is no Neocrinoid, either stalked or free, in which the primary radials remain permanently separated as they are in *Thaumatocrinus*, and for a short time after their first appearance in the larva of ordinary Crinoids. The only Palæocrinoids presenting this feature are certain of the *Rhodocrinidæ*, e. g. *Reteocrinus*, *Rhodocrinus*, *Thylacocrinus*, &c. In the two latter and in the other genera which have been grouped together with them into the section Rhodocrinites there is a single interradial intervening between every two radials, and resting on a basal just as in *Thaumatocrinus*. But in the Lower Silurian *Reteocrinus* the interradial areas contain a large number of minute pieces of irregular form and arrangement.

4. It is only, however, in *Reteocrinus* and in the allied genus *Xenocrinus* Miller, which is also of Lower Silurian age, that an anal appendage similar to that of *Thaumatocrinus* is to be met with.

Of the four distinguishing characters of *Thaumatocrinus*, therefore, one appears in one or perhaps in two genera of *Comatulæ;* another is not to be met with in any *Comatula*, though occurring in certain stalked Crinoids; while the two remaining characters are limited to one family of the Palæocrinoids, one of them being peculiar to one or at most two genera which are confined to the Lower Silurian rocks. Their appearance in such a specialized type as a recent *Comatula* is therefore all the more striking.

Cœlenterata.

Cœlenterates of the Southern Seas.*—R. v. Lendenfeld in his third communication deals with offensive polyps and stinging-cells. Taking the former as they are found in the Plumularidæ he finds that they are referable to three primary groups—offensive animals with stinging-capsules, offensive animals with attacking-cells, and offensive animals with both. The first of these are described, and it is pointed out that if we start from a *Protohydra* with hollow tentacles we find that, as it is gradually converted into an offensive polyp of a Plumularid, there is a gradual compression of the gastric cavity. The tentacles first become solid, and then the gastric walls fuse; the centralization of the gastric cavity in the person is followed by centralization in the colony.

The forms of the second class are principally found in those nematophores of the species of *Aglaophenia* which lie in front of the nutrient persons. Instead of urticating-capsules they are provided with attacking-granules which absolutely correspond in structure to the similar elements in the "fishing-lines" of the Ctenophora. The polyps of the third class have as yet only been observed in the genus *Aglaophenia;* the nematophores which contain this kind of "macho-polyp," have, in addition to the circular orifice at their end, an oval

* Zeitschr. f. Wiss. Zool., xxxviii. (1883) pp. 355–71 (1 pl.).

lateral space. At first sight it might be thought that we had here to do with two modified polyps, but the simple undivided endodermal axis shows conclusively that there is only one. The author thinks that the cells in which the attacking-granules are developed have a great resemblance to the dermal glands seen in many Cœlenterates, and he regards the granules, which, like the stinging-capsule, only act once, as being *secretions*.

In the gelatinous tissue of the umbrella of *Crambessa mosaika*, v. Lendenfeld observed granular filaments which appeared to be of a nervous nature, and which were certainly in connection with the cnidoblasts, and probably with the sensory epithelium. In other words, we here meet with a cnidocil which does not work mechanically, but under the influence of a stimulus conveyed through the fibre; the protoplasm of the cnidoblast has here the form of a closed tube, the regular contraction of which would act on the sides of the capsule and cause the protrusion of the filament.

In teased preparations of *Cyanea annaskala* the author has frequently observed cnidoblasts, the centripetal processes of which are connected with ganglionic cells of the subepithelial layer. These processes are not hyaline but granular, and their protoplasm does not differ in character from that which surrounds the urticating capsule and lies around the nucleus.

It appears to be very probable that there is a continuous connection between the nervous system and the protoplasmic covering of the urticating capsule, which, therefore, is acted upon by the pressure which the covering exercises upon it. In *Cyanea annaskala* there is, in addition, a small stellate body, which passes through the integument of the distal pole. In *Physalia* muscular fibres are developed in the protoplasm. The contraction of the protoplasm is brought about by a stimulus from the nervous system, which is comparable in its action to a reflex action; in addition, however, there is evidence of the possession by the nervous system of an inhibitory influence.

The author concludes by expressing his conviction that the cnidoblasts must be looked upon as unicellular dermal glands.

Observations on Medusæ.*—Dr. O. Hamann's first essay deals with the development of the generative organs of the Discomedusæ, as to which we have as yet only the scattered observations of Claus and the Hertwigs on mature forms. The author has been able to make some observations on *Nausithoe punctata*, a representative of a subfamily of the Ephyridæ.

In the Ephyrula-stage of *Nausithoe*, in which there is only one gastric filament in each interradius, we may detect the first rudiments of the generative organs; there is a thickening of the gastric epithelium of the subumbral wall of the stomach. Soon a distinct supporting lamella is developed, into which the ova migrate, and within the saccule a cavity is developed; where the gastric epithelium forms the wall of the saccule the cells have a palisade-like arrangement. With regard to the testes we find that the cells which lie in the centre

* Zeitschr. f. Wiss. Zool., xxxviii. (1883) pp. 419-29 (1 pl.).

of each testicular follicle soon begin to divide into smaller cells, and the spermatozoa appear in the centre of the follicle, whence they extend peripherally until at last there are only one or two layers of large cells, the rest of the space being occupied by smaller cells, and the free spermatozoa; the head of these last is pyriform.

In *Pelagia noctiluca* it was observed that the rudiments of the generative organs were laid down very early, in the form of four bands, set beneath the gastric filaments; on one side of each band the cells are thickened to form a germinal epithelium; as soon as the products have attained a certain size they pass into the supporting lamella, which, at last, becomes completely filled with them.

The chief result of these investigations is to show that, among the Discomedusæ, the Ephyridæ alone present an exception to the mode of development and structure which is found to be common to all the rest; while there are certain Ephyridæ which can be altogether brought into association with the other members of their family —e. g. *Collaspis achillis*.

In the present state of our knowledge we cannot derive the generative organs of the Discomedusæ from those of the Ephyridæ; these organs in the latter group would appear to be independent formations; and this being so it is possible that Haeckel is not justified in regarding the Ephyrid as the primitive form of the Discomedusæ.

Hamann's second essay deals with the development of *Tiara pileata;* the ova are devoid of any membrane, segmentation takes place with extreme rapidity, and cleavage is quite regular. The gastric cavity of the gastrula is an elongated slit. The observations made on this form bring to mind those of Claus on *Æquorea forskalea*, and seem to show that there is a direct connection between the processes of invagination and delamination in the formation of the gastrula.

Reproduction of Hydroid Polyps.*—A. de Varenne here gives a full account of his work.† Having studied the development of the ovum in a number of species, some of which had fixed sporosacs, some fixed gonophores, and some free-swimming gonophores, he finds that, in all, the ovum arises from a cell of the differentiated endoderm of the cœnosarc of the polyp; all intermediate stages may be observed between the ordinary endodermic cell and a well-developed egg-cell; the differentiated cells pass into a bud which, at first, is nothing more than a cæcal diverticulum of the body of the polyp; the differentiated cells thither conveyed become united into groups. Occupying the endoderm of the diverticulum, they are in direct contact with the gastro-vascular cavity. The diverticulum grows and finally becomes a sporosac, a demi-medusa, or a free medusa. Experiments have shown that it is the presence at certain points of a certain number of ovules that determines the formation at these points of gonophores or medusæ; and that, far from being anterior to the ova or spermatozoa, the gonophores are posterior to them. It seems to the author that, if the generative products arrive in the gonophores in an already

* Arch. Zool. Exper. et Gén., x. (1882) pp. 611-710 (10 pls.).

† See this Journal, *ante*, p. 72.

differentiated stage, we cannot regard the gonophore or the medusa as a sexual form or as representing the sexual generation. The author further insists on the view that a sporosac and a medusa are morphologically identical.

In answer to the question—If the products arise in the polyp itself and not in the so-called sexual buds, what are the sporosacs or medusæ? the author answers that they are individuals specially adapted for reproduction, which receive their sexual elements and insure their safe development; but they do not give rise to them. These elements arise in the colony itself and it is, therefore, impossible to regard the gonophores and medusæ as individuals which alone are sexual, in opposition to the polyp, which is generally regarded as the asexual individual. In other words, alternation of generation does not really obtain in the species examined by M. de Varenne.

The author finds that the mother-cells of the spermatozoa are endodermic in origin, and that there is no exception to this rule.

The history of *Podocoryne carnea* is followed out in detail, and the conclusion arrived at that, in species with free-swimming medusæ, the development of the ovum is exactly similar to that which obtains when the gonophores remain fixed to the colony.

New Hydroid Polyp.*—Prof. E. D. Cope describes an interesting form of hydroid polyp found in large numbers on the bark of submerged trees in Upper Klamath Lake, Oregon. Its cœnœcium is a mass of creeping yellowish stems imbedded in sarcode. Each zooid is of an elongate oval form, sessile, and with six rays of equal size, each one-half as long as the body. The zooids are translucent, but with two oval bodies in the lower half of the body-cavity of a yellow colour. These are collected in masses as large as the fist. The length of each zooid is 1 mm. They did not extend themselves beyond this length, neither did the rays elongate to beyond half the same during the time they were observed. They retracted themselves on being irritated. They do not possess any fringes like the arms of the Polyzoa. As the possession of a cœnœcium distinguishes this genus from all the fresh-water hydroids, it was proposed to distinguish it as the type of a new genus with the name *Rhizohydra*, the species being named *flavitincta*. An attempt to preserve some of the masses of zooids in alcohol was not successful.

Hard Structures of the Fungiidæ.†—Prof. P. M. Duncan has followed up his recent study of the corallum of the sub-family *Lophoserinæ* by that of the twin sub-family of the *Fungiidæ*, viz. the *Fungiinæ*. As in the former case, the synapticula have received most attention, and the general result of the investigation is to confirm and enforce the great morphological importance originally attributed to these structures by Milne-Edwards and Haime. In *Fungia scutaria* var., this is shown by several circumstances: (1) the co-existence with synapticula of the usual granules of the surface of the septa,

* Acad. Nat. Sci. Philad., 1883.

† Journ. Linn. Soc. (Zool.), xvii. (1883) pp. 137–62 (2 pls.).

showing that they are not homologous with these structures; (2) the occurrence of synapticula whose structure is seen under the Microscope to be discontinuous with that of the septa; (3) the synapticula in some cases showing a flat surface when the septum is broken off from it; * (4) the basal wall being formed of fused synapticula. In *Fungia echinata* the synapticula are more slender, are vertical instead of oblique, and near the circumference form series of granules instead of ridges.

In the multi-caliculated genus *Herpolitha* (*Herpetolitha* auctt.) the faces of the septa exhibit an ornamentation consisting of ridges and granules, varying in different parts, and none of the septa are perforated, as is the case in *Fungia*. The synapticula are either curved or vertical; towards the margin of the corallum they may be represented by discontinuous knobs; sometimes the surface which is usually in contact with the septum is found free.

Of *Halomitra*, a genus which includes *Podabacia* and part of *Fungia* of Milne-Edwards and Haime, *H. crustacea* Rumphius was examined. In the large centre calicle the septa may be either solid or fenestrate; but in the latter case the hard trabeculæ are very solid and well defined. The synapticula are usually vertical; and where the septa are fenestrate they are either confined to the non-fenestrate part of the septum or else maintain their own continuity by winding along its trabeculæ.

In the group generally the synapticula are grooved in two directions; they are as stout between thin as between thick septa. The hard, "fibrous" structure of the corallum is composed of elongate prisms or fusiform spicules. Prof. Duncan has found soaking the corals in weak carmine solution a useful plan for bringing out the more minute ornamentation and sculpture of the septa.

Porifera.

Ovum of Marine Sponges.†—H. J. Carter has discovered the presence of starch-granules in the ovum of Marine Sponges. First observed in *Suberites domuncula*, where the yolk contains starch-granules of a greyish-white colour, the observation has since been extended to *Isodictya simulans*, *Halisarca lobularis*, and others, where evidence was afforded as to the animal nature of the organisms "in spite of the resemblance of the ova of sponges to the seed of plants, inasmuch as it was found that the sponge-embryo developes a root for fixation only, and a superstructure for supporting organisms that take in crude material for food."

The author makes a few observations on the characters of the spermatozoa of sponges, and expresses his opinion that, even with the late observations of Poléjaeff on *Sycandra raphanus*, there is not yet any character given to the spermatic cell by which it may be satisfactorily recognized by the inexperienced student; and he concludes

* The author, however, admits that in some cases the synapticulum is a septal structure.

† Ann. and Mag. Nat. Hist., xii. (1883) pp. 30–6.

with the interesting observation that the colour of the ova of sponges generally follows that of the parent, becoming more marked towards maturity. Polejaeff does not state the date at which he observed the spermatozoa of *Sycandra raphanus*, though this is an important point of which observers should take due note.

New British Sponge.*—J. G. Waller describes a sponge belonging to the lowest form of film sponges, found by him at Torbay on an oyster shell cast upon the shore, filled with *Cliona northumbrica*. It apparently belongs to Bowerbank's genus *Hymeraphia* and is specially distinguished by spicules in the form of forceps, as sugar-tongs, or more nearly a lady's hair-pin. The author gives the sponge the specific name of *forceps*.

Protozoa.

Cothurnia lata.†—Prof. D. S. Kellicott thus describes a new species of *Cothurnia*, attached to a species of *Diaptomus*, having a stalked spreading lorica with an open, wide aperture, in allusion to which he named it *Cothurnia lata*.

"The lorica is transparent, light yellowish brown, extreme length twice the width of the aperture; the lorica is compressed laterally, so that the sides are nearly plane and parallel. The posterior edge is uniformly curved outwards, or convex; the other edge is concave, so it is widest at the top. The aperture is not everted, narrowly ellipticated, sometimes with one side more convex than the other; the margin of the aperture is slightly elevated near the middle. The peduncle is about one-fourth as long as the sheath, and curved. The body of the zooid is attenuated at the lower part as in *C. astaci* and *curva;* the nucleus is of the usual pattern, band-like. Length of lorica ·002 of an inch; attached to the head of *Diaptomus* sp. This species resembles the marine form, *C. compressa* C. and L., in the flattening of the shell in one direction, but in a plane in the opposite direction there is a total difference, *compressa* being urn-shaped."

The Tintinnodea.‡—Dr. H. Fol has continued his observations § on this family of Infusoria, and has been able, through the use of improved methods,‖ to rectify some of his previous statements and to demonstrate some points of detail which had previously escaped him. As the organization of the Tintinnodes is not much varied he protests against their separation into several families, regarding all known at the present day as forming a single family.

Nuclei of Protozoa.¶—Dr. A. Gruber treats of the processes of division of the nuclei of some Protozoa, and commences by stating that his method of examination has been that which he has already

* Journ. Quek. Micr. Club, i. (1883) pp. 216–23 (1 pl.).

† 'Chicago Times,' 11th August, 1883, in advance of Proc. Amer. Soc. Micr., 6th Ann. Meeting, 1883.

‡ Arch. Sci. Phys. et Nat., ix. (1883) p. 554.

§ See this Journal, i. (1881) p. 756.

‖ See *infra*, Microscopy β.

¶ Zeitschr. f. Wiss. Zool., xxxviii. (1883) pp. 372–91 (1 pl.).

described—namely, suddenly killing the animal under the cover-glass, and then colouring and preserving it. For *Actinosphærium* a two per cent. solution of chromic acid is the most satisfactory; absolute alcohol is especially to be avoided. With *Amœbœ*, on the contrary, absolute alcohol acts very satisfactorily. Wiegert's solution of picro-carmine was used as a colouring reagent, and dilute alcohol, in the place of water, was selected to wash the specimens.

For some time the author was unable to observe any phenomena of fission in *Actinosphærium eichhornii*, and he was almost led to believe in the free development of nuclei as the only means by which these structures are here formed, when he came across a small example in which division was to be observed, and an explanation of the rarity of the observation was to be found in the rapidity of the operation, and the sharp disappearance of all the characteristics of fission.

After describing the several stages in the Protozoon just mentioned, Dr. Gruber passes to *Amœba proteus*. Here, again, we have the same kind of history. Specimen after specimen was examined before one was seen in which the process of nuclear division could be traced: it was then seen that the nucleolus first divides into two equal parts, which, at first closely approximated, begin to separate from one another; between them, and in the equator of the nucleus, there appears a line in which is developed the new cortical layer for the daughter-nuclei. The author thinks that we have here to do with a low form of indirect division, this mode being, as it seems, conditioned by the arrangement of the chromatic substance in the nucleus. It is arranged circularly in a cortical layer, and forms a single central regular mass. Direct division is occasionally, though rarely, to be seen among the Protozoa, as e. g. the division by constriction of the nucleus in *Amœba polypodia*. Mechanical difficulties may oppose direct division; thus, if it take place while the *Amœba* is in movement, the whole protoplasm and the nuclei will be affected by currents.

The paper concludes with the account of some observations on an undetermined species of *Amœba*, in which the nucleus was seen to divide into two, generally unequal, halves. We find, therefore, that among the *Amœbœ* there are two kinds of nuclear division—a direct one, in which the nucleus undergoes a kind of hour-glass constriction, and a more indirect one, in which the nucleoli are primarily and the halves of the nucleus only secondarily affected.

Observations on Actinosphærium eichornii.*—Miss S. G. Foulke states that while observing *Actinosphæria* four individuals were seen to become fused, as it were, into one mass. At the end of an hour, this mass had separated into three *Actinosphæria*, two of the original four remaining fused into one. This double one then became constricted, a little to one side of the middle, apparently being about to separate. In a few minutes the *Actinosphæria* began to eject, at the point of constriction, a thin protoplasmic substance containing transparent granulated globules and free granules. By a waving motion

* Proc. Acad. Nat. Sci. Philad., 1883, pp. 125–7.

of the rays the masses of ejected matter were broken up, and the globules set free in the water.

These globules developed from one side an extremely long ray of finely granular protoplasm slightly elongating at the same time, thus taking an oval shape. No trace of the axial threads peculiar to the rays of adult *Actinosphæria* could be discovered. The average length of these globules, including the ray, was ·1422 mm.; without the ray ·0127 mm. The next act of the globules was the sending out another ray from a point opposite to the first. Minute vacuoles appeared and ranged themselves close to the surface of the globule. Other rays were developed at various intervals of time. The appearance of the young *Actinosphæria* gradually became more perfect in resemblance to the parent. The growth was very slow, the perfect form not being attained for a period varying from one to two weeks, and the size was even then small.

The external layer of vacuoles of the *Actinosphærium* from which the globules had been ejected contained numbers of granules in active motion. In the different vacuoles the number varied from ten to about one hundred, as nearly as could be counted. They were usually congregated at one point and seemed to be trying to force a way out.

Sometimes a globular mass of protoplasm was seen to run out upon a ray, and then, instead of returning to the body as usual, drop off into the water, and develope into a perfect *Actinosphærium* in the same manner as those ejected in a mass from the body.

Several free cells, having rays, were observed, upon touching a ray of the *Actinosphærium*, to glide down it in the manner usual to captured prey, and be re-absorbed into the body.

One globule of protoplasm, running out towards the point of a ray, stopped, and while motionless sent out a long ray at right angles to that supporting the globule. Another smaller globule ran out on this secondary ray and, in its turn sent out a third ray at right angles to the secondary ray but parallel to the primary ray. It has been stated that the rays of the *Actinosphærium* never branched, but the observer thought that the above phenomenon could be truly called branching, as all the protoplasm returned to the main ray, and thence to the body.

To ascertain whether any globules of protoplasm artificially freed from the body of the *Actinosphærium* would develope in the same manner as those above described, an *Actinosphærium* was crushed in the live-box so violently as to completely disintegrate it. The vacuoles were broken up and the internal mass of protoplasm mixed with the water, only two or three small masses of the external vacuoles remaining intact. On removing the pressure all the fluid protoplasm was seen to gather itself up into globules, of sizes varying from ·0507 to ·253 mm.

These globules contained vacuoles, the size and number of the vacuoles varying with the size of the globules. The water became free from protoplasm, though a large number of the granules which had been contained in the external vacuoles preivous to the crushing of

the *Actinosphærium* remained swimming actively about in every direction.

The globules remained quiet for some minutes, and then began to extend pseudopodial rays. The vacuoles increased in number and arranged themselves close to the exterior of the globules, those of the largest size pushing out the thin protoplasmic covering, so as to produce a strong resemblance to the perfect *Actinosphærium*. The resemblance of each globule to the original *Actinosphærium* became more and more perfect. The few masses of the original vacuoles also protruded rays, thus conclusively showing that the rays of *Actinosphæria* are not necessarily dependent upon the central mass of protoplasm. The vacuole masses developed into perfect *Actinosphæria* much more quickly than the globules formed of the central protoplasm, an hour or two being sufficient to the perfect development. The rays of all the immature *Actinosphæria* were irregular and flattened and in many cases lacked the axial thread.

The *Actinosphæria* moved their pseudopodial rays freely in all directions, the ray being bent close to the peripheral layer of vacuoles.

From an original colony of eight individuals, a small bottleful was manufactured in the manner above described, the time needed for development being in proportion to the size of the fragments into which the *Actinosphæria* were divided. The above experiments were tried on many individuals, the only difference of result in the various instances being in the degree of completeness with which the protoplasm separated itself from the water. It was argued from the above facts that the power of any part of an *Actinosphærium* to develope into a perfect individual was inherent, and not dependent upon any peculiar condition of the animalcule.

Fig. 8, pl. xli. of Leidy's 'Rhizopods of North America,' which he doubtfully refers to the *Actinosphæria*, exactly resembles a medium stage in the development of the globules ejected from the body of the *Actinosphærium*.

The author also stated that the rays of *Actinosphærium* when irritated by being compressed would be retracted completely on all sides, and would again appear on the cessation of the disturbance.

The length of time needed for the development of the *Actinosphæria*, in the reproduction by natural means, was from seven to fourteen days; that needed for the development in the reproduction by artificial means was from one to two days.

In the latter case this length of time was needed only in cases when the crushing was carried to extremes, as, when the *Actinosphærium* was simply divided into small pieces, a few hours were all that was needed to complete the development of the fragments.

Dimorphism of the Foraminifera.*—MM. Munier-Chalmas and Schlumberger in a second communication on this subject,† prove that in extinct species there is a series of modifications similar to that

* Comptes Rendus, xcvi. (1883) p. 1598.

† See this Journal, *ante*, p. 380.

which obtains in existing forms. All the species of *Miliolites* that they have studied have, therefore, been found to be dimorphous. Two hypotheses present themselves, when an explanation is sought for We may either suppose that each species is represented by two forms distinct from their origin, though this is opposed by the fact that very young individuals of the second form ("form B") have never yet been detected; or, the dimorphism may be regarded as "the result of a final evolution"; in such cases every individual would pass through two successive phases; and it is important to note that in all the species examined, exact measurements showed that, were the central chamber to be absorbed, the space thus set free between the first serial chambers in "form A" would be large enough to allow the modified chambers of "form B" to be developed. To judge between the value of these two hypotheses the authors propose to trace a living form through all its developmental phases.

New Type of Arenaceous Rhizopoda.*—H. B. Brady describes a new genus of Arenaceous Rhizopods to which he applies the name of *Syringammina;* the test is extremely fragile, owing to the fact that its walls are composed of fine sand with scarcely a trace of inorganic cement, while, owing to its considerable size—the figured specimen is about an inch and a half in diameter—it can scarcely support its own weight, when taken out of water. Examination of a fractured surface reveals a congeries of branching and inosculating tubes, radiating from a common centre. Near the periphery the system of tubes takes a distinctly radial character; these tubes are not of uniform diameter, being no more than ·5 mm. near the centre, while they may be twice as wide near the exterior.

So far as its nearest living allies are concerned, this new genus stands closest to *Astrorhiza*, but it is distinguished by the great number of its tubes; from *Parkeria* it is to be distinguished by the fact that there is no cancellation of the layers, and among fossil Rhizopods it will probably be found to be most closely allied to those which Prof. Duncan has grouped together as Syringosphæridæ.

Fully formed Embryos within a Rhizopod. †—Some embryos of *Peneroplis proteus* D'Orbigny, were found by C. Schacko within the chambers of an adult, itself extracted from the intestine of a Holothurian. In the last large chamber were found 30 embryos in two rows, and each of the same size as the embryonal chamber of the mother, and in the next chamber 26; in the whole of the succeeding narrow chambers, 60 more embryos occurred, some of them of irregular form. These embryos appear to have originated by regular segmentation of the sarcode or by breaking up of the whole soft parts into equal portions, as occurs in the central capsule of Radiolaria during reproduction. The young are probably released by the bursting of the maternal chambers owing to pressure from within, exercised by the young. The presence of irregularly formed embryos may

* Proc. Roy. Soc., xxxv. (1883) pp. 155–61 (2 pls.).
† SB. Gesell. Naturforsch. Freunde Berlin, 1882, pp. 130–2.

possibly account for the great variety of form which *Peneroplis* tends to exhibit.

Detection of Polycystina within the Hermetically-closed Cavities of Nodular Flints.*—Dr. Wallich announces the discovery of a number of well-marked Polycystina amongst the loose fossilized contents of nodular flints obtained from the Surrey gravel-pits. In common with other observers he has often noticed minute objects in flint sections, which are, in all probability, the remains of these organisms ; but in no instances were the appearances revealed by the Microscope sufficiently distinct to place their identity beyond question. In the case of the structures now under notice there can be no doubt of the kind, and we are furnished with another interesting link in the chain of evidence which goes to prove the general lithological identity of the chalk with recent deep-sea calcareous deposits.

The genera of Polycystina met with in the nodular cavities are, for the most part, *Astromma*, *Haliomma* (both discoidal and spherical), and *Podocyrtis*. A few specimens of well-marked fossilized Dictyochidæ also occur. Both the Polycystina and the Dictyochidæ, as well as the mass of the loose granular material associated with them in the same flint-cavities, are more or less metamorphosed by a slight admixture of peroxide of iron and calcite, the former substance having imparted to the entire structures a bright reddish hue.

Dr. Wallich has also found, in material obtained from hermetically-closed flint cavities, by far the most perfectly preserved Foraminifera he has ever seen, the shell-structure and chambers, with every minutest detail of tubular structure, having been converted into chalcedony—the whole mass by reflected light presenting a beautifully whitish-blue opalescent appearance, whilst by transmitted light it exhibits a rich transparent burnt-sienna colour, and the well-known fibrous character of chalcedony wherever that substance is most massive, as, for instance, within the chambers. The Foraminifera represented belong chiefly to the genera *Rotalia*, *Globigerina*, and *Textularia*. As regards perfection in every minutest detail of shell-structure, these specimens greatly surpass in beauty those metamorphosed into *glauconite*, beautiful as they also undoubtedly are.

Endoparasitic Protista.†—Dr. Grassi has published a full account of his researches into this subject, the preliminary form of which has already been noticed in this Journal.‡ The present paper is much amplified and largely modified from the original: the new views alone will be noticed here.

Class *Flagellata*.—Grassi now lays but little weight on the number of flagella as a classificatory character. He recognizes the following families:—

1. *Cercomonas* (*sic*) Duj. pro parte. Posterior extremity more or less tapering or bifid, several flagella at the anterior end.

2. *Megastomidea* Grassi (new), based on *Dimorphus muris* id.,

* Ann. and Mag. Nat. Hist., xii. (1883) pp. 52–3.
† Arch. Ital. de Biol., ii. (1882) pp. 402–44.
‡ See this Journal, i. (1881) pp. 764–6.

renamed *Megastoma entericum*. Posterior extremity bifid; a deep depression near the anterior end.

3. *Lophomonadidea* Grassi. Posterior extremity more or less tapering; a knob, carrying numerous flagella, on the anterior extremity.

4. *Trichomonadidea* Grassi (new). Posterior extremity as in 1 and 3; anterior extremity provided with several flagella, as well as trichocyst-like bodies.

5. *Trypanosomata* Kent. An undulating margin to the body, prolonged at one end into a flagellum.

Under Fam. 1 are included the genera *Monocercomonas* (containing, *inter alia*, a species named *M. insectorum* = *Schedoacercomonas melolonthæ* and *gryllotalpæ* of the former paper), *Cimœnomonas* n. gen., based on *Trichomonas batrachorum* Perty, *Plagiomonas* n. gen., based on *Retortamonas gryllotalpæ* Grassi, *Monamita* n. gen., for *Cercomonas muscæ-domesticæ* Stein, *Heteromita* and *Dicercomonas* Duj. Without going into various (in part apparently gratuitous) changes introduced into the synonymy, it may be pointed out that the variety of hosts in which many of the forms are now found renders it unadvisable to name a species after any one host.

Fam. 2 embraces *Dimorphus muris* Grassi, which occurs in four species of *Mus*, in *Arvicola*, in the cat, and in man; but though often coexisting with a diarrhœic condition, it does not appear to cause it.

Fam. 3 includes *Lophomonas blattarum* Stein.

Fam. 4 contains the single species *Trichomonas melolonthæ* Grassi, which appears to assume a great variety of forms when multiplying.

Fam. 5. Besides *Trypanosoma*, the family includes a genus *Paramecoides* Grassi, containing *Trypanosoma Eberthi* Kent, and *P. costatus*, n. sp. from the blood of *Rana esculenta*; the genus is distinguished by the presence of an undulating membrane without any trace of a flagellum.

Class *Lobosa*.—Grassi thinks his *Amœba ranarum* may perhaps have some relation to *Paramecoides costatus*, with which it is found associated.

Amœba Chætognathi (= *Sagittæ* Grassi) and *pigmentifera* n. sp. are found in the six species of *Chætognatha* found in the Straits of Messina, chiefly in the caudal chamber and the vasa deferentia, and more rarely in the cœlom of the body; they are not found in young individuals. *Pigmentifera* is distinguished by a blackish eye-spot, and is only found in two species of *Spadella*. The endoplasm in both species contains a number of granules, which are considered to be of fatty nature, being stained black by osmic acid, and appear to constitute a reserve of nourishment. Reproduction is effected by modification of the internal structure of the body, resulting in its breaking up into a number of corpuscles containing granules, but still united by the body-wall of the parent; when they separate they are flattened bodies 7-1000ths mm. long, 3-1000ths broad, and 1-1000th thick, and of oval outline; from one pole proceeds a flagellum of twice the length of the body. Grassi considers that the history of their development tends to approximate the *Amœbæ* to the *Monera*,

and the forms just described probably have many connections with *Protomyxomyces coprinarius* Cunningham.

Class *Sporozoa*.—Some specimens of a probably new species of *Coccidium*, resembling *C. Rivolta*, were found in a *Coronella*, and are perhaps identical with a form found in the toad.

A Moneran from the blood of *Hyla viridis*, having obtuse motile radiating filaments, is perhaps connected with the organism of the blood of subjects afflicted with palustric fevers (Laveran). Of two forms of corpuscles found in human fæces, the larger has hyaline contents, including small shining yellowish rods, and is perhaps connected with the *Coccidia;* the smaller, which occurs also in cowdung, is perhaps an *Amœba* rendered immobile by lowness of temperature.

Studies on the Gregarinida.*—A. Schneider forms a new genus *Lophorhynchus* for *L. insignis* which was found in the digestive tube of *Helops striatus*. Allied to *Stylorhynchus*, it is distinguished by the characters of its organ of attachment; there is a subsessile rostrum attached by a wide base to the protomerite, and the actinophore is formed by a membranous expansion, which is depressed in the centre. *Trichorhynchus* is another new genus, formed from *T. insignis* found in the digestive tube of *Scutigera*, and distinguished from *Stylorhynchus* by the characters of its spores, which are never united into bands. The author also describes *Gamocystis francisci* n. sp., found in the digestive tubes of the larvæ of the Ephemeridæ; *Hyalospora affinis*, n. sp., from the intestine of *Machilus cylindrica;* and a new genus *Cnemidospora*, for *C. lutea*, from the digestive tube of *Glomeris*. This is remarkable for the characters of its protomerite, the contents of which are formed by two masses, distinguishable by various characters. The lower has finely granular, the upper highly refractive, and, apparently, fatty contents, and is of greenish, and not, as the other, of a yellow or brown colour.

BOTANY.

A. GENERAL, including Embryology and Histology of the Phanerogamia.

Morphology of the Embryo.†—E. Warming describes the embryo of *Avicennia* as entirely devoid of radicle, like that of *Utricularia*, *Ruppia*, and some other plants. The author disputes the ordinary view that the suspensor is altogether a distinct organ from the embryo itself. In some plants, as *Pistia*, *Cypripedium*, *Listera*, *Epipactis*, *Tropœolum*, &c., the suspensor is altogether wanting; when present, although its physiological value is distinct, viz. to carry nutriment to the embryo, Warming is unable to detect any morphological difference between the two; it is simply the lower portion

* Arch. Zool. Expér. et Gén., x. (1882) pp. 423–50 (1 pl.).
† Bot. Ztg., xli. (1883) pp. 215–9.

or stem of the axis of the embryo. The primary radicle differs from other roots only in the fact that its axis is continuous with that of the stem; it is also endogenous, although this is not very evident where the suspensor is very slender. Primary and secondary roots differ only in their position on the axis of the plant; the term "tigellum" (*hypokotyles Stengelglied*) ought properly also to include the suspensor. The embryo of *Avicennia* has (as described by Treub) no root-cap, because it has no primary radicle; but, on the other hand, several endogenous secondary roots at the lower end of the tigellum, as occurs in Gramineæ, *Trapa*, *Impatiens*, &c.

Cellulin, a modification of Cellulose.*—A further examination has been carried out by N. Pringsheim of the peculiar granular bodies long since observed by him in the fertilizing tubes and oogonia of the Saprolegnieæ, and described by Zopf as "amœbæ."† They are found in the fertilizing tubes at all ages. While young they are flat disk-shaped or polyhedral plates with rounded corners, composed of a dense homogeneous substance; they vary greatly in size and form. They gradually become stratified, and finally as completely and regularly so as starch-grains. They are abundant also in the oogonia, and a few grains occur in other parts of the plant.‡

The structure, mode of development, and chemical properties of these substances, show that they are neither organs of reproduction nor independent parasitic organisms, but are a special modification of the cell-contents. The stratification indicates a close resemblance to other bodies of this character. They are, however, not coloured blue by iodine; nor do they take any other colour but that of the iodine itself. They are completely insoluble in all ordinary solvents of oils and resins, even in absolute alcohol and in ether. Nitric acid, either with or without ammonia or potash, produces no effect on them, nor does Millon's reagent. They have no power of taking up colouring substances, except under special circumstances. Caustic alkalies produce, in the cold, no visible effect on these bodies; and very little change is effected by dilute or concentrated nitric or hydrochloric acid at the ordinary temperature. In moderately concentrated sulphuric acid they dissolve rapidly and completely at the ordinary temperature, as also in solution of zinc chloride, when not too dilute. They do not dissolve in ammoniacal copper oxide, even after long treatment.

These reactions show that the bodies in question belong neither to the proteinaceous cell-contents, nor to the series of oils and resins; but that they are composed of a substance closely allied to cellulose which has been separated from the protoplasm in a granular form. It is perhaps identical with so-called "fungus-cellulose," and with the "fibrose" of Fremy; and Pringsheim proposes for it the term *cellulin*. Its special chemical characteristic is its remarkable solubility in dilute sulphuric acid and in an aqueous solution of zinc chloride.

* Ber. Deutsch. Bot. Gesellsch., i. (1883) pp. 288–308 (1 pl.).

† See this Journal, *ante*, p. 248.

‡ Ibid., *infra*, p. 687.

The stratification of the cellulin-grains is concentric, around a nucleus of denser substance; they grow, however, to a considerable size before any stratification is evident. Compound grains are not uncommon. A common mode of multiplication is by a kind of budding, not dissimilar to that of torula.

When the oospheres are formed out of the protoplasmic contents of the oogonium, an unused residue remains behind, which is the substance out of which the cellulin-grains are subsequently developed. This substance is morphologically identical with the "periplasm" of the Peronosporeæ, out of which the exospore of the oospore is formed.

Experiments on the propagation of *Achlya* seem to demonstrate that these cellulin-grains belong to the Saprolegnieæ themselves, and not to any Chytridieæ or other parasites upon them.

Protrusion of the Endosperm through the Micropyle.*—In harmony with the observation of Treub respecting *Avicennia officinalis*, E. Warming states that in *Rhizophora Mangle* the endosperm also projects beyond the micropyle, but only partially, the greater part being still inclosed in the testa. The projecting portion has much the appearance of an aril.

Development of the Pollen of Juncaceæ and Cyperaceæ.†—N. Wille describes the development of the pollen-grains of Juncaceæ (*Juncus glaucus, Luzula campestris, maxima*, and *pilosa*) as differing from the typical mode. The pollen mother-cells divide, as usual, into four special mother-cells; but the wall of these special mother-cells does not, as is usually the case, become absorbed; its outermost layers cuticularize into an extine, except one spot at each corner of the tetrahedron, where the pollen-tube subsequently emerges. True pollen-grains are therefore wanting; fertilization being effected by the special mother-cells; one stage of the usual development is suppressed.

In the Cyperaceæ (two species of *Carex, Eleocharis palustris*), the departure from the ordinary development is still greater. In the free pollen mother-cells no special mother-cells are formed; their preparation only is indicated by divisions of the nucleus; the new nuclei apparently again coalescing. The outermost layer of the wall of the pollen mother-cells is metamorphosed into the extine. In the Cyperaceæ therefore the development of the pollen-grains stops short at one stage earlier even than in the Juncaceæ.

Continuity of Protoplasm through Walls of Vegetable Cells.‡—W. Gardiner is inclined to come to the conclusion that it is extremely probable that the communication between adjacent vegetable cells does not only take place in the parenchymatous cells of pulvini, in the phloem parenchyma cells, in the cells of endosperms, and in the prosenchymatous bast-fibres, but is of much wider if not of universal

* Bot. Ztg., xli. (1883) pp. 203–4.

† Christ. Videnskab. Forhandl., 1882. See Bot. Centralbl., xiv. (1883) p. 296.

‡ Proc. Roy. Soc., xxxv. (1883) pp. 163–6. Cf. this Journal, *ante*, pp. 225, 524.

occurrence. Observations now and lately recorded give us the power of a "clearer insight into such phenomena as the downward movement of a sensitive leaf upon stimulation, of the wonderful action of a germinating embryo on the endosperm cells, even on those which are most remote from it, of the action of a tendril towards its support," and of various other phenomena in connection with general cell mechanism.

The author describes the protoplasmic continuations between cells in various tissues, treating especially of pulvini and endosperm cells.

Pores in the Outer Walls of Epidermal Cells.*—It has long been known that the outer walls of the cells of the epidermis are in some cases perforated; and Mettenius has described the same phenomenon in the outer cell-walls of the very thin leaves of certain Hymenophyllaceæ; the cell-walls being in these cases also remarkably curved and folded. H. Ambronn has made a careful examination of all these cases, and divides them into two classes:—those in which the perforations perform the same function as the pores in the cell-walls of internal tissues, viz. the interchange of fluids or of gases from cell to cell; and those rarer ones in which they subserve some other function.

The object of the thickenings and foldings which occur in the cell-walls of the Hymenophyllaceæ, and also in the walls of the epidermal cells of the leaves of Coniferæ, is apparently to increase their power of resistance to traction in the tangential direction. The perforations under consideration are always found in connection with these thickenings and foldings, and Ambronn gives a detailed mechanical explanation of his reasons for adopting the view that these cavities—which are really fissures, but have from the outside the appearance of dots—are the result of the unequal growth to which these thickenings are due.

Perforations of this kind are very common in the epidermal cells of grasses, both in the stem, leaves, and leaf-sheaths; also in many Juncaceæ and Cyperaceæ. Among vascular cryptogams they occur, not only in the Hymenophyllaceæ, but also in *Equisetum*. In Coniferæ they are found especially in the genus *Abies*. They are met with also in the peculiar epidermal cells of the leaves of *Amaryllis formosissima*. In dicotyledons they are also not uncommon.

Another class of perforations is connected with the formation of reticulate thickenings, which continually increase in thickness so that the meshes between them become constantly narrower until at length they have the appearance of pore-fissures. A good instance of this occurs in the genus *Cycas*, the only genus of Cycadeæ which possesses these reticulate thickenings. They are found also in Coniferæ, as in the leaves of several species of *Pinus* and in *Cedrus Deodara*.

A peculiar kind of thickening, associated with pores, is found in the outer walls of the epidermal cells of the leaves of some species of Epacrideæ, especially in the genera *Epacris* and *Leucopogon*.

Physiology of the Undulations of the Lateral Walls of the Epidermis.†—J. Vesque finds that the epidermis of leaves has very

* Pringsheim's Jahrb. Wiss. Bot., xiv. (1883) pp. 82–111 (1 pl.).
† Comptes Rendus, xcvii. (1883) pp. 201–3.

frequently the function of accumulating water for the future necessities of transpiration, and thinks that we have here a notable example of the independent relations of the cause which produces a change in the structure of plants, and the future physiological utility of the anatomical change.

Structure and Function of the Epidermal Tissue.*—M. Westermaier treats the structure of the epidermal tissue of plants from three points of view:—1st, the cuticle; 2nd, the epidermal system as a system for the supply of water to the plant; and 3rd, in relation to its protective function.

The author brings forward evidence, experimental and theoretical, for regarding the epidermal tissue as a system which has for its function the constant maintenance of a supply of water in the plant. This is shown by the rapidity with which water passes from one cell to another in the assimilating tissue, while the epidermal tissue retains it for a much longer period. The aqueous epidermal cells are distinguished by their thin radial walls, which permit the passage of water from cell to cell of this tissue, while confining it within it; these radial walls are also provided with numerous pores. The constant supply of water to the various parts of the plants is maintained by a double aqueous system, an inner much branched one, and an outer or epidermal system.

Protective Sheath and its Strengthenings.†—S. Schwendener enumerates the following as the most important modes by which additional strength is imparted to the protective sheath of the fibro-vascular bundle:—1. Thickening of the cell-walls of the sheath itself; this occurs commonly in monocotyledons, rarely in dicotyledons; it has not been observed in gymnosperms or vascular cryptogams. 2. Thickening of the walls of the adjoining cortical cells, the cells of the sheath itself being thin-walled; characteristic of ferns. 3. Thickening of the walls both of the sheath itself and of the neighbouring cortical cells; in *Stipa pennata* and *capillata*, *Dasylirion*, *Poa compressa*, *Juncus glaucus*, &c. 4. Thickening of the cell-walls of the sheath, and of the layers of cells that bound it on the inner side; at present observed only in *Restio sulcatus*. 5. Strengthening of the sheath by addition of bast above the leptome-bundles; in the root of Lauraceæ. 6. Strengthening of the sheath by ridges in the adjoining cortical cells; the ϕ-sheaths of Russow. 7. Strengthening of the sheath by a ring of horny parenchyma, separated from the sheath by from two to four layers of thin-walled cortical cells; in the roots of various Aroideæ and Bromeliaceæ. The author notes that it is a rule without exception that the roots of all plants growing on rocks or on steppes have strongly thickened sheaths. Where the soil in which the plants grow is always soft and moist, no mechanical thickenings are found to the sheath; as in *Naias*, *Potamogeton*, *Sparganium*, *Sagittaria*, *Alisma*, *Calla*, &c.

* Pringsheim's Jahrb. Wiss. Bot., xiv. (1883) pp. 43–81 (3 pls.).
† Ber. Deutsch. Bot. Gesellsch., i. (1883) pp. 48–53.

Haptera.*—E. Warming proposes this term for organs of various morphological value which have for their function the attaching or fixing of the part from which they spring; for example, the apparatus for attachment of young *Œdogonium* filaments, ordinary rhizoids, root-hairs, the attachment-organs of the larger Fucaceæ, the adhesive tissue of *Cuscuta* and *Cassytha*, the attachment-disks of many climbing plants, such as *Ampelopsis*, *Trichosanthes*, *Glaziovia*, &c. To this category belong the peculiar organs of the Podostemaceæ, which the author had previously described as metamorphosed roots, but which, from an examination of the genus *Castelnavia*, he now regards as emergences attached to the root.

Chlorophyll and Chlorophyllan.†—The following are the main results of a fresh examination of the nature and properties of chlorophyll by A. Tschirch:—

Since the chlorophyll-pigment, probably dissolved in an essential oil, permeates the protoplasmic matrix of the chlorophyll-bodies, and presents the greatest possible surface for the assimilation of carbonic acid, it is probable that it plays not merely a physical, but also a chemical part in the process of assimilation. Chlorophyllan (the hypochlorin of Pringsheim) is the first product of oxidation of the pigment. It is formed in acid solutions, and by the action of all acids, mineral as well as organic, even carbonic acid. Vegetable acids are always present in the cell-sap, and hence chlorophyllan is always formed in time in alcoholic solutions of chlorophyll. It can be obtained by three methods:—(1) by evaporating an alcoholic solution of chlorophyll, washing the residue with water, dissolving in ether, and allowing the chlorophyllan to crystallize out; (2) by evaporating a concentrated alcoholic solution of chlorophyll to half its volume, when impure chlorophyllan will crystallize out on cooling, which can be purified by recrystallizing; (3) by extracting leaves with hot glacial acetic acid, evaporating, washing with water, dissolving in alcohol, and allowing to crystallize.

Chlorophyllan is insoluble in water, soluble in alcohol, very soluble in ether and benzin. The solutions are brownish green. It crystallizes out of impure solutions in long whiplike or corkscrew-like threads, or bone-shaped or pear-shaped masses, out of pure solutions in a spherical mass of needles collected round a centre; on very slow crystallization in rectangular plates belonging to the quadratic system. In transmitted light it is a dark olive-brown colour; in reflected light nearly black. In diffused daylight it exhibits no polarization phenomena, but in direct sunlight these are very beautiful. The spectrum of its solutions shows three lines, and continuous absorption of $\lambda = 46$. Specially characteristic is line IV. *b* of $\lambda = 51{\cdot}3 - 44{\cdot}3$, peculiar to the chlorophyllan-group. Lines II. and IV. are considerably darker and broader than in solutions of pure chlorophyll. Fluorescence of homogeneous red of wave-lengths from 64 to 68 hundred-thousandths of a millimetre.

* Bot. Ztg., xli. (1883) pp. 193–200.

† Ber. Deutsch. Bot. Gesellsch., i. (1883) pp. 137–49, 171–81, 202–7. Cf. this Journal, i. (1881) p. 479; ii. (1882) pp. 528, 817.

Chlorophyllan is identical with the crystallized chlorophyll of Gautier and Rogalski, the pure chlorophyll of Jodin, the precipitate obtained by Filhol by the action of hydrochloric acid on solutions of chlorophyll, the modified chlorophyll and acid chlorophyll of Stokes. It can be reduced by means of powdered zinc to a pure green substance, probably identical with chlorophyll; and this is the best way of obtaining the pure chlorophyll-pigment. Sodium reduces it to the pure green sodium-salt of chlorophyllinic acid. Chlorophyllan must therefore be regarded as a product of oxidation of chlorophyll. Concentrated hydrochloric acid decomposes it into a substance soluble in hydrochloric acid with a blue colour, the phyllocyanin of authors, and a brown substance insoluble in hydrochloric but soluble in ether, the xanthin of Kraus. Phylloxanthin is a mixture of the latter with the normal yellow pigment of chlorophyll. The phyllocyaninic acid of Fremy is probably identical with Hoppe-Seyler's chlorophyllanic acid. Xanthin, when dissolved in alcohol, does not show the line IV. *b*.

By treatment with potash-lye chlorophyll is converted into the potassium-salt of chlorophyllanic acid, insoluble in benzin and ether. The beautiful emerald-green solution can be precipitated by baryta or copper-salt, with formation of the corresponding salts of chlorophyllinic acid. Alkaline carbonates also cause the formation of salts of this acid. The spectrum of a solution of potassium chlorophyllinate is distinguished by a splitting of a line in the red (into I. *a* and I. *b*), and by the middle line being less distinct; the lines are also all displaced towards the refrangible end of the spectrum. The potassium and barium salts of chlorophyllinic acid pass, with ether and hydrochloric acid, into bodies belonging to the chlorophyllan-group; their spectrum has the line IV. *b*. Alkaline salts of chlorophyllinic acid are formed when leaves are extracted with dilute potash-lye; when potash-lye is added to an alcoholic solution of chlorophyll; and as a precipitate when a solution of chlorophyll in benzin or a solution of chlorophyllan is treated with sodium. When heated to 210° C. potassium chlorophyllinate assumes a purple-red colour. This solution, when treated with hydrochloric acid and ether, yields phyllopurpurinic acid, with a beautiful purple-red colour and a very characteristic spectrum.

From pure chlorophyll, the cyanophyll of Kraus, yellow substances or xanthophylls can be derived:—(1) by heating the solution with baryta hydrate, and dissolving out by alcohol from the resulting precipitate; (2) by heating cyanophyll with sodium, when the xanthophylls can be retained in solution in benzin, sodium chlorophyllinate being precipitated; (3) by decomposing the cyanophyll by potash-lye, evaporating, dissolving the potassium chlorophyllinate in water, and the xanthophyll in ether.

Yellow substances belonging to the chlorophyll group normally accompany chlorophyll in the chlorophyll-grain. The yellow colouring matter of flowers and the red colouring matter of flowers and fruits mostly belong, as is shown by their spectrum, to the chlorophyll group. To this group belong also the colouring substance of the carrot and radish, and that of green decaying wood, xylindein.

The erythrophyll of Bougarel is identical with the chrysophyll of Hartsen. It is not an accompaniment, but a product of decomposition of chlorophyll. It is produced in the cells of plants by the action of dilute acids. Etiolin, the chlorophor of Böhm, the leucophyll of Sachs, belongs also to the chlorophyll-group. A solution of etiolin is oxidized by long standing or the addition of dilute acids. Pounded zinc reproduces pure etiolin.

The pure colouring matter of chlorophyll can be produced in two ways:—(1) by reducing by means of pounded zinc chlorophyllan, which can readily be obtained pure in crystals; (2) by treating a concentrated alcoholic solution of chlorophyll with barium chloride, chlorophyll being insoluble in concentrated solutions of salts.

Tschirch contests the view of Meyer that the protoplasmic envelope surrounding the chlorophyll-grains is a result of the mode of treatment in their preparation. By experiments on living cells of *Elodea* and *Nitella* he supports the view that all chlorophyll-bodies and aleurone-grains are surrounded by such an envelope.

Chlorophyll and the Distribution of Energy in the Solar Spectrum.*—C. Timiriazeff, in a previous communication, showed the intimate relation existing between the absorption of light by chlorophyll and the intensity of the chemical action produced, and expressed the opinion that this action is dependent on the energy, as measured by its thermal effect, of the rays absorbed. He now calls attention to the fact that Langley's measurements with the bolometer justify this opinion, and prove that the point of maximum energy in the solar spectrum corresponds with the characteristic chlorophyll-band between B and C. The author is now engaged on researches on the quantitative relation between solar energy absorbed by the chlorophyll of leaves and that stored up in the chemical work performed. He finds that, under the most favourable conditions, a plant utilizes 40 per cent. of the energy absorbed.

Crystalline Secondary Pigments of Chlorophyll.†—J. Borodin finds it very easy, by treating the parts cut up very fine with alcohol, to separate from true chlorophyll several other pigments which always or commonly accompany it. On crystallizing out the alcoholic solution, a great quantity of crystals of various colours appear. The author gives a long list of species on which his experiments were made, in all of which crystallizable substances were found accompanying the chlorophyll. *Spirogyra* is a very favourable object. These various substances agree in their insolubility in cold or hot water, and ready solubility in ether, chloroform, and carbon bisulphide; they display great resistance to both alkalies and acids. In other chemical properties they manifest great differences, but they are all rendered blue by concentrated sulphuric acid. They may be divided into two groups, those which are most soluble in benzin, and those which are most soluble in alcohol. The latter are also more

* Comptes Rendus, xcvi. (1882) pp 375–6. Journ. Chem. Soc. Abstr., xliv. (1883) p. 697.

† Bull. Acad. Sci. Imp. St. Petersbourg, xxviii. (1883) pp. 328–50.

readily acted on by sulphuric acid and glacial acetic acid. To the former group belongs Bougarel's erythrophyll, which appears to be a constant accompaniment of chlorophyll; while to the second group belongs xanthophyll, which is probably in many cases a mixture of two different crystallizable substances.

Crystalloids in the Pyrolaceæ.*—C. Raunkjaer finds in *Pyrola* and allied species crystalloids which exhibit the chemical reactions of protein, especially in the receptacle, but also in the leaves, stem, and rhizome. They may be arranged, according to their form, into two groups. In the first (*Pyrola uniflora*, *secunda*, and *rotundifolia*) the crystalloids have the ordinary tabular form, and frequently quite replace the nucleus; occasionally two are found. They develope in the nucleus only with advancing age. In *P. secunda* and *rotundifolia* they were found only in the floral organs. In the second group (*P. chlorantha* and *minor* and *Chimophila umbellata*) the crystalloids are hexagonal, often somewhat elongated, but not tabular.

Inulin in the Artichoke.†—Pistone and de Regibus find in the bracts of the artichoke, *Cynara Scolymus*, a substance identical with the spherocrystals of inulin of Sachs, turning the plane of polarization to the left, even in the presence of a dilute acid, and not coloured by iodine.

Mentzelia lævicaulis as a Fly-catcher.‡—M. E. Jones, acting upon Dr. Gray's suggestion, examined this plant, with the following interesting results: The leaves are thickly beset with coarse hairs, which are furnished with several pairs of barbs pointing downward along them, while the top has an anchor-shaped summit twice as large as the other barbs. These hairs stand so close together that the barbs almost touch. Thickly studding the leaf were many dead and dying mosquitoes, species of *Aphis*, and other small insects. Some of these were caught by the head, but most of them were held by the proboscis, as their heads were too large to slip between the barbs. All were more or less mutilated, probably by other insects. A sweet fluid was secreted by the leaf, and this attracted the insects. There was no evidence of any digestion going on, as none of the victims could get close enough to the surface of the leaf to be touched by the fluid.

B. CRYPTOGAMIA.

Rabenhorst's Cryptogamic Flora of Germany, &c.—The second volume § of this important publication includes the marine algæ, the preparation of which has been entrusted to F. Hauck. After an introduction on the preparation and collection of seaweeds, the primary classification of marine algæ (excluding diatoms) is given in four

* Vidensk. Meddel. Naturh. Foren. Kjöbenhavn, 1882, p. 70 (1 pl.). See Bot. Centralbl., xiv. (1883) p. 267.

† Giorn. Accad. Med. Turin, xlv., p. 560. See Bot. Centralbl., xiii. (1883) p. 365.

‡ Bull. Torrey Bot. Club, x. (1883) pp. 69–70.

§ See this Journal, i. (1881) p. 78.

series, viz.:—(1) Rhodophyceæ, plasma red; (2) Phæophyceæ, plasma brown; (3) Chlorophyceæ, plasma chlorophyll-green; (4) Cyanophyceæ, plasma blueish green. Commencing with the Rhodophyceæ, the first order treated of is the Florideæ, which are divided into twenty families and eighty-five genera. The description of these is very nearly completed in the five parts already published, commencing with the Porphyraceæ and concluding with the Corallinaceæ. These parts are illustrated with five photographic plates and numerous zincographs.

Cryptogamia Vascularia.

Cryptogramme and Pellæa.*—K. Prantl distinguishes *Cryptogramme* from the nearly allied genus *Pteris* by its anadromous venation; *Pellæa* from its allied genus *Adiantum*, by its metadromous venation. He somewhat enlarges the bounds of these two genera, making their characteristics depend not exclusively on the form of the sori and the mode of development of the fertile margin of the leaf.

Fungi.

Abstriction and Separation of the Spores of Fungi.†—A. Zalewski has investigated the manner in which the spores are detached in those classes of fungi which produce their spores not inclosed in a sporangium:—ectospores, acrospores, basidiospores, or conidia. He enumerates the various modes under the four following types:—(1) A single spore is produced at the apex of a basidium, or several simultaneously:—as in *Haplotrichum*, *Botrytis cinerea*, *Arthrobotrys*, *Gonatobotrys*, the Peronosporeæ, and Basidiomycetes. (2) The spores are successively abstricted in a row from the apex of a basidium:—as in *Oidium lactis*, *O. anguineum*, the conidia of the Erysipheæ, *Cystopus*, *Penicillium glaucum*, *Spicaria Solani*, *Aspergillus*, and the æcidiospores of many Uredineæ. (3) The spores are formed by a torula-like budding from the basidium, and from the older spores, which are mostly united into branched chains:—*Cladosporium herbarum*, *Penicillium viride*, *P. cladosporioides*, *Torula*, *Polydesmus*, *Dematium pullulans*. (4) The spores are formed by simultaneous transverse division of rod-shaped mother-cells, themselves springing simultaneously from basidia:—*Piptocephalis*, *Syncephalis*.

In the formation of acrospores a gelatinous middle lamella may be formed, or not, in the primary division-wall which separates the spores. In the first case the primary septum is divided by this middle lamella into two plates which belong to the adjoining hyphal members, i. e. to two spores, or to the spore and the sterigma which bears it, as in *Oidium lactis*, *Cystopus*, *Peronospora*, *Haplotrichum*, &c. The chains of æcidiospores show a great difference in this respect, the gelatinous middle lamella not being separated in them in the primary septum, but being formed out of the entire pedicel or intermediate cell. In the second case the primary septum which separates the spore from

* Engler's Bot. Jahrb., iii. (1883).

† Flora, lxvi. (1883) pp. 228–34, 249–58, 259–71.

the sterigma remains without any middle lamella, and there is no sharp separation between the wall of the sterigma and that of the spore; the sterigma is merely closed at its apex by the cell-wall of the spore. This wall either becomes detached, when the spore falls off, by an annular zone close to the spore, or at a certain distance from it; the point of detachment can be detected on the sterigmas which no longer bear spores by a more or less marked indentation, as in *Corticium amorphum*. To this class belong the Hymenomycetes and Entomophthoreæ.

The actual detachment of the acrospores of fungi may be effected in either of the two following ways:—(1) by special contrivances for forcible detachment, when the spores are thrown off with considerable force, as in *Empusa* and the Hymenomycetes; (2) by the solution of the gelatinous central lamella in water, or by its drying up, as in *Cystopus*, *Penicillium*, *Peronospora*, *Botrytis*, and *Chætocladium*.

The formation of the sporidia on the promycelium of *Puccinia* and some Ustilagineæ does not appear to differ in any essential point from that of the spores of Hymenomycetes.

Fungus parasitic on a mature Coleopter.*—H. Hoffmann describes a fungus which he found growing from between the upper and lower maxillæ of a coleopter (*Carabus* sp.), and which appears identical with *Torrubia cinerea*, described by Tulasne as parasitic on a larva, also of a *Carabus*. The brown mycelium and the perithecium of Tulasne's species were however not seen. On account of the more abundant branching of the upper part of the main stem, the author proposes for it the varietal name *brachiata*.

New or Little-known Parasitic Fungi.†—B. Frank describes the following pathogenous fungi which are either new or hitherto but imperfectly described:—

1. *Fusicladium tremulæ* n. sp.; on the aspen, destroying the leaves, which it turns dark brown or black, especially towards the summit of the young shoots. No mode of reproduction was observed except by means of the conidia, which are produced in great abundance, the germinating filaments attaching themselves to the host by means of "appressors" or organs of attachment. Frank thinks that several generations can be produced in the course of a single summer.

2. *Glœosporium lindemuthianum* Sacc. and Mag.; on the French bean, *Phaseolus vulgaris;* but only on the green unripe legume, on which it produces brown spots, doing great damage.

3. *Polystigma rubrum* Tul.; producing red spots on plum-leaves. This fungus belongs to the Pyrenomycetes, and the author considers that it places beyond doubt the function of the spermatia, as the male elements which fertilize a female organ by means of a trichogyne, this process resulting in the production of a perithecium. This process he describes as always taking place outside the leaf on its under side.

4. *Hypochnus Cucumeris* n. sp. This is a hymenomycetous fungus,

* Flora, lxvi. (1883) p. 380 (1 pl.).

† Ber. Deutsch. Bot. Gesellsch., i. (1883) pp. 29–34, 58–63.

parasitic on the cucumber, causing rapid destruction of previously sound leaves, which turn entirely yellow from the apex downwards, at length completely destroying the plant. The hymenium is abundantly produced on the surface, where the mycelium has completely permeated the tissue of the host.

Exoascus of the Cherry.*—Following out Ráthay's observations on *Exoascus Wiesneri*,† which he considers identical with *E. cerasi* Fkl., D. Kutsomitopulos states that in all the cases where the cherry is attacked by the malformation known as "witch-broom," all the branches are plentifully permeated with the mycelium of the parasite. This is the case even in the inflorescence, which seldom reaches maturity; it could be traced in the pedicels, calyx, stamens, ovary, and style, permeating the parenchymatous fundamental tissue, but without any perceptible effect on the organs, the petals only seeming to be completely free from it. In the infected wood the author found the medullary rays to be from 4 to 8 cells wide, and each about 66 μ in diameter, while in the healthy wood the rays are only 2 cells wide, and each only 27 μ on an average in diameter. The woody bundles of the sound part are about 60 μ wide, and contain no parenchyma, while those of the diseased part average about 30 μ in diameter, and contain much parenchyma in addition to the fibrovascular bundles. These facts account for the much greater looseness of the tissue of the diseased portions of the wood.

Hyacinth-diseases.‡—J. H. Wakker has investigated the "yellow disease" to which hyacinths are subject. An examination of infected bulbs in the autumn shows that the vascular bundles are permeated or even replaced by a yellow slime, in which are immense quantities of a bacterium which he proposes to call *Bacterium Hyacinthi*, very closely resembling *B. Termo*. While imbedded in the slime it is motionless, but when removed soon commences a lively motion, and begins to divide. In the spring the same slime thronged with bacteria is found in the vascular bundles of the leaves.

The "black smut" (*der schwarze Rotz*) of hyacinths is due to the attacks of an ascomycetous fungus closely resembling *Peziza ciborioides* Fr., parasitic on clover, the sclerotia of which are found in the underground parts, from which the aerial parts, with the asci, can be developed by placing the diseased bulbs in a pot and copiously watering.

Identity of Oidium monosporium West, Peronospora obliqua Cooke, and Ramularia obovata Fkl. §—C. A. J. A. Oudemans clearly identifies these fungi, described as three distinct species. Rejecting the inappropriate specific name "monosporium," and adopting that of Cooke, the author proposes to call the fungus *Ovularia obliqua*, being clearly distinguished from *Peronospora* by its much-septated hyphæ.

* SB. Phys.-med. Soc. Erlangen, 1882. See Bot. Centralbl., xiii. (1883) p. 373.

† See this Journal, iii. (1880) p. 835.

‡ Bot. Centralbl., xiv. (1883) pp. 315–7.

§ Hedwigia, xxii. (1883) pp. 81–6.

New Form of Potato Disease.*—A hitherto unknown form of the potato disease, which has been making slow but steady progress near Stavanger during the last ten or twelve years, has recently begun to show increased energy. The stalk of the plant is the part affected, and here Herr Anda has discovered small white fungoid growths, which after a time assume a greenish, and finally a black, colour, after attaining the size of a small bean. While the fungus is rapidly increasing at the expense of the plant, the interior of the stem is first reduced to a pulpy condition, and next shrivelled and hollowed out, until nothing remains but a mere outer shell, which breaks down on being touched. When the ripe black germs of the fungus have remained in the earth through the winter, they are found after the return of the next year's warmth to have developed small stalked fruits filled with minute spores, which penetrate into the young plants before they appear above the ground. The end of July or beginning of August is the time when the ravages of the fungus are most conspicuous, and at those periods whole fields of potato plants are often rapidly reduced to the condition of withered straw.

Spermamœbæ of the Saprolegnieæ.†—As the result of a fresh series of observations, N. Pringsheim confirms his previous statement that the fertilization of *Achlya* and *Saprolegnia* is effected by means of peculiar bodies, "spermamœbæ," which enter the oogonia; in opposition to the view of Zopf,‡ that these bodies are nothing but parasitic amœbæ.

He affirms that the spermamœbæ are produced within the antheridium, and do not occur in any other part of the plant; that they are formed only during the period of fertilization, and do not continue any longer than the fertilizing tube. Parasitic amœbæ endowed with a power of motion he has never seen in the fertilizing tubes or oogonia of the Saprolegnieæ. It is impossible to confound the spermamœbæ with the well-known swarmspores of Chytridieæ—*Olpidiopsis*, *Woronina*, *Rozella*, and a *Rhizidium*-like parasite—which enter healthy Saprolegnieæ by boring through the walls of the fertilizing tubes. The amœbæ which abound in the water surrounding the Saprolegnieæ never enter the tubes in this way.

The bodies which Zopf describes as larger and smaller amœbæ, Pringsheim believes to be structures of a peculiar nature, which superficial observation might mistake for the spermamœbæ. But they are distinguished from them by a variety of characters, morphological, optical, and chemical. They are grains of a kind of fungus-cellulose or of some modification of it. These occur abundantly in the fertilizing tubes, and some of them pass into the oogonia among the oospores.

Pringsheim further supports his view as to the mode in which the process of fecundation is effected in the Saprolegnieæ—which differs also somewhat from that of de Bary—by the following considera-

* Naturen, 1883. Cf. Nature, xxviii. (1883) p. 281.

† Bot. Centralbl., xiv. (1883) pp. 378–82; also Pringsheim's Jahrb. Wiss. Bot., xiv. (1883) pp. 111–31. Cf. this Journal, *supra*, p. 676.

‡ See this Journal, *ante*, p. 248.

tions:—The fertilizing tubes come into contact with every oosphere in the polysporous oogonia, accompanied by the obvious disappearance of a portion of the contents of the tube. Protoplasmic structures, which can be proved to belong to these contents, are often subsequently found free in the oogonia in addition to the oospores. These processes correspond exactly in time with the transformation of oospheres into oospores. In *Pythium* the passage of the contents of the tubes into the oospheres can be directly observed. In *Achlya polyandra*, not only does this contact of the fertilizing tube take place with a definite spot of the oosphere, but the latter is produced into a papilla. Although, undoubtedly, true parthenogenesis occurs in *Achlya*, Pringsheim believes that de Bary's statement that in the sexual forms reproduction takes place by a kind of apogamy is founded in error.

Schizomycetes.*—W. Zopf gives an exhaustive account of the Schizomycetes as a contribution to Schenk's 'Encyklopædie der Naturwissenschaften.' The chief point brought forward, in opposition to the older view of this class of organisms, is the genetic connection between the various forms hitherto considered distinct by Cohn and others. The coccus-form (micrococcus) may under certain conditions develope into the shorter (bacterium) or longer (bacillus) rod-form; and if these divide continually, remaining side by side, we get the filiform (leptothrix) form, which again may bend (vibrio) or coil spirally (spirillum, spirochæte). Continual division of any of these forms again produces the micrococcus, which may be regarded as the final product, of the nature of gonidia. These different conditions may even be displayed in different parts of the same filament, though this is not usual. No true branching ever takes place, nor any differentiation of the cells into vegetative and sterile, as in the Schizophyceæ. In the most highly developed forms, as *Crenothrix*, *Beggiatoa*, and *Cladothrix*, a distinction of base and apex may be made out. The mode of vegetative reproduction is always by bipartition, which may take place in two, or even in three directions, though usually only in one. The cells are always inclosed in a cell-wall, composed, in the bacteria which accompany putrefaction, of a peculiar proteinaceous substance, mycoprotein, in the others of cellulose. The cell-contents consists of a homogeneous protoplasm, mainly mycoprotein, together with oil (the so-called granules). There is no nucleus. Other substances are occasionally also present. Under certain conditions of nutriment all the forms except the filiform become provided with cilia as organs of locomotion. They are apparently contractile threads of protoplasm which project through an opening in the membrane, and can be again withdrawn. Besides the motion imparted by them, they have another oscillatory movement.

Besides division by bipartition, the Schizomycetes are reproduced by spores. The contents of the cell contract into the smallest possible space, become very dense, and encyst themselves with a thick,

* Zopf, W., 'Die Spaltpilze. Encyklop. der Naturwiss.,' Abth. i., Lief. 32; 97 pp., Breslau, 1883.

apparently bilamellar, smooth, colourless membrane. This process may take place in different conditions of the organism, in that of coccus, bacillus, vibrio, or spirillum, but most frequently in the bacillus-form. Rarely is more than one spore formed in a mother-cell, which does not thereby lose its power of swarming. They escape by the gradual absorption of the wall of the mother-cell. The spores germinate immediately, by the contents bursting through the cell-wall at a definite spot, and elongating into a bacillus, which escapes from the membrane of the mother-cell.

The production of the gelatinous or zooglœa-form of the Schizomycetes depends on the accumulation of resting-cells, and on the tendency of their cell-walls to gelatinize; this may be accompanied, or not, by division; and may take place in all the various stages of development. Occasionally the zooglœa-colonies swarm out, leaving nothing but the jelly behind.

A scientific classification of the Schizomycetes is at present impossible; the forms that are better known Zopf divides provisionally into the four following classes:—1. *Coccaceæ*. Known only in the coccus-form, and the leptothrix-form resulting from it. Genus, *Leuconostoc*. 2. *Bacteriaceæ*. Four stages of development known—coccus, bacterium, bacillus, and leptothrix, the latter with no distinction of base and apex; no spiral form. Genera, *Bacterium*, *Clostridium*. 3. *Leptotricheæ*. Known in the coccus, bacillus, leptothrix, and spirillum-form, the leptothrix-form displaying distinction between base and apex. Genera, *Leptothrix*, *Beggiatoa*, *Crenothrix*, *Phragmidiothrix*. 4. *Cladotricheæ*. Known in the coccus, bacillus, leptothrix, and spirillum-form; the leptothrix-form provided with spurious ramifications. Genus, *Cladothrix*.

All the various forms are described in detail; the following are but little known:—

Leuconostoc mesenterioides Cienk. Appears spontaneously in the sap of turnips and in molasses, forming massive gelatinous lumps with the appearance of frogs' spawn. The germinating spore first produces a coccus-cell inclosed in jelly, which elongates into a bacterium, and then divides into two and afterwards into a greater number of cocci connected together into a chain, and surrounded by a gelatinous envelope. These break up into longer or shorter pieces. If the supply of nutriment is defective, spores are formed within some of the cells of the chain, causing them to swell up; the membrane of the spore coalescing with that of the mother-cell, and cuticularizing.

Bacterium aceti Kütz. Occurs in the coccus, bacterium, bacillus, and leptothrix-form; the bacilli and leptothrices often not cylindrical, but irregularly swollen. Has the power of converting alcohol into acetic acid.

B. merismopodioides Zopf. Occurs in putrid slime, and is distinguished by the peculiarity of the coccus-form dividing in two directions into a merismopodium-like colony.

Clostridium butyricum Prazm. In putrid vegetables; causing the butyric fermentation. When the bacilli develope spores, they swell up into a fusiform or ellipsoidal form.

Beggiatoa roseo-persicina Zopf. Previously described as *Cohnia roseo-persicina*. Known in the coccus, bacillus, leptothrix, and spirillum-forms.

Action of Heat on Pathogenous Bacteria.* — A. Chauveau has carried on a series of experiments on the effects of a high temperature both on the development and on the infectivity of pathogenous bacteria. For this purpose sterilized infusion of meat was infected with fresh cattle-distemper blood, and the vessel placed in a thermostat with a uniform temperature of 42°–43° C., from which it was transferred, after about twenty hours, to another with a temperature of 47° C., and left there for some hours. The bacteria were found, from this treatment, to have suffered no deterioration of their vital activity, but they had more or less entirely lost their pathogenous property, in proportion to the length of time that the higher temperature had lasted. Exposure for three hours to a temperature of 47° C. was sufficient entirely to destroy the infectivity, while the appearance of the culture had scarcely changed; the proliferation of rods and filaments had ceased; while the development of the rudimentary spores appeared to be rather promoted.

Fermentation of Bread.†—G. Chicandard thinks that the fermentation process by which bread is made does not consist in the hydration of the starch, followed by an alcoholic fermentation, nor that it is due to a *saccharomyces;* it consists rather in a transformation of a part of the insoluble albuminoids in the gluten into, first, soluble albuminoids, and then into peptones. The starch is only modified by heating, which gives rise to soluble starch and a little dextrine; the agent in the fermentative action is a bacterium which is normally developed in the dough; yeast only accelerates its development. The author discusses the observations and views of previous authors, which he rejects, and gives an account of some experiments on which he has based his own theory.

Lichenes.

Morphology and Development of Cladoniaceæ.‡—As the result of a careful examination of several species of Cladoniaceæ, G. Krabbe comes to the conclusion that this family does not belong exclusively to the fruticose lichens, but that the species must be distributed, according to the nature of their thallus, among the fruticose, foliose, and crustaceous lichens. The classification of the heteromerous lichens into these three families he regards as artificial. The Cladoniaceæ consist in fact of genera widely separated from one another, the precise relationship of which to one another cannot at present be defined; but the family cannot be retained with its present limits. The genus *Stereocaulon* departs widely from *Cladonia* in its course of development and in its morphological relationships.

* Comptes Rendus, xcvi. (1883) pp. 553, 612.
† Ibid., pp. 616–7.
‡ Ber. Deutsch. Bot. Gesellsch., i. (1883) pp. 64–77.

Structure of Calicieæ.*—E. Neubner has investigated the structure and development of this little-known family of lichens, especially the species *Cyphelium trichiale*, *Calicium populneum*, *C. roscidum*, *Acolium tympanellum*, and *A. tigillare*. The thallus varies from true crustaceous to granular-pulverulent, and offers an additional illustration of the fallacy of the old classification of lichens into those with homoomerous and those with heteromerous thallus.

The gonidia of the Caliciæ are of three kinds:—Cylindrical, corresponding to *Stichococcus bacillaris* among unicellular algæ; and spherical, corresponding to the forms *Cystococcus* and *Pleurococcus*. The course of growth of the thallus is that described by Schwendener under the term "orthogonal-trajectoral," and which belongs especially to the fruticose and foliose forms. For the greater number of species the gonidia closely resemble *Cystococcus humicola* Näg. The *Pleurococcus* form of gonidium does not correspond precisely to any known species of that genus, but the author regards it as a modification of *P. vulgaris*. These globular gonidia have a strong tendency to assume a cylindrical form, accompanied by a decrease in size, thus becoming transformed, owing to the mechanical circumstances of their environment, into the typical *Stichococcus bacillaris*. The genera *Stichococcus* and *Pleurococcus* cannot therefore be maintained as distinct. When freed from the enveloping hyphæ the *Stichococcus* may either remain permanently in that condition, or may become again transformed into its original *Pleurococcus* form. Transitional forms of all kinds may be observed, and the author compares these two stages of the same organism to the bacterium and coccus stage of bacteria.

Algæ.

Structure and Fertilization of Florideæ.†—F. Schmitz has made a detailed examination of the most important points in the structure of the vegetative and reproductive organs of several families of Florideæ, of which the following are some of the more important details.

The thallus of the Florideæ is always composed of branched filaments, which are sometimes held together by a more or less dense gelatinous envelope, sometimes by a very dense and tough intercellular substance, so closely that they form a pseudo-parenchyma; or they may be quite free. The separate filaments increase in length by apical growth, which is often followed by a very strong intercalary growth of the separate cells. Whenever a cell divides, a peculiar opening is formed in the septum, by means of which the two new cells remain in communication with one another so long as they are in a living condition; they are usually circular, and are closed by extremely thin membranes, through which pass strings of protoplasm connecting the two cells. There is not usually any passage of the cell-contents from one cell to another, which does, however, occur through larger orifices in some Corallinaceæ.

* Flora, lxvi. (1883) pp. 291–301, 307–17 (3 pls.).
† SB. Akad. Wiss. Berlin, 1883, pp. 215–58 (1 pl.).

The sexual reproductive cells are formed on the thallus by the differentiation of terminal cells of filaments.

The male cells are usually collected in groups, constituting the antheridia of various forms, exposed in the form of tufts, or buried in depressions in the surface of the thallus. Within the antheridia are formed the male fertilizing bodies or spermatia, usually of a spherical or elongated form, sometimes with a beak-like appendage; they are formed and discharged in succession. Although the author has been unable at present to detect any spontaneous power of motion in these spermatia, he does not consider the question altogether decided.

The female sexual cells are always developed out of the terminal cell of longer or shorter lateral branches. At the base of this female cell or carpogonium is always formed the long hair-like appendage known as the trichogyne. The ventral portion of the carpogonium always incloses an abundant protoplasm, and sometimes chromatophores in addition; the protoplasm of the trichogyne is always colourless.

In impregnation the spermatia attach themselves to the apex of the trichogyne, and at the same time clothe themselves with a cell-wall. At the point of attachment the cell-wall of both spermatium and trichogyne is absorbed, and through this opening the contents of the two coalesce; the united protoplasmic mass contains at first two distinct nuclei; subsequently only one nucleus is to be found in the carpogonium, probably from the coalescence of the two. The trichogyne then becomes detached, and disappears.

The impregnated carpogonium now divides into two cells of unequal value; the lower one only contains a nucleus, and is the ovum-cell or oospore; the upper one is functionless, and ultimately disappears. The oospore does not, as is the case with the green algæ and the higher cryptogams, become released from the tissue by which it is surrounded, but remains closely associated with it; sometimes it is scarcely distinguishable, except in its power of development, from an ordinary cell of the thallus. The mode of its development varies greatly in the different classes, and is described in detail.

The simplest mode of development of the cystocarp occurs in the Helminthocladieæ, where a number of branches, the "ooblastema," spring from the surface of the oospore; this tuft of hairs may be either exposed, or more or less concealed in the tissue; in the cells of these branches the carpospores are finally produced. In the Gelidieæ only a single ooblastema-filament is produced, which enters into intimate connection with the other cells of the fertile branch of the thallus, deriving its nutriment from them; the carpospores then being formed in the cells of the fertile ooblastema-filament, which has in the meantime branched abundantly. The cystocarp, or mass of fertile cells, forms a swelling within the fertile branch. In the Cryptonemieæ and Squamarieæ (e. g. *Dudresnaya*) this process is further modified by the fertile cells entering into actual communication with certain special sterile cells, rich in protoplasm, through orifices in their cell-walls; the details of this conjugation with the so-called "auxiliary cells" are subject to great variety in the different genera,

as also in the further development of the fertile cell. In some cases the protoplasmic contents of the two cells (fertile cell and auxiliary cell) coalesce, the nuclei remaining distinct; in others the union is complete. The cell resulting from this conjugation then displays rapid growth, and marginal cells divide off from it, leaving a large central cell; this central cell alone remains sterile; all the rest, which form a dense envelope around it, producing carpospores, the whole structure constituting a complicated cystocarp. In the Corallinaceæ the process is similar, but somewhat more complicated, the ooblastema-filament of the oospore entering into successive conjugation with several neighbouring auxiliary cells. In a very large number, perhaps a majority, of the Florideæ, including the Ceramiaceæ, Wrangelieæ, Rhodomeleæ, Chylocladieæ, Rhodomenieæ, Sphærococcæ, and Gigartineæ, the mode of formation of the cystocarp is, with modifications in the different groups, as follows:—A short branch of the carpogonium, usually consisting of three or four cells, becomes attached laterally to a branch of the thallus, and becomes curved in such a way that the carpogonium-cell is closely applied to the nearest auxiliary cell, or reaches it by means of a short protuberance from one or both of the conjugating cells. The entire protoplasm, or at all events the nucleus, of the oospore, then passes over into the auxiliary cell, which then developes into the cystocarp in different ways in the different groups. In the Gigartineæ, the auxiliary cell itself becomes the central cell of the cystocarp.

As a general result of these observations, Schmitz asserts that in the Florideæ there is invariably a material conjugation between the male cell or spermatium and that cell which developes into the sporiferous tissue of the cystocarp (the "nucleus" of systematists). Nowhere has he observed any indirect fertilizing action of the conjugation of spermatium and carpogonium on a third distant cell.

The remarkable phenomena here described appear to point to a double process of impregnation in the same individual occurring in many Florideæ; first of the male spermatium with the female carpogonium cell, secondly of the oospore or fertilized contents of the carpogonium with one or more auxiliary cells; and the author discusses this hypothesis at length. He points out that in the simplest case the contents of the oospore pass, without any intermediate formation of ooblastema-filaments, into the auxiliary cell; and this process appears to form a connecting link between an ordinary process of absorption of nutriment and an act of sexual union. If an act of sexual conjugation is regarded simply as a strongly specialized instance of absorption of nutriment, then the repetition of this process in a single individual ceases to have the exceptional character which would otherwise belong to it. In the simplest forms, as *Nemaleon*, the second process is altogether wanting, and the development of the cystocarp corresponds closely to that of the sporogonium in Muscineæ, and might even be regarded as displaying a kind of alternation of generations. In some groups of Florideæ this alternation of generations is further complicated by the production of non-sexual individuals, or those that bear tetraspores, these not,

however, being produced in alternate succession with the sexual individuals.

As regards the systematic position of the Florideæ, Schmitz considers them as most nearly allied to the Coleochæteæ among the Chlorophyceæ. He dissents from Berthold's location of the Bangiaceæ * as constituting the lowest group of Florideæ, pointing out many important features in which they differ from the true Florideæ, especially in the structure of the thallus, the position of the sexual reproductive cells, the mode of impregnation, and the further development of the fertilized oosphere. The arrangement of the families of which the Florideæ are themselves composed must remain at present altogether uncertain.

New Cyanophycea.† — Under the name *Plaxonema* E. Tangl describes a filamentous alga with the habit of an *Oscillatoria*, presenting the peculiarity of a disk-shaped chromatophore in the blueish-green protoplasm. Under normal conditions reproduction takes place by fragmentation by means of the formation of dead cells. Under cultivation the filaments first of all lose their motility and break up into fragments of various lengths, preceded by the formation of narrow interstices between the cells separated from the common envelope. These fragments behave in two different ways. Some break up directly into separate cells, while others develope into spherical zooglœas, which are either terminal or intercalary. The formation of zooglœas is followed by peculiar movements of the cells, which separate and distribute themselves through the gelatinous mass, caused by tensions of the common envelope resulting from the escape of gelatine from the contents of the cells as an excretory product. The zooglœa cells thus isolated have a cylindrical form with flattened ends; no further development was observed. They may be regarded as the form of development of the alga described by Zopf as belonging to the Chroococcaceæ group.

Organic Bodies in the Thermal Waters of the Pyrenees.‡— N. Joly has determined that the so-called "sulfuraire de Fontan" of the sulphurous waters of the Pyrenees is not, as was stated by Agardh, a conferva, but a true *Oscillatoria*, to which he gives the name *O. vitrea* n. sp., endowed with the usual motility of the genus.

Fossil Confervites.§—M. Staub describes all the known species of this group of fossil algæ, which he estimates at nineteen, including one described for the first time. He considers that they became differentiated from the large group of Chondrites, which died out in the Tertiary. These algæ have great stratigraphical importance in the formation of rocks, from the great quantity of carbonic acid which they removed from sea-water, thus bringing about the precipitation of calcium carbonate.

* See this Journal, *ante*, p. 408.

† K. Akad. Wiss. Wien, May 4th, 1883. See Bot. Centralbl., xiv. (1883) p. 285.

‡ Mem. Acad. Sci. Toulouse, iv. (1883) pp. 115–35 (1 pl.).

§ SB. Ungar. Geol. Gesellsch., xiii. (1883) pp. 71–2. See Bot. Centralbl., xiv. (1883) p. 303.

Cell-division in Closterium.*—A. Fischer has followed closely the process of reproduction by means of cell-division in *Closterium*, especially in *C. Ralfsii* Breb. f. *Delpontii* Klebs, and *C. moniliferum* Ehrenb. f. *typicum* Klebs. The process of division of the nucleus agrees with that described by Strasburger in the case of *Spirogyra*. The septum which separates the two halves of the cell is always situated exactly in the middle where the nucleus lies between the two symmetrically arranged chlorophyll-bodies. Before the commencement of the formation of this septum and the division of the nucleus into two halves, which then lie on each side of the septum, the cell in all probability becomes slightly constricted, and the entire membrane opens by a circular crevice. The process of renewal appears to differ from that observed in other Desmidieæ, and varies also somewhat in the different species of *Closterium*.

The normal process occurs in the first-named species, where the old cell-wall remains unchanged. In the second species, on the other hand, the halves of the old cell continue to increase in size, the size of the daughter-cell being in this way influenced. A third type, of periodical renewal, occurs in *C. striolatum* f. *erectum* Klebs, where the halves of the old cell develope into new individuals in two distinct periods separated by a period of repose.

Although these three modes of renewal appear to differ considerably at first sight, all three lead to the same result, the isolated cell-halves developing into a new individual, resembling as closely as possible the parent generation. The mode of division of the nucleus and chromatophores is the same in all three types. The nucleus appears to undergo a second transference, apparently passive, and reaches the new cell-half, in which it takes up its permanent position. The two portions of the chlorophyll-body develope into two perfect chromatophores, each occupying one-half of the new individual. The variability of form within the same species of *Closterium* is probably due to variations in the mode of renewal, which may also account for the occurrence of transitional forms.

Sections of Diatoms.†—W. Prinz criticizes the remarks of E. W. Burgess on this subject,‡ which were based on the deeper colour of the centre of the areolæ of certain diatoms.

"It might be hoped," says M. Prinz, "that the images due to effects of diffraction would no longer serve to support the hypothesis of elevations on the surface of certain diatoms. I think it useless to recall the theoretical explanations given specially for *Coscinodiscus Oculus-Iridis* by Stephenson, or the more general considerations developed in the works of Professor Abbe. It is sufficient to know that the Radiolaria, whose perforations are admitted by all observers, present exactly the same dark spots in the centre of the pores which traverse them.

This discussion has lasted nearly fifty years; and we shall

* Bot. Ztg., xli. (1883) pp. 225–35, 241–7, 257–66, 273–5 (1 pl.).
† Bull. Soc. Belg. Micr., ix. (1883) pp. 124–6.
‡ See this Journal, *ante*, p. 264.

certainly be able to celebrate its centenary if it is left on the basis to which it is incessantly brought back.

I will not offer other objections to Mr. Burgess's note, because they would be a repetition of the views enunciated by Dr. van Ermengem and myself in the paper which the Society has accepted for vol. viii. of the 'Annales.' I will confine myself to pointing out that the uncertainty in which Mr. Burgess finds himself is reflected in the drawing of *Coscinodiscus* which he publishes, in comparison with that which I have myself given and which he reproduces. His drawing shows a line of fracture passing generally *above* the apertures, and consequently does not allow us to judge of the nature of the latter. Each time, on the contrary, that this fracture passes *through* an areola, Mr. Burgess draws it clearly open. I have maintained nothing else. But this figure does not accord with the text, and exactly that which it was necessary to represent is absent in the drawing, that is to say, the form of the membrane which Mr. Burgess supposes to close the apertures of *Coscinodiscus Oculus-Iridis* and of *Trinacria Regina*.

I profit by the opportunity which is offered by Mr. Burgess's note to communicate to the Society, in concert with Dr. van Ermengem, the results obtained by fresh researches on the black opaque matter which covers certain diatoms of the Für rock.* These researches complete, in certain respects, our previous observations on this important peculiarity. The first attempts at analysis of the rare specimens which we possessed at that date, had led us to think that this coating was charcoal, arising from a slow combustion of one of the organic layers of the envelope of these diatoms. We succeeded in procuring a fragment of the rock in which this substance is more abundant, and, after again making the chemical analysis, we are forced to conclude that, side by side with the carbonaceous masses, are found a great number of concretions, and even octahedric crystallizations, formed by pyrites.

The covering of the valves of *Trinacria*, amongst others, is due to a deposit of this body. The metallic aspect which it presents, when examined with the Beck reflector, leaves moreover no room for doubt. The presence of this mineral incrustation—distributed sometimes over the whole surface of the valves and faithfully reproducing all their markings, without filling up in any way the *lacunæ* which correspond to the portions taken by the different experimenters for marks in relief or else for depressions—constitutes in our eyes a decisive argument in favour of the thesis which we defend.

Moreover this pyritization enables us to establish the most interesting comparisons with the mineralized diatoms of the London clay. The mode of mineralization of the diatoms of the Für rock appears to be the same as that of which the diatoms of the London clay show such remarkable examples, and it seems to us incontestable that these latter are perforated."

* See this Journal, *ante*, p. 411.

MICROSCOPY.

a. Instruments, Accessories, &c.

Bailey's Portable Microscope.—The possible variations in the form of portable Microscopes might be supposed to be pretty well exhausted, but Mr. J. W. Bailey has been able to adapt to the instru-

FIG. 120.

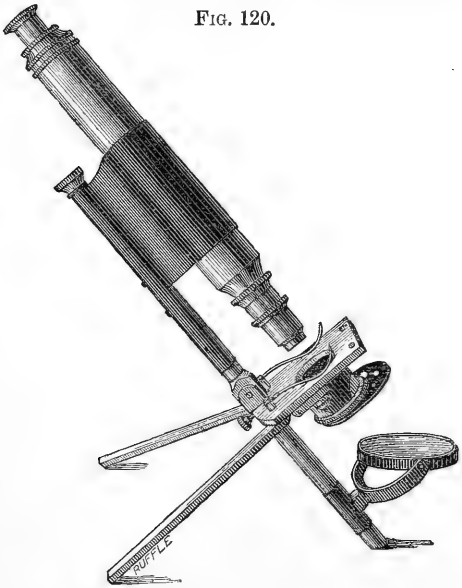
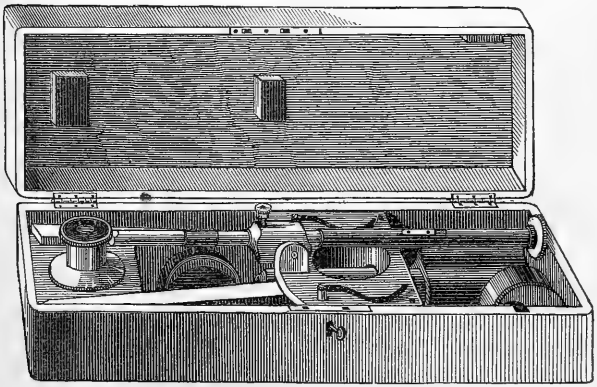


FIG. 121.



ment shown in figs. 120 and 121 some ingenious points of novelty which make it very portable and at the same time steady.

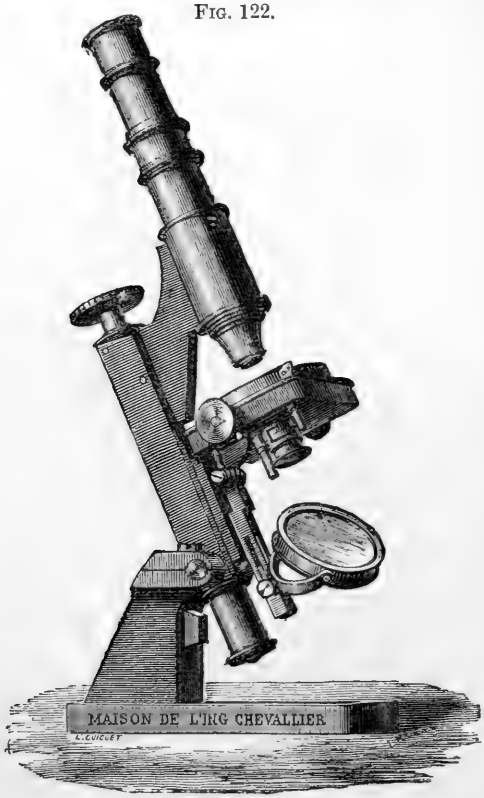
The instrument, when inclined, is shown in fig. 120. To put it

into its case (fig. 121) the stage is turned upwards on a cradle joint against the limb, the two legs, which move with it, then being also parallel with the limb. On closing together the legs (which turn on pivots fixed underneath the stage) and sliding the body-tube down, the instrument is reduced to $11\frac{1}{2}$ in. by 3 in. by $2\frac{1}{2}$ in. A milled head behind the stage secures it if desired.

The instrument can be used in a vertical position by bringing forward the legs on their hinge joints, so that they project in front of the stage and mirror.

Chevallier's Inclining Microscope (large model).—We give a figure of this somewhat peculiar Microscope (fig. 122) in illustration

FIG. 122.



of one of the various designs adopted in the evolution of the modern instrument. The base is solid, and forms one piece with the upright. The limb is suspended in a peculiar manner, being attached to a trunnion axis very near the lower end—much too near to give stability to the inclination. The coarse adjustment is by sliding-tube. The

fine focusing screw is at the top of the limb, but acts not on the tube but on the stage, causing this to slide up or down. The mirror-bar is of somewhat uncommon form, having a hinge-joint close beneath

Fig. 123.

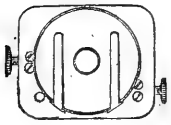
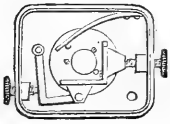


Fig. 124.



the stage on which it can be swung considerably forward for oblique illumination; the mirror also slides in a slot to focus the light on the object.

Fig. 125.

A mechanical stage can be applied on the ordinary stage; the mechanism is shown in fig. 123 (upper side) and fig. 124 (lower side). This construction has been largely adopted (with more or less

modification) on the Continent, and was originally devised by M. Nachet, Senr. The rotating movement has the disadvantage, common to the older forms of movable stage, of being acted upon by the rectangular movements, so that the centering in the optic axis is disturbed whenever these movements are used, their utility being thereby seriously reduced.

The Microscopes now issued by the firm of Chevallier are on a more modern type: their large stand is shown in fig. 125.

Hirschwald's Microscope-Goniometer.*—J. Hirschwald has devised a Microscope-goniometer for measuring the angles of crystals not having reflecting surfaces, the principle of which consists in employing the sensibility of a Microscope in the accurate focusing of a plane surface. The instrument (fig. 126) consists essentially of three parts—(1) a Wollaston goniometer, (2) a Microscope, and (3) a telescope.

The goniometer is firmly attached to a horizontal base-plate C. The circle M is divided into half-degrees, and by means of a vernier N reads to single minutes. The lens L allows of a still closer estimation. By the milled head O^1 the object can be turned without the circle, the movement of the latter simultaneously with the object being effected by turning the larger milled head O^2. By screwing down P the turning of O^2 is prevented, and the circle with the object can then only be moved by the screw Q, which presses against the end of the lever J attached to the axis, giving a very slow movement to the circle.

The crystal is attached to the holder R, which, besides rotating on the goniometer axis, allows of four other motions, viz. two rectangular movements in a plane at right angles to the axis, and two similar movements, but in segments of a sphere.

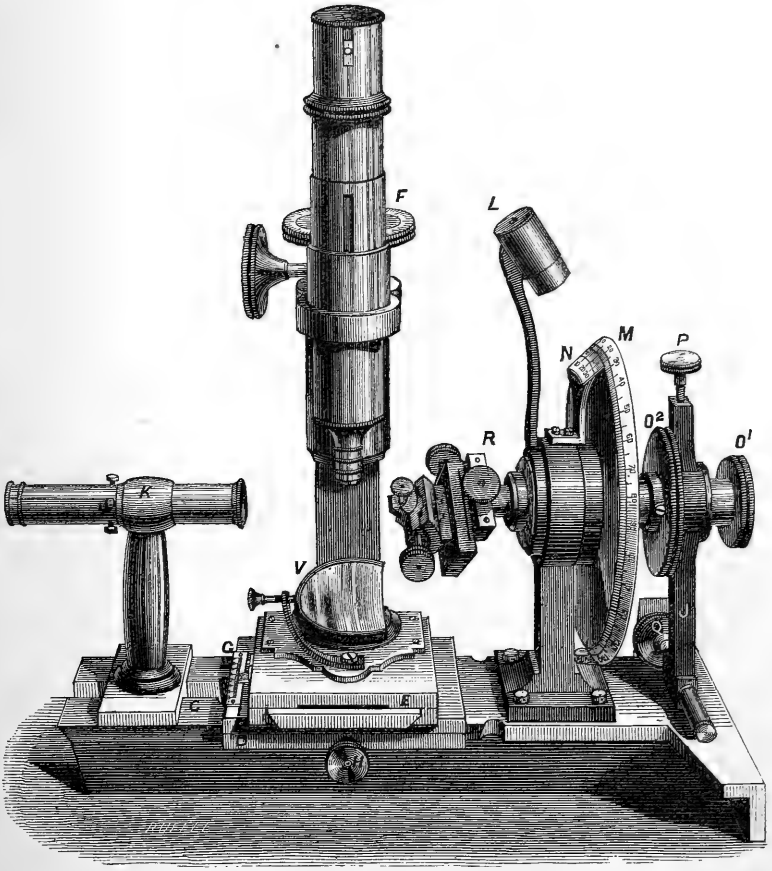
The Microscope rests on a double slide D E, by means of which it can be moved either parallel or at right angles to the axis of the goniometer, so that the entire surface of a crystal can be examined. The slide E has an index mark, which indicates the extent of movement upon a scale G in half-millimetres. The slide D can be fixed to the base-plate by clamping the screw H. The micrometer-screw F of the Microscope has a pitch of 0·4 mm., and is graduated so that the raising or depression of the Microscope can be read to 0·004 mm. The eye-piece has cross-threads, one parallel and the other at right angles to the axis of the goniometer-circle. The former will lie in the vertical plane of the axis when the Microscope is adjusted so that the index mark is at the zero of the scale G. The Microscope with the three lenses of the dividing objective has a magnifying power of 500 times, a focal distance of 0·76 mm., and a sensitiveness of focus of 0·0015 mm. Without the lower objective the figures are 350, 1·2 mm., and 0·004 mm. respectively; and on

* Neues Jahrb. f. Mineral. Geol. u. Palaeontologie, 1879, pp. 301 (1 pl.) and 539; 1880, p. 136.

removing the lower and middle lenses the power is reduced to 200, with a focal distance of 6 mm. and a sensitiveness of 0·008 mm. For the illumination of transparent objects there is a mirror V, a condensing lens on a separate stand being used for opaque ones.

The centering telescope K has cross-threads (movable by four

Fig. 126.

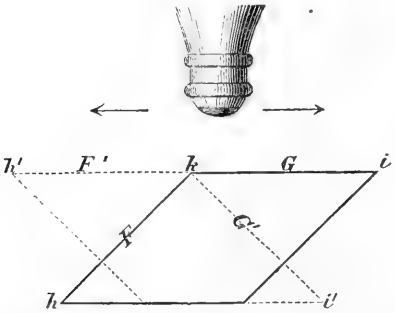


small screws), adjusted exactly in the axis of the goniometer. It moves in a groove in the base-plate in the direction of the axis.

The method of measuring is briefly as follows:—(1) the edge of the surfaces to be measured is placed parallel to the goniometer-axis by means of the thread in the eye-piece; on turning the

crystal the edge and the thread must remain parallel. (2) The edge is so centered that it appears in the middle of the cross-threads of the telescope, and remains in this position on turning the crystal. (3) The screw H is turned to fix the lower slide of the Microscope, so that the latter can only be moved at right angles to the goniometer-axis. The Microscope is focused on one of the two surfaces F G (fig. 127), forming the edge k to be measured, and having focused the

Fig. 127.



part next to k, the Microscope is passed over the surface G, and the crystal slightly moved until the part next i is in focus. When G has been adjusted exactly horizontal, the crystal is then turned, and the surface F similarly adjusted. The angle indicated on the goniometer through which the crystal is turned in order that the second surface F may occupy the position of the first, G, is the complementary angle of the edge measured.

The degree of exactness of the measurements for a diameter of the crystal surface of x mm., and for a defect in the focusing of the Microscope of u mm., will be given by the formula $\tan \alpha = 2\frac{u}{x}$. Therefore for

$x = 10$ mm. and $u = 0{\cdot}004$ mm.,	$\alpha = 2'\ 45''$
$= 5$	$= 5'\ 30''$
$x = 10$ mm. and $u = 0{\cdot}008$ mm.,	$\alpha = 5'\ 30''$
$= 5$	$= 11'\ 0''$

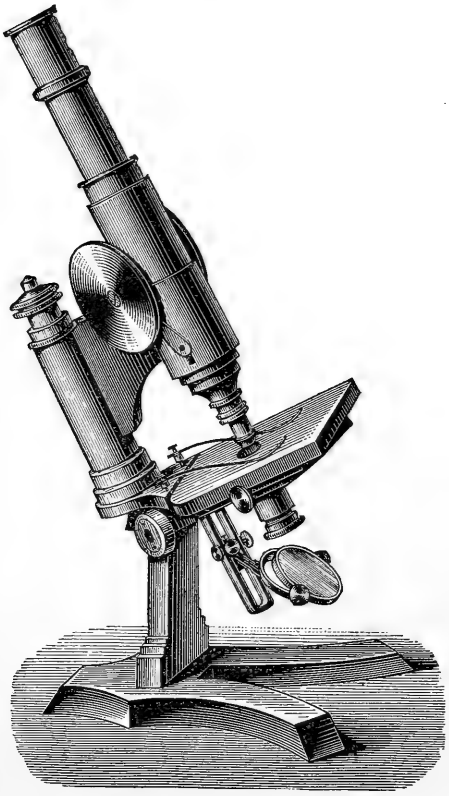
These figures, however, involve extreme assumptions: by careful repetition of the measurements exactness to $1'$ and less can be secured.

It is recommended to dust the surface of transparent crystals with very fine lime-wood charcoal, the focus not, however, being adjusted to the grains of charcoal, but upon the surface on which they rest. For opaque objects fine gum arabic is best.

Plössl's Large Stand.—This instrument (fig. 128) has a coarse adjustment of unusual construction, which is claimed to be eminently simple and to work very smoothly and surely, much better than rack and pinion.

Each of the two milled heads, 48 mm. in diameter, has near its

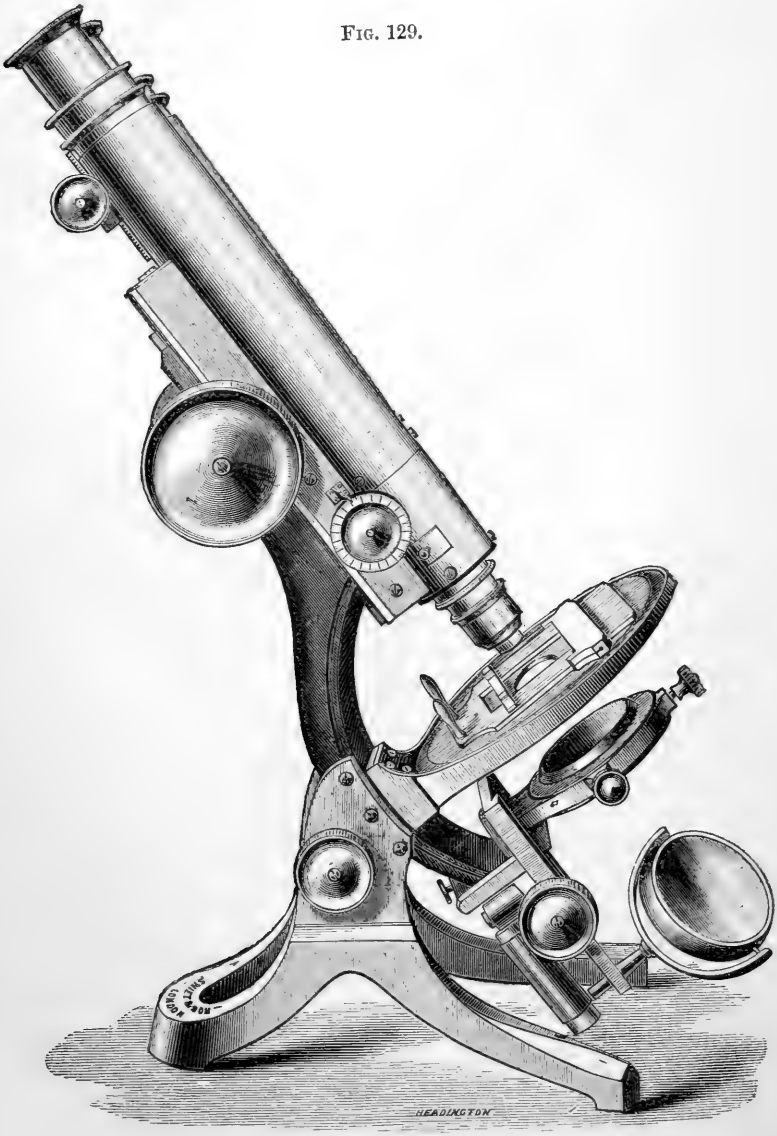
FIG. 128.



periphery a steel pin, to which is attached, so as to be movable, one end of a short rod. The latter is similarly movable at its other end on a pin on the body-tube, which moves in a rectangular slot 35 mm. long, cut parallel to the optic axis in the outer tube, lined with cloth, in which the body-tube slides. The result of the arrangement is, that on turning the milled heads the body-tube is correspondingly raised or depressed.

Swift and Son's Radial Inclining Microscope. — Figs. 129 and 130 show a new Microscope, made by Messrs. Swift and Son, which is an improvement of Wale's Working Microscope. The improvement

Fig. 129.



consists essentially in making the movement of inclination radial with the object on the stage, so that a beam of light from a fixed source directed upon the object remains on it during any inclination given

Fig. 130.

to the Microscope. Thus, suppose the light from the mirror to be directed as in fig. 130, then if the limb is inclined to the horizontal the light will still be upon the object, the incidence being, however, greatly increased in obliquity.

This result is obtained by making a sector-groove on either side of the limb radial with the object on the stage. The top of the tripod is provided with jaw-pieces fitting in the sector-grooves, and a clamp-screw causes them to grip the limb at any position of inclination.

The under face of the stage is flat, so as to present the least obstacle to oblique illumination, and the required strength in the attachment to the limb is obtained by thickening the rim on the upper edge as it approaches the limb, as devised by Mr. Tolles.* Friction-stage movements carry the object. The substage fits on the lower end of the limb by a dove-tail slide, which appears to be a convenient arrangement for rapidly attaching or removing it. The mirror can be used as shown in fig. 130, or on the tail-piece as in fig. 129. A telescope rod carries a bull's-eye lens or prism with ball-and-socket joints, as shown in fig. 130. The fine adjustment is on the system applied to Messrs. Swift's previous model.†

The new Microscope is extremely steady in all positions of inclination, in this feature meriting the favourable opinion of Wale's original model expressed by Dr. Carpenter.‡

Projecting Lanterns.§—Prof. C. H. Stowell describes his experience with a Marcy's lime-light sciopticon with one of Zentmayer's microscopic attachments, using ordinary Microscope objectives (1½ and 3-4ths in.), although the field is flatter and lighter if objectives are used especially for this kind of work. To work nicely the gases should be under heavy pressure. When the pressure in the cylinders is down to 60 or 70 pounds, such good results are not obtained.

With this simple outfit the Professor illustrates his lectures on histology. A transverse section of the spinal cord of a pig can be enlarged to 10 ft. in diameter on the screen. To show the nerve-cells a power of 500 diameters is very easily obtained. The cells will show so clearly that their poles can be counted and their nuclei clearly discerned. Sections of injected kidney, liver, intestine, &c., show very clearly and beautifully as well. Sections of cancer will show the stroma and cells. Pneumonia lung will show air-cells 6 in. in diameter more or less filled with the exudate.

One of Dr. A. Y. Moore's double-stained blood slides will show the individual corpuscles and their nuclei at a distance of 20 ft. from the screen very clearly, and this with a disk 6 ft. in diameter. The striæ and sarcolemma of muscle can be exhibited also. The circulation of the blood can be exhibited, using the tongue of the frog, on a disk 12 ft. in diameter.

By a simple device opaque specimens are thrown upon the screen. A frog is pithed, the thoracic walls removed, and the heart beating

* See this Journal, i. (1881) p. 944. † Ibid., p. 297.
‡ Ibid., iii. (1880) p. 1086.
§ The Microscope, iii. (1883) pp. 51–3.

in situ exhibited. The heart will appear about a foot in length, and will powerfully contract, stimulated by the heat. The heart may be removed from the body, pinned to a card, and this thrown on the screen, still there is vigorous motion. Again, the heart may be halved and quartered, yet still the pieces will be seen to contract.

No complex or wonderful apparatus is required. "Two hundred dollars and a little patience and ingenuity will go farther than some fifteen hundred dollar outfits."

Mr. R. Hitchcock,* on the other hand, considers that taking facts as they are at present, it is certainly much better to use photographs of microscopic objects, taken either from the objects themselves by aid of the Microscope, or else from good woodcuts—which is often the better plan—than to grapple with the difficulty of using the projecting Microscope. "We regard the latter as a useful instrument for popular demonstrations, and no doubt it has a limited sphere of usefulness in more strictly scientific work, but until it is greatly improved in several respects, it cannot be of very great value to lecturers upon scientific subjects."

Assyrian Lens. — Sir A. Henry Layard, in his 'Nineveh and Babylon,' describes a lens which he found in the course of his excavations, and which is now in the British Museum. By the kind permission of Dr. Birch, the Keeper of Oriental Antiquities, we have been enabled to figure it here (figs. 131 and 132).

The lens is thus referred to by Sir A. H. Layard †:—"With the glass bowls was discovered a rock-crystal lens, with opposite convex and plane faces. Its properties could scarcely have been unknown to the Assyrians, and we have consequently the earliest specimen of a magnifying and burning glass. It was buried beneath a heap of fragments of beautiful blue opaque glass, apparently the enamel of some object in ivory or wood, which had perished.

Fig. 131.

Fig. 132.

I am indebted to Sir David Brewster, who examined the lens, for the following note:—'This lens is plano-convex, and of a slightly oval form, its length being $1\frac{6}{10}$ in., and its breadth $1\frac{4}{10}$ in. It is about 1-4th ‡ of an inch thick, and a little thicker one side than the other. Its plane surface is pretty even, though ill polished and scratched. Its convex

* Amer. Mon. Micr. Journ., iv. (1883) pp. 125–6.
† 'Nineveh and Babylon,' pp. 197–8. 8vo, London, 1853.
‡ "9-10ths" in original.

surface has not been ground or polished on a spherical concave disk, but has been fashioned on a lapidary's wheel, or by some method equally rude. The convex side is tolerably well polished, and though uneven from the mode in which it has been ground, it gives a tolerably distinct focus, at the distance of $4\frac{1}{2}$ in. from the plane side. There are about twelve cavities in the lens, that have been opened during the process of grinding it: these cavities doubtless contained either naphtha, or the same fluid which is discovered in topaz, quartz, and other minerals. As the lens does not show the polarized rays at great obliquities, its plane surface must be greatly inclined to the axis of the hexagonal prism of quartz, from which it must have been taken. It is obvious, from the shape and rude cutting of the lens, that it could not have been intended as an ornament; we are entitled, therefore, to consider it as intended to be used as a lens, either for magnifying, or for concentrating the rays of the sun, which it does, however, very imperfectly.' " *

Lindsay's Microscope.†—This is represented in figs. 133 and 134. *a* is the lens fixed in a concave speculum; *b* the object-holder; *c* is a handle to which a longer arm can be screwed, and which can be turned up beneath the Microscope; at *d* is a graduated scale for roughly focusing the various lenses belonging to the instrument; *e*, *f*, *g* is a lever on which the observer can place the forefinger at *e*, and the thumb at *f*. Since the lever turns on *h*, whilst *i* moves in a slit in the plate of the object-holder, the latter by this means is adjusted at the required distance from the lens.

Fig. 133.

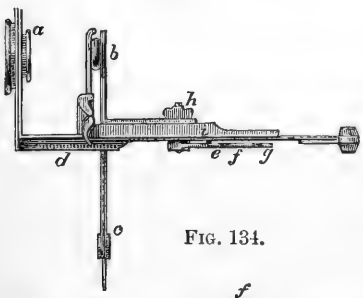
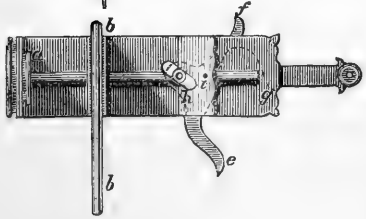


Fig. 134.



Janssen's Microscope.‡—Professor P. Harting, in the course of an examination of some old optical instruments found in Middelburg in 1866,§ and attributed to Janssen, discovered a compound Microscope, of which a section is represented in fig. 135 (1-4th natural size). The two tubes holding the lenses *a* and *b* are of tin roughly soldered together, and sliding in a somewhat wider

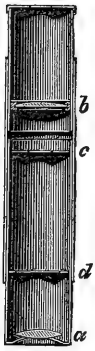
* The shading of fig. 131 representing internal striæ, is too strong, suggesting more opacity than really exists.

† Bericht über die wissenschaftlichen Apparate auf der Londoner Internat. Ausstellung im Jahre 1876 (Achenbach und Falk), 1878, Part 1, pp. 52–3 (2 figs.).

‡ Ibid., p. 50 (1 fig.). See also p. 46. § Album der Natur, 1867, p. 261.

third tube. *c* is a diaphragm and *d* an annular support upon which, on inverting the instrument, the lens *a* falls, whilst *b* is held in the usual way by a wire ring. Why the lens *a* is left loose is not apparent. The magnifying power obtainable with the instrument is not great. If the tubes containing the lenses are drawn out as far as possible it magnifies nine times, the object being at a distance of 14 cm. The instrument was presented by Mr. J. Snyder to the "Zeeuwsch Genootschap der Wetenschappen," and from that time its existence was so unknown, even in Holland, that it is not mentioned in such a complete history of the Microscope as that of Harting. It had been long in the possession of the Snyder family, but there are no authentic documents concerning it. Harting came to the conclusion, after examining it, that it was really made by Janssen.

Fig. 135.



Messrs. Beck made several facsimiles of the Microscope from the original in the South Kensington Loan Collection.

"Contribution to the History of the Compound Microscope."* —Professor Heschl, of Vienna, describes nine compound Microscopes found in Austria. The one shown in fig. 136 was made by G. F. Brander, of Augsburg, between the years 1760-90. It is 32 cm. high, has a massive foot *a*, of brass, with a standard *b*, into which fits a prolongation *c*, which carries a square brass box *f*, open at the sides. Into the lower plate of this is screwed the tube *g*, carrying a bi-convex lens *m*, acting as a condenser, and into the upper (at *i*) the objectives, together with the double tube (of brass below and wood and paper above) carrying the Ramsden eye-piece *n*. In the box are two movable plates *h*, forming the "stage," and between which the slider containing the objects is placed. The upper plate is pressed down to the lower by a spiral spring *l*, while the lower plate can be raised or lowered by screwing in or out the tube *g*. The mirror *d* is attached to an arm *e*, so that it can be used excentrically if desired.

There are seven objectives, two of them with Lieberkuhns. The five without Lieberkuhns can be used as simple magnifiers when the tube is removed and the lower part of the stand only employed. The two former could not, however, be then attached to the instrument, and an arm is accordingly supplied to take them (and also the others), which fits into the top of *f*, and projects laterally over the slide on the right. The tube with the eye-piece also fits on this arm, so that the instrument can be used as simple or compound in this position also. The mirror can be brought under the object in the altered position of the objectives by means of its arm above referred to.

A second form, shown in fig. 137, has no maker's name, and its date is doubtful, probably about 1800–10. It is inclosed in a

* Arch. f. Mikr. Anat., xviii. (1880) pp. 391–402 (1 pl.).

wooden case 21 cm. high (with a glass cover), the front of which is removed when in use, and it can be set at any angle on its horizontal axis by the screw *a*. The speciality of the construction is the large stage, 12 cm. by 9 cm., consisting of a lower plate *c c*

FIG. 136.

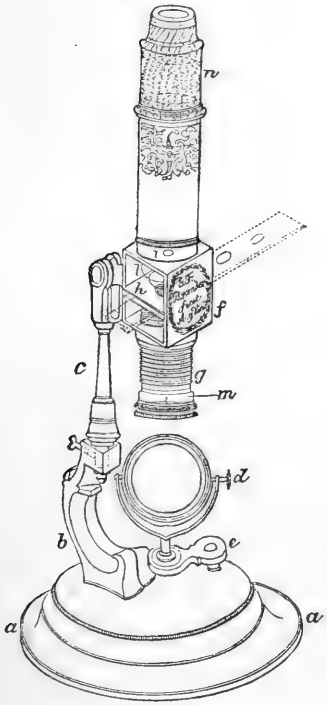
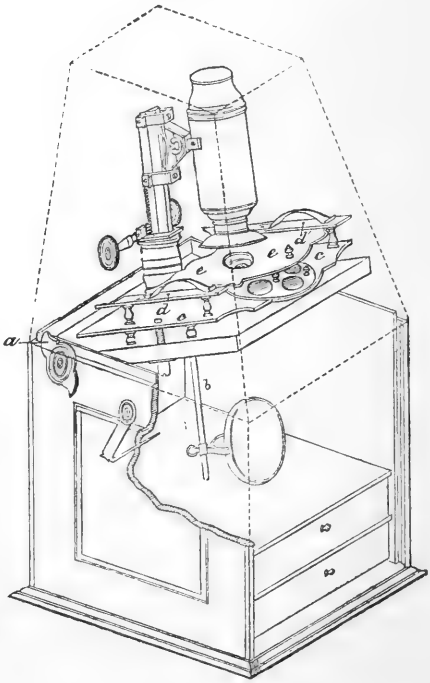


FIG. 137.



carrying a wheel of diaphragms, and an upper plate *e e* sliding between two pieces *d d'* (with spring clips) supported on four short uprights.

The eye-piece is Huyghenian, without any diaphragm, and the (concave) mirror is of metal attached to the bar *b*.

The third Microscope figured is one given by Franz I., in 1815, to the Vienna Technical High School, resembling most that of Tiedemann described by Harting.* It is engraved with the name of an unknown maker, "Otteny," with "Mecha. Fe. in K.K. Phis. Kabin." added.†

The remaining six are not figured. One is a Cuff instrument,‡

* Harting, P., 'Das Mikroskop,' iii. p. 126.
† In the plate "Schis. Kab."
‡ Harting, P., 'Das Mikroskop,' iii. p. 114.

dating from about 1750. A second is in the form of a square turret of wood with an opening in front for light to reach the mirror within, and two lateral slits for the insertion of the slide. In the upper end is a double (sliding) tube of wood and paper carrying the objective and eye-piece. It was probably made in Nuremberg in the last century. The other four have no special history, and date from 1817 (then bought of Voigtlander for the Vienna University), 1811–20? (by Utzschneider, Reichenbach, and Fraunhofer), 1820–6 (Utzschneider and Fraunhofer), and probably before 1830 (Chevallier).

Standard Eye-pieces.*—Dr. Blackham, on behalf of the committee on Eye-pieces, presented the following report to the Chicago Meeting of the American Society of Microscopists: "Your committee on nomenclature and sizes of oculars would unanimously report:—

1. In favour of naming oculars, like objectives, by their equivalent focal lengths in English inches. We believe this method to be the best adapted to practical use, sufficiently precise for its object, and capable of general introduction with less inconvenience, opposition, or delay than any other rational system. Assuming that 1 in. indicates an amplification of ten diameters, 5 in. of two diameters, 1-5th in. of fifty diameters, &c., as actually obtained by a compound Microscope with a 10 in. tube (from the diaphragm of the ocular to the front lens of the objective), the image being measured by the camera lucida at a distance of ten inches from the camera, and that the amplifying power in use can be approximately determined by multiplying together the powers thus implied in the names of the objective and ocular, an extremely simple and comprehensive system is obtained, whose practical benefits are believed to greatly exceed its technical or theoretical faults, and whose adoption would add much to the definiteness and intelligence of the microscopical work. A table showing the simplicity and scope of this system is given in the Journal of the Royal Microscopical Society for 1882, page 105.

2. In favour of adopting one or more standard sizes for the tubes of oculars. That uniformity in this respect would be a great convenience to students, and, to say the least, no disadvantage to manufacturers, we do not doubt; but the difficulties in the way of adopting such a policy at the present time are evidently great, far beyond comparison with those encountered in the introduction of the 'Society screw.' Furthermore, the great variety of tastes among both makers and buyers as to sizes, styles, and pieces of stands seems to call for not less than two or three standard diameters of tube. As an important step toward uniformity we would gladly recommend the adoption of the sizes recently proposed by the Royal Microscopical Society, 0·92 and 1·35 in., were they adapted to the conditions existing in this country. But 0·92 is a smaller size than we are willing to recommend for any purpose, being much too little, in our judgment, for even the small, compact stands of the 'Continental' model. On the other hand, we would have preferred 1·40 for the

* 'Chicago Times,' 9th August, 1883, in advance of Proc. Amer. Soc. Micr., 6th Ann. Meeting, 1883.

large tube, but do not regard the difference as sufficiently important to justify the naming of still another size. There remains, however, a very large variety of medium-sized stands, a class believed to be rapidly increasing in numbers and importance, which cannot, without a total change of character, be raised to 1·35, and which should not, in our opinion, be reduced even to 1. We therefore propose a standard medium size, 1·25, which we believe well adapted to a great majority of purposes, with the alternatives of 1 and 1·35 for those who wish smaller or larger tubes. Suitable adapters would harmonize apparatus previously made with these sizes, and these sizes with each other. We would also suggest the great convenience of uniform diameter in the upper tube of the ocular for the easy interchange of camera-lucidas, analyzers, &c. There seems to be no serious disadvantage in having this tube of uniform diameter in stands of various styles and sizes; and we would recommend that 0·75 in., or some smaller size, be made a standard. We would also recommend that the diameter 1·50, recommended by the Royal Microscopical Society for substage tubes, is in very general use and well adapted to both large and reasonably small stands, and we recommend its adoption to this Society.

3. The following resolutions are therefore submitted to the consideration of the Society:—

Resolved, That this Society recommends that oculars be named by their equivalent focal distances on the basis of 1 in. focus corresponding to 10 diameters of amplification at 10 in. distance, and that this nomenclature be employed in the Proceedings of this Society.

Resolved, That this Society recommends the adoption of the diameter 1·25 in. outside measure as a standard size of ocular tubes, with a preference for 1 and 1·35 where smaller or larger sizes are required, and recommend 0·75 outside measure for ocular cap tubes, and 1·50 in. measure for substage tubes.—R. H. Ward; A. L. Smith; J. D. Hyatt; George E. Blackham."

Mr. W. H. Bulloch objected to the report on the ground that the committee appeared to have followed the English system, which has 1·35 for the largest piece. The system is not well adapted for America, he said, because there are no instruments there that are made according to the English system. No changes in the parts of an instrument can be made. The amplifying power of the eye-piece ought to be the basis of the standard, and not the focal size. There is no make of instruments that correspond to the standard the committee recommends. He also spoke of variations that the density of the glass will cause in the magnifying powers of eye-pieces that are made according to the same formula.

Dr. G. E. Blackham thought the report should be postponed till next year.

Mr. J. D. Cox thought it questionable if the standards should be so confined as the report recommended, "because different grades are required even by the profession."

The Society in the result ordered the report to be published in the

Proceedings, referred back to the committee with instructions to continue its investigations, and the matter considered at the next annual meeting.

Grunow's Camera Lucida.*—Mr. J. Grunow has modified his camera lucida by a slight change in the opening through which the image of the object on the stage is seen. By reducing the opening to a diameter of ·05 inch, he states that the pencil point is still more clearly seen, while sufficient light comes from the object to show the details.

Standard Body-tube for Microscopes.†—Mr. G. E. Davis sees "no other way of bringing about a standard gauge than by publishing the diameters of all stands now in the market, and advising purchasers to choose the larger bore. A small eye-piece will fit a *large tube*, and can be centralized and kept tight by a paper adapter or collar made by the microscopist himself; but a small tube will only take a small ocular, and no other, so that the diameter of the body-tube of the Microscope should always be taken into consideration on the purchase of an instrument."

A table of thirteen English and three foreign stands is given with the diameters of the oculars, both the body and the neck over which the camera lucida usually fits.

Sliding Body-tubes.‡—Dr. J. Edwards Smith thinks that there are some advantages in a sliding body, that are not to be obtained by the use of the rack and pinion.

For example: supposing we are working over wet preparations, and unfortunately the front of the objective becomes immersed in the liquid, a misfortune liable to occur daily. It is then, in such cases, a *positive convenience* to be able to pull the body-tube out of the jacket, clean the objective, and return to its place. All this can be done in much less time than would be required, were the instrument furnished with rack and pinion, to unscrew the lens, clean, and screw in place again.

McCalla's Nose-piece.§—Prof. A. McCalla refers to a form of nose-piece which he considers to have some advantages over Pease's "Facility" nose-piece and that of Nelson. "It is simply a form of bayonet catch which would dispense entirely with the screw, and hold the objective perfectly secure against sagging on one side or working loose when the adjustment collar was in use."

Smith's Rotating Stage.‖—Dr. J. E. Smith describes "the stage which he has had in daily use for years, and one that has to a considerable extent been copied by his friends."

Provide a sheet of well-hammered brass, heavy enough, so that when planed or turned down the stage shall be 1-16th of an inch in

* Amer. Mon. Micr. Journ., iv. (1883) p. 138.
† Micr. News, iii. (1883) pp. 219–20.
‡ 'How to See with the Microscope,' 1880, pp. 44–5.
§ 'Chicago Times,' 8th August, 1883.
‖ 'How to See with the Microscope,' 1880, pp. 27–8.

thickness, with both faces truly parallel. Cut the circle which is to form the stage as large as the instrument will permit, and in accordance with the following directions.

Cut the well-hole 1-16th inch larger than the well-hole of the stage; make a collar, or short tube, out of the same material used for the stage; turn the outside to proper dimensions, so as to fit the well-hole of the new stage, the upper edges of both being "flush," and solder in position.

Next turn accurately the under and projecting part of the short collar, or tube, so that it will *exactly* fit the well-hole of the main stage; place it thereon, and cut off any portion of the collar that may project beneath the stage.

In the stage thus far towards completion, if the collar projects 1-16th inch, this will be found ample for its support.

All that remains to be done is to fit the new stage with plain spring-clips, which can be done in a few moments out of a piece of watch-spring; or, if there is room enough, an object-carrier can be provided on Zentmayer's principle. As to rotation in the optic axis, the author says that if it did so rotate with one objective, it would be pretty sure to fail with another. The compensation must be supplied by finger manipulations easily acquired and as easily practised. "A grand good thing about this improvised stage is, that it can be placed in position or removed therefrom in a moment's time."

Bausch and Lomb Optical Co.'s Compressors.—The first of these (fig. 138) is simply a modification of the Optical Co.'s Trichinoscope,* made, however, shorter and broader. Besides its use as a compressor, it forms with the addition of the lens a convenient pocket Microscope for field use in collecting Infusoria, Algæ, &c.

FIG. 138.

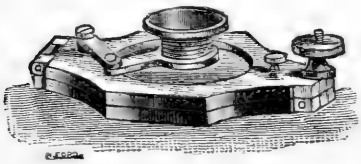
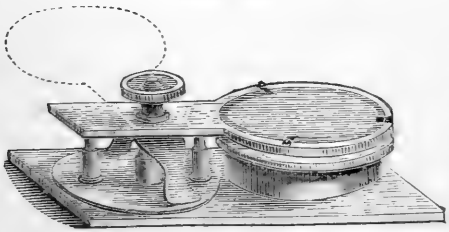


FIG. 139.



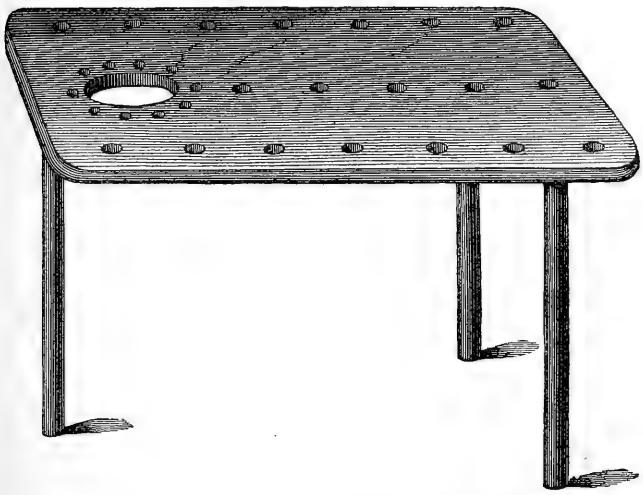
The other form (fig. 139) is a parallel compressor. Parallelism is obtained by attaching a spring and two pins on the under side of the arm carrying the upper plate. The pins slide in two sockets and when the milled head is screwed down the upper plate is pressed on the lower, the pins descending into the sockets. On releasing the screw, the spring forces back the arm. In order that the upper plate may be turned on one side as shown by

* See this Journal, ii. (1882) p. 258.

the dotted lines the sockets are not attached to the lower plate, but to a disk which rotates with the arm.

Frog-plate.—The form shown in fig. 140 differs from the frog-plates usually supplied by opticians for observing the circulation in the web of the frog in that it is of ebonite and not of brass, that it is not intended to be laid upon the stage but to stand on its own supports

FIG. 140.



just over it, and that it can also be used for the study of the tongue. For the latter purpose half of a ring of cork must be fixed with brass pins round the large aperture, on the side next the end of the plate, and to this cork the cornua of the tongue may be attached. The large aperture is of course to be arranged over that of the stage.*

Apparatus for Examining the Circulation in the Lung and Mesentery of the Frog.—One of the best objects for observing the capillary circulation is the lung of the frog. The first difficulty in its use is, however, that it is often emptied by the frog and is then useless for observation. On the other hand, when it is swelled up it is so convex that it cannot be covered with a cover-glass, and the use of high powers is prevented. Holmgren, by an ingenious apparatus (figs. 141, 142, and 143), has surmounted these difficulties.†

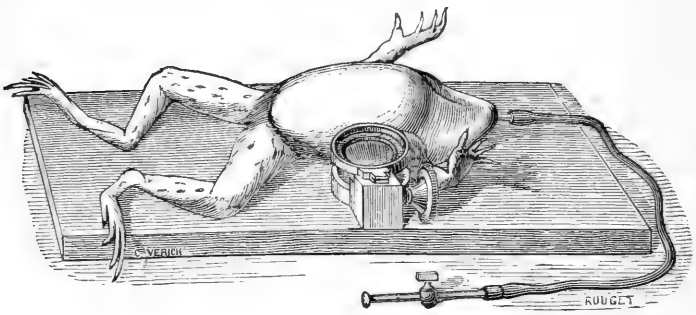
The frog is first immobilized by the subcutaneous injection of curare, and to regulate the state of repletion of the lung, a tube with a tap at the free end (fig. 141) is introduced into the glottis: the

* Cf. Dr. Klein in 'Handbook for the Physiological Laboratory,' 1873, p. 42 (1 fig.).

† Ranvier's 'Traité technique d'Histologie,' 1878, pp. 600–3 (3 figs.).

pulmonary sacs can then be distended at pleasure and the distension maintained by closing the tap. To prevent the air returning

Fig. 141.



through the lips of the glottis, that end of the tube (fig. 142) is provided with a membranous bag *m* (formed of a piece of frog's

Fig. 142.

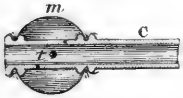
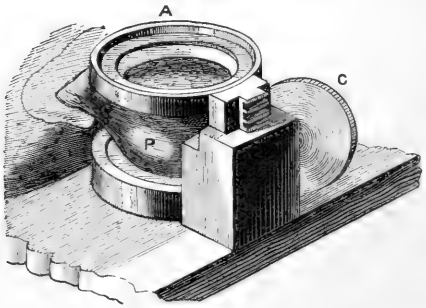
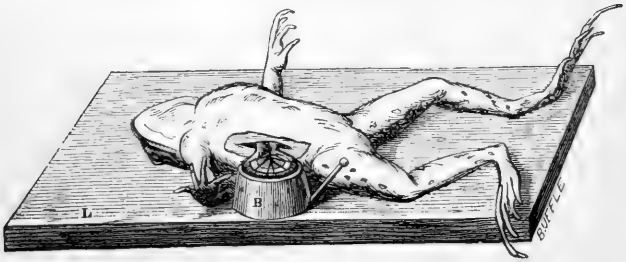


Fig. 143.



intestine tied round the end communicating with the tube *c* by three holes *t*. When the tube is filled with air this bag dilates and

Fig. 144.

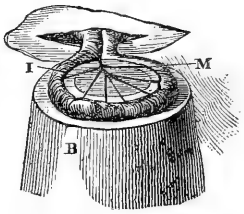


closes the mouth of the glottis against any return of the air from the lung.

The lung P being dissected out is placed as shown in figs. 141 and 143, and is covered by a cover-glass held in a ring A which can be raised or lowered by the rack and pinion C, and the surface can be reduced to a plane.

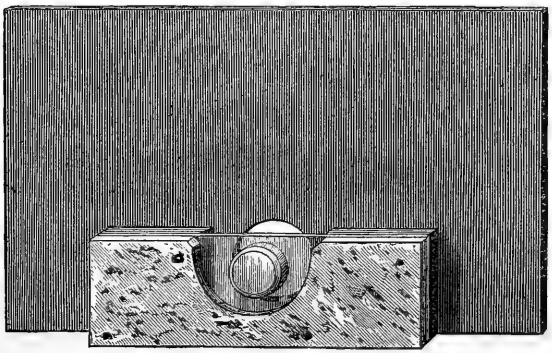
Ranvier's apparatus for the mesentery,* shown in figs. 144 and 145, consists simply of a plate L with an aperture, over which is attached a cork disk B, having a hole drilled through the centre so as to allow light to be transmitted from the mirror. The intestine is dissected out and attached to the disk as shown in the figure. If it is not thus elevated above the level of the wound, blood and lymph will run out and hinder observation. To fix the intestine and mesentery, the disk B has its upper surface cut away so as to leave an annular projection in the centre, on which the mesentery M rests and round which the intestine I is placed.

Fig. 145.



Another arrangement † is shown in fig. 146. A wooden or ebonite plate, to carry the frog, has a circular aperture, over which a glass slide is supported on two corks or pieces of ebonite about 1-6th in.

Fig. 146.



deep. The slide is covered with cork 1-8th in. thick, having a semicircular piece cut out in the centre. In the middle of this, and just over the aperture in the bottom plate is a glass disk, 1-8th in. thick, on which the mesentery lies, the space between it and the cork forming a trough for the reception of the coil of intestine.

A simpler form of apparatus is shown ‡ in fig. 147, where a glass plate A has attached to it two pieces of wax C C, which support and

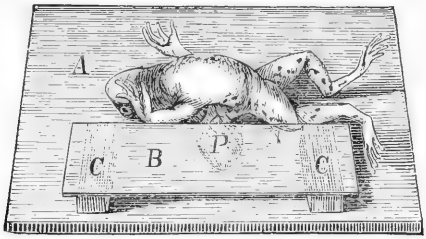
* Ranvier's 'Traité technique d'Histologie,' 1878, pp. 603–5 (2 figs.).

† Cf. Dr. E. Klein in 'Handbook for the Physiological Laboratory,' 1873, pp. 108-9 (1 fig.).

‡ Thanhoffer, L., 'Das Mikroskop,' 1880, p. 152 (1 fig.).

firmly retain a slide B by which the lung P is pressed flat. If high powers are used, the wax supports must be closer together, and cover-glass used.

Fig. 147.



Madan's Modification of Darker's Selenite-Holder.—H. G. Madan has devised a modified form of selenite-holder, which he finds preferable to the holder usually made.

"The ordinary form of Darker's selenite substage fitting is well known; three films of selenite, giving retardations of $\frac{1}{4}$ wave, $\frac{3}{4}$ wave, and $\frac{2}{4}$ wave, respectively, are mounted in circular brass cells, which rotate in rings attached to a side-arm, and can be thrown in and out of the field as required. This arrangement is perfectly effective, but it has two inconveniences: (1) that no means is provided for changing the films for others, such as Ackland's neutral-tint film, or Klein's plate; (2) that when the selenites are in position for use it is difficult to see, and impossible to tell by feeling, the exact azimuth of that direction in the crystal-film, which is usually marked by opticians P↑A; i. e. the direction in which the retardation of one of the two rays behind the other is greatest, and which lies, of course, at an angle of 45° with the acute bisectrix, or 'median line.'

The arrangement described below is intended to avoid both these inconveniences.

The selenite films are mounted in cells of the shape shown in fig. 148; a groove being cut in the edge of the cell before the handle A is soldered into its place. The holder is in the form of a ring, about 3-7ths of which are cut away, as shown in fig. 149; the remaining part being quite sufficient to retain the cell in position, and yet allow it to rotate freely when it is 'sprung' into its place.

Three of these holders are jointed to a side-arm, so that they can be thrown in and out of use, as in the usual Darker's stage.

The handle A is made of such a breadth as to allow the selenite an angular movement in azimuth of exactly 90°; which is, of course, sufficient for all modifications which it is capable of producing in a polarized ray.

Thus the various combinations of the films are obtained by merely moving the projecting handle 45° on either side of its central position, motions as simple and easy as those of a signalman in throwing over his levers for altering points and signals. In my own case, I have mounted the films in such a position that the acute bisectrix is in a

line with the centre of the handle (fig. 150). Hence, the plane of polarization of the light being supposed vertical (i. e. at right angles to the length of a slide placed on the stage): (1) When the handles of the selenite holders are also vertical, the ray passes through the films

Fig. 148.

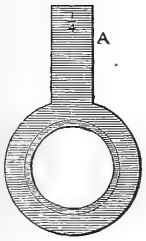
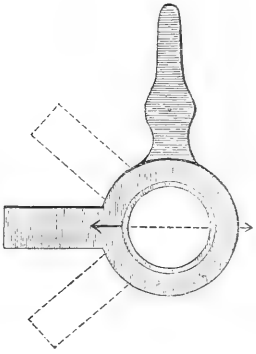


Fig. 149.

Fig. 150.



without change; (2) When the handles are thrown 45° to the right hand, the maximum retardation due to the sum of the thicknesses of the films is produced; (3) When any one of the handles is thrown 45° to the left hand of its central position, the retardation due to that film is subtracted from that of the others.

Thus it is easy to obtain any given retardation within the range of the series of films without removing the eye from the Microscope. So again, to obtain right-handed circular polarized light, the two thicker films are either thrown out of the field, or placed in the median position, and the handle of the $\frac{1}{4}$ wave film is thrown 45° to the right. To obtain left-handed polarized light it is thrown 45° to the left.

In my analyser-cap a holder of somewhat similar construction is fitted for a single $\frac{1}{4}$ wave film, so that it is easy to analyse the light circularly, when desired. If, for special purposes, an entire rotation of a film is desirable, it is only necessary to omit the handle, and mill the edges of the cell on either side of the central groove—in fact, I have several cells thus made. But I prefer the handle from its convenience in showing the exact optical position of the film.

I should like also just to call attention to the ease with which almost any microscope-stand can be made to serve as a Nörremberg's polariscope for examining crystals under strongly convergent polarized light, in order to see the rings, &c., round the optic axis. All that is required is, to remove the nose of the main body, and screw into its place the usual system of converging lenses (which answers much better than any microscopic objective), the fourth lens of the system being fitted into the draw-tube. A similar system of lenses is then fitted below the stage, in place of the condenser, and the crystal to be examined is placed on the stage; or, preferably, supported in a holder like Beck's opaque object-holder, which allows it to be rotated.

Microscopes which, like Ross's newest pattern, have the fine adjustment separate from the main tube, and in which the stage can be swung to any angle, or removed altogether by simply loosening a screw, are especially adapted for the above fitting, since the upper lens-system can be as large in diameter as the main tube.

The lenses I used were the ordinary 'spectacle' lenses, including a pair of hemispheres, and the field is nearly as great as that of Hoffmann's instrument, just taking in the two axes of Brazilian topaz.

With such an arrangement, combined with the selenite stage, nearly or quite all the beautiful experiments given in Dr. Spottiswoode's little treatise on 'Polarized Light,' can be made.

It is more than a dozen years since I made the above addition to my Microscope; and I am surprised that Nörremberg's lenses are not included among the usual 'accessories' of (at any rate) first-class Microscopes."

Sternberg's 'Photomicrographs and how to make them.'—Dr. G. M. Sternberg, Surgeon-Major U.S.A., has just published a work entitled 'Photomicrographs and how to make them,' with illustrations of microscopic subjects, printed by the Boston Heliotype Printing Company from his original negatives.

The subject is dealt with carefully, and the prints afford evidence of the value of the method employed, which differs somewhat from that generally used in this country. He largely advocates for low powers the use of light reflected from a blue sky, and giving long exposures, the apparatus being a little elevated from the usual horizontal position. With high powers, Dr. Sternberg advises direct sunlight, the employment of a heliostat, ammonio-sulphate of copper cell, long focus condensing lens, and substage achromatic condenser. His arrangement for these, and the position of the focusing screen, when using a room as a camera, are not quite the same as are commonly adopted. Some of the figures clearly show that, with a proper selection of objects and this mode of taking the negatives, photomicrography can render very useful service to the microscopist. There is one plate, No. xii. (the fourth square of one of Möller's type-plates of the Diatomaceæ), which is a marvel of excellence, considering the difficulty of the subject, the photograph being made by a Powell and Lealand's 1-2 in. objective. There is also an admirable figure, pl. xvi., of *Navicula lyra*, taken with a Zeiss 1-6th dry objective, and Tolles' amplifier, the heliostat being used. Full directions are given for the use of the apparatus and development of the plates. Dr. Sternberg, to render the work more useful, has selected a series of objects, and has given explanations, so as to carry the student forward in his studies by what may be called "elementary lessons in biology," passing from *Amœba* to bacteria, unicellular algæ, epithelium and other scales, blood-globules, pollen, epidermis, hairs and woody tissue of plants, diatoms, adipose tissue, sarcoma and insect parasites, &c. One figure is given illustrating the great difference in the appearance of the print from a negative of a diatom illuminated by direct light, and by the use of the "spot-lens," much greater solidity being given by the latter, though unfortunately with less detail. There is also a

figure of the stellate hairs of *Deutzia scabra*, as imaged by reflected light. Some of the plates when compared with silver prints rather lack their brilliancy, yet still show the value of the method adopted.

The book will, we have no doubt, prove very useful to the student, especially now that photomicrography appears to be coming into favour for illustrations.

Photomicrography by Lamplight.—Dr. C. Kiaer, although his process is nearly the same as that described by Mr. G. M. Giles,* thinks it may be useful to describe the advantages and defects which lamplight, according to his experience, has in comparison with sunlight. Dry bromsilver-gelatine plates were used. He formerly tried to use lamplight on wet collodion-plates but without satisfactory result, even with the lowest objectives. The feeble light necessarily demands a much longer time for exposure than sunlight. The wet collodion plates are too little sensitive for lamplight and dry up before the necessary time has expired. The bromsilver-gelatine plates are much more sensitive, so that the time for exposure may be shortened to one-third or one-eighth of the time necessary for the wet plates.

To develope the negative he uses a mixture of a solution of neutral oxalate of potassium with a solution of protosulphate of iron with a few drops of sulphuric acid.

The lamp was a petroleum lamp, with a "sun-burner." The round wick has a diameter of 25 mm., and the centre of the flame is elevated about 22 cm. over the base of the apparatus. The lamp is placed close to the (Nachet) Microscope, the latter being in an oblique position about 30° from the vertical. This is preferable because the focusing of the Microscope is more convenient, and because the horizontal position would not permit the use of the concave mirror of the Microscope. The distance between the flame and the mirror is 16 cm., and between the two is a biconvex lens of 8–9 cm. focus, and 5½ cm. diameter. The distance of the object from the ground glass was always ½ m. With Nachet objectives No. 0 and No. 1, the plane mirror should be used, and with No. 5 the concave mirror.

As the lamp produces a light of constant intensity it is easy after a few trials to fix the exact time of exposure for each objective. For objective No. 0 the proper time for exposure (without lens and with plane mirror) is 9 minutes; for objective No. 1., with lens and plane mirror, 3½ minutes for more transparent, and 7 to 10 minutes for yellow to brown coloured objects; for objective No. 5, with only concave mirror, 30 minutes; with lens and concave mirror, according to the transparency of the object, from 7 to 15 minutes.

During exposure, the whole apparatus must stand entirely unmoved. Incautious walking in the room or the shaking produced by a passing vehicle is deleterious. To make the apparatus more steady the coarse adjustment should be screwed down.

It was formerly very difficult to photograph *yellow and brown coloured objects* by sunlight with collodion plates, because these colours act very slowly upon the plates. But when the bromsilver plates are exposed (for double the time) the result is very satisfactory.

* Mon. Micr. Journ., xv. (1876).

As to *visual* and *chemical* foci, Dr. Kiaer found, by lamplight, no difference either with low or high powers. Lamplight has very few actinic rays, which probably are united at the same plane as the visual ones.

By sunlight, moreover, it is often difficult to avoid *interference* effects, whereby the margins of the image are surrounded by dark lines, while by lamplight this inconvenience is avoided.

Another advantage of lamplight is its not being injurious to the preparation, whereas the warmth of the sun may liquefy and blister the gelatine-glycerine, in which the objects may be mounted.

Focusing the Image in Photomicrography.*—"Every operator," writes Mr. G. E. Davis, "has at one time or another of his experience had great difficulty in satisfying himself of the necessary sharpness of the image on the ground glass. Veterans of the art are known to have constructed appliances by means of which many of the difficulties may be bridged over; but the tyro is, as a rule, unacquainted with these so-called 'little dodges,' and therefore we purpose devoting a little of our space to the description of several methods for getting the exact focus of microscopic objects on the ground glass.

Dealing with low powers is not so troublesome as with high ones, as there is always sufficient light to enable a tolerably good focus to be obtained; but with high powers, and consequent loss of light, it requires all the skill at the operator's command to obtain even a passable picture in focusing by means of the ground glass alone. It has been the practice with some to use the finest ground glass obtainable, and to oil this over with olive oil, whilst others have discarded the use of ground glass as a focusing medium, and have thrown the pictures upon fine Bristol cardboard placed in exactly the same plane subsequently occupied by the sensitive surface of the plate.

There is no doubt that the oiled ground glass enables the picture to be more accurately focused than when an unprepared surface is employed, but the want of light in the case of high powers is a difficulty not dealt with by this method.

Some years ago, Mr. J. B. Dancer described to us his method, which is as follows:—Draw two lines over the roughened surface of the ground glass from corner to corner, with a writing diamond, and in the centre, where the lines cross, cement a thin cover-glass, three-quarters of an inch in diameter, with balsam and benzol. This produces a transparent circle, and as aids other circles of a similar character may be dotted over the plate in the portion usually occupied by the picture.

Upon throwing the enlarged image upon a ground glass prepared as above, a little effort will enable the operator to distinguish the details of the picture upon the transparent portion, and in many cases, without any further aid, an exceedingly sharp focus may be obtained. In many cases, however, it is better to use an auxiliary Microscope to examine this image on the transparent circle. Such an auxiliary Microscope may be easily constructed: a piece of brass tube to hold the A ocular at its upper end, while the lower end is

* Micr. News, iii. (1883) pp. 233-4 (1 fig.).

fitted with the Society thread to allow a 2 in. objective to be screwed in. This combination is made to slide in another tube furnished with a set-screw, in order that the inner tube carrying the optical portion may be fixed in any required position.

In use, the outer tube is placed in contact with the glass, and the inner tube carrying the ocular and objective withdrawn until the cross lines on the glass, made with the diamond, are exactly in focus. When the focus is accurately obtained the set-screw is tightened, and it follows that when the lower end of the outer tube is placed over the transparent circles, the sharpest image must be in the same plane as the diamond scratches, when its details are best seen with the auxiliary Microscope.

We can scarcely imagine a simpler or more accurate method than the foregoing, nevertheless, some may object to it on the ground that an auxiliary Microscope is required, and therefore another method is given, which, if not so handy or so accurate as that already described, has the merit at least of being inexpensive. A focusing slide is used, in addition to the ground glass prepared as before described, and this slide is pierced with a series of holes to take an ordinary ocular, the A preferably. The first step is to secure the best focus on the transparent circle, *to the unaided eye*, and the proboscis of the blow-fly will be the best object to work with. When this is obtained, set the eye-piece in the position of sharpest focus in the focusing slide, and always use it in that position, which can be insured by a collar of sufficient depth fitting up to the shoulder."

Aylward's (H. P.) Camera Lucida.

[*Ante*, p. 593. "Mr. Aylward has made a further improvement in this important accessory, and it is certainly not the least of its advantages that it will fit any ocular of English pattern. It can be made to fit foreign stands also."]

Micr. News, III. (1883) pp. 237–8.

Banqueting a Microscopist.

[At a banquet at Charlestown to Professor J. Leidy, a great delicacy was served—tails of fishes having a tumour-like excrescence—this the Professor found contained a tape-worm.]

The Microscope, III. (1883) pp. 128–9, from *The Bistoury*.

Bausch, E.—Microscopical Illumination. Title only of U.S.A Patent 277869 of 24th June, 1882. (Taken from Zeitschr. f. Instrumentenk., July 1883, wrapper.)

Binghamton, N.Y., New Microscopical Society.

Amer. Mon. Micr. Journ., IV. (1883) p. 140.

Bradbury, W.—The Achromatic Object-glass, XXVI.–XXVIII.

Engl. Mech., XXXVII. (1883) pp. 498–9 (1 fig.), 521–2 (1 fig.), and 591–2 (1 fig.).

Bussereau, B.—Nachet's Black-ground Illuminator.

Micr. News, III. (1883) p. 236, transl. from *Journ. de Phot. et Micr.*

Crowther, H. See Harris, W. H.

Davis, G. E.—A Standard Body-tube for Microscopes. [*Supra*, p. 713.]

Micr. News, III. (1883) pp. 219–20, 264.

" " Focusing the Image in Photomicrography. [*Supra*, p. 722.]

Micr. News, III. (1883) pp. 233–4 (1 fig.).

Dippel, L.—Das Mikroskop und seine Anwendung. (The Microscope and its use.) Part I. Handbuch der allgemeinen Mikroskopie. (Handbook of General Microscopy.) Sec. 3. 2nd ed. 8vo, Braunschweig, 1883, pp. 737–1030, ix.–xviii. (figs. 507–79).

GRUNOW's (J.) Camera Lucida. [*Supra*, p. 713.]
Amer. Mon. Micr. Journ., IV. (1883) p. 138.

HARRIS, W. H., and H. CROWTHER.—Suggestions for an Exchange Club.
["Something after the style of the Postal Microscopical Society, but with less routine, which might be put briefly thus:—No fees, no secretary, no journal, no annual meeting."]
Sci.-Gossip, 1883, pp. 209–10.

HITCHCOCK, R.—Instructions in Dry-plate Photography. (*Concluded.*)
Amer. Mon. Micr. Journ., IV. (1883) pp. 124–6.

" " Notes from abroad.
[Describes a visit to E. M. Nelson's studio and his methods of illumination —Fisheries Exhibition — Fresh-water medusa at the Quekett Club— Möller's 1600 type-slide—Watson's new Microscope—Photomicrographs.]
Amer. Mon. Micr. Journ., IV. (1883) pp. 129–32.

" " The Aperture Shutter.
["An examination of the subject with Mr. Davis to make the demonstration has fully satisfied us that the aperture shutter does greatly increase the penetration of a low-power objective. We mean by this an objective of not more than 1-2 in. focal length."]
Amer. Mon. Micr. Journ., IV. (1883) pp. 134–5.

" " The American Society of Microscopists. [Reminder of the Chicago Meeting.] *Amer. Mon. Micr. Journ.*, IV. (1883) pp. 135 and 140.

" " Oculars.
[Many oculars show objects greatly distorted. "This is mainly owing to the fact that makers have departed from the proper formula for placing the lenses in relation to their respective focal lengths."]
Amer. Mon. Micr. Journ., IV. (1883) p. 136.

" " A "Scientific Evening."
[Describes the Scientific Evening of the Royal Microscopical Society on 2nd May.]
Amer. Mon. Micr. Journ., IV. (1883) pp. 136–7.

" " Resolution of *Amphipleura pellucida* by central light.—Oblique light for resolution.
["Mr. E. M. Nelson . . . states that any of the homogeneous-immersion objectives in use will resolve the lines with central artificial light. . . . Nevertheless, the ease and distinctness with which the resolution was made by Prof. Forbes (by sunlight) is surprising."—"Mr. Nelson does not approve of oblique light for resolution. He prefers to use central light in the study of markings on diatoms because oblique light often shows lines when central light shows dots—hence oblique light is misleading. One need not look far to discover a fallacy in the argument thus suggested."]
Amer. Mon. Micr. Journ., IV. (1883) pp. 137–8.

" " Mr. W. Teasdale's Spot-lens.
["A good-sized glass fish-eye . . . mounted in a piece of cork makes a very satisfactory spot-lens indeed."]
Amer. Mon. Micr. Journ., IV. (1883) p. 138.

" " Zeiss's Catalogue.
["Zeiss now makes a corrective-adjustment for his homogeneous-immersion lenses, but the object of the adjustment is to correct for the varying length of tube and not for different thicknesses of cover-glasses."]
Amer. Mon. Micr. Journ., IV. (1883) pp. 138 and 139.

" " Homogeneous-immersion Objectives.
[Satirical account of their condemnation by an English microscopist.]
Amer. Mon. Micr. Journ., IV. (1883) p. 139.

" " "New Wenham Binocular Prism."
["Ross and Co. have at last succeeded in reducing the cost . . . so that they are able to introduce it."]
Amer. Mon. Micr. Journ., IV. (1883) p. 139.

HITCHCOCK, R.—Messrs. Rogers' Microscopic Scissors.
[Twelve pairs of perfect scissors which are overbalanced by a half-grain weight.]
Amer. Mon. Micr. Journ., IV. (1883) p. 139.
„ „ The American Association for the Advancement of Science.—Meeting at Minneapolis. *Amer. Mon. Micr. Journ.*, IV. (1883) p. 140.
„ „ Notes from Abroad.
[Visit to E. Ward—Quekett Club Gossip Meeting—Fresh-water Medusa.]
Amer. Mon. Micr. Journ., IV. (1883) pp. 147–9.

HOBSON, B.—The Electric Light applied to the Microscope.
[Describes his experience of the Stearn-Swan lamps, with description of his simple apparatus for applying it. "I am perfectly satisfied with the electric light, it is quite steady, very convenient, can be used close to the object, and shows colours like daylight. I believe that it is perfectly adapted for photography. The Rev. W. H. Dallinger, F.R.S., tells me better light for the Microscope can be obtained in other ways, but I like it more than anything I have seen."]
Sci.-Gossip, 1883, pp. 171–2 (1 fig.).
„ „ On Drawing Microscopic Objects.
[Description of a "micrographic camera" made from a tin biscuit canister.—C. G. Leland's receipt for making tracing paper which can be reconverted into ordinary opaque drawing-paper.—J. C. Leake's dark tent, and miscellaneous remarks.]
Sci.-Gossip, 1883, pp. 193–6.

International Bureau of Weights and Measures.
[Describes the "Comparateurs" for lengths with two Microscopes and micrometers.] (In part.)
Nature, XXVIII. (1883) pp. 464–6 (2 figs.), from *La Nature*.

[JAUBERT'S] Institut populaire du Progrès—Section de Micrographie—Laboratoire et École populaires de Micrographie.
[Announcement of the section having been definitively constituted, and statement of its objects, &c.]
Les Sciences, I. (1883) pp. 31, 45, and 46; see also p. 3.

JUNG, H.—Neuer beweglicher Objectträger für Mikroskope. (New movable Stage for Microscopes.) [*Post.*]
Zeitschr. f. Instrumentenk., III. (1883) pp. 246–7 (1 fig.).

LEITZ Oil-immersion Objectives.
[Notice of 1-15th in. and 1-18th in. (or 1-20th in.) of 1·26 N.A.—the working distance of the latter ·01 in.]
Micr. News, III. (1883) p. 265.

LOWE, C. A.—A Substitute for a Revolving Table.
["Board set on rollers and carrying the Microscope and lamp round a house table by revolving on a centre through the medium of an arm on stalk. . . . As a screw put into a mahogany table would be objectionable," a centre is made of two disks of wood between which the stalk revolves freely on a screw, a 10 lb. weight on the uppermost disk preventing the centre from slipping about the table.]
Sci.-Gossip, 1883, pp. 208–9 (1 fig.).

MIQUEL, P.—Atmospheric Dust and Germs.
[Extract from his paper communicated to the Faculty of Medicine, Paris, with figures of Apparatus—*Post.*]
The Microscope, III. (1883) pp. 111–19 (11 figs.), from the *Scientific American*, from *Le Génie Civil*.

MOORE, A. Y.—The Measurement of Numerical Aperture.
[Describes the method suggested by Prof. Abbe, Vol. I. (1881) p. 400, of measuring the diameter of the emergent pencil with an auxiliary Microscope.]
The Microscope, III. (1883) pp. 97–9.

ONDERDONK, C.—American and German Objectives.
[Complaint of the high price of the former.]
Amer. Mon. Micr. Journ., IV. (1883) pp. 159–60.

Rezner (W. B.), death of—Memorial Resolutions passed by Cleveland Microscopical Society. *Amer. Mon. Micr. Journ.*, IV. (1883) pp. 158–9.

Royal Microscopical Society, Foreign Fellows, proposed increase of subscription. *Engl. Mech.*, XXXVII. (1883) p. 550.

Schröder's New Analysing Prism. [*Post.*] *Amer. Mon. Micr. Journ.*, IV. (1883) p. 157.

„ New Ocular. [*Post.*] „ „ „ p. 157.

Stowell, C. H.—Gleanings from the Journal of the Royal Microscopical Society for June. *The Microscope*, III. (1883) pp. 104–6.

Stowell, C. H., and L. R.—Extreme Minuteness.

["There is a question . . . that remains unanswered, which is whether any object may become so attenuated that it cannot be made visible by any means. . . . The limit of angle of aperture having been reached—no opportunity remaining of increasing capacity in that direction—is it not reasonable to suppose that with present appliances no greater skill in manufacture can be expected?"]

The Microscope, III. (1883) p. 136.

Suffolk, W. T.—Microscopic Vision.

[Report of "Demonstration" illustrating and explaining Prof. Abbe's discoveries.]

Journ. Quek. Micr. Club, I. (1883) pp. 248–52.

Swift, J.—The Microscope and Accessory Apparatus: Notes on the Construction, Selection, and Use. 8vo, London, 1883, viii. and 83 pp., and 61 figs.

Comments on same, see *Engl. Mech.*, XXXVIII. (1883) pp. 50–1.

T. T. T.—Lighton's Dark-field Illuminator.

[See Vol. I. (1878) p. 347. "Its work is so surprising and new that I would suggest that you give to the microscopists of the country . . . a reprint of the drawing and description."]

Amer. Mon. Micr. Journ., IV. (1883) p. 140.

Voit, C. v.—Verwendung der elektrischen Beleuchtung bei anatomischen, mikroskopischen und spektroskopischen Arbeiten. (Use of the electric light for anatomical, microscopical, and spectroscopical researches.) [*Post.*]

Centr.-Ztg. f. Opt. u. Mech., IV. (1883) p. 206.

(Aus Die Elektro-Medecin in der Internat. Elektr.-Ausst. zu München im Jahre 1882, von Dr. R. Stintzing.)

Walmsley, W. H.—Illustrated description and price list of Walmsley's Photomicrographic Apparatus [*ante*, p. 556], and directions for use. 8vo, Philadelphia, 1883, 11 pp. and 2 figs.

Ward, J. W.—Presidential Address to the 8th Annual Meeting of the Buffalo Microscopical Club. pp. 4–15. 8vo, Buffalo, 1883, 17 pp. (with Secretary's Report and List of Officers and Members).

Watson's Student's Microscope.

[Description of Microscope, *ante*, p. 554 "We would suggest to Messrs. Watson the advisability of applying a clamp-screw to the tailpieces so that they may be fixed rigidly in the normal position when axial light is being used. We also think it would facilitate the manipulations of the substage and mirror if the pillar support were taller so as to permit the tailpieces to be longer. At present the tailpieces are so short that there is some difficulty in adjusting the illumination beneath the stage, especially when the Microscope is vertical."]

Engl. Mech., XXXVIII. (1883) pp. 52–3 (1 fig.).

Wenham's New Fine-Adjustment. [*Post.*] *Amer. Mon. Micr. Journ.*, IV. (1883) p. 136.

„ Radial Microscope. [Vol. II. (1882) p. 255.] *Amer. Mon. Micr. Journ.*, IV. (1883) pp. 145–7 (3 figs.).

Western Microscopical Club. [Note as to its position.] *Sci.-Gossip*, 1883, p. 210.

White, T. C.—Photomicrography. [Report of "Demonstration"—*post.*] *Journ. Quek. Micr. Club*, I. (1883) pp. 229–31.

β. Collecting, Mounting and Examining Objects, &c.

Collecting, Cultivating, and Displaying Microscopic Aquatic Life.*—Mr. J. Levick, in his presidential address to the Birmingham Natural History and Microscopical Society, recommends for collecting, "a ring net, made of fine French canvas—a material used by ladies, I am told, for the purpose of wool-work—a still finer net of muslin, which will slip over it easily, making the one screwed ring do for both, and being of great use when the specimens sought are too small for the coarser net. A cutting hook, also, to screw to the stick; a small grapnel or four-pronged hook made of soft copper wire, about as thick as a straw (or No. 9 B.W.G.) cast together by means of lead or soft solder), with a few inches of brass chain attached, weighing about 18 ounces altogether. Then a plaited flaxen or cotton line, which will not gnarl when wet, of 50 or 60 yards in length, and sufficiently strong to stand a considerable pull, enough even to straighten the soft hook, and so to set it free should it meet with wood or any hard substance in the water which renders it fast.

A little practice with this apparatus will enable one with a fairly strong arm to throw, or rather sling, it out and gather aquatic plants from a large area, 50 or 60 yards even from any favourable spot for "paying" out the line, where it will meet with no obstacles when running out.

How much importance I attach to the use of proper apparatus may be gathered from the fact that I attribute the non-discovery of *Leptodora* before 1879, not to its non-existence in our locality, but to the want of a suitable net properly used, these creatures escaping through a net too rough, and being unnoticeable, owing to their extreme delicacy on the one hand, and the quantity of alga they are usually taken with on the other, when a net too fine in the mesh is used.

It is quite true that the first one I obtained from Olton Reservoir was taken by dipping an inverted bottle to a considerable depth, and then by a quick turn allowing the water to rush in; but I have often repeated the experiment where these creatures are fairly abundant, and have usually failed to capture a single individual, when a few sweeps with a suitable net would make a good gathering."

Mr. Levick, in dealing with the question of choice of localities, refers to "that elysium of microscopic life, the reservoir at Barnt Green, which, until a large area had been scoured by means of the before-mentioned hook and line, had been considered barren of anything of special interest. It is certain that, when the bottle only was dipped in near the side, nothing of more than ordinary character was found; and when the hook was sent flying through the air, and a good bundle of weeds (*Polygonum amphibium*, I believe), was brought to shore from a distance of 30 or 40 yards and carefully examined, living treasures were found in perplexing abundance. I need scarcely

* Report and Trans. Birmingham Nat. Hist. and Micr. Soc. for 1882, pp. iii.–xxv.

remind our members of the many splendid creatures which that locality yielded. . . . Now I do not think it too much to say that this, like many other localities, had never been thoroughly searched before, and am quite sure that some of our neighbours who regard their districts as unfavourable for pond life may find riches within their reach quite as great if they will only adopt the same vigorous means of seeking them."

On a country road, in a small patch of water not more than three inches deep in the wheel-ruts or holes made by the feet of cattle, Mr. Levick found *Pandorina morum*, and another rotifer *Notommata brachionus*. The latter was traced to a pond from which sheep drank, and "here was a ready solution to the problem as to how the rotifers had got to the puddle on the roadside. These unintentional distributors of microscopic life would go to the pond and paddle in the water, and then readily carry either the eggs or the rotifers themselves upon their feet, and possibly leave some behind in the first puddle they passed through on their way."

On the question of cultivating microscopic fresh-water life, Mr. Levick says that in indoor aquaria animals and plants also are stimulated into such rapid changes, that sooner or later they come to grief, and he "most earnestly commends all lovers of the study to acquire a garden pond." His "is a brick structure of about 8 feet outside diameter, and about 2 feet 6 inches in depth, measured from the top edge to the base; the inside is made to slope at a good angle, which is very important. It stands about 18 inches above the level of the surrounding ground, making nice sloping banks for about half its circumference, the inside being asphalted, which renders the whole perfectly water-tight. It has an outlet and temporary means of supplying water, but the former is never required, and with the bountiful supply of rain we have had during the past few years, it has rarely been necessary to add any water whatever, occasionally just a little to keep up the level during any warm and dry period we may have happened to have, few of which have troubled us for a long time past. The bottom and sides have a good layer of sandstone rubble, with a little clay, furnishing innumerable nooks and crevices where plants may root and animals may hide, no attempt whatever being made at architectural ornamentation. The rubble, however, is carried to and over the edge of the brickwork, which it completely hides, and is continued down the outside, making just a bit of ordinary garden rock-work, planted in the usual way with ferns, saxifrages, &c., forming in summer-time a perfect maze of plant life, shading the water from some of the sun's rays, and affording shelter for the numerous reptiles which also find a home in or about the pond."

In the remaining part of the address, relating to the examination or rather "display" of objects, *Volvox* and *Amœbæ* are more particularly referred to.

Mr. A. D. Michael, at one of the "Demonstrations" of the Quekett Microscopical Club, gave an admirably practical account of sea-side

collecting,* which we regret not to be able to print *in extenso*. He deals with "where to go," outfit, hints on shore collecting and climbing, the best collecting places, and the period for work, preparing hydrozoa and polyzoa with extended tentacles with osmic acid; also notes on getting insects, acari, &c., in the best condition to mount, and on mounting insects, &c., in balsam.

Collecting and Preparing Infusoria.†—Dr. H. Fol, in a fourth contribution to the knowledge of the family Tintinnodea, says that in the natural sciences method plays a principal part, but it is nowhere of greater importance than in microscopical researches: here the fitness of the investigator consists much less in any particular perspicuity than in the art of bringing into view the points that he wishes to know. Hence, the employment of a new method has enabled him to see clearly many things which he had previously been unable to see, or which he had seen imperfectly and misunderstood.

The collection of the Tintinnodea in the sea is an easy matter. There is no danger of damaging them at the moment of their capture, seeing that their test, into which they withdraw at the smallest sign of danger, sufficiently protects them. They are pretty robust and swim briskly about in the bottles several hours after their capture, and at a time when many delicate animals are already dead or disfigured. It is not, however, at the surface of the sea or under a bright sun that we find them in the greatest abundance. In cloudy weather they rise to the surface more readily than in bright weather; and in the daytime they are found chiefly at a depth of several fathoms.

For their capture he employed a net of fine muslin of a conical form attached to a ring about 50 cm. in diameter. The bottom of the net presents a contracted opening like that of a "weel," which opens at the middle of a much smaller net made of silken sieve-cloth with very fine meshes. This latter is attached to a ring equilibrated by a fragment of cork. This net of silken gauze does not injure the animals at all, and it captures at least twice as many as the glass bottle which some naturalists substitute for it. It is easy to understand in fact, that the impermeable walls of the bottle compel the water to turn in its interior, and cause eddies which carry out a considerable proportion of the captured animals.

With creatures so active and so difficult to observe alive under a high power, it is of great importance to have a process which enables them to be fixed instantaneously in their natural attitude before they have had time to withdraw into their test, and which preserves faithfully the details of their structure.

Dr. Fol tried the various reagents most in vogue without attaining his purpose. With weak osmic acid, he did not succeed in preserving the cilia of the peristome; and with a stronger dose the body became absolutely opaque: in both cases there was always a strong contraction.

* Journ. Quek. Micr. Club, i. (1883) pp. 233–43.

† Arch. Sci. Phys. et Nat., ix. (1883) p. 554. Ann. and Mag. Nat. Hist., xii. (1883) pp. 13–88 (1 pl.).

Acetic acid, chromic acid, and picrosulphuric acid only gave him a fixation which was too slow, so that the animal died contracted in the bottom of its test. Finally he "succeeded with a reagent which is not employed in histology, perchloride of iron"; by its means he has obtained a considerable number of specimens of various species fixed in a state of full expansion. These subjects, washed with alcohol and treated with gallic acid, present a brown coloration which is especially localized upon the nuclei and renders them very visible; the other parts of the animal acquire a light brown tint, which renders them easy to see.

The specimens thus treated may be mounted in Canada balsam, which produces permanent preparations; but they are much more distinct and more instructive if simply placed in glycerine.

By treating in the manner just indicated the whole produce of a capture, we can afterwards, on returning home, seek at leisure for the infusoria, a more or less considerable number of which will be fixed in a state of full extension of the body and peristome, with the cilia and the vibratile palettes preserved in perfection.

Tests slightly tinged with gallic acid and mounted in balsam in glycerine are especially instructive.

Potassic Iodide for Preserving Infusoria.*—Mr. W. S. Kent has found potassic iodide to act in a manner almost identical with osmic acid, and in some instances even more efficiently. The medium possesses the additional advantage of yielding no deleterious exhalations, which have to be carefully guarded against in the use of osmic acid. The formula for preparation is as follows:—Prepare a saturated solution of potassic iodide in distilled water. Saturate this solution with iodine, filter, and dilute to a brown sherry colour.

A very small portion only of the fluid is to be added to that containing the Infusoria.

Preparing Insects and Spiders.†—Mr. S. Green formerly found great difficulty in arranging insects and spiders in proper position. Legs would double up and wings would not remained expanded. It is only very recently that he has overcome the difficulty, and as the method may also be novel to other amateur mounters, he describes it in full.

On capturing an insect, consign it at once to the poison bottle if convenient, and there let it remain until it is quite dead. Do not let it lie in the bottle for longer than half an hour. Ten minutes is generally sufficient. The action of the cyanide of potash would in a few hours injure materially the muscular structure of the insect, and spoil it as a microscopical object. You should remove the insect before its legs and wings become rigid; but first have ready a small piece of glass, on the surface of which spread a thin film of rather stiff Canada balsam. Then place the fly, or any other insect you may be

* Kent, W. S., 'Manual of the Infusoria,' 1880–1, p. 114.
† Journ. Quek. Micr. Club, I. (1883) pp. 224–6 and 253–4.

operating on, lightly upon the Canada balsam film in the position you desire. If a dorsal view is required, and a winged insect the subject, place it back upwards, then with a fine needle or pin arrange its legs and wings. The legs may be made to adhere their entire length to the balsam, but it is desirable that only the tips of the wings be held down by the balsam. In this position the insect should remain for two or three hours to allow the balsam to become harder and the limbs of the insect stiffer. Then place the piece of glass with the insect adhering to it in spirits of wine, where it should be allowed to remain for two or three days. It is not unlikely that in the course of a few hours the action of the spirits may cause the film of balsam to become detached from the glass. This will not matter, for the hardened film will be found sufficiently dense and strong to keep the legs and wings of the insect in the position they were originally placed in by the setting needle. Should, however, the film not become detached when it is time to withdraw the piece of glass from the spirits, it is easy to remove the insect by placing the piece of glass in spirits of turpentine, which will dissolve the hardened balsam. If, as mentioned before, the film has become detached from the glass, a few hours after its first immersion in the spirits, it should remain undisturbed in the spirits for some days, and then it can be treated with turpentine. It should be kept in clear spirits of turpentine until it has become sufficiently transparent for mounting in Canada balsam.

There are some species of spiders that will crumple up their legs unless pinned out. The pinning out is not at all a difficult process; it merely takes a little more time. Fasten with fine tin wire a thin cutting of cork to a piece of glass, then spread a thin film of Canada balsam on the cork. Lay the spider in position on the balsam, and having previously cut the points of a number of fine pins, take the points up with a pair of light forceps and stick them into the cork against the inner side of the legs of the spider. One point, if properly placed, will be sufficient for each leg. The palpi and mandibles may also be kept in position in the same way. After this has been accomplished put the whole in spirits of wine and follow out the treatment described for flies. The piece of glass must, of course, be sufficiently heavy to sink the cork in the spirits. Care should be taken in withdrawing the pin-points when the spider is ready for transfer to spirits of turpentine. The hardened balsam must first be dissolved, then the pin-points taken out and the spider carefully removed from the cork. When quite clean place it on another piece of cork or glass, and pin out as before and put it into the turpentine bath, where it should remain until it is fit for mounting in balsam. The pins should be about one-quarter of an inch long and tolerably fine. In setting ants on the film of Canada balsam their jaws will not always remain open. To prevent their closing a small splinter of wood may be placed between the points of them, which, if carefully done, keeps them well open. The precaution is not necessary while they are in the turpentine bath.

If it is desirable to keep insects for any length of time before mounting them in Canada balsam, or if they have to be sent to a dis-

tance by post, the preparation of them should be stopped after they have been in spirits of wine on the film of Canada balsam. The film, with the insect on it, can be detached from the piece of glass by cutting the former with the point of a fine needle drawn round the insect. Remove the detached piece of film and place it in a small glass bottle full of clean spirits of wine. The hardened balsam can at any time be dissolved away from the insects by spirits of turpentine. It is sometimes easier to set small insects in position by placing them on their backs upon the film of balsam. Their legs can be arranged in that position with greater facility.

Fluid for Preserving Delicate Crustacea and Cœlenterates.*—Dr. F. C. Noll has found a fluid which is very suitable for permanent preparations of delicate crustacea and their larvæ, preventing their shrinking or becoming too transparent.

It is a mixture of equal volumes of Farrant's medium and Meyer's fluid No. II. It is never cloudy nor entirely dry, although it has such a consistency that air-bubbles scarcely ever occur. The preparation is sealed with asphalte or some other varnish. In order to prevent cracks arising in the asphalte varnish, it is better after a time to pass over it a layer of transparent shellac.†

Hydroids, small medusæ, and other cœlenterates which have been hardened in alcohol and then stained, may, the author says, be splendidly preserved in the above fluid.

Hertwigs' Macerating Fluid.‡—For the isolation of tissues in the Cœlenterates, O. and R. Hertwig recommend the following mixture:—Acetic acid, 1 part; osmic acid, 1-5th part; sea water, 1000 parts.

By means of this fluid not only the nerve-cells, muscle-cells, &c., can be isolated so that the exact form of the individual cells may be easily recognized, but also the tissues in the form of thin lamellæ may be separated and studied as a whole. Pieces of tissue or whole animals are left in the mixture five to ten minutes, and then washed for several hours in 1-5th per cent. acetic acid. The macerated parts can be further prepared, and afterwards coloured on the slide; or they can be coloured at once before preparation with needles. In the first case picrocarmine is used, in the second Beale's carmine, because it does not harden the tissues, but assists rather the process of maceration. Pieces of tissue may be preserved a long time in glycerine diluted with an equal volume of water, provided a few drops of carbolic acid have been added to secure against mould and Bacteria.

To obtain preparations of single cell-elements of *Actiniæ*, the macerated portion must be carefully divided up into smaller parts by needles, and one or more of these parts placed under the cover-glass. Light blows on the cover-glass with a needle will cause the cells to

* Zool. Anzeig., vi. (1883) p. 472.

† "Mit einer Lage des durchsichtigen Schutzleisten-(Schellack-)Kitts, wie ihn die Hirsch-apotheke in Frankfurt a. M. liefert."

‡ Jen. Zeitschr. f. Naturwiss., xiii. (1879) p. 462. Cf. Amer. Natural., xvii. (1883) pp. 806-7.

separate. Care should be taken to support one side of the cover by a hair, which is removed quite gradually, after the object has been reduced to very small cell-masses. Sliding of the cover may be avoided by placing wax feet under its corners.

Dr. Mark has employed this method, and obtained excellent results with it. As he remarks, the great merit of this fluid is, that it separates the cell-elements and hardens them at the same time. The *dissociative* and the *preservative* agent are combined in such proportions, that the action of the former is confined within desired limits by that of the latter.

Blue Stain.*—T. F. Hazelwood, using the carmine stain of Dr. Seiler, but not satisfied with the differentiation of the single stain, found a blue stain composed of rosanilin, anilin oil, and sulphuric acid, which gives the finest demonstration of tissues he has ever seen, for while the carmine gives the nuclei, the blue will give the outlines of the cells, fibrillæ of muscles and nerves, connective tissue fibres, &c. Several tongues of frogs, which had been stained with carmine and mounted in glycerine and acetic acid, after Beale, and left for nearly two years sealed up in glycerine, were taken out of their cells and put through the blue stain, and then mounted, each tongue in a series of slides, with glycerine as the medium. A magnificent demonstration of simple and compound papillæ was the result, with the branched muscle-fibres and delicate nerves *in situ*, also nerve-trunks and ganglion cells.

The skin of the frog has, by the use of this same double stain, furnished another means of studying the arrangement of the nerves. Even the most delicate nerve-fibres are thus brought out with great distinctness. In vertical sections of nerve-trunks, by this treatment, the outline of the individual sheaths is distinctly seen, with the axis-cylinder in the centre. So great is the change wrought by this blue stain that the author has dismounted many of his slides and put them through this process, and then remounted in balsam or glycerine at pleasure.

The stain gives equally surprising results in differentiating the tissues of insects. Nerves and tracheæ and cell-walls are finely coloured. The fine network of muscles and nerves on the stomach and intestines and on the glands is thus brought out with stereoscopic effect.

In the case of the muscles of the Lampyridæ the accessory disks of Engelmann can be distinctly seen. The nerves and ganglia in the thin membrane of the bat's wing are also well brought out.

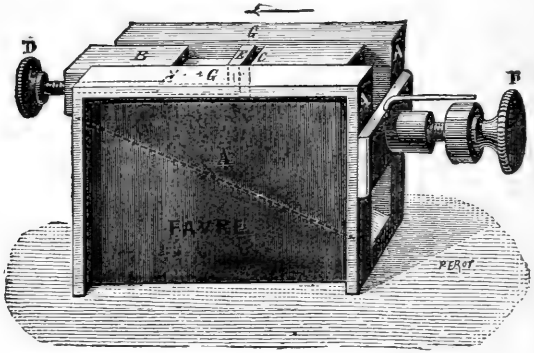
Lelong's Microtome.†—M. Lelong's apparatus, fig. 151, consists of two vertical plates A, having a space between them partly occupied by an inclined plane on which slides a piece B containing the object to be cut, which is put in the cavity C, where it is kept in place by the screw D, which by pushing forward or withdrawing the piece E,

* Amer. Mon. Micr. Journ., iv. (1883) pp. 109–10.

† Latteux, P., 'Manuel de technique microscopique,' 2nd ed., 1883, p. 41 (1 fig.).

allows the cavity C to be made larger or smaller; on the other side the screw F pushes the inclined plane in the direction of the arrow, and elevates the object more or less above the plate G.

Fig. 151.



Dr. P. Latteux recommends the instrument more particularly for hairs.

Cutting Sections of Hairs.*—Dr. P. Latteux has found that transverse sections of hairs are very difficult to obtain by the methods indicated in text-books, the section not being made at right angles to the direction of the hair, so that instead of being round it is oval. He has therefore been driven to devise the following process which enables excellent preparations to be made.

A small piece of wax is placed at one end of a piece of glass, and the hair which it is desired to cut is fixed in the wax by making a hole for it with a hot needle. A second and a third hair are fixed in the same way by the side of the first.

A small piece of diachylon plaster of the width of the glass is then applied at the other end. It will readily adhere to the glass on being simply pressed with the finger. A small quantity of wax is then placed on the plaster, and taking the hairs one by one they are fixed by their free ends so that they are all parallel and arranged like the strings of a violin.

The point now is to fix them in a medium sufficiently solid to keep them in their place, and so that they may not spring back and become sinuous. For this purpose nothing is so useful as collodion. A layer of this is to be spread between the two points where the wax has been placed, and when the ether has evaporated the hairs will be imbedded in a layer of the substance. It sometimes happens that at this moment the hairs relax. The strip of diachylon plaster is then to be carefully detached and fixed a little further off, stretching the hairs gently. Another layer of collodion is then to be poured on and this repeated

* Latteux, P., 'Manuel de Technique microscopique,' 2nd ed., 1883, pp. 263–6.

until we have a membrane of about 1 mm. thick. The hairs are thus fixed so that they cannot move whatever may be done with the layer of collodion.

When dry the sections are cut in the Lelong microtome (*supra*, p. 733). All that is necessary is to cut out of the plate of collodion a square of about 1 cm., and to inclose it between a small piece of soft wood and some elder-pith. We thus obtain small plates of collodion containing sections of the hairs absolutely perpendicular to their greater axis, and these can be mounted in glycerine or better in Canada balsam, but in the latter case, oil of cloves must be avoided, which would dissolve the collodion and free the sections, allowing them to lose their horizontal position.

By this process the author has been able to demonstrate in the clearest manner the torsion of the hairs of the negro. The hairs being fixed in the collodion a small piece of cork cut in the form of a rectangular triangle is fixed to the slide and the sections are made by cutting both the cork and the collodion. It is thus possible to orient them all in the directions which they took originally. The great axis of a section is first observed, and a little afterwards we come upon one whose direction is at right angles to the former, which demonstrates the torsion. From the examination of a great number of sections the author has been able to establish how much the forms vary with the different races and he thinks it will perhaps be possible by the measurement of different diameters to establish a special classification.

Fixing Sections.*—Dr. J. Frenzel, referring to his former paper † and that of Mr. R. Threlfall ‡ recommending caoutchouc instead of guttapercha, says that the former substance has certainly the advantage of giving more quickly a serviceable solution with the solvents used (chloroform or benzine), and the layer spread on the glass dries more quickly than guttapercha; but the latter has the more important advantages, (1) of adhering better, as it never quite dries and softens with heat; and (2) of dissolving less quickly in the common solvents, especially in naphtha, and is therefore considerably more resisting than caoutchouc.

A remarkably good guttapercha solution (1 : 100) can be obtained of Beyrich of Berlin. To prepare the solution oneself, the filtrate must be left to stand from two to three weeks, frequently well shaken, and finally filtered from the deposit. The solvent suggested by Threlfall—naphtha or paraffin oil—is on the contrary, Dr. Frenzel considers, very useful and satisfactory in every respect, at least as far as regards the former, which alone he has tried. Threlfall has, however, he considers, described the mode of operation so insufficiently that few will succeed in obtaining a good result with this method. Dr. Frenzel therefore gives his method.

After the sections are arranged on the *dry* adhesive layer, the slide is warmed for a short time to (at the most) 50° or 55° C., for which a few seconds are sufficient and even a considerably lower tempera-

* Zool. Anzeig., vi. (1883) pp. 422–4.
† See this Journal, *ante*, p. 307. ‡ Ibid., p. 600.

ture. After cooling an *abundant* quantity of naphtha oil is poured over the preparation, and the liquid allowed to run off *quickly until the sections appear almost dry.* Then, without any danger, the preparation can be placed in absolute alcohol, staining fluid, water, &c., in order to stain the sections and treat them further. Only when they are very small is there danger of their being washed away. In order to prevent this, spread over them, after the naphtha oil is almost all evaporated, a few drops of guttapercha solution, allow it to dry, and then place in alcohol, &c. The staining succeeds perfectly in this case also, as the guttapercha has not time to penetrate into the tissues but only covers the sections, without hindering the entrance of other liquids.

If, for any reason, the methods here given are not applicable, or should the sections become detached, Dr. Frenzel uses another method which, although longer than the preceding, has been of great service to him. After the sections have been fixed according to Giesbrecht's method, or with gum arabic, and the paraffin has been removed with oil of turpentine, the latter is allowed to evaporate as much as possible, or is washed out with chloroform; then a few drops of guttapercha solution are put upon the section, the fixing substance is allowed to dry somewhat, and the preparation then placed in alcohol, &c. This latter method is an absolutely certain one, although considerably more lengthy than the previous one.

The end of the process is the same in all cases, being that previously recommended by the author and later by Threlfall.

Fixing and Staining Sections on the Slide.*—H. Schällibaum, finding that Giesbrecht's method will not allow of the staining of the sections on the slide, at least when they are to be afterwards mounted in balsam, suggests the use of a solution of nitro-cellulose in oil of cloves. One part of collodion is mixed (according to its consistence) with 3–4 volumes of oil of cloves or lavender oil, and well shaken. The clear solution is spread with a brush over the slide in a thin layer, which at ordinary temperatures remains fluid for a long time, and adheres well. After the sections have been arranged, the oil of cloves is evaporated by gentle heat over a water bath, which takes 5–10 minutes. The sections thus fixed can be treated for days with oil of turpentine, chloroform, alcohol, and water, without losing their adhesion. The subsequent staining is accomplished in the ordinary manner.

Sections from all imbedding masses known to the author can be fixed in this way, and afterwards mounted in balsam or in glycerine. Cloudiness may appear between the sections, through the solution having been too concentrated and laid on too thick; this may be removed by passing a brush wetted with oil of cloves several times between the sections.

Freeing Objects from Air.†—A writer, whose name is not given, describes the following very simple but efficient process for freeing

* Arch. f. Mikr. Anat., xxii. (1883) pp. 689-90.
† Nature, xxviii. (1883) p. 322.

objects from air before mounting in glycerine jelly, depending on the great solubility of air in water:—

A wide-mouthed bottle, of about four ounces capacity, with a closely fitting *solid* stopper, is completely filled with water, which at the time is, and for half an hour previously has been, boiling in order to expel all traces of dissolved air. The stopper being then inserted without inclosing a single air-bubble, the bottle is set aside until cool enough to receive the sections which are then to be put into it. A few drops of boiling water are then to be added to make good the inevitable loss in removing the stopper; the bottle is to be again closed, wiped dry, and securely sealed with melted paraffin. After twelve hours it may be opened, and the whole contents turned into a white porcelain shallow dish. The sections can then be easily seen, and picked out with a section-lifter, and should be soaked for half an hour in a 50 per cent. solution of glycerine before mounting.

Making Cells of Thin Glass.*—Dr. H. T. Whittell considers that Dr. Beale's plan of making rings by fastening a cover-glass on a metal ring with melted marine glue, and afterwards knocking out the centre with the end of a file, remelting the glue to loosen the ring, and afterwards clearing it off, is a troublesome, time-taking process, and, after experiment, finds that thick gum mucilage may be substituted for the marine glue, and that the cells can then be made with great ease.

Take any number of the thicker glass rings or squares used for making microscopical cells, fasten on each a piece of cover-glass by means of gum mucilage, let them stand in a warm place for 24 to 48 hours till the gum is firmly set. After this break out the centres as in Dr. Beale's method; the part of the thin glass fastened to the rings will remain intact. It is well, as a precaution, to scratch round the inside of the ring with a writing diamond before knocking out the centre. If desired, the inside edge of the ring may now be smoothed with a fine file; but he believes the ragged edges are an advantage in giving greater firmness to the adhesion of the glass in its after uses. The centres being cleared, the whole are thrown into water and left there for a few hours, after which, the gum being dissolved, the thin glass rings will be found loose, clean, and ready for use. The beginner will probably break a few pieces before he acquires the knack of clearing the centres, but after a little practice nine out of twelve will remain perfect. Thick rings with broad edges will be found best to commence with.

Dry Mounting.†—Prof. A. H. Chester, at the Chicago meeting of the American Society of Microscopists, read the following paper:—

"The great difficulty in successfully mounting objects dry has been the deposit on the under side of the cover-glass which is apt to appear sooner or later, and which often so obscures the view of the specimen as to render it comparatively useless. At the Montreal meeting of the American Association for the Advancement of Science, last year,

* Journ. Quek. Micr. Club, i. (1883) p. 193.

† 'Chicago Times,' 9th August, 1883, in advance of Proc. Amer. Soc. Micr., 6th Ann. Meeting, 1883.

Prof. W. A. Rogers suggested a plan for overcoming this difficulty by means of a cover-glass held in place by a wire ring, using a perforated brass plate instead of the usual glass slip. While this may answer for his expensive rulings, it clearly will not be convenient for ordinary mountings; but from his suggestions I have worked out the following method. The object is fastened to the glass slip in the usual way, and a cell built up around it by means of one or more tin rings. When the cell is high enough so that the cover-glass laid on top will not touch the object, a tin ring having a little larger hole is cemented on, thus forming a ledge on which the cover-glass may rest, with room above it for the wire ring, which holds it in so firmly that there is no danger of its being jarred out. The tin cells are made as described at the Elmira meeting last year, by punching rings from thick tinfoil, and afterwards stringing the rough rings on a mandril that just fits the hole, clamping them fast and turning them down until they are just the right size outside. After considerable experiment I have adopted the following sizes in the various parts of this work, using a 5-8ths in. cover-glass. For the cell rings a No. 29 punch is used, having a diameter of 0·543 of an inch. For the top rings the punch is No. 22, with a diameter of 0·505 of an inch. This cuts a little larger than its inner diameter, and will just admit the 5-8ths cover-glass. For the outer rim of both a No. 11 punch may be used, 0·751 of an inch in diameter, and making the rings large enough to allow for turning down. The tinfoil for the upper ring should have a thickness of about 0·032 of an inch, No. 21 of the Birmingham wire gauge. Made with a gun-wad punch, the rings will have a bevel on the inside, and being set with the smaller hole uppermost, the bevel will help to hold the brass ring in place. The wire rings are made from No. 24 spring brass wire, 0·022 of an inch in diameter. These rings are easily made by winding a wire on a spindle about 0·4 of an inch in diameter, forming a spiral spring, every coil of which, when cut open, makes a ring. The exact size of this spindle is not important, for the size of the spiral can be varied by putting more or less strain on the wire, or by the rate at which the spindle is revolved. The rings should be a trifle larger than the opening in the cells, so that small pieces must be cut out to make them fit exactly when sprung into place. They can then be taken out and the cover-glass removed with the greatest ease. The cover-glasses should not be more than 1-100th of an inch thick, and several thicknesses of tinfoil may conveniently be used for the lower cells. The thinnest I use is 0·005 of an inch. For objects requiring less than that I simply turn a cement ring on the glass, and then put the top cell on that.

The advantages claimed for this method of mounting are many, some of which I will mention. In the first place, no deposit will collect on the under side of the cover-glass, or, if it does, the glass can be cleaned or replaced by another. Next, there will be no running in of cement, for there will be no partial vacuum, as is often the case when cells are hermetically sealed. If the object becomes dislodged, as often happens when comparatively heavy pieces are mounted dry,

they can easily be fastened in place again. I also find this a quicker method of mounting, it not being necessary to take so much pains to avoid running in. If the cover-glass is broken by accident, it is, of course, easily replaced, which is another decided advantage. But the greatest gain is in the fact that the object can be examined uncovered. In working with metallic crystals and the binocular I have often experienced great difficulty from the interference caused by the cover, and find it a great advantage to remove it altogether when studying. Such are the advantages of the new method. If it has any disadvantages I have failed to find them, after a year's trial."

Glycerine Mounting.*—Referring to Prof. Hillhouse's method, *ante*, p. 599, Mr. J. W. Neville, from practical experience, suggests the sealing of the cover-glass with pale copal varnish instead of dilute balsam. It can be obtained of as light a colour, is much tougher, and not likely to get so brittle as that medium. He has preparations that have been put up in this way for seven years or more, and several of his friends have used it as long a time, preferring it to glycerine jelly, as it does not show such a disposition to leak. Practical microscopists will be glad to learn that after this space of time the objects show no signs of deterioration, but rather wear an improved appearance.

Mr. G. E. Davis also writes:†—"Much has been said against glycerine mounts and their leaky propensities after a lapse of time. We have lately seen some glycerine preparations put up ten years ago, and they are to-day as tight as when first mounted. The only varnish used for cell and cement was white zinc varnish. We have many glycerine mounts in our cabinet, and have come to the conclusion long ago that if every care were taken to clean away the superfluous glycerine there would be no more complaints of leakage. No cement will adhere where there is even the slightest film of glycerine."

Dr. H. T. Whittell ‡ has tried, with limited success, all the plans and cements that he has seen recommended for mounting objects lying under the cover-glass floating in a drop of water or glycerine, with some of the same fluid outside the cover-glass so as to preserve the object in the exact condition in which it has been found, but has obtained much more satisfactory results by the following simple plan:—

As much glycerine as possible is first removed from the slide by the usual plan of wiping, and absorbing with bibulous paper round the edges of the cover. A little gold-size—that sold to artists is best—is rubbed up with a little whiting that has been previously well dried in an oven, and this is poured into a bottle for use. Some of the whiting settles to the bottom, but a quantity is held in suspension, and a larger proportion can always be obtained by shaking up the bottle. By means of a fine brush a little of this chalk cement is passed along the edges, and just outside the cover-glass, taking care to fill up the angle between the slide and cover. To prevent moving the preparation, it is better in this stage to imitate what the artists call "stippling," that

* Midl. Natural., vi. (1883) p. 190.
† Micr. News, iii. (1883) p. 238.
‡ Journ. Quek. Micr. Club, i. (1883) pp. 191–3.

is, to take the brush along in one sweep. The cement falls from the brush as one proceeds, and it is easy to see when enough has been applied. While taking care to have sufficient cement to fill up the angles, the aim should be to have as narrow a line as possible around the edges of the preparation. The slide is now set aside for twelve or twenty-four hours, when the layer of cement will have become tough, and will be found to hold the cover effectively in its place. The slide is now put into water, to wash off all trace of glycerine, and is afterwards set on end to drain and dry. A ring of gold-size or other cement may afterwards be applied in successive layers, and in due time, when all is firmly set, a finishing layer of white cement or of asphalt.

Mounting Objects "Opaque" in Balsam.*—Mr. E. Ward calls attention to the fact that there are some few objects which, although too opaque for transmitted light, are yet more beautiful, if mounted in balsam, than when dry. This is most apparent in the various parts of some diamond beetles, such as the genera of *Entimus* and *Cyphus*. In the old days, when paper-covered slides were much in vogue, this kind of preparation was readily made, it being only necessary to paint the slide at the back with black varnish, which was protected by the covering paper; but when it was seen how much better appearance the slides presented if uncovered, but neatly ringed, it was found a more difficult matter to get this same opacity for balsam mounts, as if the opaque varnish was placed inside the cell it was frequently dissolved by the balsam, and if painted on the under side, it almost always became unsightly through being rubbed, offending those who care for the neatness of finish of their slides.

Mr. Ward has succeeded in producing a black which can be used with safety under the cell, and which he has given plenty of trial; the process being moderately easy, and the materials to the hands of almost every worker.

Having affixed to the glass slip, by means of the brown cement originally introduced by the author, a metal cell of sufficient depth (and it is absolutely necessary that it be quite as deep as the object to be mounted, or the after process will be more difficult), allow this to dry, and then paint the inside of the cell on the glass with a black varnish made by adding lamp-black to brown cement. This black varnish should only be made as required, and for a small quantity it is only necessary to put a few drops of brown cement into a watch-glass, and stir in with a camel-hair brush a small quantity of the black; this brush will also do for the painting of the cell.

The varnish having been painted in, the cell will dry in an hour or so, particularly if put in a moderately warm place; and though the surface will be very granular, this granulation will not interfere with the after result.

The elytron, or other object, may now be fastened down to the cell-button with gum or brown cement, and when dry, the cell should be filled with benzole, which will penetrate every crevice and nook.

* Micr. News, iii. (1883) pp. 197–8.

Before the benzole has quite evaporated, fill up the cell with balsam and benzole until it appears heaped up above the top of the cell.

The slide should now be put on one side, covered with something, such as a wine-glass or chip-box, to keep off the dust until the benzole has evaporated, which will leave the balsam nearly hard in the cell. It will however be found that, even with care, some dust will have settled upon the surface of the balsam. This can be removed by a camel-hair brush dipped in benzole, and drawn across the surface. If this surface is still higher than the cell, the slide is now ready for the last process, and only needs a cover-glass, which should be warmed and pressed upon the surface, and held down by a spring clip until the existing balsam has become hard, when it can be cleaned off, and the slide subjected to the usual process of ringing.

Styrax and Liquidambar as Substitutes for Canada Balsam.*—Dr. H. Van Heurck, desiring to obtain a fluid of high refractive index which would not be open to the inconveniences of monobromide of naphthaline as regards the difficulty of sealing up and the disagreeable odour, found that styrax from *Liquidambar styraciflora* and liquidambar from *L. orientalis* were excellent media for the purpose, and much less alterable than Canada balsam. Styrax is supplied by Gehe and Co., of Dresden. It contains a granular substance, which is got rid of by dissolving it in chloroform and filtering the solution, which is used for mounting. Liquidambar is preferable as being very pale yellow instead of a brownish yellow, but it does not appear to be obtainable from European druggists.

The index of refraction is not given. *Amphipleura pellucida* is said to show the striæ in a "perfect manner," and the author "believes that the use of the above products will rapidly spread, and by reason of their great advantages will completely supplant Canada balsam."

Practical Processes in Vegetable Histology.†—L. Olivier writes as follows:—

In studying the structure of a living organism, it is not sufficient to examine under the Microscope the form and relations of its elements. We must, in addition, determine the chemical nature of each. In this physiology is as much concerned as general anatomy, physiological functions being the resultant not merely of the molecular composition but also of the arrangement of the organic structures.

The endeavour has therefore been to find for histology reagents capable of discovering in the interior of the cells the presence of the analysed substances.

Two methods have been adopted. The older and more general consists in examining, under the Microscope, different preparations of the same organ, before and after the successive action of certain

* Bull. Soc. Belg. Micr., ix. (1883) pp. 134–6.

† Rev. Sci. Nat., i. (1882) pp. 436–54; ii. (1882) pp. 71–91. We have been unable to verify the footnotes so as to print them in the form usual in this Journal, and they are therefore given for the most part as in the original.—Ed.

agents on it. Note is taken of what this complex treatment eliminates, precipitates, or colours. This result is compared with that obtained by a different treatment of the same organ, or by the similar treatment of a different organ, thence deducing the chemical characters of the tissues experimented on. Thus pieces of wood, in which the Microscope reveals the existence of cells, vessels, and fibres, no longer show cells after being subjected to the influence of certain substances. Another series of reagents causes them to lose their fibres without destroying their vessels, whilst the former resist the treatment which dissolves the walls of the vessels.

It is to this kind of analysis that we have been so long limited. The increasing perfection of practical microscopy now enables us to substitute for it a more certain and productive method, that of microchemical reactions.

When an organ is acted upon by a whole series of acids, bases, or salts, and then examined under the Microscope, it is difficult to distinguish clearly the histological elements, and still more to pronounce upon the nature of the changes to which a given treatment has subjected them. Given several kind of elements, it is impossible to decide what action they may exercise one upon the other in a mixture. Besides, all the elements being more or less disintegrated by the chemical treatment, we are rarely in a position to pronounce upon the histological nature of those which have not been completely dissolved. If, on the contrary, they are all observed in *the same preparation*, in a thin section where they are only juxtaposed, all the phases of the reaction can be followed under the Microscope, and there is no longer any risk of being mistaken as to the localisation of the phenomena.

In animal histology this method is already very advanced. In vegetable histology it is still very rudimentary, the sparse data which science possesses on the matter not having been yet collected into a systematic method in botanical treatises.*

Let us first call attention to the fact that the same reagent does not always produce identical modifications in all those elements whose fundamental composition is the same. In order to produce the same effects in all the organs in which the elements are found it must often be employed in *different degrees of concentration.* Sometimes even its action must be preceded by that of another agent, which eliminates from the element to be discovered the substances masking the phenomena. It is therefore important to note, in the case of the majority of the reactions which will be indicated, in which special cases they have given good results.

The operator ought not, moreover, to be content with a single reaction, *the accuracy of a determination resting entirely on the concordance of numerous observations.* Hence the many series of manipulations intended to render the preparations transparent, to fix the microscopical forms, to contract the structures, to precipitate or dissolve certain substances, and to colour and finally to preserve them.

* V. A. Poulsen published at Copenhagen a very excellent little book on this subject, translated into German ('Botanische Microchemie,' Cassel, 1881) by C. Müller, from which, as will be seen, we shall borrow largely.

I. Clarification.

1. Generally the tissues are made transparent at the same time that thin sections are prepared. For this purpose recourse is had to the alkalies (ammonia or potash), to glycerin, and to chromic, acetic, carbolic, and nitric acids.

Ammonia.—Prof. Dippel * uses ammonia to give transparency to delicate sections of plants whose tissues would be lacerated by too long immersion in concentrated alkali. The ammoniacal gas, being rapidly disengaged in the open air, the action which it exercises on the tissues in an evaporating dish is weakened in proportion to the thinness of the sections.

Potash.—This substance is of more general use than ammonia. It especially thins cell-walls of cellulose membranes. Poulsen,† Nägeli,‡ Dippel, § Wiesner, || and Sachs ¶ have tried it in very different researches, and are unanimous in recommending its use for thinning the cell-walls and making them clearer.

In a weak solution it also renders protoplasm transparent.

It is dissolved in water or alcohol.

The solution is made to act either on the preparations themselves or upon the organs before they are cut. In this case the alcoholic solution is the best. Russow ** has made a good preparation of it by pouring into alcohol of 85 or 90 per cent. a concentrated aqueous solution of potash in such quantity that after twenty-four hours there will be a deposit at the bottom of the vessel. It is then sufficient to decant the liquor to obtain it in the requisite condition.

Hanstein †† has made use of it to study the root-cap and the embryo. Sections of stems, leaves, or roots immersed in it acquire great distinctness. Hanstein leaves them in it for several hours, then washes them in very dilute hydrochloric acid or weak acetic acid, so as to neutralize the alkali. Sometimes the latter treatment darkens the cells; the preparations are then exposed to the action of ammonia and washed in distilled water before placing them in glycerin, which further clears them.

Glycerin.—This liquid only clears thin objects preserved in it *after a considerable time.* This property is strengthened by the addition of acetic acid to the glycerin.

Acetic acid.—The effect of this acid is very perceptible when care is taken to wash the preparations in distilled water before submitting them to its action. It assists the examination of the nuclei, which it

* 'Das Mikroskop,' i. (1867) p. 279.

† Loc. cit.

‡ 'Das Mikroskop,' 1877, pp. 472 and 525.

§ 'Das Mikroskop,' i. (1867) p. 278.

|| 'Technische Mikroskopie,' 1867, passim.

¶ "Ueber die Stoffe welche das Material der Zellhäute liefern," in Pringsh. Jahrb., iii. 1863.

** Mém. Acad. St. Petersburg, xix. p. 15.

†† "Die Entwickelung des Keimes der Monocotyl. und Dicotyl." in Hanstein's Bot. Abhandl., Bonn, 1870.

renders more visible, chiefly by effect of contrast, rendering the protoplasm which surrounds them soluble in the water.

Carbolic acid.—E. Warming, whose interesting work on bacteria and monads is well known, has found in carbolic acid a valuable agent for rendering these little organisms transparent.

Alcohol and Nitric acid.—We have obtained preparations of *extreme thinness and of the greatest transparency* * in the following manner:—Place in a watch-glass the objects to be thinned (sections of stems or roots); add to them alcohol of 36°, into which pour, drop by drop, concentrated nitric acid until the red vapours of hyponitric acid are disengaged. If the preparations are violently attacked, cover the watch-glass with a small bell-glass, observing through it what takes place in the liquid; as soon as the preparations rise to the surface of the mixture, raise the cover, and by means of two *wooden* needles push them to the bottom of the glass.

When there is no disengagement of red vapour at the normal temperature, set fire to the alcohol in order to concentrate it further, and warm the watch-glass on a piece of wire-gauze over a gas-burner.

Under these conditions, the cell-walls undergo a considerable thinning, but all their contents disappear. They become so delicate that the difficulty is to remove them from the water in the evaporating dish (into which the watch-glass has been emptied) to transfer them into the glycerin of the slide. We attain this object by adding to the still warm alcohol a little chloroform; this treatment hardens the preparations, which can then be transferred by means of little *wooden* spatula into the glycerin, where they soon recover the same flexibility as in the watch-glass.

We have obtained better photographs of vegetable sections thus prepared than with those obtained by other processes.

Chromic acid.—According to Hohnel † this acid gives transparency to tissues of a corky nature, such as cells of cork, epidermis, cuticles, and the envelopes of pollen-grains, to the extent of making details perfectly visible, which, without the aid of reagents, could not have been seen.

The solution of chromic acid admits of very different degrees of concentration, the important point being that it should be free from sulphuric acid.

Calcium chloride.—When it is desired to give transparency to the preparation without thinning it, it may be very useful, especially if the tissues are young, to have recourse to the process employed by Treub,‡ and afterwards by Flahaut, § which consists, as described by the latter author, "in placing the sections in a watch-glass or in a small porcelain capsule with one or two drops of water; the drop is covered with a little dry calcium chloride in powder, and slowly

* 'Recherches sur l'appareil tégumentaire des racines' (8 pls. and 50 microphotographs). Paris, 1881.

† "Ueber Kork," SB. Wiener Akad., 1877, 1 Abth.

‡ 'Le méristème primitif de la racine des monocotylédones.' Leyde, 1876.

§ "Recherches sur l'accroissement terminal de la racine chez les Phanérogames," Ann. Sci. Nat., vi. (1878) p. 24.

warmed over a small flame until the desiccation is nearly complete. The sections are withdrawn directly from the action of the flame, and a few drops of water added, which dissolve the calcium chloride. The sections immediately float in the water; they need only be collected and placed in the glycerin, in which they attain sufficient transparency after a few hours. This treatment results, not in dissolving all that the cells contain, but in darkening their contents by slightly thickening the originally very thin walls; these walls become at the same time clear and brilliant. The opacity of the cell-contents obstructs the study of several layers of cells at the same time.

II. Fixation of Forms.

The ternary parts of the plant being generally tolerably rigid, it is only necessary to fix the proteid matters (protoplasm, nuclei, vibratile cilia, &c.). The following agents are employed for this purpose.

Absolute alcohol.—When absolute, alcohol fixes the protoplasm without contracting it. It can be made to act directly on the preparations to be examined, or upon the organs before making sections. Strasburger has studied in the latter mode the formation of the cells in *Iris pumila*. By immersing *Spirogyra orthospira* in absolute alcohol at different hours of the night he succeeded in fixing the different phases of the division of the nucleus in this alga, which it then became very easy to study by daylight (without its changing) the day after and the following days. The same observer succeeded in retarding division until the morning by placing the *Spirogyra* in a room without heat in November. He was thus able to follow under the Microscope all the phenomena of the division, and to fix them at the most suitable moment by immersing the plant in absolute alcohol.

Chromic acid.—L. Guignard has successfully employed chromic acid to fix the nuclei in the embryo-sac in the Mimosæ.* The good results he obtained with it mark this reagent as one of the most valuable in vegetable microchemistry.

Osmic acid.—Osmic acid, whilst fixing the form, has the advantage of giving transparency to the protoplasm and the cell-walls, but has also the inconvenience of destroying the protoplasm after some hours. Strasburger has nevertheless used it in his observations on the division of nuclei. He placed the plants in water containing 1-500th of sugar, and added one or two drops of a 1 per cent. solution of osmic acid.

Vignal † and Certes ‡ have called the attention of naturalists to the good results obtained with osmic acid for fixing instantaneously the forms of the lower organisms (*Noctilucæ*, infusoria, algæ, zoospores, microbes of virulent diseases, &c.). Generally it is sufficient

* Bull. Soc. Bot., 25th June, 1880.

† "Recherches histologiques et physiologiques sur les Noctiluques," Arch. de Physiol., 1878.

‡ "Sur une méthode de conservation des infusoires," Comptes Rendus, 3rd March, 1879.

to expose the organisms on the slide for five minutes to the vapours of a 1 per cent. solution of osmic acid. But if they are very contractile it is preferable to treat them directly with the liquid acid after all disturbance of the slide has ceased.

Certes * has succeeded in doing away with the corrosive action of osmic acid. He places the organisms to be examined in a test-tube containing 30 c.cm. of distilled water or a few drops of the water of which he intends to make a microscopical analysis. He adds to it 1 c.cm. of half per cent. osmic acid. In a few minutes he fills up the test-tube with water, and allows it to rest for twenty-four or even forty-eight hours. All the algæ, spores, bacteria, monads, vibriones, amœbæ, and infusoria which originally swarm in the water are then deposited at the bottom of the test-tube. They are collected by means of a pipette, after the greater portion of the liquid has been decanted.

For eleven months we have preserved, in the same test-tube in which they were killed, some specimens of *Monas* which, during life, were very active. Their form has hitherto undergone no alteration. It is exactly the same as at the moment when they were attacked by the osmic acid.

Taking our stand on the fixative properties of this agent, we have attempted to make use of it to determine the parts of an organism endowed with spontaneous motility. We had to decide whether the long caudal filaments, the existence of which we had recognized in the *Bacterium rubescens* of Ray Lankester, are contractile, and whether they are active or passive in locomotion.

With this object we poured into two watch-glasses some distilled water, and a few drops of the water in which they were multiplying abundantly. We added to the contents of one of the two watch-glasses a drop of osmic acid properly diluted, and then added to it distilled water.

When, after a rest of twenty-four hours, we coloured the organisms in the latter glass by means of reagents, of which we shall speak later, we succeeded in showing the long filaments. This was, on the contrary, impossible with the organisms in the other glass ; a phenomenon which we attribute to a contraction of the filament in the latter case, and to an absence of contraction in the case of fixation by osmic acid.†

Alcoholic solution of corrosive sublimate.—The effect of this solution employed as a fixative is rapid, but of very short duration. It is used with advantage in studying aleurone.

III. Contraction.

It is known that protoplasm, either free like the plasmodia of the Myxomycetes, or surrounded by a ternary membrane, as in multicellular plants, has at its periphery a hyaline layer, which remains in perfect continuity with the rest of the protoplasm, though dis-

* "Sur l'analyse micrographique des eaux," Comptes Rendus, 14th June, 1880.
† Bull. Soc. Bot., iii., 22nd July, 1881. See this Journal, ii. (1882) p. 640.

tinguished from it by its hyaline appearance and a greater refrangibility. In the interior of the protoplasm a border of the same nature surrounds the vacuoles when there are any. It is this membranous layer which regulates the osmotic phenomena of the cell. It is very permeable to water, but very little so to the salts which are dissolved in it, so that on placing the cell in pure water or in water charged with salts, the capacity of the vacuoles is increased or diminished, the protoplasm is dilated or contracted.

Amongst the substances which produce the latter effect must be mentioned solution of sugar, weak aqueous solution of chlorate of potash, *dilute* alcohol, glycerin, and sulphuric acid. These agents contract the protoplasm to the extent of detaching it from the cell-membrane. At the same time they give it a consistency which enables it to be better distinguished.

Solution of sugar, introduced gradually into the preparations, contracts the vacuoles without killing the protoplasm; when the cell-sap is abundant, as in old cells of *Spirogyra* and *Œdogonium*, it may happen that the volume of the protoplasm will be reduced one-half.*

Alcohol always kills the protoplasm. It contracts it only when dilute, the slower its action the more marked is its effect. Contracted by this agent, the protoplasmic substance becomes hard and resisting.

Glycerin produces an analogous result, with this difference however, that the protoplasm does not become so rigid.

Sulphuric acid acts in the same way, with more energy and rapidity. It is important therefore to suspend the action as soon as the contraction has taken place. It would destroy the protoplasm if the action were prolonged.

Mineral acids generally behave in a similar way.

These different substances, frequently employed in the examination of the protoplasm of the higher plants, can also be applied to the study of the lower cryptogams which the simplicity of their structure places at the confines of the two organic kingdoms. Dilute alcohol, glycerin, and the mineral acids, by absorbing water, reduce the bulk of the protoplasmic masses not surrounded by cell-walls and destitute of vacuoles. We have used them successfully to determine the general contraction of the body of *Monas Okenii* Ehr., and to show by that that this microbe, absolutely destitute of ternary envelope, must be removed from the bacteria and associated with the nudo-flagellate organisms.

Knowing the means of rendering the tissues transparent, of contracting the organisms, and of fixing them in their forms, we must now consider what kinds of histological elements or products of the vegetable economy are capable of being revealed by means of crystallization, destruction, or colouring. In each of these three cases we shall follow the inverse order to that which we have hitherto adopted; instead of indicating, for each reagent, the different substances for

* P. Van Tieghem, 'Traité de Botanique,' p. 473. Paris, 1882.

the determination of which it is appropriate, we shall examine the different substances, and for each one point out the microchemical operations which belong to it.

IV. Precipitation, Crystallization.

The substances whose precipitation or crystallization is produced in the interior of the cells are asparagin, inulin, and the saccharoses. Their deposition can be incited by a solution which contains principles different from those that are being sought for or even (according to the method originated by Borodin *) saturated with the substance itself which it is proposed to discover.

Asparagin.—Asparagin crystallizes in this way in cells when treated with a saturated solution of asparagin. It is even the best means of showing its presence. It is obtained in greater quantity by immersing the tissues in absolute alcohol, which on subsequent evaporation leaves the asparagin in crystals. But as the alcohol also takes up other substances capable of crystallizing, in order to recognize it, we treat all the crystals with a concentrated solution of asparagin, in which this substance alone remains crystallized.

It should be observed that the tissue in which it is to be studied ought to be in active life, since asparagin, which is an acid of bimalate of ammonia, constitutes a product of secretion, as it were the urea of plants.

Inulin.—Solid inulin can be obtained in the cells in two different conditions; in the amorphous or the crystalline. Desiccation causes the precipitation of this substance, which previously existed dissolved in the cell-sap; it is most frequently amorphous. Nevertheless, when desiccation is very slow, it crystallizes.

Prolonged maceration of the organs which contain the reserve-materials in alcohol causes the formation of sphero-crystals of inulin. When sections are made of the tissue thus prepared, a little acetic acid is added, and they are put in glycerin.

The alcohol used must be diluted with water. It is advantageous to reduce imperceptibly, by evaporation, the quantity of water added to the alcohol, and to keep up the level of the liquid in the vessel by adding to it gradually absolute alcohol.

When there is not time to allow the organs to remain in the alcohol before making sections, the sections themselves can be subjected to the action of either absolute alcohol or ether. In this case a deposit of amorphous inulin is obtained.

Saccharose.—The saccharoses are insoluble in absolute alcohol. It is therefore sufficient to treat the saccharine cells by this agent in order to produce the crystallization of the saccharose. Bonnier † has often had recourse to this process in the examination he has made of the nectaries. By way of verification, he treated the soluble portion of the tissue with 80 per cent. alcohol and with ether; he then saw crystals of the same form appear in the liquid.

* Bot. Ztg., 1878, p. 804.

† "Les Nectaires," Ann. Sci. Nat., 1879. See this Journal, ii. (1879) p. 748.

Sections made transversely to the saccharine tissues can also be allowed to dry. In evaporating, the cell-sap leaves the saccharoses in the form of stellate crystals, the crystallographic system of which it then becomes possible to recognize.

Aleurone.—This is the place to point out the means of preserving from solution in water the proteid part of the aleurone grains. It is known that in several plants, the peony for instance, this portion of the grain is very soluble in water. It is rendered insoluble by first subjecting it to the action of an alcoholic solution of bichloride of mercury. It is on this very phenomenon that Pfeffer relies to establish the presence of a quaternary nitrogenous substance in the aleurone grain.*

V. Dissolution and Destruction.

We dissolve certain substances either with the object of discovering what they are, or more frequently the better to see the elements which they hide. Thus it is not uncommon to destroy the protoplasm in order to make the nucleus more visible.

Protoplasm.—In order to display the nucleus, the tissue is treated with acetic acid, which renders the protoplasm transparent, and then dissolves it. A concentrated solution of potash destroys it, but that attacks the nucleus as well. It is only employed to obtain a membranous skeleton of the tissue.

Aleurone.—Sulphuric acid entirely destroys the grains of aleurone.

Oily Matters.—The oily matters have a special refrangibility under the Microscope, which distinguishes them from other substances inclosed in the tissues. Their most general solvents are ether and the essential oils; alcohol, chloroform, and benzine are also often used for this purpose.

The oily matters which exist in the solid state in plants, and which are known by the name of *vegetable butters* (cocoa-nut butter, cocoa butter, nutmeg butter, Japanese wax, palm-oil, laurel-oil, &c.), may be dissolved, like oily liquids, in ether and essential oils.

The use of alcohol is often recommended to remove the oil from sections of the albumen, the embryo, or the cotyledons of oleaginous seeds; we ought to call attention to the fact that ether acts more rapidly, and that moreover several oils are only partly soluble in alcohol, such as linseed-oil, hempseed-oil, poppy-oil, croton-oil, and nut-oil.

Essential Oils.—These oils are very unequally soluble in alcohol or ether; they are all soluble in the fixed oils. They exist in the tissues in the condition of balsams or oleo-resins. The non-volatile oils, in which the resinous substances are insoluble, allow of their extraction.

But as the use of the fixed oils is inconvenient, because of the difficulty of getting rid of them from the preparations which have been impregnated by them, we point out, according to Planchon,† the

* Pfeffer, Jahrb. f. Wiss. Botanik, viii. (1872).

† Planchon, 'Traité pratique de la détermination des drogues simples d'origine végétale,' ii.

solubility and density of several essential oils, which it is useful to know, in order to free the sections from them.

A. Essential oils denser than water:—Bitter almonds, cloves, mustard, cinnamon.

B. Essential oils less dense than water:—

Camphor.

Essence of roses, soluble in sulphuric acid.

Essential oil of aniseed: when sulphuric acid is added to it in sufficient quantity, the solution separates into two layers, of which only one is fluid.

Essential oils of conifers, only soluble in several times their volume of alcohol.

Essential oil of lavender, soluble in one volume of alcohol.

Essential oil of rosemary, mint, and thyme, very soluble in alcohol.

Resins.—When examining the oleo-resinous ducts of plants, especially in the Coniferæ, Cycadeæ, Aroideæ, Umbelliferæ, Araliaceæ, Compositæ, and Clusiaceæ, in which they are very much developed, we must eliminate the resins which accumulate in the passages where they were originally united with the essential oils, as has been done by Sachs,* Trécul,† N. J. G. Müller,‡ and Ph. van Tieghem.§ It is the same with the *resins* properly so called (betulin, colophane, jalap, lac, &c.), the *balsams* (tolu, benzoin, &c.), the *gum-resins* (gamboge, &c.). These substances, abundant in the sections of old tissues, generally prevent the study of the oleaginous cells. They can be completely dissolved in the fixed oils by heat. But it is generally preferable to treat them with essential oils, ether, or alcohol, which at ordinary temperatures dissolve the greater portion of them. The little which remains in the passages does not injure the examination of the preparation, and moreover this imperfect solution of the resin, joined to its other characters, helps in its recognition.

Waxy matters.—The waxy matters of the cuticles are but slightly soluble in cold alcohol, but they dissolve very quickly in boiling alcohol or slightly warmed ether. It is the sections themselves which are subjected to the action of these liquids in order to obtain perfectly pure cuticles, or to recognize the waxy nature of the substances developed at the surface of these membranes.

Latex.—In making sections of organs provided with latex, care must be taken to keep the razor and the preparations continually wet with ether. Without this precaution the latex blackens the razor, and consequently the tissues which are being cut, so that it becomes impossible to examine them.

Caoutchouc is composed of the corpuscles of the latex of certain plants. These corpuscles can be recognized under the Microscope by their swelling in the volatile oils, and dissolving in benzin, chloroform, and bisulphide of carbon.

* Bot. Ztg., 1859, pp. 177–85.

† Journ. de l'Institut, 6th Aug., 1862. Ann. Sci. Nat., v. and vii.

‡ 'Untersuchungen über die Vertheilung der Holze,' 1867.

§ "Mém. sur les canaux sécréteurs des plantes," Ann. Sci. Nat., xvi. (1872).

Cellulose.—Cellulose, as it is most frequently present in the cells, that is in the condition of polymerization not exceeding $(C_6H_{10}O_5)_4$, is soluble in Schweizer's ammonio-cupric solution. More condensed (for instance elder pith, the walls of thickened fibres, old vessels, ligneous cells) it is insoluble in the same reagent.

Schweizer's solution alters with time, therefore it ought to be used freshly prepared. It is obtained by pouring ammonia on copper-turnings, in a funnel; the liquid is again poured over the copper until it is coloured deep blue.

As the solution of cellulose can only be effected by a large quantity of nitrite of ammonia, care must be taken to keep a constant current of the liquid passing between the two glasses between which the preparation is compressed. For this purpose pieces of filtering-paper are used, which absorb the liquid at the edge of the cover-glass, whilst some drops of the solvent are placed at the opposite edge. The operation is hastened by disusing the cover-glass where large sections are being treated.

When the preparations are numerous and resisting they can be shaken together in a little flask filled with Schweizer's liquid, and subjected to several washings. This is the most rapid process. But if the preparations are at all delicate the first method alone is practicable; the operator should follow under the Microscope the different stages of the solution. The observation is easy with a low power; but directly it requires more than 200 diameters it becomes troublesome. In this case it is better to increase the power of the eye-piece alone; high-power objectives are inappropriate, the distance of their front lens from the preparation is so small that they risk being wetted by the reagent.

The butyric fermentation offers a slower but more accurate means of isolating in a preparation all the non-cellulose membrane by determining the cellulose. The organs or the sections from which we wish to eliminate the purely cellulose portions are placed in a glass of water, to which are added pieces of radish-roots, haricot-beans, or broad-beans, a *very small* quantity of sugar and powdered carbonate of lime. The mixture is shaken up and left exposed to the air. The fermentation is increased by keeping the vessel in a temperature of about 30° C.

When, carbonate of lime being in excess, there is no further disengagement of gas, the *Bacillus amylobacter* has formed its spore, and the fermentation has ceased; all the cellulose has then been, by a series of successive hydrations, converted into glucose, and the glucose decomposed into carbonic acid and butyric acid. The *rôle* of the carbonate of lime is to allow the formation of butyrate of lime as butyric acid is produced; this acid, free and accumulating in the liquid, would arrest the development of the *Bacillus* long before the destruction of all the cellulose.

Like Schweizer's solution, the butyric ferment does not attack cellulose whose condensation exceeds $(C_6H_{10}O_5)_4$. The action of the microbe is indeed so special that it is only exercised on a certain kind of this compound, although no chemical reagent shows two

varieties of it. Thus cells of *Chara* and *Elodea*, although dissolving in nitrite of ammonia, are not altered by *Bacillus amylobacter*.

Generally this microscopical agent does not affect starch, which is a lower polymere than cellulose. Nevertheless, Van Tieghem has found that in certain plants, contrary to what usually takes place, this microbe subjects the grains of starch to butyric fermentation, without destroying, or before destroying, the walls of the cells into which it has penetrated. This is the case with the root of *Adoxa moschatellina*.*

It is easy, with a *high magnifying power*, to study, under the Microscope, the course of the butyric fermentation. It is only necessary to guard against the preparation drying up and coming in contact with the air, which is fatal to *Bacillus amylobacter*.

Crystals of Carbonate of Lime.—In the condition of cystoliths, or of very small granular crystals, carbonate of lime is not rare in the protoplasm or septa of the cells (for example, plasmodia of the Physareæ, epidermal cells of several Urticaceæ, cell-walls of *Corallina* and *Acetabularia*). Acids, and particularly hydrochloric acid, dissolve it by disengaging, under the form of bubbles, the carbonic acid which it contains. This disengagement, easily observed under the Microscope, is very characteristic.

Crystals of Oxalate of Lime.—These crystals, which are much more frequent than the former, are distinguished from them chemically by being insoluble in acetic acid, and soluble, without disengagement of gas, in hydrochloric acid.

It is useful to apply these reactions in the case of crystals of the quadratic system with six equivalents of water. But for the raphides of the monoclinic system, with two equivalents of water, they are almost always superfluous, their form being sufficient to reveal their nature.

VI. Colouring.

1. Albuminoid substances.

Protoplasm.—It has been believed for a long time that the chemical reactions of living protoplasm are essentially different from those of dead protoplasm.† In 1874 Sachs wrote: "Solutions of different colouring matters, as aqueous solutions of the colours of flowers and the juices of fruits, especially also weak acetic solution of carmine, have no power of colouring living protoplasm; but if it has been previously killed, or if it has lost its vital properties by long-continued action of these reagents, it absorbs a relatively larger quantity of colouring material than of the solvent, and the whole substance assumes a much more intense colour than the reagent. Solutions of iodine in water, alcohol, potassium iodide, or glycerin, act in a similar manner; they all cause a yellow or brown colouring

* Van Tieghem, "Anatomie de la Moschatelline," Bull. Soc. Bot., ii. (1880) p. 282.

† Sachs, 'Text-book of Botany,' 2nd edition, p. 37.

of the protoplasm, which is more intense than that of the solution itself."*

These ideas have been accepted without dispute until the last few years; it may even be said that they are still current in science. A recent work, however, of Pfeffer† seems destined to greatly modify them. Whilst studying the osmotic phenomena in the lower plants, and particularly in the Myxomycetes, he remarked that the membranous layer of the protoplasm is soft enough during life to allow a small crystal or a bacterium to pass through it without leaving a hole. In this condition, on making an opening by means of a needle, the whole protoplasmic mass may be seen immediately to show the colours considered as exclusively characteristic of dead protoplasm. Now it is known, at least amongst a great number of Thallophytes, that a prick does not kill the protoplasm. Pfeffer concludes from this that, whilst living, it is permeable by all the substances which colour it after death; but that the membranous layer, as long as it is entire, prevents the introduction of certain of these substances into the interior of the protoplasmic body. He founds this opinion on the fact, observed by himself, that the peripheral layer becomes hard and brittle as soon as the protoplasm dies. Any slight cause is then sufficient to break through it, and consequently to allow the colouring reagent to penetrate the protoplasm. But this does not take place, in his opinion, when, after infinite precautions, the organism is killed without injury to the membranous layer. Under these conditions, those agents which do not colour living protoplasm will also not colour it when dead.

The possibility of colouring the central protoplasm of the *Amœbæ*, whilst the pseudopodia remain hyaline, seems to contradict the theory of the German botanist; but it must be observed that the pseudopodia of the *Amœbæ*, like the cilia of the Infusoria, are of the same nature as the membranous layer of the protoplasm. It would therefore seem that the latter behaves, in regard to colouring matters, in the same way as with different mineral agents, admitting some and being impermeable by others.

To the first category belong cyanin or quinolein blue, eosin, fuchsin, and anilin-brown. To the second the infusion of logwood or saffron, solution of cochineal in weak acetic acid, and the ammoniacal solution of carmine.

The following is a list of the principal reagents in use for colouring protoplasm:—

Iodine.—It is well known that iodine colours albuminoid substances a dark yellow. Poulsen recommends its use in the following form for colouring protoplasm a pale brown, and showing more easily the bacteria and vibratile cilia of the micro-organisms.

	gr.
Bisublimed iodine	0·05
Iodide of potassium	0·20
Distilled water	15·00

* Sachs, loc. cit., p. 39.

† 'Pflanzenphysiologie,' i. (1881) pp. 31 and 50.

For the same purpose is also used a solution of iodine in water or in alcohol (tincture of iodine), of different strengths, and in glycerin, to which is added a small quantity of iodide of potassium.

Alkalies.—Treated with nitric acid, then with ammonia or potash dissolved in water, the protoplasm is coloured yellow; it assumes a dark violet tint when the action of the alkali has been preceded by that of a concentrated solution of sulphate of copper, followed by washing in water. The colouring can be better judged of by the introduction of the alkali in a slow current between the slide and the cover-glass, the liquid being sucked through by means of filtering-paper.

Hydrochloric acid.—The protoplasm becomes pink or slightly violet when left for a few seconds in boiling hydrochloric acid.

Sulphuric acid and Sugar.—The preparations are treated with sulphuric acid, and then washed in distilled water, so as to free them as much as possible from the acid; then, between the two glasses inclosing the objects, is passed a current of concentrated solution of sugar; all the protoplasm becomes pink or violet. In this operation the difficulty lies in exactly regulating the time of the immersion in the sulphuric acid. When too short, it is useless; when too long, it destroys the whole of the protoplasm. Generally speaking, when English concentrated acid is used, the action must be stopped as soon as the protoplasm becomes very slightly pink.

Acetic acid and Cochineal.—To a solution of cochineal in alcohol at 60° C., 2 per cent. of acetic acid must be added. This reagent gives a pinkish or violet tint to the protoplasm.

Carmine.—The carmine is dissolved in ammonia, and the solution allowed to evaporate in the air, so that it may be as little alkaline as possible. In these conditions it colours the protoplasm red.

Anilin colours.—The use of anilin colours as reagents for protoplasm is of recent date. It gives very good results. Unfortunately the reactions differ according to the origin of the products, which are not identical in all makes. Purple, blue, and yellow are used principally in alcoholic solution. Anilin violet dissolved in alcohol is particularly valuable, because it colours the principal mass of the protoplasm a blue violet, whilst under its influence the nuclei, ternary substances, gums, and amylaceous substances become reddish.*

Koch† made use of anilin-brown and hematoxylin to colour bacteria, and photograph them more easily; these may then be preserved in glycerin with the addition of potassium acetate; in this solution the colouring is preserved. The same precaution must be taken when the bacteria are treated with methyl-violet or violet of Paris.

This reagent in alcoholic solution has been of great use to the author in the study of micro-organisms. When very concentrated, it may be used for the vibratile cilia, which are invisible when they are not coloured, but can be seen very distinctly in this liquid. The fundamental protoplasm being easily stained with this substance, it is

* Poulsen, loc. cit. p. 48.

† Cohn, Beitr. z. Biol. der Pfl., ii. p. 406.

often necessary, at the risk of concealing its inclosed substances, to employ very dilute methyl-violet; one drop of a solution containing 1-10,000th or even only 1-50,000th poured over the preparation is sufficient in many cases.

This solution can be made to act either immediately on the protoplasm or even after treatment with osmic acid. In the latter case there is still a coloration. It may be seen in *Clathrocystis roseo-persicina*, the *Euglenæ*, several nudo-flagellate organisms, and in the cells of the Phanerogams. Certes, who has successfully applied this reagent to the microscopical analysis of water, recommends its application mixed with diluted glycerin. He says*: "Precautions must be taken to make the action of the glycerin very slow, so as to avoid the shrivelling of the tissues. In these conditions the absorption of the colouring matters is better effected; the organisms remain transparent, and if we wish to preserve specimens, the glycerin constitutes a preservative medium, and keeps the organisms from evaporation."

Whilst methyl-violet kills the protoplasm at the same time that it colours it, very weak aqueous solutions of anilin-brown, fuchsin, and eosin, colour the protoplasm without killing it immediately. Organisms have been seen to live many hours after having been coloured by these substances.

Koch has used an alcoholic solution of eosin to kill and colour a reddish pink the protoplasm of *Sarcina*, *Bacterium*, and *Bacillus*.

The aqueous solution of cyanin or quinolein blue, whilst penetrating the living protoplasm, condenses the colouring matter in sufficient quantity for its tint to be perceptible. Certes† was able to show the members of the Zoological Society of France some living infusoria which he had coloured many hours previously by means of cyanin and anilin-brown, also called Bismarck-brown.

These results are important: by taking them into consideration, in the future we may be able to study, on the living subject, the phenomena of conjugation and reproduction in the Algæ and the Infusoria, instead of being, as hitherto, confined to the study of the organisms killed in different stages of their evolution.

Nucleus.—Generally speaking, the substances which colour the protoplasm, iodine, fuchsin, and carmine, also colour the nucleus, which absorbs the colouring matter in greatest quantity. It can be further studied, moreover, by means of particular reagents.

Subjected to the action of osmic acid, the nuclei become black. Iodized glycerin makes them yellow. According to Treub,‡ methyl-green colours very dark green those nuclei which are not in process of division, and pale green those which are dividing, because in reality this reagent only colours the chromatin in the nucleus.

In his researches on the division of cells, Strasburger§ employed the anilin colours with 1 per cent. of acetic acid as reagents for the nuclei. The very deep colouring which they take in these con-

* Comptes Rendus, 14th June, 1880.
† Bull. Soc. Zool., 22nd February, 1881.
‡ Arch. Néerland., xv. (1880).
§ 'Zellbildung und Zelltheilung,' 1880. See this Journal, i. (1881) p. 621.

ditions clearly differentiates them from the other portions of the protoplasm.

For the same object acetic acid and cochineal are used. Strasburger * immerses the preparations in acetic acid, washes them in distilled water, sometimes neutralizing the acid by a weak alkaline solution, and then uses the tincture of cochineal. Guignard † prefers carmine to this reagent for studying the nuclei in the embryo-sac and the suspensor of the Leguminosæ. He dissolves it in a mixture of 1 part of water, 2 parts of absolute alcohol, and 1 part of glycerin containing borax.

Poulsen ‡ gets the solution of carmine for colouring the nuclei by warming 0·6 gr. of carmine in 2 gr. of ammonia until the solution is reduced to half its bulk; he adds to it 60 gr. of water, 60 gr. of glycerin, and 15 gr. of absolute alcohol. The liquid is allowed to stand until clear, and then filtered.

The author has used the carmine to follow the curious phenomenon of the fragmentation of the nuclei in the hypertrophied cells in consequence of wounds.§ He has obtained an excellent result with hæmatoxylin. Although an extract of logwood, this substance only exists in very small quantity in the tincture of logwood.

The method indicated by Poulsen ‖ is to use 0·35 gr. of powdered hæmatoxylin in 10 gr. of water; a few drops of a filtered solution of alum containing 3 gr. of alum to 30 gr. of water are added to it to fix the colour. When the preparations remain for some time in hæmatoxylin thus prepared, the nuclei are coloured a fine blue. Picrocarminate of ammonia (or Ranvier's picrocarmine) is also of great use in the study of nuclei, both in the Phanerogams ¶ and in the Microphytes and Infusoria.** For the latter Certes †† thus prepares the solution of this reagent:—glycerin, 1 part; water, 3 parts; picrocarminate, 1 part.

The colouring is effected either after the fixing by osmic acid or independently of the action of this acid.

These various reagents may be employed (provided their concentration be varied) for studying in the midst of the protoplasm the minute structure of the nucleus, the nucleoli, the mode of distribution of the chromatin, all the phenomena of the division, the formation of the "barrel," of the equatorial plate, and the poles, &c. On this subject may be advantageously consulted the papers of Baranetzki,‡‡ Zacharias,§§ Strasburger,‖‖ Schmitz,¶¶ Treub,*** and Guignard,††† and the *resumé* of their works given by Van Tieghem in his 'Traité de Botanique,' in course of publication.‡‡‡

* 'Studien über Protoplasma,' 1876.
† Ann. Sci. Nat., xii. (1881).
‡ Loc. cit., p. 42.
§ Bull. Soc. Bot., 10th March, 1882.
‖ Loc. cit., p. 46.
¶ Poulsen, loc. cit., p. 46.
** Cf. Ranvier, 'Traité d'Histologie.'
†† Comptes Rendus, 3rd March, 1879.
‡‡ Bot. Ztg., 1880.
§§ "Ueber die chemische Beschaffenheit des Zellkerns," Bot. Ztg., 18th March, 1881. See this Journal, i. (1881) p. 769.
‖‖ Loc. cit., 1880.
¶¶ SB. Naturf. Gesell. zu Halle, 1878 and 1879.
*** Arch. Néerland., xv. (1880).
††† Loc. cit., 1881.
‡‡‡ Paris, 1882. Fasc. 4, pp. 343, &c.

Pigmented bodies.—The influence of chemical agents on the pigment-bodies of protoplasm has been much studied; nevertheless but few reagents are known. Etiolin becomes blue when treated with sulphuric acid or chlorine water; the green substance to which the name of chlorophyll is now appropriated turns yellow under the prolonged action of diluted acids, whilst concentrated hydrochloric and sulphuric acids colour it blue or blue-green. The use of hydrochloric acid or of water at 50° C. is recommended for isolating hypochlorine, and potash for colouring brown anthoxanthin and madder,* and chloride of iron to turn this last substance red or orange. But here ends our knowledge of the reagents for these substances, whose study presents great interest for physiology, agriculture, and manufactures.

Proteid Crystalloids.—The colouring which these bodies take under the influence of certain reagents, helps, independently of other characters, to distinguish them from mineral crystals. "Their substance exhibits," says Sachs, "all the more essential reactions of protoplasm, its power of coagulation and of taking up colouring matters, the yellow reaction with potash after treatment with nitric acid, as well as that with iodine."†

Recourse is also had to these agents to diagnose the crystalloids of protoplasm when they are colourless, like those of the potato, *Lathræa squamaria*, the aleurone grains of oleaginous seeds and of the albumen of castor-oil. In the petals of the pansy (*Viola tricolor*) and the orchids, the fruits of *Solanum americanum* and the sporangiferous filaments of *Pilobolus*, when they are coloured, they may be decolorized by alcohol, and then coloured afresh by the agents just mentioned.

2. Ternary Substances.

Starch.—Iodine is the best reagent for starch. It is generally said in treatises on chemistry that it turns it blue. It is important to know under what conditions this takes place. When the starch-granules of the haricot bean, for instance, are subjected to an aqueous solution of iodine they immediately turn blue. But it must be remarked that:—1st. The colouring disappears under the influence of great heat, and reappears when cold again. 2nd. The blue colour of the granules is only due to a portion of the substance which composes it. The *amylose* can be distinguished in each granule, of which it forms in some degree the skeleton, as also the *granulose* which fills the interstices, and may be extracted by diastase. The former turns yellow, whilst the latter turns a deep blue under the action of iodine. Most frequently they exist together; but there are cases in which they are isolated. The amorphous starch of *Bacillus amylobacter* and of *Spirillum amyliferum* is entirely composed of granulose; iodine colours it blue. In the Florideæ starch exists in the form of grains of pure amylose to which a solution of iodine gives a yellow colour. When, as in the potato, amylose and granulose

* Decaisne, 'Recherches anatomiques et physiologiques sur la Garance,' &c., (10 pls.) 1837.

† Loc. cit., p. 49.

exist together in the starch-granule, the granule can be turned yellow by iodine after the granulose has been extracted.

The reactions of starch are so delicate that they can be recognized in the very small starch-granules contained in the chlorophyll-bodies. The colouring by iodine is distinctly visible when care is taken to render the chlorophyll-body transparent by acetic acid, or to increase its permeability by submitting it to the action of potash.

In the *Euglenæ* there is a variety of starch called paramylon, formed of long cylindrical rods, disks, or ellipsoid bodies; when coloured yellow by iodine it appears exactly similar to amylose.

Certes,* by making use of the iodized serum described by Ranvier,† has demonstrated in several Infusoria an amylaceous substance coloured mahogany-brown or wine-red by this reagent. He considers it as identical with the glycogenous matter, the existence of which was shown by C. Bernard in the liver of the higher animals and of many Invertebrates. It is probable that it exists with these same characters in many plants, the percentage constitution of starch and of the substance called glycogen being the same.

Tannins.—Salts of iron are the reagents for the tannic acids. They generally colour them black or dark blue, sometimes green. Acetate of iron gives a very deep blue colour, and chloride of iron a dark green; chromate of potash, alcoholic solution of anilin-violet and dilute chloriodide of zinc may also be used. The tannins become brownish red in the first case, red in the second, red or violet in the third.

The development of *Penicillium glaucum* and of *Sterigmatocystis nigra* in a solution of tannin exposed to the air separates the tannin into glucose and gallic acid. Perhaps this phenomenon is due to a diastase formed in very small quantities in the cells of the plant. The same division takes place with dilute acids. It is probable that it also takes place in the interior of tanniferous cells by the progress of vegetation, for these cells are sometimes seen gradually to lose their tannin, in proportion as they acquire more and more glucose, a transformation which is particularly evident during the ripening of fruits.‡ This is an interesting subject of study; we can by micro-chemistry exactly determine the localization of the tannin; it would be very important to follow its metamorphoses. The difficulty probably lies in distinctly showing the diastase, for there are many ways by which the sugars may be revealed.

Sugars.—Sulphate of copper, followed by the action of potash after washing, gives a colour to the sugars which enables them to be recognized in the tissues of plants. But the colouring differs according to whether the sugar belongs to the group of saccharoses ($C_{12}H_{22}O_{11}$) or glucoses ($C_6H_{12}O_6$). Poulsen § recommends the following process: Make a tolerably thin section of the tissue; immerse it

* Comptes Rendus, 12th January, 1880.
† 'Traité technique d'Histologie,' p. 158.
‡ Van Tieghem, 'Traité de Botanique,' 1882, p. 542.
§ Loc. cit., p. 33.

from two to ten minutes in a concentrated solution of sulphate of copper, then wash it quickly in distilled water, and submit it to the action of a warm solution of potash. The cells inclosing saccharose then show a pale blue colour, whilst those inclosing glucose assume an orange-red tint.

When the former are treated with warm sulphuric acid or nitrate of potash, they lose their blue colour and become, like the latter, orange-red. Gaston Bonnier,* by using Fehling's solution, has succeeded in determining under the Microscope the localization and the relative abundance of the saccharoses and glucoses in the nectaries of flowers. "A drop of Fehling's liquid, diluted, is put in the preparation, which is then warmed. We observe under the Microscope in which part the yellow or reddish-yellow precipitate is formed; we then invert; add a drop of cupropotassic liquid, and warm again. The precipitate is again examined. If it is much more abundant than at the first examination it is because there is a considerable accumulation of saccharose. There must be, of course, an excess of tartrate in the first operation to cause the precipitation of the glucose."

This method of working is very delicate, requiring great dexterity and numerous precautions. If the liquid is boiled under the cover-glass in such a way as to cause violent movements, the precipitate gets distributed over the preparation; which then assumes a general tint of yellow, from which no conclusion can be drawn. The operation must, moreover, be executed as quickly as possible, without which, the water gradually dissolving the sugars, we should again have a general precipitate. Finally the preparation must not be very thin if we wish to form a correct judgment of the relative intensity of the colours obtained by the reaction. The best conditions for operating are therefore with moderately thin sections. If the result is too much obscured by the dissolving of the sugars in the water of the preparation, the sections must be warmed in a small tube and taken up again with forceps to be examined as soon as the precipitate is formed in the cells. As all these precautions were not taken in the first attempts, this process of research appeared to be impracticable. Since then it has given very good results in many cases; for by comparing the observation of these more or less intense precipitates with the results given by the preceding process in well-marked cases, I have found sufficient agreement.

In fact, the yellow colour produced by Fehling's solution, and the increase of the colour after inversion, are not absolute proofs of the presence of glucoses and saccharoses;† but it is an important character, which, taken with others, may serve to demonstrate the presence of sugars in the cells. If the real presence of the two kinds of sugar has been recognized by testing, this process gives excellent indications of the manner in which they are distributed in the tissues.‡

Oils; Oily matters; Resins.—The general reagent for these sub-

* "Les Nectaires," Ann. Sci. Nat., 1879.

† "As certain gums precipitate the tartrate, the same takes place with certain varieties of dextrine and ordinary dextrine in the presence of acids."

‡ G. Bonnier, loc. cit., p. 83.

stances is the alcoholic tincture of *alkanet*. The colouring matter is extracted from the roots of *Alkanna tinctoria*. The tincture colours red, not the individual drops of oil, but the entire mass composed of these drops and the protoplasm which contains them, when they are in sufficiently large quantity. This is also the case with oleaginous seeds. The reagent shows that the oil is always outside the grains of aleurone.*

Tincture of alkanet also colours the resins red.

Cyanin is also used as a reagent for oily matters. These substances absorb very energetically the colouring matter of the aqueous or alcoholic solution of quinolein blue. The smallest oily particles of the protoplasm thus acquire a great distinctness, as has been shown by the experiments of Certes † on many lower organisms, animal and vegetable.

Gums.—The anilin colours stain deeply the mucilaginous membranes which iodine alone or iodine used after the action of sulphuric acid does not colour blue. Chloriodide of zinc gives them a yellow colour; they assume, according to Solla‡ and Hohnel,§ a fine yellow colour after being immersed for some time in ammonia, to which nitrate of potash has been added.

Cellulose.—The cellulose of the cell-wall has the formula $C_6 H_{10} O_5$; it exists in plants in different stages of condensation.

The polymere $(C_6 H_{10} O_5)_4$, which may be taken as the type of cellulose, is not turned blue by iodine, but shows a fine blue colour after treatment with iodine and sulphuric acid. The polymere $(C_6 H_{10} O_5)_3$, which is rather rare, turns blue directly with iodine like granulose. The same takes place with the paraphyses and the walls of the asci of the lichens and of many fungi.

Good results have been obtained with an iodized solution of the strength of 1 gr. of iodine in 3 gr. of iodide of potassium and 600 gr. of water.||

Sulphuric acid and iodine are used in succession. The iodine may be in an aqueous or alcoholic solution. The sulphuric acid may be replaced by phosphoric acid. Instead of using the two agents, iodine and sulphuric acid successively, a single reagent may be substituted which has the same effect, chloriodide of zinc. It is very important to observe that the chloriodide of zinc cannot be rigorously defined quantitatively; the same reagents not suiting all species of plants equally well. The chloriodide of zinc which may have just given excellent indications on sections of one species, does not act effectively on another species. This is because the vegetable cells contain different substances, which, in many cases may prevent the reaction.

* Poulsen, loc. cit., p. 41.

† Cf. Balbiani, 'Recherches sur les phenomènes sexuels des Infusoires,' note 1, p. 27, 1861. Ranvier, loc. cit., p. 102. Certes, "Sur un procédé de coloration des Infusoires," Comptes Rendus, 8th March, 1881.

‡ "Mittellamelle des Holzelemente u. d. Hoftüpfel Schliessmembran," Bot. Ztg., 1880, No. 26.

§ See Poulsen, loc. cit. p. 61.

|| "Beitr. zur Kenntniss d. chem. und phys. Beschaffenheit der Intercellularsubstanz," Oester. Bot. Zeitschr., 1879.

Therefore the plan should be adopted of washing them well (either in water, alcohol, ether, or chloroform) before subjecting them to the action of the reagents.

The author employs four or five different preparations of chloriodide of zinc, and when one does not give any result recourse is had to another. The chloriodide is prepared by adding to an aqueous solution of very concentrated chloride of zinc a variable quantity of iodide of potassium. Sometimes a small quantity of iodine may be added.

By modifying the proportions and by adding or not adding water to the mixtures, a series of four, five, or six is obtained, of which at least one may be useful when the others are not.

Poulsen * recommends the successive use of potash and sulphate of copper to colour the old cellulose membranes deep blue.

Carmine in alum solution colours cellulose membranes deep red. Tangl† prepares the reagent in the following manner. He saturates distilled water with alum, adds to it a small quantity of carmine, allows it to boil for ten minutes and when clear filters it. The solution has the advantage of not colouring either the lignin or suberin.

Lignin or *Lignose.*—Under the influence of chloriodide of zinc employed alone, or of iodine and sulphuric acid employed simultaneously the lignified membranes turn yellow. They turn blue when the action of these substances has been preceded by the immersion of the tissues in an acid, particularly sulphuric, chromic, and nitric acids. These reactions being common to the walls of the ligneous cells, the lignified fibres, and the old vessels, we are justified in concluding that they are composed of the same ligneous substance.

The lignification consists in an impregnation of the primitive cellulose; that is, the polymeric molecule $(C_6 H_{10} O_5)_4$ is decomposed into a lower polymere which becomes coloured and impregnates the other part of the polymere remaining in the state of cellulose. According to Bergmann, the formula of lignose is $C_{18} H_{26} O_{11}$ which for comparison with that of cellulose may be approximately written $C_{12} H_{18} O_7$. The substance which impregnates cellulose is therefore less oxygenated than this latter substance. The action of the acids consists in eliminating the membranes.

Van Tieghem made known in 1863 a reaction of the lignified membranes, on which has since been founded a means of characterizing them. This means consists in the production of a substance which is formed in the presence of acids in the lignified membranes. It originated with Wiesner.‡ Poulsen § operates in the following manner. An aqueous, or better still an alcoholic solution of phloroglucine is made, and a drop is placed on the slide on which is the vegetable tissue, this having been previously immersed in acetic acid; the

* Loc. cit., p. 59.

† "Ueber offene Communication zwischen den Zellen des Endosperms," Pringsh. Jahrb., xii. (1880). See this Journal, i. (1881) p. 70.

‡ SB. Wien. Akad., lxxvii., 1 Abth.

§ Loc. cit., p. 40.

lignified portions soon assume a deep red colour, which they retain for a long time.

Wigan,* Maschki,† and Vogel,‡ following Poulsen,§ have used the aqueous solution of cochineal mixed with acetic acid or alum, to colour the prosenchymatous cells of the liber. The colouring, which is red, becomes very intense after the tissue has remained for a long time in the solution.

Cutin; Suberin.—True suberin is a definite compound, not a mixture. When membranes supposed to be suberized or cutinized turn blue under the influence of chloriodide of zinc, after being treated with a boiling acid, it is because they are only lignified. True suberin turns yellow under the action of this reagent, even after immersion in boiling acids. The reaction is the same when iodine or sulphuric acid is substituted for chloriodide of zinc.

The cutin which behaves in this way seems to be identical with suberin. It may be correctly enough represented by the formula $C_{12}H_{22}O_5$. But cuticles in which the treatment by acids still allows the cellulose to be separated and coloured can only be considered as lignified.

The author has proved that lignin and suberin retain the anilin colours much more persistently than cellulose. Relying on this observation, he has succeeded, by the use of these colours, in well differentiating in microscopical sections of vegetable tissues, the cellulose and non-cellulose portions of the membranes. The sections are put to soak in a solution of fuchsin, half alcoholic and half aqueous, then immersed in absolute alcohol. After this last treatment the cellulose portions are decolorized, whereas the cutinized or suberized portions retain for a very much longer time the red colour of the fuchsin. This process would not be useful for analysis, but it is very convenient in enabling the sections to be rapidly passed in review, and the most prominent differences of their chemical constitution immediately distinguished.

On these micro-chemical reactions of cellulose, lignin, and suberin is partly founded the determination of the nature of the fibres which enter into the manufacture of fabrics. Vetillart‖ has published an important work on this subject, from which the following directions are taken:—

To isolate the fibres of the tissue to be examined, it is boiled for half an hour in a lye containing 10 per cent. of carbonate of potash or soda. The object of this operation is also to swell the cell-walls, and to render them more pervious to the reagents. In cases where it is insufficient (which are very rare), H. Beauregard and V. Galippe¶ recommend the tissue to be soaked for ten minutes in

* Bot. Ztg., 1862, pp. 129, 139.

† Ibid., 1859, p. 22.

‡ "Anat. und Histol. der unterirdischen Theile von *Convolvulus arvensis*," SB. Wien. Akad., xiii. (1863).

§ Loc. cit., p. 42.

‖ 'Etudes sur les fibres végétales textiles employées dans l'industrie,' 1876.

¶ 'Guide de l'élève et du praticien pour les travaux pratiques de micrographie,' 1880.

a concentrated solution of potash or soda. This should be followed by a washing of the tissue in distilled water. When dry, the fibres are separated; a third part is submitted to the action of the reagents.

We must here confine ourselves to pointing out the distinction which iodine and sulphuric acid, or chloriodide of zinc, allow us to establish between the elements which they colour blue and those which they colour yellow. To establish this distinction, Vetillart advises the use of a solution of iodine freshly prepared by saturating with this metalloid 100 gr. of distilled water, to which has been previously added 1 gr. of iodide of potassium. For the sulphuric acid he recommends 2 volumes of concentrated glycerin to be added to 1 volume of distilled water, into which solution is to be introduced little by little 3 volumes of commercial sulphuric acid marking 66° Baumé. The vessel in which this operation is carried out should be surrounded by water.

The fibres which are subjected to the action of these reagents should be as dry as possible; with this view they are exposed to heat. The fibres are placed on the glass slide, and one or two drops of the iodized solution are added. When the fibres are well soaked, the excess of liquid is removed by filtering-paper. The cover-glass is then placed over the fibres, and a current of the solution of sulphuric acid is made to pass beneath the cover-glass. The reactions produced are then observed. Amongst Dicotyledons, jute is coloured yellow; flax, hemp, sunn, and cotton are coloured blue; amongst Monocotyledons, *Phormium tenax* and *Agave americana* turn yellow; alfa and esparto completely blue. Those who are interested in this microchemical examination of textile fabrics may consult with advantage the work of Vetillart, which is full of details for which there is no room here.

VII. Preservation.

The processes for preserving histological preparations being generally well known, there need be but little said on the subject.

Glycerin is the liquid most often used for this purpose. There are, however, many cases in which it is not generally known that it is worthless. It must not be used for the Florideæ, diatoms, or bacteria. The cell-walls of the Florideæ, especially when they have not been previously immersed in absolute alcohol, swell up in glycerin to such an extent that the form of the cells is no longer recognizable. The markings on the diatoms are not shown clearly, and the cell-walls of the bacteria become so transparent in glycerin that it is very difficult to see them.

These algæ, on the contrary, keep very well in glycerin jelly. Nordstett* especially recommends it for the Desmidieæ; he prepares it by mixing *hot* gelatin (pure), 1 part; distilled water, 3 parts; glycerin, 4 parts; which he afterwards decants.

* "Om anwändandet af gelatin-glycerine vid untersökning og preparering af Desmidieer," Bot. Notiser, 1876, No. 2.

We owe another preparation to Kaiser.* He leaves for two hours 1 part by weight of French gelatin in 6 parts of distilled water; he afterwards adds 7 parts of pure glycerin; and into 100 gr. of the mixture he introduces 1 gr. of carbolic acid. He heats and shakes the whole for ten or fifteen minutes, until it becomes fluid and clear, after which he filters it.

This glycerin jelly in a thin film has the clearness and transparency of water. It is useful for all those preparations which, requiring a cover-glass, are yet so delicate that the cover injures them; such as pollen-grains, starch-grains, feculæ, yeast-cells, and spores, especially those of unicellular algæ like Desmidieæ.

The same liquid is excellent for preserving the structure of the protoplasm and the distribution of the chlorophyll-bodies whose form and position have been fixed by absolute alcohol or osmic acid. When the preparation has been thus fixed it is put into dilute glycerin, then into the glycerin jelly. After this liquid has become cold, the cover-glass can be luted.

Canada Balsam, by reason of the difference of the refractive powers, is preferable for the preservation of diatoms; it is liquefied by warming. "The finest striæ on the diatoms are visible in it."

A very concentrated solution of balsam in ether or chloroform can be substituted for pure balsam; this mixture is purer. Delicate objects which contain much water do not keep well in balsam until they have been dried in the air, or treated with absolute alcohol or oil of cloves.

All the preparations, even those in balsam, should be luted.

Rapid Method of Demonstrating the Tubercle Bacillus without the use of Nitric Acid.† — The following method, which Dr. H. Gibbes has used for some time with great success, will, he thinks, prove useful to those requiring the demonstration of the tubercle bacillus for diagnostic purposes in a rapid manner. The great advantage consists in doing away with the use of nitric acid.

The stain is made as follows:—Take of rosanilin hydrochloride two grammes, methyl-blue one gramme; rub them up in a glass mortar. Then dissolve anilin oil 3 c.c. in rectified spirit 15 c.c.; add the spirit slowly to the stains until all is dissolved, then slowly add distilled water 15 c.c.; keep in a stoppered bottle.

To use the stain:—The sputum having been dried on the cover-glass in the usual manner, a few drops of the stain are poured into a test-tube and warmed; as soon as steam rises pour into a watch-glass, and place the cover-glass on the stain. Allow it to remain for four or five minutes, then wash in methylated spirit until no more colour comes away; drain thoroughly and dry, either in the air or over a spirit-lamp. Mount in Canada balsam. The whole process, after the sputum is dried, need not take more than six or seven minutes. This process is also valuable for sections of tissue containing bacilli, as

* Bot. Centralbl., 1880, p. 25. Cf. 'Glycerin-gelatine for Mounting,' this Journal, iii. (1880) p. 502.

† Lancet, i. (1883) p. 771.

they can be doubly stained without the least trouble. Dr. Gibbes has not tried to do this against time, but has merely placed the sections in the stain and allowed them to remain for some hours, and then transferred them to methylated spirit, where they have been left as long as the colour came out. In this way beautiful specimens have been made, without the shrinking which always occurs in the nitric acid process.

Dr. Gibbes subsequently adds :*—"This process gives the most satisfactory results, and the horrible nuisance of the nitric acid is avoided. It brings out the bacilli quite as well as the other process, and it stains all putrefactive bacteria and micrococci very deeply, so that in the field of the Microscope blue micrococci and bacteria may be compared with the red bacilli of tubercle. The stain can be used cold equally well. The cover-glass in that case must be left in the stain for at least half an hour."

Grinding down a Slice of a Calcareous Fossil for Microscopical Examination.†—Mr. H. J. Carter gives the following directions :—

"Take about one part of half-dry Canada balsam, and place it on the centre of a glass slide : heat it until melted over a spirit-lamp with about half an inch vertical flame, moving the slide backwards and forwards to prevent the latter from cracking ; add two parts of shellac ; and when the whole has bubbled up, stir it with the point of a needle so as to mix it well, and spread it altogether over a little more of the glass than the size of the slice to be reduced.

Previous to this, cut off with a watch-spring or very fine saw fixed in an iron bow-frame (all of which may be obtained from an ironmonger at a very small charge) the slice to be ground down ; and if there be much siliceous matter in the fossil, the saw (which is very cheap) may be sacrificed by the addition of emery powder and water to the groove, as this accelerates the cutting. (Of course where a machine with horizontal turning-wheel is possessed, such as is used for cutting siliceous fossils, flints, &c., this is the quickest and most economical way to obtain the 'slice.')

Having thus obtained it, so far prepared, rub one side (viz. that to be examined) down to *scratchless smoothness* on a schoolboy's slate or very fine honestone with level surface, to effect which it is absolutely necessary that all the materials should be entirely freed, by washing, from every particle of emery or siliceous mineral that may happen to be present, otherwise the calcareous surface will become almost irremediably furrowed.

Next dry the slice on a tin or paper tray placed inside the fender by the fire, where it can remain until the next part of the process is completed.

Now remelt the material on the glass slide as before, and when sufficiently fluidified to present a uniformly level surface (but *not burnt*, for this would destroy the tenacity of the cement, and thus give it a crispness which, by cracking, would defeat all attempts at further

* 'Practical Histology and Pathology,' 2nd ed., 1883, p. 142.

† Ann. and Mag. Nat. Hist., xii. (1883) pp. 29–30.

reduction), quickly transfer the warmed slice (which should now be close at hand) to it, while with a little pressure the 'smoothed' surface is brought into direct contact with that of the glass. Thus let it remain on the table where this is done until the glass feels cold to the touch.

After this reduce the slice to the thinness of a wafer over a very fine vertical rotating grinding-stone, or on a copper plate with emery powder and water, horizontally.

Now wash it well in water, and, placing the slide on a piece of buckskin leather spread on the table or on a level surface (to keep it from slipping) with the slice uppermost, continue the reduction in water with a piece of very fine siliceous limestone, that may be obtained from a statuary of convenient form (that is, one which will admit of the surface of the slice coming into direct and continuous contact with that of the limestone), with which it should be horizontally rubbed until reduced to the required thinness, which must be ascertained by repeatedly transferring the slice to the field of the Microscope with a 1 in. object-glass and high ocular. The nearer this thinness is approached the oftener this transfer should be made, washing the slice by dipping the slide into a bowl of water each time that it is examined.

When sufficiently reduced, wash the slide as before, and stand it up to drain until the slice is perfectly dry. Then cover with benzol, followed by balsam and thin glass, for preservation and more deliberate examination.

I make no apology for introducing these remarks, as the 'process,' although open to criticism and improvement, no doubt, answers the purpose; and while inexperienced, I myself should have been very glad of such aid. Dr. Holl suggested to me the use of shellac, which is the most valuable hint that I have received."

Verification of Microscopical Observation.*—This formed the subject of the address of President A. McCalla to the Sixth Annual Meeting (at Chicago) of the American Society of Microscopists.

After remarks on the practical value of the Microscope and microscopical studies, "the world at large not being enough aware how great is the debt it owes to microscopic research," the address referred to the danger of a neglect of the painstaking precautions necessary to insure truth and the necessity for careful and laborious investigation into a thousand minutiæ whose after-importance cannot always be known, the substantiating a phenomenon observed by chance by many a set experiment, the framing an hypothesis to account for the facts observed and testing its truth by a series of observations under many varying conditions. That very popularization of the Microscope which is so encouraging in our day tends to a lack of care in its use.

"When we reflect, then, on the high order of knowledge and of skill which the scientific use of the Microscope demands it is no

* 'Chicago Times,' 8th August, 1883, in advance of Proc. Amer. Soc. Micr., 6th Ann. Meeting, 1883.

wonder that, while it is the most perfect and the most fruitful instrument of precise research, its own announced results oft need verifying. It is not strange that theories have been put forth, discoveries proclaimed, by observers young and old, which later and more careful researches have failed to substantiate or have entirely overthrown. How many theories have been advanced in regard to the nature of the diatoms, the structure of their frustules and of their living substances; as to their mode of motion, and even as to their place in the broad classification of biology. Are they animal or vegetable, or alternately one and the other? There is authority and argument for either view. And when we ask as to the real nature of the regular and beautiful systems of markings their valves display, we can find theories in plenty, but all as yet unverified. They have been declared to be ridges, or furrows, rows of knobs, of areolations, or of minute apertures through the glassy wall of the valve. We have been told we see them most perfectly when they show as hexagons or as circles, or as a wicker basket pattern; their size and distance apart have been given a most diverse measure. But now we have learned from Abbe's researches how little reliance is to be placed on any of these appearances, and how easily many of these various images may be made to appear from a given structural detail by proper manipulation of the light and of the focus. . . .

But more particularly does microscopic vision itself need verification. The things seen must not too readily be taken to be the invisible realities. The eye in ordinary vision needs, more than the other senses, to be trained to see aright, and when so trained surpasses all the rest in the fullness of its revelations. So still more does the microscopic vision require careful training that we may be able to safely judge of the reality from the appearances that it affords us.

Permit me then to suggest in brief outline some of the means which we should employ for microscopic verification, and I would name the most obvious :—

1. The Repetition of Observations.—Under varying conditions and by various observations, that which really exists ought still to be seen. It is, of course, not true that every eye can see what the trained adept at the Microscope can easily discover, or that a rare form can be seen again whenever desired. But in general, what man has seen that man can see again, and unsupported discoveries must always be regarded as doubtful till they are verified by repetition. One who has any experience in microscopy can at least see what is in focus beneath the instrument, when his attention has been once called to it, while on the other hand, even the well-trained eye is in danger of projecting the mental preconceptions of the observer into the focal plane of the objective, and seeing in the object under examination, not what is really there, but what some theory demands shall be. Spectral lines seem real to one observer that are easily rejected by another, and images seen under one set of conditions disappear under another, and their presence or absence can be accounted for. One of the greatest benefits of a Society like this, and of the smaller local associations, is that they afford opportunity for this comparison of observa-

tions and correction of our errors of vision, our mistaken or imperfect views, by mutual interchange.

2. The use of the Camera Lucida.—A second means of verification is the use of this instrument, by which we may record in permanent form the fleeting vision of a single observation. Our memory is imperfect even when strongly impressed; we forget the details of what we see, or confuse them with later images. But a drawing preserves the forms we have observed secure against memory's obliteration, and at the same time, by the very act of drawing, our attention is quickened and our recollection made more clear. A drawing thus made serves, too, a double purpose. It preserves for us a transcript of what we saw to compare with our own later studies, and it serves as a ready means of interchange of views with others, outweighing, often, many a page of mere description. The various new and improved forms of the camera lucida which have been brought out in the past year or two are therefore matters of congratulation.

3. The use of Photomicrography.—This is, perhaps, a still more important adjunct for verification. By this beautiful application of the art preservative we have not alone a quick and easy mode of obtaining a record of our observations, for comparison with those of others, or with our own later studies, but we have a record that is almost entirely free from the fallibility inherent in a mere drawing. Photography has errors of its own, but it eliminates the errors of the hand and eye and judgment. The shadowy distortions projected into the microscopic image by our imagination disappear when the light writes down its own impressions of the structure it traverses. And thus the photographic evidence of what can be seen is a verification indeed. The service it wrought in the hands of Dr. J. J. Woodward in first demonstrating the resolution of the finer diatoms and of Nobert's higher bands of ruled lines by American objectives, you all remember. The photograph itself is not free from possible error; it cannot focus itself, it will record diffraction images as well as negative or dioptric ones, and hence its own record needs careful interpretation. As in astronomical work the photographs of the comet or nebula, of the eclipse of the sun, or the transit of Venus, do not give the final truths that are sought after, but need to be carefully collated and measured and studied in many ways, that from them may be deduced the structure of the corona or the comet, the parallax and distance of the planet and the sun—so with the photomicrographs of the objects of our study. They may not be absolute proofs on their face of the real structure under examination, especially in the case of very minute lines or particles near the limit of visibility, but they present a record of that structure, freed from the 'personal equation' of the observer, and they preserve that record for study and comparison in the indefinite future, when details now unthought of, and therefore unnoticed by the eye, shall be seen to be of importance in its interpretation. And may not the photograph do even more than this in microscopic verification? Its achievements in astronomy and in recording the swift motions of the racehorse may yet be duplicated

here. The eye can only see under certain very definite conditions. There must be a definite amount of light in the retinal image or the optic nerves will not be at all affected. Hence a very swiftly-moving object which sends from any one position light for an infinitesimal instant only, is invisible, or is seen only as a blur. So one that is quite at rest may send too little light and be unseen. But the eye whose retina is gelatine and silver bromide, can be made so quickly sensitive that it can catch with ease the swiftest leap of greyhound or racehorse, or the still swifter, though far remote, uprushings of the great fire-clouds of the photosphere; or it can be made so sensitively slow, that it will gather in for hours the dim light that comes from the distant star-depths, and build up by slow degrees an image that the eye alone could never see. So, may not photography compass the same results in microscopic work? In high amplification the loss of light becomes soon a limiting value to the possibility of ocular vision, and all details are lost in dimness, but the gelatine plate can be made to take its time to it, as the eye cannot, and slowly gathers up out of the thick darkness an image for our study, if only we can correct and focus properly. It may not be even swift enough to follow the molecule or atom in its flight; but there are other motions, now in dispute, that it may yet be made to seize, the waving cilia, the yet unseen motile organs of the diatom, the flagella of the bacterium, and still others yet unknown. Still more, it is not impossible that photography may verify exceedingly minute structure in another way—by subjecting the details of the photographic image to further enlargement. To make the process of service in this direction, however, will demand a much greater perfection of manipulation than in other departments of photographic work, where it has been successfully employed, and whether it can ever give a true image of details finer than the limit of visibility is, I think, doubtful, in spite of Prof. Abbe's seeming indorsement of its possibility in the article in 'The Monthly Microscopical Journal' of November, 1875. It is, however, well worth the thorough trial.

4. Media and Reagents.—A wise and careful use of the diverse chemical fluids which have, of late years, been brought into notice, will form the most efficient means of verification. I have already referred to the large part that the preparation of an object has to do with its successful microscopic examination. The different media that have been proposed from time to time for preparing objects, for permanently mounting them, and for various test reactions upon them, are almost endless. But of late years there has been a more intelligent application of chemistry and chemical physics to the aid of microscopic investigation, the principles involved are better understood, and we are now armed as never before, with means of putting nature to the test and verifying our vision of her most intricate minutiæ. Yet many microscopists work on in old ruts, mounting everything in one and the same medium. Some look on staining as only a refinement of dilettantism, a thing of mere looks, like coloured varnish rings and ornamental labels. But these staining fluids, as

this use is now developed, differentiate the various tissues from one another, and are a most invaluable help to exact knowledge. As the presents of sword and spear and shield, offered, along with the jewelry and costly robes, to the daughters of Lycomedes, by the crafty Ulysses, in the old Homeric story, served to discover the young Achilles in spite of his womanly disguise, so do these chemical staining fluids serve to disclose to us by their selective power the different tissues and organs in substances otherwise alike transparent and invisible. The various aniline colours with which chemistry has enriched the world, transforming a waste product from a nuisance to a source of wealth, have given a new and almost inexhaustible apparatus of verification to the microscopist. But perhaps a still more important means of verification is to be found.

5. Improved Lenses and Accessory Apparatus.—Abbe's introduction of the homogeneous immersion system of objectives, and the greatly increased aperture which at once resulted, and the more perfect adjustment by motion of the inner system of lenses of the objective as designed by Tolles, mark an era in the history of the Microscope and afford a new and powerful adjunct to the verification of former discovery. And this is being done. Dr. W. B. Carpenter, in his Montreal address last year, somewhat loftily asserted that we in America were, in the matter of wide aperture, simply going over the track which the English microscopists traversed twenty-five years ago, and have now abandoned. The statement is wide of the mark in its literal meaning. If any English microscopists had dry 4-10ths of 110° or glycerine immersions 1-6th of 130° balsam angle twenty-five years ago they were strangely reticent about them. But in another sense his words are most true. American microscopists are traversing again the ground passed over twenty-five years ago, that the observations made then with inferior lenses may be corrected and verified by the superb glasses of to-day. But Americans are not alone in this. English and Continental scholars are enlisted in the same work, and a London optician leads the world in making lenses of wide aperture. Let me not be understood, however, as claiming all perfection for all uses for the wide-angled lenses. The views of Prof. Abbe in regard to the limitations of wide apertures seem to me eminently just. But not alone in the objective do we find means of more accurately testing our observations. Many improvements in the accessory apparatus are of great value.

6. A Better Knowledge of Optics.—This is perhaps the most important of all means of verification of microscopic observations. Without this all the rest will be in vain. We must elaborate or the simplest apparatus will yield no real gain of knowledge to the world unless the eye be trained to comprehend what it sees, to interpret the appearances that present themselves and discriminate the causes that produce them, and so trace back the effects of the lenses themselves, of the diaphragm, of the obliquity of the light, and the effects due to the real structure of the object under examination. The mathematical reasonings of Helmholtz and still more those of Abbe on the true theory of microscopic vision may not

need to be followed by every one who would use the instrument, but to be acquainted with the main facts of Abbe's theory—to comprehend the doctrines he has propounded and the experiments by which he has made it plain, so as to use it in the interpretation of what the lens reveals, is as necessary for the one who would be a well-skilled observer as for him who would improve the powers of the instrument itself.

The best natural endowments of clear vision and delicate touch, and the greatest attainment of that 'manual dexterity,' which, as Beale says, 'although subordinate to many higher mental qualifications, is essential for the successful prosecution of microscopic observation,' are not enough, unless guided by that clear mental perception of the general principles of optical physics which can help the eye to recognize the origin of the appearances it sees and lead the way to decisive experiment. The studies of Abbe in particular have done more to establish a firm footing for further improvement of the Microscope and a more intelligent use of it in the form we now have, than all the laborious but ill-directed efforts of a host of other workers. As a knowledge of chemical science has led to a great advance in the use of reagents, mounting media, hardening, clearing, and other preparatory fluids, so a knowledge of the laws of light is essential to the proper use of the Microscope in examining the objects prepared. To discriminate between bubbles of air or globules of oil in water, to understand what forms a transparent, solid, or hollow cylinder may appear to take by transmitted or reflected light, and in media of an index more or less varying from its own, have long been recognized as questions the microscopist should exercise himself upon by theory and practice till he cannot be misled. Yet how often still are men misled in these cases? Especially important is it to learn to discriminate between proper and imperfect focusing, and to use the adjustment collar of the higher power lenses to the best effect. 'There is no doubt,' says President Duncan, of the Royal Society, 'that, with very few exceptions, the microscopic work relating to the morphology of the animal and vegetable kingdom has been conducted either without corrected objectives or with those which have an average adjustment,' and, remarking that very minute bodies appear abnormally thick from lack of correction, &c., when highly magnified, goes on to say he has no doubt but that similar abnormalities are constantly recorded as truths. So, too, there is no doubt that lines, fine dots, and beaded structures of various kinds have been constantly misunderstood. Lines have been recorded which have no real existence, or which, if existent, are neither so wide nor so numerous as they appear to be, nor in the direction they appear to lie. A careless use of the diaphragm, a more or less complete employment of the aperture of the objective, or of one part of that aperture rather than another, or error in focusing, may transform elevations into depressions, squares or triangles into circles, or rhomboids, or hexagons, or simple lines, and vice versâ. One of the most interesting questions we are called to meet to-day, as it seems to me, is whether we can discover any sure and satisfactory diagnosis of the real nature of

minute structure near the present limits of vision from the images it gives. At present we can scarcely say more than that a single series of lines will never appear as anything else but lines under an objective of sufficient aperture and with proper amplification, though they may appear doubled or quadrupled in number and fineness. They will not appear more widely spaced than in reality, and will not take on the semblance of dots or hexagons. But dots may appear as lines of varying fineness, or in varying direction, or as dots or bodies of various shapes and sizes, according to the manipulation used, and we are as yet without any sure way of judging of their real nature from their microscopic image. But that these structures can yet be verified and their true nature ascertained I confidently believe, even though Abbe himself has been unable as yet to solve the puzzle, and the inquiry may be long and difficult. Whether the Microscope can ever reveal the existence of any structural detail finer than that which now seems to mark the limit of vision, is another question. Doubtless with other materials than our present crown and flint glass, and with still fuller understanding of the principles involved, objectives transcending the present limits may yet be made and new difficulties of resolution appear. But at present we are not ready for such machines. We have not learned to use correctly what we have. The finer structures now revealed as at present are not understood by us. When we have learned how to verify what we now can see we will be ready for further gifts, for more powerful lenses from our opticians,—objectives of wider aperture, immersed in fluids of refractive index equal to their own—and when we are ready for them they will doubtless be produced. At the present time the Abbe diffraction plate offers itself as a most fruitful field of study, and when we can learn to discriminate without hesitation the various appearances of its squares and rhomboids we can attack anew the mysteries of histology, resolve the diatom frustules in a truer and more perfect sense, investigate the bioplasm theory to a final and satisfactory conclusion, and perhaps discriminate optically between the septic and the pathogenic bacteria, learn the true structure of muscle and the real meaning of its striations, and in a thousand other ways approach a little nearer to an understanding of the mystery of life and the wonderful, beautiful symmetry of the structure of the universe of God."

Examination of the Corpuscles held in Suspension in Water.*— Amongst the essential characters of the potability of water, limpidity, E. Marchand says, ought to be imperiously exacted. The perfect transparency of the liquid can generally be sufficiently ascertained by simple examination, but a more accurate observation can be made by passing a ray of sunlight through the water inclosed in a glass flask surrounded by black paper, in which are two opposite rectangular apertures, through one of which the ray passes while the observer looks through the other. When the liquid is optically pure the light traverses it without obstacle, but however few particles there may be held in suspension, each of these, on being illuminated, is visible

* Comptes Rendus, xcvii. (1883) pp. 49–50.

when otherwise they would remain invisible. There is nothing new in this method of examination; it is an application of the process employed by Prof. Tyndall to prove the optical purity of air, but it does not appear to have been put into practice up to the present. It has led the author to what he considers a conclusion of the very highest interest, viz. the constant presence of certain corpuscles in all the waters of Caux and which he is now certain will be found in the natural waters of all countries.

These corpuscles are hyaline and endowed with a refractive power about equal to that of water. Amongst them are some which present vacuoles filled with water or gas. Others appear under the form of disks, similar to the discoid diatoms. They all have a density greater than that of sea water (1·026) which contains myriads of them, at least at Fécamp. They resist the attacks of dilute mineral acids and also of dilute caustic alkalies. They were found in all the waters which the author has been able to examine hitherto; sea water, spring water, well water, running water, rain water, and even in distilled water which has been for some time exposed to contact with the air, which leads to the belief that they are also dispersed in the atmosphere.

Although about 2 mm. in diameter they are so flexible and plastic that they pass through the finest filters; for a great number of those which are contained in drinking water pass through the kidneys and are found again in the urine.

The germs of *Euglenæ* exist among these corpuscles, and this circumstance explains the profusion with which green substances, especially that bearing the name of Priestley, are developed in all the places exposed to solar light, direct or diffused, and to damp.

Amongst these little organisms there are some which appear to the author to play an eminently active part in the purification of waters charged with organic matters in a state of putrefaction, or capable of entering into putrefaction, when these waters, either running or stagnant, are exposed to contact with the air. We know that the substances in question are then oxidized and are transformed into carbonic acid and ammonia, or into nitric acid. Hitherto it has been admitted that the intervention of the combustive element is manifested by a direct action. The author is now led to believe that this intervention is only the consequence of a phenomenon of nutrition, undergone by some of the corpuscles in question, perhaps even by all. With respect to this he has begun a series of experiments and observations the results of which he intends later on to submit to the Academy. The present communication is chiefly made to establish priority, "but, in any case, the profusion with which these *non-microscopic* little beings are diffused ought, it seems to me, to be considered as a certain sign of the importance of the *rôle* which they are destined to play in nature."

ANDRES, A., GIESBRECHT, W., and MAYER, P.—Neuerungen in der Schneidetechnik. (Novelties in section-cutting.) [*Post.*]
MT. Zool. Stat. Neapel, IV. (1883) pp. 429–36 (2 figs.).

BENNETT, R. A. R.—Mounting Insect Organs.—Cement for securing slides.
Sci.-Gossip, 1883, p. 208.

BOLTON'S (T.) Exhibition of living organisms under the Microscope.—Aquaria, Microscopes, &c., at the Fisheries Exhibition.
Micr. News, III. (1883) pp. 182–3 and 268.

BRUN, J.—Préparation des Diatomées. (Preparation of the Diatomaceæ.) 12mo, Genève, 1883, 4 pp.

CAPUS, G., and ROCHEBRUNE, A. T. DE.—Guide du Naturaliste préparateur et du voyageur scientifique, ou instructions pour la recherche, la préparation, le transport et la conservation des animaux, végétaux, minéraux, fossiles et organismes vivants et pour les études histologiques et anthropologiques. (Guide for the Naturalist and scientific traveller, or instructions for searching for, preparing, transporting, and preserving animals, plants, minerals, fossils, and living organisms, and for histological and anthropological studies.) 2nd ed. with an introduction by E. Perrier. 18mo, Paris, 1883, xii. and 324 pp. and 223 figs.

CHESHIRE, F.—Cutting sections of probosces of honey-feeding Insects. [*Post.*]
Proc. Entomol. Soc. Lond., 1883, p. xix.

COLE, A. C.—Popular Microscopical Studies. No. I. Hebridian Gneiss. Description by Prof. F. Heddle. pp. 1–6 (1 pl. × 25).
[Contains "How to prepare a rock section for the Microscope." *Post.*]
„ „ Studies in Microscopical Science. Vol. II. No. 3. Sect. I. Animal Histology. Chap. I. The Morphology of the Cell *continued*, pp. 3–4.

DAVIS, G. E.—Glycerine Mounts. [*Supra*, p. 739.]
Micr. News, III. (1883) p. 238.

Evenings with the Microscope. II. Multiple Images. Crystals.
[Describes the preparation (1) of insects' eyes for showing an image in each of the facets, and (2) of crystals.]
Amer. Mon. Micr. Journ., IV. (1883) pp. 126–8.
„ „ „ III. [Mounting of Polycistina.]
Amer. Mon. Micr. Journ., IV. (1883) pp. 143–4.

FRENZEL, J.—Neuer Beitrag zur microscopischen Technik. Aufkleben der Schnitte. (Further contribution to microscopical technics. Fixing the sections.) [*Supra*, p. 735.] *Zool. Anzeig.*, VI. (1883) pp. 422–4.

GIESBRECHT, W. See Andres, A.

GRAFF, T. UP DE.—A Magnificent Cabinet.
[Dr. L. M. Eastman's, President of the Baltimore Microscopical Society.]
The Microscope, III. (1883) p. 133, from *The Bistoury*.

GREEN, S.—On an easy Method of Preparing Insects for the Microscope.
[*Supra*, p. 730.]
Journ. Quek. Micr. Club, I. (1883) pp. 224–6 and 253–4.

HAACKE, W.—Zur Aufstellungs- und Behandlungsweise von Alcoholpräparaten. (On the putting-up and treatment of alcohol preparations.)
[Additions to the papers of Möbius (*ante*, p. 292), Zietz (*ante*, p. 471), and others. Deals with macroscopic preparations.]
Zool. Anzeig., VI. (1883) pp. 518–20.

HEURCK, H. VAN.—De l'emploi du styrax et du liquidambar en remplacement du baume de Canada. (On the employment of styrax and liquidambar in place of Canada balsam.) [*Supra*, p. 741.]
Bull. Soc. Belg. Micr., IX. (1883) pp. 133–6.

HITCHCOCK, R.—Microscopic Objects at the Fisheries Exhibition.
[E. Pott's collection of American fresh-water sponges, &c. (*ante*, p. 616); the author's slides of selected foraminifera and of ova; Mr. Bolton's exhibits.]
Amer. Mon. Micr. Journ., IV. (1883) pp. 128–9.

JONES, T. R.—The importance of minute things of life in past and present times.

[Deals with the following: Important, though minute, things of life in the vegetable world: Nullipores and nullipore-limestone; corallines and coralline shore-sand and raised beaches; Characeæ and chara-limestone; Diatomaceæ and diatomaceous earths; Equisetums and grasses (canes, wheat, hay, &c.); puff-ball, lycopodium, and spore-coal; lichens on rock and the formation of soil. In the animal world: Sponges and spicules and spicular sandstones (chert, &c.); polycistina and polycistine beds (Barbadoes); entomostraca (ostracods), marine and freshwater, ostracodous limestones; Foraminifera, and foraminiferal limestones.]

Trans. Hertfordshire Nat. Hist. Soc., II. (1883) pp. 164–72.

KLEIN, E.—Elements of Histology. 342 pp. and 168 figs. 8vo, London, 1883.

KNOTT, J. F.—Sections of Hair-follicles stained.

[Exhibition at Dublin Microscopical Club—Sections perpendicular to long axis of hairs. Stained with picro-carmine and anilin violet, which latter tinges the outer (Henle's) layer of the inner root-sheath. Huxley's layer staining with picrocarmine as well as the outer root-sheath, the various layers of the complex wall of the hair-follicles are extremely well differentiated.]

Ann. & Mag. Nat. Hist., XII. (1883) p. 126.

LEVICK, J.—Presidential Address to the Birmingham Natural History and Microscopical Society.

[On "the collecting, growing or cultivation, and examination or display of microscopic aquatic life." *Supra*, p. 727 and *post*.]

Report & Trans. Birm. Nat. Hist. & Micr. Soc. for 1882, pp. iii.–xxv.

M'NAB, Dr.—*Protococcus pluvialis* to show nucleus.

[Exhibition to Dublin Microscopical Club of specimens of the ciliated state of *Protococcus* (*Chlamydococcus*) *pluvialis* treated with osmic acid and carmine. The nucleus was most clearly seen in each free cell, and also in others which had divided or were then undergoing division into four or eight new cells.]

Ann. & Mag. Nat. Hist., XII. (1883) p. 124.

MAYER, P. See Andres, A.

MICHAEL, A. D.—On Sea-side Collecting.

[Report of demonstration. *Supra*, p. 729.]

Journ. Quek. Micr. Club, I. (1883) pp. 233–43.

Michigan, University of.—Central Laboratory for Microscopy and general Histology.

[Statement of the subjects in which instruction is given and synopsis of the plan pursued in the principal divisions:—Normal human histology. Vegetable histology. Advanced normal and pathological histology. Embryology and Urinalysis.]

Science, II. (1883) pp. 208–9.

Mounting and Photographing Microscopic Objects.

[Intended to "show how any possessor of a Microscope may make for himself preparations which though they may not equal by many degrees the productions of the best professional mounters, yet have a far higher educational value, as their preparation will afford information which could not be otherwise acquired." Deals with materials and instruments; the objects of mounting; details of mounting a section of deal and a piece of sole's skin (dry); mounting a flea (in balsam); hardening; imbedding; staining; vegetable sections; mineral and rock sections; mounting in glycerine jelly (*supra*, p. 736); photomicrography.]

Nature, XXVIII. (1883) pp. 300–3 (4 figs.), 321–2.

NEVILLE, J. W.—New methods of mounting for the Microscope. [*Supra*, p. 739.]

Midl. Natural., VI. (1883) p. 190.

NEWTON, E. T.—Some methods of preparing parts of Insects for microscopical examination.

[Report of "Demonstration" showing "how he had been in the habit of preparing a series of sections of . . . the head of a cockroach."]

Journ. Quek. Micr. Club, I. (1883) pp. 245–6.

NOLL, F. C.—[Eine Flüssigkeit für Dauerpräparate von zarten Crustaceen und deren Larven.] (A fluid for permanent preparations of delicate Crustacea and their larvæ.) [*Supra*, p. 732.]
Zool. Anzeig., VI. (1883) p. 472.

PERRIER, E. See Capus, G.

QUINLAN, F. J. B.—Bacillus-mounting.
The Microscope, III. (1883) p. 138, from *Medical and Surgical Reporter*, from *Medical Press*, 28th March, 1883.

RATABOUL.—Les Diatomées. Récolte et préparation. (The Diatomaceæ. Collection and preparation.) 39 pp. and 1 pl. 8vo, Toulouse, 1883.

RICHTER, P.—Zur Manipulation von Süsswasseralgen, für das Herbarium bestimmt. (On the manipulation of Fresh-water Algæ intended for the Herbarium.) *Hedwigia*, XXII. (1883) pp. 97–100.

ROCHEBRUNE, A. T. DE. See Capus, G.

RUTRIDGE, T.—Tracings for the Lantern.
[Description of the Rev. W. H. Dallinger's plan.]
The Microscope, II. (1883) p. 198.

S., W. J.—Cyclosis.
[As to low powers which will show the phenomenon in *Vallisneria*. The rotation of cell-sap can be seen with a wide-angle 2 in., and better still with a good working 1 in. or 1–2 in., although the 1-4th in. is the glass for it."]
Sci.-Gossip, 1883, p. 209.

SCHALLIBAUM, H.—Ueber ein Verfahren mikroskopische Schnitte auf dem Objectträger zu fixiren und daselbst zu färben. (On a process for fixing microscopical sections on the slide and there staining them.) [*Supra*, p. 736.]
Arch. f. Mikr. Anat., XXII. (1883) pp. 689–90.

SCHUCHARDT'S (T.) Chemically pure reagents for use in botanical-physiological Institutes. [*Ante*, p. 607.]
Bot. Centralbl., XV. (1883) pp. 158–9.

SLACK, H. J.—Pleasant Hours with the Microscope.
[The Proboscis of the fly—Hairs of Plants—Preparing leaves of *Deutzia scabra* and *Pinus austriaca* (*post*)—Pollen.]
Knowledge, IV. (1883) p. 71 (7 figs.), 103-5 (6 figs.), 130–1, 162–3 (4 figs.).

STOWELL, C. H.—Laboratory Work.
[Kidney—Liver—Brain.] *The Microscope*, III. (1883) pp. 100–4.

WARD, E.—Microscopical Mounts and Mounting and Micro-crystallization. 8vo, Manchester, 1883, 20 pp.
[Two papers read before the Manchester Science Association and the Manchester Microscopical Society. *Post.*]

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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.

Edited by

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and a Vice-President and Treasurer of the Linnean Society of London;

WITH THE ASSISTANCE OF THE PUBLICATION COMMITTEE AND

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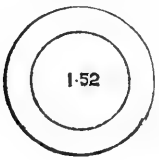
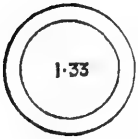
I. Numerical Aperture Table.

The "APERTURE" of an optical instrument indicates its greater or less capacity for receiving rays from the object and transmitting them to the image, and the aperture of a Microscope objective is therefore determined by the ratio between its focal length and the diameter of the emergent pencil at the plane of its emergence—that is, the utilized diameter of a single-lens objective or of the back lens of a compound objective.

This ratio is expressed for all media and in all cases by $n \sin u$, n being the refractive index of the medium and u the semi-angle of aperture. The value of $n \sin u$ for any particular case is the "*numerical aperture*" of the objective.

Diameters of the Back Lenses of various Dry and Immersion Objectives of the same Power (¼ in.) from 0·50 to 1·52 N. A.	Numerical Aperture. ($n \sin u = a$.)	Angle of Aperture ($= 2u$). *Dry* Objectives. ($n = 1$.)	*Water-Immersion* Objectives. ($n = 1{\cdot}33$.)	*Homogeneous-Immersion* Objectives. ($n = 1{\cdot}52$.)	Illuminating Power. (a^2.)	Theoretical Resolving Power, in Lines to an Inch ($\lambda = 0{\cdot}5269\ \mu$ = line E.)	Penetrating Power. $\left(\frac{1}{a}\right)$
	1·52	..	..	180° 0′	2·310	146,528	·658
	1·50	..	..	161° 23′	2·250	144,600	·667
	1·48	..	..	153° 39′	2·190	142,672	·676
	1·46	..	..	147° 42′	2·132	140,744	·685
	1·44	..	..	142° 40′	2·074	138,816	·694
	1·42	..	..	138° 12′	2·016	136,888	·704
	1·40	..	..	134° 10′	1·960	134,960	·714
	1·38	..	..	130° 26′	1·904	133,032	·725
	1·36	..	..	126° 57′	1·850	131,104	·735
	1·34	..	..	123° 40′	1·796	129,176	·746
	1·33	..	180° 0′	122° 6′	1·770	128,212	·752
	1·32	..	165° 56′	120° 33	1·742	127,248	·758
	1·30	..	155° 38′	117° 34′	1·690	125,320	·769
	1·28	..	148° 28′	114° 44′	1·638	123,392	·781
	1·26	..	142° 39′	111° 59′	1·588	121,464	·794
	1·24	..	137° 36′	109° 20′	1·538	119,536	·806
	1·22	..	133° 4′	106° 45′	1·488	117,608	·820
	1·20	..	128° 55′	104° 15′	1·440	115,680	·833
	1·18	..	125° 3′	101° 50′	1·392	113,752	·847
	1·16	..	121° 26′	99° 29′	1·346	111,824	·862
	1·14	..	118° 00′	97° 11′	1·300	109,896	·877
	1·12	..	114° 44′	94° 56′	1·254	107,968	·893
	1·10	..	111° 36′	92° 43′	1·210	106,040	·909
	1·08	..	108° 36′	90° 33′	1·166	104,112	·926
	1·06	..	105° 42′	88° 26′	1·124	102,184	·943
	1·04	..	102° 53′	86° 21′	1·082	100,256	·962
	1·02	..	100° 10′	84° 18′	1·040	98,328	·980
	1·00	180° 0′	97° 31′	82° 17′	1·000	96,400	1·000
	0·98	157° 2′	94° 56′	80° 17′	·960	94,472	1·020
	0·96	147° 29′	92° 24′	78° 20′	·922	92,544	1·042
	0·94	140° 6′	89° 56′	76° 24′	·884	90,616	1·064
	0·92	133° 51′	87° 32′	74° 30′	·846	88,688	1·087
	0·90	128° 19′	85° 10′	72° 36′	·810	86,760	1·111
	0·88	123° 17′	82° 51′	70° 44′	·774	84,832	1·136
	0·86	118° 38′	80° 34′	68° 54′	·740	82,904	1·163
	0·84	114° 17′	78° 20′	67° 6′	·706	80,976	1·190
	0·82	110° 10′	76° 8′	65° 18′	·672	79,048	1·220
	0·80	106° 16′	73° 58′	63° 31′	·640	77,120	1·250
	0·78	102° 31′	71° 49′	61° 45′	·608	75,192	1·282
	0·76	98° 56′	69° 42′	60° 0′	·578	73,264	1·316
	0·74	95° 28′	67° 36′	58° 16′	·548	71,336	1·351
	0·72	92° 6′	65° 32′	56° 32′	·518	69,408	1·389
	0·70	88° 51′	63° 31′	54° 50′	·490	67,480	1·429
	0·68	85° 41′	61° 30′	53° 9′	·462	65,552	1·471
	0·66	82° 36′	59° 30′	51° 28′	·436	63,624	1·515
	0·64	79° 35′	57° 31′	49° 48′	·410	61,696	1·562
	0·62	76° 38′	55° 34′	48° 9′	·384	59,768	1·613
	0·60	73° 44′	53° 38′	46° 30′	·360	57,840	1·667
	0·58	70° 54′	51° 42′	44° 51′	·336	55,912	1·724
	0·56	68° 6′	49° 48′	43° 14′	·314	53,984	1·786
	0·54	65° 22′	47° 54′	41° 37′	·292	52,056	1·852
	0·52	62° 40′	46° 2′	40° 0′	·270	50,128	1·923
	0·50	60° 0′	44° 10′	38° 24′	·250	48,200	2·000

EXAMPLE.—The apertures of four objectives, two of which are dry, one water-immersion, and one oil-immersion would be compared on the *angular* aperture view as follows:—106° (air), 157° (air), 142° (water), 130° (oil).
Their actual apertures are, however, as ·80 ·98 1·26 1·38 or their numerical apertures.

II. Conversion of British and Metric Measures.

(1.) Lineal.

Micromillimetres, &c., into Inches, &c.

μ	ins.	mm.	ins.	mm.	ins.
1	·000039	1	·039370	51	2·007892
2	·000079	2	·078741	52	2·047262
3	·000118	3	·118111	53	2·086633
4	·000157	4	·157482	54	2·126003
5	·000197	5	·196852	55	2·165374
6	·000236	6	·236223	56	2·204744
7	·000276	7	·275593	57	2·244115
8	·000315	8	·314963	58	2·283485
9	·000354	9	·354334	59	2·322855
10	·000394	10 (1 cm.)	·393704	60 (6 cm.)	2·362226
11	·000433	11	·433075	61	2·401596
12	·000472	12	·472445	62	2·440967
13	·000512	13	·511816	63	2·480337
14	·000551	14	·551186	64	2·519708
15	·000591	15	·590556	65	2·559078
16	·000630	16	·629927	66	2·598449
17	·000669	17	·669297	67	2·637819
18	·000709	18	·708668	68	2·677189
19	·000748	19	·748038	69	2·716560
20	·000787	20 (2 cm.)	·787409	70 (7 cm.)	2·755930
21	·000827	21	·826779	71	2·795301
22	·000866	22	·866150	72	2·834671
23	·000906	23	·905520	73	2·874042
24	·000945	24	·944890	74	2·913412
25	·000984	25	·984261	75	2·952782
26	·001024	26	1·023631	76	2·992153
27	·001063	27	1·063002	77	3·031523
28	·001102	28	1·102372	78	3·070894
29	·001142	29	1·141743	79	3·110264
30	·001181	30 (3 cm.)	1·181113	80 (8 cm.)	3·149635
31	·001220	31	1·220483	81	3·189005
32	·001260	32	1·259854	82	3·228375
33	·001299	33	1·299224	83	3·267746
34	·001339	34	1·338595	84	3·307116
35	·001378	35	1·377965	85	3·346487
36	·001417	36	1·417336	86	3·385857
37	·001457	37	1·456706	87	3·425228
38	·001496	38	1·496076	88	3·464598
39	·001535	39	1·535447	89	3·503968
40	·001575	40 (4 cm.)	1·574817	90 (9 cm.)	3·543339
41	·001614	41	1·614188	91	3·582709
42	·001654	42	1·653558	92	3·622080
43	·001693	43	1·692929	93	3·661450
44	·001732	44	1·732299	94	3·700820
45	·001772	45	1·771669	95	3·740191
46	·001811	46	1·811040	96	3·779561
47	·001850	47	1·850410	97	3·818932
48	·001890	48	1·889781	98	3·858302
49	·001929	49	1·929151	99	3·897673
50	·001969	50 (5 cm.)	1·968522	100 (10 cm. = 1 decim.)	
60	·002362				
70	·002756				
80	·003150				
90	·003543				
100	·003937				
200	·007874				
300	·011811				
400	·015748				
500	·019685				
600	·023622				
700	·027559				
800	·031496				
900	·035433				
1000 (= 1 mm.)					

decim.	ins.
1	3·937043
2	7·874086
3	11·811130
4	15·748173
5	19·685216
6	23·622259
7	27·559302
8	31·496346
9	35·433389
10 (1 metre)	39·370432
=	3·280869 ft.
=	1·093623 yds.

Scale showing the relation of Millimetres, &c., to Inches.

1000 μ = 1 mm.
10 mm. = 1 cm.
10 cm. = 1 dm.
10 dm. = 1 metre.

Inches, &c., into Micromillimetres, &c.

ins.	μ
1/25000	1·015991
1/20000	1·269989
1/15000	1·693318
1/10000	2·539977
1/9000	2·822197
1/8000	3·174972
1/7000	3·628539
1/6000	4·233295
1/5000	5·079954
1/4000	6·349943
1/3000	8·466591
1/2000	12·699886
1/1000	25·399772
	mm.
1/900	·028222
1/800	·031750
1/700	·036285
1/600	·042333
1/500	·050800
1/450	·056444
1/400	·063499
1/350	·072571
1/300	·084666
1/250	·101599
1/200	·126999
1/150	·169332
1/100	·253998
1/50	·507995
1/25	1·015991
1/20	1·269989
1/16	1·587486
1/15	1·693318
1/12	2·116648
1/10	2·539977
1/8	3·174972
1/6	4·233295
3/16	4·762457
1/5	5·079954
1/4	6·349943
5/16	7·937429
3/8	9·524915
	cm.
7/16	1·111240
1/2	1·269989
9/16	1·428737
5/8	1·587486
11/16	1·746234
3/4	1·904983
13/16	2·063732
7/8	2·222480
15/16	2·381229
1	2·539977
2	5·079954
3	7·619932
	decim.
4	1·015991
5	1·269989
6	1·523986
7	1·777984
8	2·031982
9	2·285979
10	2·539977
11	2·793975
1 ft.	3·047973
	metres.
1 yd. =	·914392

JOURNAL

OF THE

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.

Edited by

FRANK CRISP, LL.B., B.A.,

one of the Secretaries of the Society and a Vice-President and Treasurer of the Linnean Society of London;

WITH THE ASSISTANCE OF THE PUBLICATION COMMITTEE AND

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S. O. RIDLEY, M.A., of the British Museum, and JOHN MAYALL, Jun.,

FELLOWS OF THE SOCIETY.

THIS Journal is published bi-monthly, on the second Wednesday of the months of February, April, June, August, October, and December. It varies in size, according to convenience, but does not contain less than 9 sheets (144 pp.) with Plates and Woodcuts as required. The price to non-Fellows is 5*s.* per Number.

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(2.) SUMMARY of CURRENT RESEARCHES relating to ZOOLOGY and BOTANY (principally Invertebrata and Cryptogamia, with the Embryology and Histology of the higher Animals and Plants), and MICROSCOPY (properly so called): being abstracts of or extracts from the more important of the articles relating to the above subjects contained in the various British and Foreign Journals, Transactions, &c., from time to time added to the Library.

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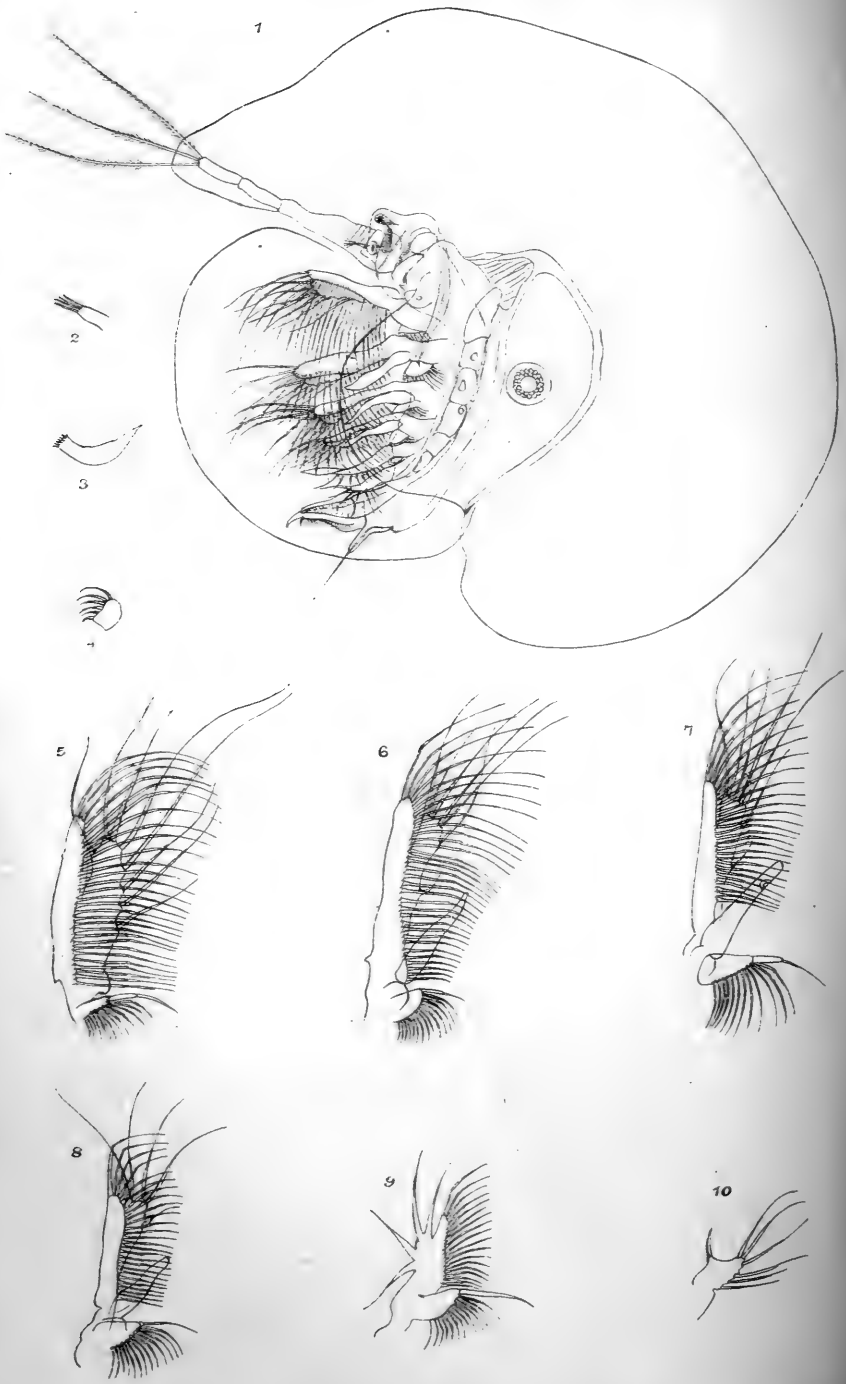


C. Beck del.

West, Newman & Co. Lith.

Holopedium gibberum.

C. Beck del.

West, Newman & Co. lith.

JOURNAL

OF THE

ROYAL MICROSCOPICAL SOCIETY.

DECEMBER 1883.

TRANSACTIONS OF THE SOCIETY.

XIII.—*On some new Cladocera of the English Lakes.*

By Conrad Beck.

(*Read 13th June*, 1883.)

Plates XI. and XII.

In the summer of 1881 I found, whilst dredging in some of the English lakes, three species of Cladocera previously unknown to England. Prof. E. Ray Lankester was good enough to draw attention to this in the 'Annals and Magazine of Natural History' (ix. 1882, p. 53). Although these species have been described by foreign authors, no account of them has yet appeared in English, so I think that a short notice of them may be useful to those interested in the subject.

EXPLANATION OF PLATES XI. and XII.

Plate XI. *Holopedium gibberum.*

Fig. 1.—Lateral view.
„ 2.—First antenna.
„ 3.—Mandible.
„ 4.—Maxilla.
„ 5.—First foot.
Fig. 6.—Second foot.
„ 7.—Third „
„ 8.—Fourth „
„ 9.—Fifth „
„ 10.—Sixth „

Plate XII. *Bythotrephes Cederströmii.*

Fig. 1.—Lateral view.
„ 2.—First antenna.
„ 3.—Second „
„ 4.—Mandible.
Fig. 5.—First foot.
„ 6.—Second „
„ 7.—Third „
„ 8.—Fourth „

Latona setifera.

Fig. 9.—Ventral view.
„ 10.—Lateral „
„ 11.—First antenna.
Fig. 12.—Second antenna.
„ 13.—Mandible.
„ 14.—Maxilla.

Holopedium gibberum Zaddach (plate XI.).

The chief feature of this Entomostracan (fig. 1), and one which cannot fail to make it of great interest, is that it is entirely enveloped in a large gelatinous case, which, on account of its extreme transparency and equal density with water, is almost invisible when swimming, although when brought into air it is at once apparent. This has been found with no other species, and belongs to *Holopedium* alone. When noticed by Zaddach, who first discovered the species in 1855, he considered it as a disease from which the animal would soon die. This view has, however, been proved to be incorrect, from the fact that it is never found without it, and that it always bears the same definite form. On close examination it is seen to consist of two portions: a dorsal and a ventral. Of these, the former is the larger, extending round the anterior and dorsal portions of the animal for a distance about equal to the diameter of the animal itself. The ventral is in the form of two flaps which are fixed to the shell-valves and project beyond them so as to cover the otherwise unprotected legs and post-abdomen. Between these flaps is a sufficient space for the free movement of the feet, so necessary for respiration.

The head is small, conical, and slightly bent forwards; concave anteriorly. The shell is strongly arched behind in the form of a hump, thus making a large chamber for the reception of the eggs, of which there are often as many as twenty at a time. The valves of the shell are small, and leave the extremities of the feet and the post-abdomen uncovered. They are widely open at their ventral border, and the shell tapers back to a sharp edge at the dorsal border, presenting the form of a V when looked at anteriorly. At the posterior junction of the shell-valves there is an obtuse point corresponding to the terminal spine which is generally found in the Daphniadæ.

The diameter of *Holopedium* is about 0·1 in., exclusive of its gelatinous case, with which it is as much as 0·2 in. It is delicately transparent, and every muscle and organ can be easily distinguished.

The eye is situated in the anterior portion of the head. It is composed of a central pigment-mass surrounded by spherical lenses, and is small in comparison with those of allied species. A short distance below it is the pigment-spot, or nauplius eye, which is unusually large, being about 1-3rd the size of the eye. The brain is situated below the eye and near the pigment-spot; it is a pear-shaped body, from the anterior portion of which a large bundle of nerves runs to the eye.

The digestive system is simple. Folding over the opening of the œsophagus is a large upper lip or labrum, and below is a minute lower lip or labium. Underneath the labrum the two mandibles meet, and below these is a pair of small maxillæ; these constitute the organs of the mouth from which the œsophagus, a muscular tube, conveys the food to the stomach. The stomach has no cæca, but is laterally dilated anteriorly; it extends the complete length of the body, and terminates in the anus between the terminal spines of the abdomen. The ovaries lie one on either side of the digestive tract. The heart, which is situated at the back of the animal above the brood-chamber, is large, and of a triangular form; the venous openings are in the centre, one on each side, in the form of long slits.

Appendages.—The first pair of antennæ (fig. 2) are situated on the ventral surface of the head. They are short cylindrical bodies fixed immovably to the shell, and provided with a few setæ at their extremities, alike in both sexes. The second antennæ are unlike those of any other Cladocera, in which a basal joint articulates on the shell, and carries two branches at its end. But in *Holopedium* the large basal joint is fixed firmly to the shell, though it is so flexible as to make up for the loss of the joint, which would be of little use within the jelly. At its end there is only one branch, consisting of two segments, the last of which carries three long apical setæ beset with fine hairs on each side. This pair of appendages protrudes through the jelly, is the sole organ of locomotion, and by its slow wavy strokes produces a gradual upward motion. In the male it is biramous and prehensile.

The mandibles (fig. 3) and maxillæ (fig. 4) do not require special notice, being essentially the same as those of the Sididæ.

The six pairs of feet (figs. 5–10) are similar to those of the Sididæ, but are longer in comparison; they are kept in constant motion, and thus serve both to respirate the blood and to bring food to the mouth. In the male the first pair is prehensile, and carries a hook at its end.

The post-abdomen is short and conical, being nearly in a straight line with the body and not bent up as is the case in the Daphniadæ; it is thus entirely uncovered by the shell. It is beset with two rows of spines on each side, and each of the terminal spines carries a smaller one at its base. The abdominal setæ are situated at the end of a cylindrical lobe, which projects some distance from the hinder part of the abdomen.

Hellich states that wherever he found *Holopedium* he also found *Conochilus Volvox*, and I may add that in the waters where I found *Holopedium* abundant, I also found swarms of grouped

rotatoria. I made no accurate drawings of these at the time but think probably they were the same.

From these few remarks on the structure of *Holopedium* it will be seen that it differs in most important points from any other Cladoceran in possessing a surrounding case of jelly, and in the remarkable form of its second pair of antennæ, though in other points it closely resembles *Sida*. It has therefore been placed in a separate family Holopedidæ, which with the Sididæ forms the order Ctenopoda.

Distribution.—In September 1881, I first discovered *Holopedium gibberum* in Grasmere, in small quantities, but on returning in the following May I found them in vast numbers, drawing up as many as a solid tumbler-full after pulling the net about 100 yards across the middle of the lake. In May I also found them in Windermere in small quantities, but on again returning in September I found no trace of them there whilst there were still many in Grasmere. This time I found them in Easedale Tarn, more than 900 feet above the sea. The water from this tarn runs into Grasmere, and then on through Rydal Water to Windermere. I was unable to ascertain whether they were present in Rydal Water, as the proprietor of that lake being anxious to preserve his fish and perhaps his Entomostraca, would not allow me to use his boat. In September I dredged in most of the other lakes of Cumberland and Westmoreland, but failed to find a trace of them in any. This however cannot be taken as conclusive evidence as I failed to find them in Windermere at that time of the year.

Bythotrephes Cederströmii Schödler (plate XII. figs. 1–8).

This species (fig. 1) is closely allied to *Polyphemus pediculus*. The anterior portion of the head is almost entirely occupied by the eye, a large pigment-mass surrounded by a number of long transparent crystalline lenses. The brain, which lies closely underneath the eye, is large, and composed of two parts. The body is narrow, except for the brood-cavity, which is at the back, and is sometimes very large.

The most striking feature, however, of this Cladoceran is that it possesses an extremely long spine at the end of its abdomen, more than twice as long as the rest of the animal itself. At the base of this spine is a pair of small spines standing out from it on a small knob almost at right angles. The number of these spines varies in different specimens, in some there is only one pair, in others three. This is accounted for by the fact that the animal is not always able to shed the covering of its long spine when it changes

the rest of its shell; the smaller spines are taken out of their old shell which is not completely thrown off and gives the appearance of two pairs of spines.

The development of this curious spine can be gradually traced through existing species. In *Daphnia*, the post-abdomen carries two terminal spines, between which is the anus, and some distance behind these are the abdominal setæ. In *Daphnella*, the terminal spines are similar to those of *Daphnia*, but the abdominal setæ are attached to small knobs. In *Holopedium*, though very similar, they are situated at the end of a long cylindrical lobe. In *Lathoneura*, whilst the abdomen still possesses features similar to those of *Daphnia*, the lobe on which the abdominal setæ are situated is much increased in size. In *Polyphemus* the abdomen has become aborted, whilst this lobe is much lengthened, and in *Bythotrephes* there is but a small prominence with two spines to represent the abdomen of *Daphnia*, whilst the long spine takes the place of the lobe on which the abdominal setæ are carried.

The alimentary canal is simple. A labrum covers the entrance of a narrow œsophagus which leads into the stomach; this has no cæca but is considerably dilated at its anterior end. It runs down almost straight to the anus, which is between the terminal spines. The matrix sometimes attains an enormous size, holding as many as from ten to twenty embryos at a time. These are readily distinguished by their large eyes and long spines which are curled round them. The heart is large, triangular, and situated just above the matrix.

Appendages.—The first pair of antennæ (fig. 2) are situated in the front of the head; they are short round processes, and are terminated by three or four fine setæ. The second antennæ (fig. 3) are jointed to the head below the brain; they are much like those of *Polyphemus;* they each consist of a long basal joint carrying two four-jointed branches, the first joint of each branch is very short and has no setæ. The second and third joints of the anterior branch each have one seta, the fourth carries two on its side and three at its apex. In the posterior branch the second joint has one seta, the third two, and the fourth five. All these are jointed at the middle and finely plumose.

The mandibles (fig. 4) are long, and are articulated on the shell at the back; they curve round the body and meet in front of the mouth. In front they have a set of sharp teeth. Although I have dissected several specimens I have altogether failed to find any maxillæ. I cannot but think however that there must be some, although they may be rudimentary.

There are four pairs of legs (figs. 5–8) which project altogether

from the shell, and are much like those of *Polyphemus*, but longer. The first pair have three joints, the first of which is long, and has several short setæ on its posterior margin ; near the base of this joint is a two-jointed palp with short hairs at its end. The second joint is shorter and carries two setæ near its extremity ; the third joint is longer and at its end has three or four long jointed setæ. The second and third pairs of legs are similar in structure to the first, they are shorter and broader, each carrying an unjointed palp on its basal segment. The fourth pair is short and two-jointed, the second joint carries setæ which radiate round it.

There are two known species of *Bythotrephes*, *B. Cederströmii* and *B. longimanus*. The latter has never yet been found in England. These two species, together with *Polyphemus*, *Pleopis*, and *Evadne*, form the family Polyphemidæ.

Distribution.—I found *B. Cederströmii* first in Grasmere, but subsequently in most of the large lakes in Cumberland and Westmoreland. It lives in the middle of large pieces of water and seems to be more abundant in the autumn than the spring.

Latona setifera Straus (pl. XII. figs. 9–14).

Latona setifera presents several distinctive features from other Cladocera. It is at once remarkable whilst swimming in the water for its rectangular appearance, as seen in fig. 9. Its head is large, and seen laterally (fig. 10) it appears, when compared with those of other Cladocera, to be tilted backwards. The eye is situated at the back, and the brain, which is small, in front; the optic nerves therefore run almost horizontally instead of vertically. The eye consists of a pigment-mass surrounded by a number of lenses which have a slightly reddish tinge. The pigment-spot is small and lies near the brain.

The division between the head and body is well marked. The head has no rostrum, and as it is tilted backwards a large portion in front would be left quite exposed were it not that from the edge of the shell a tongue-like projection extends downwards and covers in all the organs of the mouth. This is a fixed portion of the head unprotected by the shell and is not present in any other known Cladocera.

The shell valves are closely fringed with short setæ along their free margins, whilst at their anterior and posterior angles there are bunches of unusually long setæ ; it is from these that the name of *setifera* has been given to the species. Each seta of the posterior groups springs from a little knob on the margin of the shell, and they present a very beautiful appearance.

The alimentary canal is simple. The labrum covers the entrance of the narrow œsophagus, which leads into the stomach dilated anteriorly; it then runs down without convolution to the anus between the terminal spines; the rectum is muscular, and continually contracting. The heart is at the back, below the division of the head and body. The matrix enlarges laterally, and this helps to give the animal a broad appearance. The size of different specimens of *Latona* varies considerably; it is often as large as 1-10th in. in length.

Appendages.—The first antennæ (fig. 11) are attached to the head near the pigment-spot. They consist of a small joint, followed by a long flagellate segment fringed with fine hairs, which are thickly bunched at the base of the segment. This pair of appendages is almost alike in both sexes. The second pair of antennæ (fig. 12) have a broad stout segment with apparently three branches at its end. On closer examination, however, it is seen that there are only two branches, but that the basal segment of the posterior branch is enlarged and drawn out into a leaf-like portion, as seen in fig. 12. This is found in no other Cladocera. The appendage corresponds to that of *Daphnella*. The anterior branch, as in *Daphnella*, is three-jointed; the first joint is small, the second and third are larger, and carry setæ at their ends. The posterior branch in each case consists of two joints; in *Daphnella* both are fringed with setæ on their anterior edge, whilst in *Latona* the first joint is, as it were, drawn out, and both it and the second are thickly beset with setæ.

The mandibles (fig. 13), maxillæ (fig. 14), and six pair of feet are very similar in construction to those of *Sida*. The first pair is, however, considerably longer. Each of the terminal spines of the post-abdomen has only one small supplementary spine at its base.

Latona setifera more clearly resembles *Sida* and *Daphnella* than any others of the Cladocera, and belongs to the family of the Sididæ.

Distribution.—This species, unless disturbed, lies on its back at the bottom of the water amongst the reeds. In order to obtain specimens, a net must be dragged along so as to scrape the bottom. I found it at a depth of about three or four feet. I have at present only found it in Grasmere and Rydal Water, although I think it would probably be found in the other lakes if properly hunted for. They are not common; I found none in May, and only small quantities in September.

Besides these three species I found many other interesting forms, including *Strebloceros serricaudatus*, which was found for the first time in England last year by the Rev. A. M. Norman. At the top of Langdale Pike, a height of 2400 feet above the sea,

I found *Chydorus* and *Bosmina* in a small pool. I append a list of the species I have already found in the Lake district. This is very incomplete, and does not give any idea of what would probably be found by a more thorough search.

Sida crystallina
Daphnella brachyura
Daphnia pulex
„ *vetula*
„ *longispina*
„ *reticulata*
Hyalodaphnia berolinensis
Bosmina longirostris
Strebloceros serricaudatus
Acantholeberis curvirostris
Eurycercus lamellatus
Lynceus Harpæ
Lynceus macrurus
„ *elongatus*
„ *quadrangularis*
„ *gutatus*
„ *testudinarius*
„ *truncatus*
„ *lævis*
„ *nanus*
„ *globosus*
„ *sphæricus*
Polyphemus pediculus
Leptodora hyalina

XIV.—*On an Improved Method of Preparing Embryological and other Delicate Organisms for Microscopical Examination.*

By Edward Lovett.

(*Read 10th October*, 1883.)

During the progress of microscopical science, that department which relates to the preparation, either temporarily or permanently, of the various objects required for investigation has naturally received a very large share of attention; whilst some workers have devoted the whole of their time and attention to the careful study of this or that particular branch of natural history, others have on their part been the means of bringing the Microscope and its apparatus to its present high state of perfection, whilst others again have sought out the best method for preparing and preserving the countless subjects of microscopical examination.

It is more particularly to the latter branch that my paper refers, although the process which I shall describe was merely the result of a strong desire on my part to preserve the beautiful forms I so constantly met with during my study of the Stalk-eyed Crustacea of the English Channel.

The methods of permanent preparation for the Microscope have until recently been unsatisfactory, except for certain objects, namely, sections and specimens having no thickness; but the old system of mounting whole insects crushed, flattened, bleached and contorted was calculated to lead to error upon error, and it is fortunate that a general wish to mount "without pressure" is rapidly being carried into effect, not only in Canada balsam, but also in various fluids. For minute examination of parts, however, with high powers, the flattened method is of course necessary, though very misleading for general outline, structure, and form.

There are many objects to which Canada balsam could not be applied, and which owing to their great delicacy would never dry for the purpose of being examined as opaque objects, simply because an attempt to dry them would result in their almost complete disappearance, their structure being supported, so to speak, by the water in which they existed.

I refer to the delicate organisms of our seas and more especially to their embryological stage, which renders them still more delicate and fragile.

On the 27th of April, 1877, I collected in Mounts Bay, Cornwall, some egg-capsules of a mollusc *Nassa reticulata*, these I placed direct into Haentsche's fluid and mounted in a sunk cell, using marine glue as a cement and finishing with asphaltum and zinc white.

It was not, however, a success, and for some time I did not attempt the experiment of preserving marine ova. But three or four years later I was brought into constant contact with quantities of marine material, and as I overhauled the so-called "refuse" of scallop-boats for the purpose of selecting the crustacea already referred to, I regretted that some means could not be found for preserving the many beautiful objects that I was obliged to throw away.

Besides this there were so many points of interest connected with the crustacea themselves that required microscopic investigation, that it was absolutely necessary to do something to try and retain them.

Without attempting to go into details, apart from the immediate subject of my paper, I should like here to mention that as regards the crustacea alone, not only is it possible to identify a species by an examination of its ova, but even the habits and mode of life can be in most cases determined by such examination.

As regards fish embryos, the importance of being able to preserve them easily for the Microscope cannot be overestimated, whilst for less important forms the bare fact that the zoœa of crustacea were once thought to form a separate order of animals, shows how necessary a knowledge of such comparatively unfamiliar objects is.

With the desire therefore to retain these ova for microscopical examination, I tried many methods, all of which resulted more or less in failure; the means I now adopt, though perhaps not perfect, is at any rate suitable for the purpose, chiefly I believe owing to the strength of the cement employed. This cement is composed of 2 parts carbonate of lead or white lead, 2 parts red oxide of lead or minium, and 3 parts of litharge or oxide of lead. These parts should be ground very finely, mixed dry, and kept so in a wide-mouth bottle; when required for use, a little of this powder should be mixed in a small china pan with gold size to the consistency of ordinary paint: care being taken that no trace of grit or unground matter exists, for the slightest atom of this will prevent the cover-glass from settling down firmly to the cell, and cause an influx of air at once.

The first operation is to fix a cell to a glass slip by means of this cement; as soon as it is set apply a coat of the cement to the upper surface of the cell and to the outside angle of the same; this done, the slide should be put aside in a dry place to harden, and I consider it best to allow this to occupy a fortnight at least before further use, by which time there will be no fear of any leakage or fault; in fact, the cell will have become so firmly fixed that it can be entirely filed off, if a metal one, without breaking it away from the cement.

The cell having been duly constructed, I scrape round the inner edge with a pointed knife, which removes any foreign matter from the side of the cell and clears away any of the cement which may show itself on the inner angle; after cleaning carefully with a dry cloth, the cell is ready for the reception of the object. Before proceeding further with this stage, I will describe the preparation of the object about to be mounted.

I have already referred to the medium used in this work, which is on the basis of what is known as Haentsche's fluid; namely, a composition of 3 parts absolute alcohol, 2 parts pure glycerine, and 1 part distilled water. I say it is on this basis, for it is necessary to alter the density for certain objects, and I never think of using these proportions for mounting, but simply for preparing for that operation.

Now as regards the necessity for altering the density of the above formula, I find that the proportions mentioned answer very well for parts of the young of Crustacea; for zoœa; for young fish, if more than three or four days old; for nearly all hard ova; for young Echinoderms; for most insects, and for plants excepting the most delicate tissues: but I have found that it often crushes such organisms as the delicate ova of some fishes, the ova of the Nudibranch Mollusca and such fragile substances; so that I reduce the glycerine, and in some cases make the proportions 3 parts distilled water to 1 part each of alcohol and glycerine; but as experience is the best master, it is always as well to find out by practice the proportions best suited to the particular class of object under consideration.

Should the fluid be too dense, the objects will show it by becoming crushed; should, on the other hand, the fluid be too weak to preserve the specimens properly, a tendency to disintegrate and part company will be noticed on their part.

Having provided a number of small corked glass tubes, with numbers on the corks for the purpose of keeping the particulars of their contents in a book of reference—for I must here urge upon marine zoologists the value of keeping a proper record of the date and locality as well as the names of their specimens, for much depends on this—having then prepared the tubes of fluid, the specimens should be dropped in alive, or at any rate in a perfectly fresh condition; this is absolutely necessary with marine organisms, where the decomposition and breaking-up of minute bodies takes place in an incredibly short space of time after death. In shore work or in dredging or trawling a number of these tubes should be at hand, for, however conversant the naturalist may be with the objects of his search, it would be most rash to place all his specimens into one receptacle, with the intention of sorting them out at a more convenient season.

The tubes, having received their occupants, should be kept in a place where they can be easily examined. I find it a good system to rig up a box into divisions by means of double cross strings; by this I can store about five dozen tubes of ordinary size in a box 10 inches by 4 inches, and by means of the number on the cork can abstract any particular tube at pleasure. The reason for being able to obtain easy access to the specimens during their preparation is this: in a short time the fluid will become more or less discoloured, the mature ova of Crustacea are especially liable to cause this; that of fishes gives off a milkiness which would be simply ruinous to a slide, and plants would obviously stain the fluid with chlorophyll. These various discolorations can however be overcome by repeated washings. The tubes should be overhauled occasionally and their contents washed as follows: pour off the discoloured fluid gently, so as not to lose any of the objects, then fill up the tube with distilled water; the specimens, owing to their being charged with a heavier fluid, sink rapidly, and thus allow the tainted water to be poured off; repeat this operation until the water carries off no more extraneous matter, and then pour in some fresh fluid as before. It will be found necessary to allow some specimens to remain in preparation, with periodical washings, for six or eight months, but I have many that have been so treated for two years, with the result that they are exceedingly clear and beautiful. The majority of objects may however be finally mounted in less time, although I do not consider that marine objects would remain clear with less than at least three months of such preparation.

Having thus referred to the construction of the cell and the preparation of the object, I will describe the final stage of mounting.

A cell having been thoroughly cleaned, a rim of cement should be applied to its upper edge, and upon its becoming nearly set, which can readily be noticed by its losing its gloss and becoming dull, the cell should be filled to a convexity with fluid. The fluid I use for this part of the operation differs considerably in density from that used in the preparation of the objects; for instead of 3 parts alcohol, 2 parts glycerine, and 1 part distilled water, I use a fluid as weak in some cases as 6 parts distilled water to 1 part each of alcohol and glycerine. Here again, however, discretion must be exercised, for such proportions are only safe to use when the specimen to be mounted is thoroughly well preserved in the stronger fluid first, and if such be not the case, a stronger mounting medium than this must be made.

Having then filled the cell with fluid, the object should be placed in it and a few seconds allowed for the mingling of the two fluids of different density, which will often set up rotatory motions of a remarkable character amongst the objects. When this motion

ceases, take a clean cover-glass and breathe upon the side intended to come into contact with the fluid, thus enabling it to flow evenly without inclosing air-bubbles; press the cover-glass very gently into the cement, which will cut through the fluid, and attach the cover firmly. Then remove the superfluous fluid by means of a large camel's-hair brush, and lay aside for a few minutes to set, when a stiff coat of the same cement should be applied to the junction of the cell to the cover-glass.

In about a week this structure will have become so hard and tough, that nothing short of actual unfair treatment will damage it, and it may be finished off with such varnishes as fancy may dictate.

I have submitted specimens of my work to the most severe tests, with certainly more satisfactory results than would have been the case with an ordinary balsam or even dry mount.

I inclosed some slides, prepared in this manner, in a tin box, and buried them in frozen snow for twelve hours, from which I had to cut the box out with a chisel; I then placed them in an oven and submitted them to a dry temperature of 140° F. for four hours, at the end of which time the slides exhibited no change or deterioration. The cement itself, when once hard, is so exceedingly powerful, that, as before stated, a metal cell affixed by it to a polished slip can be filed completely away with a heavy coarse file without loosening the cement in the slightest degree: its advantage in being insoluble in the fluid used is also obvious, and I am surprised that it has not been more generally adopted by microscopists, considering its vast superiority over marine glue, or, in fact, over any cement in ordinary use.

The fluid itself, by judicious admixture of various proportions of alcohol, glycerine, and water, can be used satisfactorily for the preparation and final mounting of Fishes, Mollusca, Crustacea, Echinodermata, Insects, Arachnida, and Plants; many of the most delicate of which could not retain any form whatever in a dried state, and would be simply ruined in balsam.

I hope, therefore, that I have been able to show how such delicate organisms may be preserved for microscopic examination in a comparatively simple and easy manner; and as so much attention is just now directed to the very important question of our food-supply as derived from the ocean, there can be little doubt that the study of the early forms of life of our edible fish, mollusca or crustacea, is one of the most useful and valuable to which the microscopist can possibly devote his attention.

XV.—*The Relation of Aperture and Power in the Microscope (continued).**

By Professor E. Abbe, Hon. F.R.M.S.

(*Read 14th June*, 1882.)

II.—*The Rational Balance of Aperture and Power (continued).*

(ii.) *Division of the entire Power of the Microscope between Ocular and Objective.*

Having determined—as definitely as the circumstances will permit—what total power of the *Microscope* is necessary or useful for the utilization of a given aperture, the next question can now be discussed, which is: What power of the *objective* is required for the same purpose?

From the principles on which the former discussion was based, this question has raised a distinct issue. If we find that with an aperture of 0·50 (60°) a total amplification of 265 diameters is required, in order to display the smallest dimensions which are within its reach under a visual angle of 2′, it follows that for the actual effectiveness of that amplification the microscope-system (objective and ocular combined), must so collect the rays in the ultimate image that the image-points shall have sufficient sharpness for the distinct exhibition of details of that small visual angle. The question will therefore be: What composition of the Microscope must be used, and in particular, what power or focal length of the objective is necessary and sufficient, in order to obtain these 265 diameters without an obvious loss of sharpness of the image? If we are able to determine that focal length, we have at the same time assigned the *proper* focal length for the aperture of 0·50.

1. The discussion of this subject is based on the following optical principles:—

(1) If we could obtain lenses or systems, of an ideal perfection, collecting *all* rays to mathematically sharp points without any aberrations, the composition of the whole Microscope would be absolutely unimportant. If the effect of the aberrations is disregarded, *all* functions of the Microscope depend solely on the aperture and the focal length of the *entire* system, and are quite independent of the number and arrangement of its constituent elements. Upon this assumption a given short focal length of the whole Microscope, which means high linear amplification of the ultimate image (which is the quotient of the distance of vision by

* The paper (received 14th June, 1882) is written by Professor Abbe in English. The corrected proof was not received from him in time for insertion in the last number of the Journal.

the focal length) could therefore be obtained just as well by means of a strong ocular at the upper end of the tube, as at the lower end by means of a strong objective. The only reason why a difference of division is of importance, is the *accumulation of the effects of faults and aberrations of the lenses in the ultimate image of the Microscope.* In order to prevent an obnoxious accumulation, and for no other reason, we are confined to certain limits in the distribution of the total power as between objective and ocular.

(2) The ocular is practically unimportant under the actual conditions of the Microscope, so far as the sharpness of the image at the *central* portion of the field is concerned—the quality of the field outside the axis being disregarded. The length of the tube being always a considerable multiple of the clear diameter of the objective, the pencils of light are contracted to very small angles at their entrance into the ocular. The numerical computation of the spherical and chromatic aberrations originating in similar pencils, in the case of ordinary Huyghenian or Ramsden oculars, shows at once that in the neighbourhood of the axis their amount is utterly inconsiderable in comparison with the residuary aberrations of the most perfect objective. Consequently the axial aberrations which are inherent in the *objective*-image, can neither be increased nor diminished by any kind of ocular; they are enlarged only for the eye in the same ratio as the image itself is enlarged. Other properties of the image (outside the axis)—flatness of the field, uniform amplification, &c.—which *are* influenced by the ocular, are doubtless of practical importance in the use of the instrument, but they do not touch the essential points, whether a given degree of sharpness and distinctness is reached with a given power. For it makes no difference, in regard to this question, whether the available field of maximum excellence is somewhat greater or somewhat less. The interference of gross defects of workmanship being, of course, disregarded, the ocular may always be considered as being unimportant except as a means of enlarging the objective-image; and all further discussion may therefore be confined to the circumstances on which the sharpness of that image which is projected by the *objective* depends.

(3) In objectives two different kinds of faults and aberrations must be distinguished. There are, firstly, *accidental* defects, arising from coarse errors of figure and want of centering of the lenses, or from the use of an unsuitable formula, or from temporary derangement of the corrections, as when the cover-glass is too thick or too thin, or the image is projected to a distance other than that for which the system was corrected. Defects of this kind can always be avoided by careful construction and proper management, and are therefore beside the question before us.

Secondly, we have *essential* defects in the performance of objectives; the accumulated influence of certain slight imperfections in the technical work of the lenses and certain residuary aberrations which cannot be eliminated by the most skilful construction under the actual conditions of optical work at the present time. These alone can claim a general signification, and admit of an approximate estimation according to the existing standard of optical art.

In such an estimation we do not need any detailed analysis of the various sources of defective performance. For our present purpose it is quite sufficient to enunciate certain optical propositions, by means of which the problem may be reduced to *one* question, to be answered on the grounds of practical observation.

It may be easily shown, on well-established principles, that with one and the same objective the total effect of all essential aberrations, if measured by the *linear* diameter of the dissipation-circles in the image, always varies *in direct proportion to the linear amplification of that image*, provided the distance to which the image is projected is a considerable multiple (not less than about the ten-fold) of the clear opening of the objective. This holds good (with the restriction just named) for every position of the image, and whether this is changed from a real image to a virtual image, and *vice versâ*—that is to say, that if the linear amplification is increased in the proportion of $1 : n$ by projecting the image to a greater distance from the objective, the dissipation-circles which appear instead of sharp points are always increased in the same proportion, if the accidental aberrations attendant upon the change of the conjugate foci are eliminated. This latter condition means that if an objective has its *best* correction for a certain distance (A) from the back of the objective, and the image is now projected to another distance, n A, on the same side (or on the opposite side, the image being virtual in the latter case), the correction will probably be largely deranged by the alteration, and a large amount of new aberrations introduced thereby. But if this is properly compensated by any of the ordinary means, and the *best* correction for the new position of the image is obtained, the residuary aberration will be reduced to an amount which will exactly correspond with the change in the amplification according to the above rule.*

This statement leads now to several inferences of practical importance, which are:—

(*a*) The total effect of the aberrations (therein including the

* The tacit assumption which is implied in the proposition that the compensation for change of the conjugate foci is always possible, without introducing new aberrations and without altering the focal length and the aperture, may be readily shown to be true under the restrictions in regard to the distance of the images which have been indicated above.

strictly residuary aberration as well as the irregular dissipation of the rays in consequence of technical faults of the lenses) in the ultimate image of the entire Microscope is, *with every given objective*, always proportional to *the total amplification of the image*, and does *not* depend on the length of the tube alone, or the depth of the ocular alone, with which that amplification may be obtained. This is easily seen, if it is borne in mind that the ocular merely effects an enlargement of the objective-image, together with the dissipation-circles which are inherent therein. For if a certain total amplification N—say 500 diameters—is obtained with the whole Microscope, the objective amplifying the object by N′ diameters, and the ocular amplifying the objective-image by N″ (say 50 and 10 respectively), then will $N' N'' = N$, and the linear diameter of the dissipation-circles in the *ultimate* image will be $N''.\epsilon$, if ϵ denote the diameter of the dissipation-circles in the objective-image. If now the same total amplification N should be obtained with the same objective by means of a longer tube and a lower eye-piece, N′ will be increased (say to 100), and in the *same* proportion ϵ also, but N″ will be diminished in the *inverse* ratio (to 5). The product $N'' \epsilon$ therefore retains its former value. But if, on the other hand, the total amplification N should be increased (either by increasing the length of the tube and therefore the value of N′, or by increasing the amplification of the ocular N″), the product $N'' \epsilon$ will vary in the ratio of N, because in the one case the second factor, and in the other case the first factor, are increased in that ratio.

(*b*) According to a fundamental dioptrical proposition, the linear amplification N′ of the image, which is projected by a system of given focal length *f*, is *strictly* determined by the formula

$$N' = \frac{\Delta}{f},$$

in which Δ denotes the distance of the image from the posterior principal focus of the system (the place where rays are collected from distant points in front of the system); and this is the same whether the image be real or virtual. The objective-image of a given system is therefore always amplified in exact proportion to the length Δ; and the linear diameter of the dissipation-circles (ϵ) of that image must also be proportional to Δ, since ϵ is proportional to N′. Taking now the *angular* diameter of these dissipation-circles at the posterior principal focus, i. e. the visual angle under which they would appear *at that place*, this angle must obviously be the same for every position and amplification of the image, because the linear diameter ϵ always varies in direct proportion to the distance Δ. We thus arrive at the theorem:—

If an objective projects a real or virtual image without the

interference of an eye-piece, the visual angle of the dissipation-circles of that image, taken for the place of the posterior principal focus, is the same for every position and amplification of the image, and is a constant quantity in every system.

This proposition shows the method of estimating numerically the degree of optical perfection in objectives. The constant visual angle defined above (which I shall denote by the letter u in the following discussion) exhibits an exact measure of the smaller or greater dissipation of the rays *inherent* in a given construction, and one which is independent of the various accidental circumstances under which an objective performs.

(*c*) Suppose now the angle u (the inherent angular dissipation of the light) to be given for a certain objective, and an image projected by that objective to a distance Δ from its posterior principal focus (which focus is generally in composite systems not very far from the back surface). The linear dissipation of the light in that image will be

$$\epsilon = \Delta u,$$

whilst the amplification of the object is

$$\mathrm{N}' = \frac{\Delta}{f}.$$

This objective-image being observed by means of an ocular of a focal length ϕ, and a virtual image being projected to a distance l from the eye-point (the distance of distinct vision) the linear amplification N'' to which the objective-image is submitted will be

$$\mathrm{N}'' = \frac{l}{\phi},$$

and the total amplification of the ultimate image

$$\mathrm{N} = \mathrm{N}'\,\mathrm{N}'' = \frac{\Delta\, l}{f\,\phi},$$

which is the general and strict formula for the determination of the power of a compound Microscope by means of the focal lengths of objective and ocular, and the distance Δ, which I shall call the optical length of the tube.*

* As the focal length of a composite system is always the quotient of the linear amplification N of the image, by the distance of that image from the posterior principal focus of the system (which is in the case of the Microscope the place of the Ramsden circle above the ocular, or the eye-point, very approximately), we have the *focal length of the entire Microscope*

$$\mathrm{F} = \frac{l}{\mathrm{N}} = \frac{f\,\phi}{\Delta},$$

where the length Δ may be defined now as the distance between the *posterior* principal focus of the objective and the *anterior* principal focus of the ocular, because this latter focus must coincide with the objective-image (very approximately at least) in order to obtain the ultimate virtual image at a considerable distance.

At the same time we obtain the *linear* dissipation of the light at the ultimate (virtual) image, owing to the simple enlargement of the circles ϵ through the ocular,

$$\mathrm{E} = \mathrm{N}'' \epsilon = \epsilon \frac{l}{\phi},$$

or

$$\mathrm{E} = \frac{\Delta}{\phi} l u.$$

The *angular* diameter of the same dissipation-circles in the visual image is therefore

$$\mathrm{U} = \frac{\mathrm{E}}{l} = \frac{\Delta}{\phi} u,$$

which shows that the enlargement, by the action of an ocular, of the dissipation-circles which are inherent in a given objective, is numerically expressed by the quotient of the optical length of the microscope-tube by the focal length of the ocular.

If, for example, an objective of any kind be used with an ocular of say 1 inch, the length of the tube being such that the anterior principal focus of the ocular is 10 inches above the posterior principal focus of the objective, we shall have the *optical* length of the tube $\Delta = 10$, $\phi = 1$, and the quotient will yield the number 10; and this will express the fact, that under these conditions the dissipation of the light in the ultimate image of the entire Microscope has a visual angle ten times as large as any image which is projected by the same objective without an eye-piece. This result, obviously, does not depend on the supposition of any definite distance of projection (l). The same will hold good for every position of the image, be it a virtual image (as in the ordinary use of the Microscope) or a real one, as is the case when the image is projected by objective and ocular conjointly on a screen or photographic plate.

The foregoing proposition admits, however, of a simpler and more expressive enunciation still, which is shown by the above formula for the amplification of the entire Microscope:

$$\mathrm{N} = \frac{\Delta}{f} \frac{l}{\phi},$$

which may be written:

$$\mathrm{N} = \frac{l}{f} \frac{\Delta}{\phi}.$$

In this equation the quotient $\frac{\Delta}{\phi}$ (which may be denoted by the letter ν) is one factor of the total amplification N; and the other factor $\frac{l}{f}$ indicates that amplification which the objective alone will

yield for the same distance of projection (l). The value of $\frac{l}{f}$ which I shall denote by the sign [N] may be conveniently called the *normal amplification* (the *own proper* amplification) of the ob-objective, because it is realized when the objective is used without an eye-piece, as a "simple Microscope."

We have now

$$N = [N]\nu$$

and conversely

$$\nu = \frac{N}{[N]}.$$

The value of ν, which was defined above by the quotient $\frac{\Delta}{\phi}$, and which indicates the enlargement of the dissipation-circles by the ocular, is therefore also the quotient of the total amplification of the Microscope by the normal amplification of the objective, and thus expresses the *increase of power*, beyond the normal power of the objective, which is obtained in the compound Microscope by the tube and ocular combined. I shall, therefore, call the quantity ν the *super-amplification* which is applied to a system, or which it has to bear when it is the objective of a compound Microscope with a given length of the tube and a given ocular.

We arrive now at the proposition:—When an objective (for which the constant visual angle of the inherent dissipation of light is given) is used with any length of tube and with any power of the ocular, the angular dissipation is always increased in the ultimate image in proportion to the super-amplification which the objective has to bear, i. e. according to the quotient of the total amplification of the Microscope by the normal amplification of the objective.

The foregoing considerations lead to a comprehensive expression and measure of the combined effect of tube and ocular in the compound Microscope, which holds good (as may be shown) in regard to *all* functions of the instrument. If, for example, we know that the objective of a Microscope has a focal length $f = \frac{1}{2}$ inch—which gives the normal amplification [N] = 20, for a distance of vision $l = 10$ inches—and that this objective is used for a power of N = 200, we have a super-amplification $\nu = 10$. We have thereby analyzed the composition of the total power of the instrument as between objective and ocular, or the manner of co-operation of these two elements of the composite system, in quite a general manner; and we know that all essential conditions of the optical performance remain the same as long as the same value of ν is maintained, whatever may be the particular conditions as to length of tube and depth of ocular. At the same time we have established a numerical test of the *strain* to which an objective must be submitted in order to obtain a certain total power of the Microscope. We know that

if an amplification of 200 is required with a 1-inch instead of a 1-2 inch as in the preceding example, the necessary super-amplification will be = 20, and all aberrations and other defects inherent to the system will appear in the image under twice the visual angle of that in the other case.

(*d*) In order to compare the performance of *different* objectives under various powers, it will be necessary and sufficient, according to the foregoing theorems, to determine for any given system the constant quantity u, by which the inherent dissipation of the rays is measured.

One part of this problem may be settled by means of the following proposition:—With objectives of equal aperture, similar construction, and equal degrees of technical excellence, the constant visual angle of the dissipation-circles is always the same *and independent of the focal length.*

This may be proved by a very simple consideration. Suppose a system A of a certain aperture and given focal length f to be brought to the best possible correction of which the construction may admit for a certain distance of the image. Another system B of exactly similar composition may now be obtained by reducing the linear measures of *all* the elements (all radii, diameters, distances, &c.) and all technical defects of figure and positions of the lenses in the same proportion (say, e. g., of 2 : 1), just as if the diagram of the system and the transmitted rays had been drawn on a reduced scale. The focal length will thereby be changed in the same proportion ($f : \frac{1}{2}f$) and also the distances of the conjugate foci of best correction; but the aperture will not be changed, and the angles of all emerging rays—of regular or irregular transmission—will be the same as the angles of the corresponding rays in A, by virtue of the strict geometrical similarity of all the elements. If now the space over which the rays of *one* pencil are dissipated at the image of A, subtends a certain angle u in regard to the posterior principal focus of A, the same angle u must obtain for the image of B in regard to the corresponding principal focus of B; and that angle u must persist, as has been shown, if B should afterwards project an image to any other distance (e. g. at a corresponding distance to A), provided the best correction for the new position of the conjugate foci be obtained. Consequently the angular value of the dissipation-circles (u) is the same for all *similar* systems, however different the focal lengths may be.*

* Strict similarity cannot of course obtain, except when the distances of the conjugate foci, for which the objective is corrected, are proportional to the focal length. We may, however, disregard all differences of construction which could be effected, or undone, without introducing new essential aberrations; and those changes of a system which are necessary in order to compensate for different

Though this proposition allows a comparison of those objectives only which have equal apertures and are of similar construction, it leads to important inferences. Firstly, it shows that the characteristic constant quantity u, which is the "measure of perfection" of the objectives, does not require a separate determination for every single system. If the value of u be known for one system, it is known for all systems *of the same kind*, i. e. for all which have the same aperture, are constructed on a similar formula and with an equal degree of technical skill. Secondly, the proposition indicates the method by which a direct comparison of objectives of *different focal lengths* may be obtained in regard to the *quality* of images of equal amplification.

Suppose the angular dissipation of the light—the constant angle u—to be given for a particular kind of objectives of definite aperture. If any one of these objectives has a focal length $= f$, its normal amplification is $[\mathrm{N}] = \frac{l}{f}$ (l = 250 mm. or 10 inches). If now the total amplification of the Microscope is required = N, the necessary super-amplification to which the said system must be subjected will be

$$\nu = \frac{\mathrm{N}}{[\mathrm{N}]} = \frac{\mathrm{N}}{l} f,$$

and this super-amplification will introduce an angular dissipation of the rays at the ultimate images, which is shown by the expression

$$\mathrm{U} = \nu u = \frac{\mathrm{N}}{l} f u.$$

Consequently: For objectives of the same kind and the same aperture, but with different focal lengths, the manifestation of the inherent defects and aberrations under a given power of the Microscope is always in direct proportion to the focal length (or in the inverse proportion of the objective-power) by which such amplification is obtained.

2. If we could suppose objectives of ideal perfection—absolutely free from all technical defects and all unavoidable aberrations—the

positions of the image, belong to that kind. The proposition will therefore hold good for all objectives of a *similar formula* and equal aperture.

The assumption of a proportionate reduction of the geometrical defects (defects of figure, centering, &c.) with decreasing focal length, which is implied in the demonstration above, will not be in full accordance with the actual circumstances. In practice the *relative* accomplishment of smaller lenses will be inferior to that of larger ones. According to the experience of the author, the difference is, however, not very considerable except when the dimensions are very minute. Though some difficulties of exact workmanship are increased with smaller dimensions, there are others which are diminished; and the relative amount of those defects which cannot be overcome by careful and skilful work, may therefore be considered as nearly equal for all focal lengths, within rather wide limits.

quantity u would be $= 0$. In that case the dissipation of the light at the ultimate image of the Microscope would also $= 0$, i. e. the image would retain its full ideal perfection, with every amount of super-amplification; and it would, therefore, be entirely unimportant whether a certain total power had been obtained by an objective of long or short focal length. If, however, the objectives in question are afflicted with certain defects, however small, the quantity u will obtain a certain value; and the dissipation of the rays corresponding to that value, being more and more enlarged as the super-amplification is increased, there must always exist a certain maximum super-amplification or value of v which the objective will bear without a visible or an objectionable loss of sharpness or perfection of image. Consequently we have a maximum of the total amplification N which can be obtained with a given focal length under the condition of a certain degree of sharpness of the image; and, conversely, a maximum focal length which admits of a given amplification under the same conditions. If, for example, the inherent dissipation of a certain kind of objective were confined to an angle of 15″, no eye would recognize the dissipation-circles if such a system were used only under its own normal amplification (using it as a simple Microscope). The dissipation would, however, become visible, and would introduce a perceptible indistinctness of the image, if the super-amplification much exceeded 4, and the deterioration would become very great should it amount to 16, because in these cases the circles of indistinctness would be displayed in the respective ultimate images under a visual angle of more than 1′ and of 4′. If now a certain amplification, say 320 diameters, is required with objectives of that degree of perfection, a 1-8th inch would yield that number with a super-amplification of 4, but a 1-2 inch would require 16; the perfection of the image in the latter case being very much less than in the former.

It would be useless to attempt to assign by way of example numerical values of the constant u for different kinds of objectives, and of the limit of U which would be consistent with a sufficient perfection of the image, in order to compute theoretically the amount of super-amplification which every objective would bear. The circumstances on which the first two elements depend, are much too complicated for a theoretical estimation of their influence in regard to the actual performance of the Microscope. Nevertheless, the foregoing considerations indicate the aim of the problem, which is to determine the adequate focal length for every aperture. It will be quite sufficient for our purpose to determine the limits of admissible super-amplification *directly* by practical observations, without further caring for the elementary conditions on which it depends; and if this is done, we have obtained all necessary data for the problem under consideration.

Having already settled the total amplification N, which is required for the utilization of a given aperture,* we need only to find the super-amplification ν which an objective of that aperture will bear, without a perceptible depreciation in the quality of the image if objectives up to the present standard of excellence are supposed. The quotient $\frac{N}{\nu}$ will then indicate at once the normal amplification [N] of the objective which is necessary in order to obtain the said N under the best possible conditions; and having thus determined [N], the quotient $\frac{l}{[N]}$ will yield the focal length which an objective of the aperture in question ought to have for utilizing the delineating-power of that aperture in the most favourable manner. (The focal length thus assigned for a given aperture will be expressed by millimetres or by inches, according as l is taken $= 250$ mm. or $= 10$ inches.)

Though the problem in this way leads us to practical questions which are to be answered by observation, apart from all theory, it will not be useless to point out some theoretical considerations which may elucidate certain experimental facts, or guide the observer in experiments on that subject.

(a) One fact which we may foresee in theory, is that the limit of useful super-amplification must depend on the *aperture* of the objectives, and that the former must diminish with increase in the latter. The greater the aperture the wider the range for the deviation of the rays from the ideal collection of the pencils to mathematical image-points. All technical faults of the lenses—slight defects of figure and of centering—must give rise to increased deviations, and therefore to an increased amount of their accumulated effects, because the clear diameter of the lenses which transmit the pencils bears a greater ratio to those radii of curvature which are required for the wider aperture. Exactly the same holds good with the strictly residuary aberrations which are the predominant source of defective performance in modern objectives (the unavoidable technical faults being much less apparent with the excellence of workmanship which has now been attained).

The sources of the residuary aberrations in question are perfectly well known in theory. Some of them result from the disproportionate increase of the positive and negative spherical aberrations in different parts of the system, arising from the increase of obliquity and in regard to different colours, which disproportionality prevents a strict compensation of the opposite spherical aberrations even for the rays of one colour and gives rise to still more considerable residuals in the totality of the rays of mixed light.

* See this Journal, ii. (1882) p. 463.

Other defects arise from the disproportionate increase of the dispersion from the red to the blue, which is found in all kinds of optical glass hitherto produced, and forbids a really perfect chromatic correction of the systems. In regard to all of these aberrations it may be readily shown that they *must* introduce greater and greater uncorrected residuals as the numerical aperture of the cone of collected rays is more and more increased, other circumstances being equal.*

It is therefore obvious that under equal conditions of technical construction the inherent dissipation of the light will always be greater with the wider apertures, and consequently the super-amplification which is compatible with any given degree of precision of the image will be confined to a *lower* figure with objectives of wide than with objectives of low aperture, which inference is fully justified by experience.†

(*b*) On the other hand, theory indicates different conditions for the residuary aberrations, with even the same (numerical) apertures, when objectives of *different systems—dry and immersion*—are compared. The uncorrectable residuals of the aberrations will always be greater when the total amount of aberrations requiring correction is greater. Now the front-aberration, which is a very predominant part of the total amount in dry lenses of somewhat wide aperture, is considerably diminished with water-immersion and almost entirely suppressed by the homogeneous-immersion system. We expect therefore a higher value of admissible super-amplification in the case of homogeneous immersion than in that of water-immersion; and a still higher for water-immersion than for dry—provided always that objectives of the same (numerical) aperture are compared; and conversely, one and the same super-amplification

* That the numerical aperture is the essential element and *not* the aperture-angle, results from the fact that all the effects considered above depend on the proportion of the clear aperture to the focal length of the objective, which proportion is exactly expressed by the numerical aperture.

† The above statement does not of course imply the opinion, that an objective of lower aperture should, under *all* circumstances, admit of a higher super-amplification practically than one of wider aperture. The "definition" of a lens, in the generally adopted sense, is quite another thing to the dioptrical precision of the image, which is in question here. There may be lack of "delineating power" when a certain amplification is reached, and then every increase of the amplification renders the impression of the image worse and worse, notwithstanding the utmost perfection of the dioptrical performance of the lens. If, for instance, an objective of 0·1 N.A. were made with the short focal length of a 1-8th, it would not bear even the lowest eye-piece, because the normal power of the system (80 diameters) is already an empty power for so narrow an aperture, whilst a well-made 1-8th of 0·8 N.A. will give a satisfactory image with a relatively strong ocular. If, however, an objective of 0·1 N.A. has a focal length of say 1 inch, it will bear a deeper eye-piece than a 1-8th of 0·8 without any perceptible loss of sharpness. In order to compare microscopic images in regard to their dioptrical conditions, the strange element of "lack of definition of empty powers" must be excluded.

will admit of an equal degree of perfection of image with a greater aperture in objectives for homogeneous-immersion than in water-immersion or dry lenses—which is also in accordance with the facts.

(*c*) Another point which deserves particular attention in every attempt to assign the proper relation of aperture to power, relates to the great influence of the *illumination* and the *nature of the object* on the visibility of the residual defects of the objectives. If we could determine numerically the inherent angular dissipation of the rays (the angle u) for a given objective, either by computation or by experiment, the value of u would then indicate the visual angle of the circles of indistinctness in an image which is obtained under the normal amplification of the objective (if, for instance, the objective were used without an eye-piece, as a hand-magnifier) and $U = \nu u$ the same visual angle for a super-amplification of ν—but both elements under the obvious supposition, that the *whole* pencil of light which is collected by the objective, is under comparison, or the full area of the aperture effective at the same time. If in any particular case a portion only of the clear aperture should be utilized by the delineating pencils, the actual dissipation of the light will of course be confined to more or less small spots than would correspond to the angles u and U, and would accordingly become less apparent. In the practical use of the Microscope we always have very variable conditions, according to the illumination in use and the structure of the objects under observation. With very low apertures the range of difference is not so great, it is true, because the illuminating cone of light will generally fill the whole aperture, or at least the greater part of it. But with wide-angled objectives the incident beam from the illuminating apparatus is—and in most cases must be—confined to a much narrower angle than the aperture of the system. How much of the aperture is actually utilized by the delineating pencils will entirely depend on the dissipation of the incident rays by the structure of the object—in particular the diffraction effect of the structure; and according as the illuminating cone, after its transmission through the object, is spread out to a smaller or greater angular extension, smaller or greater aberration-circles will disturb the image. Thus it may happen that with one kind of preparation an objective may bear a deep ocular very well, whilst with other objects a great deterioration of the image becomes visible under even a lower ocular. Objects which show a regular striation, and in general all regular periodic structures, are particularly *insensible* to the residuary defects of the objectives, because they produce only a limited number of *isolated* diffraction-beams, and thus leave the greatest part of the objective's aperture entirely unemployed. In observing an object with only one set of parallel lines which are near the limit of the resolving

power of the objective, only two small portions of the aperture are simultaneously utilized, one by the direct beam, the other at the opposite edge of the opening by the diffracted beam, as may be ascertained by a glance at the objective's clear aperture. All defects and aberrations of the system which inhere in the inactive portions, do not exist for the image in that case, whilst they will at once become effective when those objects of a very complicated and irregular structure, which produce a continuous and widely spread out diffraction-pencil, are observed. This consideration will show that the ordinary test-objects of the Microscope—particularly lined objects, and in a somewhat less degree all kinds of diatom markings—are the most unsuitable preparations for a proper judgment of the performance of the instrument in regard to the *general* conditions of scientific work inasmuch as the latter are always much less favourable than those of diatom observations.

3. In the face of the many intricate circumstances hinted at in the foregoing discussions, a *numerical* estimation of the super-amplification which is favourable or even admissible with various kinds of objectives, must be a very difficult if not impossible task. It would rarely be possible to assign any measure which would receive the general assent of microscopists, because so many elements are concerned in the question which cannot be estimated apart from the individual opinions of the observers.

One particular difficulty in observations for this purpose is to decide whether a given objective is really up to date or is afflicted with accidental defects, which might be avoided by more accomplished workmanship, and must therefore be disregarded. Another drawback to an accurate estimation arises from the before-mentioned very different sensibility of the image to difference of structure; and not the least of all is the large amount of personal equation which is always met with, when a judgment as to difference of quality has to be formed in regard to microscopic images. Moreover, every one who estimates the value of the element in question must be conscious of its provisional character. For whilst the amount of super-amplification which a system is able to bear with a certain degree of perfection of the image is the true standard of the progress of microscopical optics, the determination of the said element cannot claim anything more than a temporary value: those figures of ν which may very well conform to the present conditions will not be true for the Microscopes of a former period, and will perhaps be upset within a few years by the further progress of optical science and art.

I have now made observations for the purpose in question during many years—studying the performance of a large number of objectives of various kinds and various origins, upon very dif-

ferent objects (artificial preparations and natural objects), and checking my own observations by the judgments of some experienced working microscopists in the department of Biology. What I consider as the outcome of that systematic trial will be briefly indicated here, with all that reserve which is necessitated by the nature of the problem. The principal points are :—

(1) With the best *wide-aperture* objectives which have been made anywhere up to the present time (1882), dry or water-immersion, of apertures not less than 0·80 and 1·10 respectively, the deterioration of the image by the manifestation of aberration-effects becomes visible as soon as the super-amplification (ν) in use is greater than about 4 times ;* that is to say, that any trained observer would recognize a decided falling off in sharpness and definition in the images in comparing two objectives of equal aperture under the same total power, when that power is obtained with one objective (of shorter focal length) by a fourfold super-amplification, and with the other (of longer focal length) by a perceptibly higher one, e. g. sixfold; and that the *advantage will always be found on the part of the lower ocular-power*—whilst *no* advantage will be gained when the same power is obtained with a still more diminished value of ν (less than 4). It being of course always understood that objectives of equal and best attainable construction are compared on sensitive objects, and that only the central portion of the field of vision is considered.

For example, if a total amplification of 480 diameters is obtained in one case with an objective of 1-12th in. focal length, and in another case with an equally good 1-8th of the same aperture—the figures of ν being now 4 and 6 respectively—my view is that no practical microscopist would hesitate to declare the image of the 1-12th to be the *better* image; provided suitable preparations (of complicated structure) be observed; though *not* probably on simply lined objects and perhaps not on diatom-markings of any kind. On the other hand, no decided advantage of any kind will be recognized if, instead of the 1-12th, a 1-18th or 1-24th of equal aperture is used for obtaining the same power of 480 diameters, with of course lower ocular powers.

Hence it appears that the inherent dissipation of the rays arising from technical defects and residuary aberrations remains, in carefully finished wide-angled lenses of the dry and the water immersion-system, below the threshold of distinct vision as long as it is not enlarged by more than four times, but it is elevated beyond that threshold with every greater enlargement. That

* I leave out of consideration here some particular objectives (recorded in this Journal, vol. ii. (1879) p. 815) which were made some years ago by C. Zeiss, for experimental purposes, on a system of construction which is not applicable to, and was not intended for, regular use.

my observations do not indicate a decided difference between dry and water-immersion lenses may be well accounted for by the fact that the advantage of diminished front-aberrations in the immersion system is balanced by the increased aperture. With immersion-lenses of not more than 1·0 or less (other circumstances being equal), a somewhat higher value of ν would be found. On the other hand, I have always observed a perceptible lowering of the *critical* super-amplification with objectives of greater apertures than 0·90 for the dry system, and of 1·20 for the water immersion, when preparations are used for the experiment which put the utmost marginal zone of the aperture in action *simultaneously* with the intermediate portions between the centre and the margin.

(2) A decided advance in the performance, in regard to the critical value of ν, is found in well-made objectives of the homogeneous-immersion system. With the same standard of judgment, and on the same principle which has been explained above, I consider a super-amplification of about 6 as that which will just raise the inherent aberrations up to the threshold of vision, for an aperture of about 1·30.* It appears quite intelligible that the total (or nearly total) suppression of the front-aberrations should not only compensate for the increased aperture but in fact should leave a surplus benefit, as is indicated in the higher value of ν.

(3) Regarding the lower apertures of the dry system, my comparisons show a relatively *slow* increase of the critical ν, as the apertures diminish. This may be sufficiently accounted for by the circumstance that these lower apertures are always made with relatively greater working-distance (the *clear* air-space between the front surface and the radiant being a greater fraction of the focal length) than is adopted in the wide-aperture systems.

The relief to the front-aberration, and the corresponding reduction of the residuary aberrations, which is due to the reduction of the angle of the pencil, is therefore partly compensated by the

* If any one should wonder at the *low* super-amplifications assigned here, and should consider the above statements to be poor evidence of the present condition of microscopical optics, I would ask him to reflect upon what it means, that objectives even of rather short focal length should bear a super-amplification up to 4 and 6, without any perceptible injury to the sharpness of the image. This means nothing less than that the Microscope is capable of showing objects enlarged to more than 800 diameters under the same conditions, so far as the geometrical precision of the observation is concerned, as if the microscopic objects could be enlarged in that degree *corporeally*, not optically, and were then seen with the naked eye at a distance of 250 mm., without the interference of any optical apparatus. Up to those high figures of amplification the modern Microscope maintains therefore the undiminished sharpness of naked-eye vision, and performs without any perceptible difference in the same way as if material bodies, instead of mere enlarged images, were depicted upon the retina. The time is not long past when no system, except very low-angled lenses, could bear even its own proper power without any super-amplification, and not 100 diameters could then be obtained without great inferiority when compared with direct vision.

increased aberration attendant upon a relatively thicker air-space in front of the system. Considering the medium-power objectives as they are generally (and properly) made with the view to a convenient working distance, I cannot admit of a higher number for the critical ν than 5 to 6, even for apertures down to about 0·40 (47°). If the aperture is reduced below this, the increase of ν becomes decidedly more rapid, in so far that for 0·15–0·20 N. A. (17°–23°), 8 to 10 appears to me to be the correct super-amplification which very good objectives will bear without a perceptible loss of definition (under the condition, of course, that the total powers obtained thereby are not empty powers in regard to the delineating capacity of the aperture in question).

Similar indications for still lower apertures would be of very subordinate interest; and, besides that, they could not be given on the basis of reasoning established here, which depends on the condition of a *constant* visual angle of the inherent dissipation of the rays for different distances of the objective-image. This condition (as has been observed) holds good with sufficient approximation only as long as that distance—the length of the microscope-tube practically—is not *too* small a multiple of the focal length of the objective; this is *not* fulfilled, under ordinary circumstances, with the very low-power systems which would come in question for apertures of only a few degrees.

4. The values of ν assigned above for different kinds of objectives express, in my opinion, the conditions of the *best possible* performance of the Microscope under present circumstances. I by no means contend, however, that much higher super-amplifications might not still be very useful; but if it cannot be denied that with the objectives which are made at this date, a *better* image is obtained under a four-fold, or six-fold, super-amplification than can be obtained under a higher figure, it is absolutely certain that the lower powers ought to be used, when the *utmost attainable degree of perfection* is required. It is quite immaterial for that conclusion, whether the loss of sharpness ("definition") attendant upon higher values of ν, may be deemed small or great, and whether it may become obvious with all preparations or with a few only. If there *is* a loss, however small, and if only *one* kind of object is found with which it can be perceived, this alone will be sufficient to prove the advantage of the lower numbers; for there cannot be a reasonable doubt, that even the slightest difference in the perfection of the microscopic image may become a matter of decisive importance in critical cases of difficult research.

The conclusion from the foregoing experimental facts must therefore be:—

In order to obtain the best possible conditions for the utilization

of the delineating capacity of any aperture, the focal lengths of the objectives must be sufficient to yield those powers which are necessary for distinct vision of the least details, with no greater super-amplification than is indicated by the critical values of ν defined above.

We shall therefore arrive at the point which is the aim of the whole discussion—the determination of the proper focal lengths for the various apertures—by tracing the practical inferences from this principle.

(1) The maximum apertures of the various systems—dry, water-immersion, homogeneous-immersion (for crown glass)—which are fit for ordinary use, may be approximately assigned by the numbers

$$\alpha = 0{\cdot}90 \qquad \alpha = 1{\cdot}20 \qquad \alpha = 1{\cdot}35$$

because apertures which approach the ultimate limit of any system by less than about 10 per cent. cannot at all events be satisfactorily used for regular scientific work. The critical values of ν for these apertures may be put, as has been pointed out,

$$\nu = 4 \qquad \nu = 4 \qquad \nu = 6$$

The total powers which are *necessary* for the proper utilization of the same apertures are shown by the fourth column of the first table (Vol. II. 1882, p. 463), inasmuch as no observer of normal eyesight will be able to recognize *distinctly* details under a smaller visual angle than 2′ of arc. Adopting the figures of the table in round numbers, we obtain therefore the normal amplification [N] which is required for the wide-angled objectives of the various systems—

$$\frac{480}{4} = 120 \qquad \frac{640}{4} = 160 \qquad \frac{720}{6} = 120$$

and consequently the focal length $\left(f = \frac{l}{[N]}\right)$

2·1 mm. = 1-12th in. 1·56 mm. = 1-16th in. 2·1 mm. = 1-12th in.

According to the views developed above, objectives of these short focal lengths cannot be dispensed with, under the *present* conditions of microscopical optics, for those lines of scientific work in which it is of importance to obtain the *best possible* quality of the image (sharpness, definition), viz. such a degree of dioptrical perfection of the image as is not perceptibly inferior to the naked-eye vision of real objects, even on sensitive preparations.

As has been previously observed, higher powers than are strictly necessary for exhausting the attainable apertures, are desirable, and even indispensable, for many particular purposes. These may be obtained satisfactorily by using higher super-amplifications with the same objectives. Inasmuch as in that case the aim is merely

to enlarge the image without displaying *new* details of the objects, the increase of the dissipation-effects with increasing ν is not a serious drawback, because the visual angle of the minutest detail is increased in the same proportion. Though the absolute precision of the image will be diminished under the higher ν, the *relative* will remain the same, and must still be sufficient for the more enlarged image if it was sufficient for the less enlarged. Now as *twice* that super-amplification which raises the defects of the systems just up to the threshold of vision, is always borne by objectives without any considerable or objectionable loss of definition, the increase of the ocular-power alone will be sufficient for reaching the *upper* limit of generally useful amplifications for the various apertures which is shown by the fifth column of Table I. Nevertheless it may be desirable that such higher powers should be occasionally obtainable under still more favourable conditions, that is with the lowest figure of ν. I admit, therefore, that objectives of shorter focal lengths—down to *half* the values assigned above at the utmost—may still be useful for the *immersion*-apertures. (Not for *dry* lenses, because it would be decidedly irrational to force such high amplification from apertures which leave the delineating power much below the attainable limit.)

On the other hand, it is quite certain that even the minimum powers which are required for the utilization of the said apertures, may be obtained under much higher super-amplification with a sufficiently satisfactory quality of the image, when the *utmost* degree of perfection is not required or when objects of less sensibility, e. g. diatoms, are in question. Twice the critical value of ν (i. e. 8, 8, 12, for the three systems respectively) will, however, be the limit in regard to objectives intended for somewhat general application, and $2\frac{1}{2}$ (i. e. 10, 10, 15 respectively) the utmost admissible figure in regard to lenses for diatom work (the minimum amplifications, 480, 640, 720, being regarded); because if still higher ocular-powers should be required even for these minimum amplifications the deterioration of the image, attendant upon the enlargement of the aberration-circles, will become so perceptible, even with the least sensitive objects, that satisfactory recognition of the minutest details must be unquestionably lost. Though the details which are within the reach of the aperture may still be *seen*, the quality of the image will be so much inferior to that obtained by higher objective-powers and lower ocular-powers that it is obviously unwise to obtain under unfavourable conditions what may *as easily* be otherwise obtained. I must therefore consider as irrational constructions all those wide-angled lenses which do not yield even the lowest total power required for proper utilization of the aperture, except by a still greater amount of eye-piecing than is assigned above.

With these various concessions to personal customs and to particular purposes, the principles established here appear to be reconcilable with a rather wide latitude in their practical application. The *normal* focal lengths for the wide-angled objectives of the three systems being taken as above, we have the admissible maximum values of f (or minimum powers):

Dry.	Water-immersion.	Homogeneous-immersion.
$5{\cdot}2$ mm. $= \frac{1}{4{\cdot}8}$ in.	$3{\cdot}9$ mm. $= \frac{1}{6{\cdot}4}$ in.	$5{\cdot}2$ mm. $= \frac{1}{4{\cdot}8}$ in.

And the minimum values of f (or maximum powers):

$2{\cdot}1$ mm. $= \frac{1}{12}$ in. $\qquad$ $0{\cdot}78$ mm. $= \frac{1}{32}$ in. $\qquad$ $1{\cdot}05$ mm. $= \frac{1}{24}$ in.

(2) As to those objectives which do not aim at the attainable maximum of delineating power, the discussion may be confined to the dry lenses, because in practice the other systems are not in use with much lower apertures (which is of course very prudent). In order to determine now the proper gradation of the focal length for the lower apertures of the dry system, the figures of ν must be determined which correspond to the different apertures. These values, as has been pointed out above, depend on many circumstances besides the aperture—particularly on the type of construction and (in the higher and medium apertures) the ratio of the working distance to the focal length. It will be impossible, therefore to assign values of ν which could claim a general acceptance, even for one standard of estimation. Any definite aperture (with the exception of very low ones) will admit of a higher super-amplification if realized in a triple system than in a system of two lenses only, and at the same time (once more with that exception) of a still higher one, when the system is made with relatively short working distance, the best possible constructions being always supposed. In order to obtain any numerical data at all, I must therefore confine myself to a few particular kinds of objectives, which conform to those generally adopted standards of construction which may be considered as typical. With this view I have submitted to a careful trial *two* kinds of objectives: for the medium apertures, triple systems of about $0{\cdot}50$ aperture, with single plano-convex fronts and a working distance of about one-fifth of the focal length; for the small aperture, systems composed of two compound lenses with an aperture of about $0{\cdot}15$ and a working distance of about one-third of the focal length. Having compared a considerable number of specimens of both types of widely different origin (all being excluded which exhibited any defect of correction or technical construction), I found the critical super-amplification for the first type ($a = 0{\cdot}50$)

$\nu = 5$, and for the second type ($a = 0{\cdot}15$) $\nu = 9$ in round numbers.*

Combining these values with the figure of ν assigned above for the apertures 0·85–0·90, we have obtained a numerical determination of *three* points of the series of apertures in the dry system; and we shall arrive at an approximate estimation for the intermediate points by interpolating the values of ν between the said three points. The annexed tabular statement exhibits in the fourth column

PROPORTION OF APERTURE AND FOCAL LENGTH IN A NORMAL SERIES OF DRY LENSES.

Numerical Aperture, a.	Aperture Angle (air).	Total Power corresponding to a, N.	Critical Value of the Super-amplification, ν.	Objective Power required, [N].	Focal Length required, f.
					mm.
0·10	11°·5	53	10·0	5·3	47·2
0·15		79·5	9·0	8·8	28·4
0·20	23·0	106	8·2	12·8	19·4
0·25		132	7·4	17·9	14·0
0·30	35·0	159	6·7	23·7	10·5
0·35		185	6·1	30·4	8·2
0·40	47·0	212	5·6	37·9	6·6
0·45		238	5·3	45·0	5·5
0·50	60·0	265	5·0	53·0	4·7
0·55		291	4·8	60·6	4·1
0·60	73·7	317	4·6	68·9	3·6
0·65		343	4·4	78·1	3·2
0·70	89·0	370	4·3	86·0	2·9
0·75		397	4·2	94·4	2·65
0·80	106·3	423	4·1	103·2	2·42
0·85		450	4·0	112·4	2·22
0·90	128·3	476	4·0	119·0	2·10

the series of ν which results from the data given above, if the interpolation is made by means of a parabolic curve. The third column repeats the figures of the minimum total amplification N required for the various apertures, according to Table I.; the fifth column shows the objective-amplification [N] which results from the corresponding value of ν; and the sixth column gives the focal length f which will afford that objective-power in every single case. Retaining fractions in the values of ν and f, whilst the basis of the calculation is not determinate, has of course no other purpose than to prevent arbitrary leaps in the series of figures, which, according to the nature of the case, must show a continuous gradation.

According to the observations from which the figures of ν have

* The observations mentioned above were made several years ago, 1874–5. In the mean time nothing, however, has occurred which can have changed the essential conditions in regard to the construction of dry lenses.

been derived, *triple* systems of moderate working distance must be supposed down to apertures of about 0·3, and *duplex* systems for all the lower ones which are considered here. The medium apertures, if realized with two lenses only, and the lower ones, if realized with single lenses, would show *considerably* smaller figures of v than are given above. On the other hand, triple systems with apertures much below 0·3 do not afford any perceptible increase of the admissible super-amplification—a fact which is well accounted for by the theory of the aberrations.

So far as the basis of my reasoning is admitted as valid, the table given above will exhibit the proper ratio of aperture to focal length in an *ideal* series of dry objectives of increasing apertures, traced out in *strict* conformity to the principle that every objective should yield, under the *best possible* conditions, such a total amplification as is *just* sufficient for fully exhausting the delineating power of its aperture—wherein "best possible conditions" means that no higher super-amplification, by tube and ocular combined, should be required than that which will *just* raise the dioptrical defects of the image up to the threshold of vision.

It is not my opinion that the *standard series* thus obtained should always be strictly adhered to in the practical construction of objectives. It is rather advanced here as a theoretical guide which will give a *general direction* in designing systems on a *rational* basis, but does not prohibit any deviation from that standard, provided it be justified by this or that practical consideration.

Deviations in the direction of *diminished* aperture (or increased power) need not be discussed here, since at present no tendency of that kind is met with, except in Microscopes of quite an inferior class. The only question which deserves consideration is therefore, What latitude may be properly admitted for deviations from the standard proportion in the direction of *increased* apertures (or diminished objective-powers)?

The case here is somewhat different from that discussed above in the consideration of the proper utilization of the maximum aperture of any kind of system. For the angles which come into consideration now, being more or less within the attainable maximum, aperture is no longer difficult to attain. A surplus being easily obtained, may be sacrificed without hesitation, whenever such a benefit may be expected therefrom as is not counterbalanced by greater disadvantages. The question will therefore come to merely practical grounds: how far a surplus of aperture may afford a real (not only illusory) advantage, and what is the balance between these advantages and disadvantages which are perhaps attendant upon the increase?

As has been pointed out before (Vol. II. 1882, p. 469), there *is* a reasonable consideration which will recommend in some cases,

viz. for the lower angled systems, the use of somewhat wider apertures than can be fully utilized by the total amplifications for which the systems are constructed, or—what is the same thing—will recommend the use of *lower powers* with a given aperture than is indicated by the corresponding figures of N of Table I. The surplus of aperture which is thus left unemployed in regard to the delineating power is utilized in promoting the illuminating power (or the brightness of the image), at least when narrow incident pencils are required for proper illumination of the objects. On the other hand, it has been shown that the said benefit is practically confined within somewhat narrow limits.

As I have said already, I am fully aware of the uncertainty of the numerical data on which the above computations are based, which uncertainty will scarcely ever be overcome in a matter like that in question. Though in *my* opinion the figures advanced above will conform as nearly as possible to the present state of the Microscope, I should make no serious objection if any other observer arrived at figures which differ from mine by twenty or even thirty per cent., bearing in mind the interference of so many elements of individual judgment. I do not, therefore, lay any great stress upon the numerical details; the reader may try to improve them, or take them as a mere exemplification of general principles, illustrating their application to actual systems. What I insist upon is only that the theory of the Microscope is competent to indicate a distinct guide for the *rational* construction of objectives on the principle of proper economy of the independent capabilities of the systems (delineating power and amplifying power); that this principle leads necessarily to a certain proportion between aperture and focal length; and that this proportion may be determined with such a degree of approximation as is required for a practical guide, at all events sufficient for showing the limits between rational and irrational aims.

In my opinion the question discussed here is of some general importance in regard to microscopy. It will, of course, do no harm that systems of lenses should be made of any design whatever and according to any particular taste, and full liberty must always be conceded in that respect. On the other hand, however, the Microscope has an important vocation as an aid to scientific research, and microscopical science is therefore fully justified in demanding that the prominent feature in the improvement of the instrument should always be to render it as useful as possible for its primary purpose, and that no hobbies of any kind should be permitted to take the lead in microscopical optics. In order to prevent this, and to secure progress in the direction of useful aims, the discussion of the question of the "rational" construction of objectives cannot be dispensed with.

XVI.—*On a New Camera Lucida.* By Dr. Hugo Schröder.

(*Read* 10*th October*, 1883.)

In the recent volumes of the Journal of this Society I have met with descriptions and figures of several forms of camera lucida which were new to me. I obtained an example of each, and made a series of trials in comparison with the older forms with which I was already familiar. In all of them I found more or less defects, such as limitation of field, distortion, indistinctness of image or of drawing-point, awkwardness of position, &c. Being engaged later in endeavouring to simplify and perfect the construction and adjustment of Mr. Wenham's high-power binocular prism, I was much interested by the ingenuity of this device, and it occurred to me that that arrangement of prisms might be modified, so as to be available as a camera lucida in which the defects of the forms hitherto made would be considerably reduced if not entirely eliminated.

Assuming a 45° inclination of the Microscope to be the position most generally convenient for drawing, I (in June last) drew on a large scale the system of prisms which appeared to me suitable for a camera lucida. Messrs. Ross undertook to construct the prisms to my drawings, and the apparatus was found upon trial to answer my expectations fully. I am induced to describe it here because it has also met with much approbation from microscopists, who were previously disinclined to believe in the possibility of any new device at the present day, which should be substantially better than the numerous older forms which apparently exhausted the subject!

It is well known that all forms of reflecting prisms acting by means of *one* reflection are extremely sensitive in regard to the position of the mirror in relation to the Microscope, as also in a less degree in relation to the eye; the slightest deviation from the normal position in many cases entirely destroying the effectiveness of the apparatus. For this reason cameræ lucidæ acting by *one* reflection have not found favour, though their apparent simplicity has induced the construction of many such forms.

In order to obviate the difficulties incident to the use of *one* reflection, many devices have been made acting by *two* reflections, and where these have been so contrived as to act like parallel mirrors the reflected image has possessed the advantage peculiar to this principle, of being practically insensitive to slight differences of position relative to the Microscope or to the eye, remaining in fact stationary within a considerable range of adjustment, as in Wollaston's camera lucida.

My device (fig. 152) consists of a combination of a right-angled prism (fig. 153), A B C, and a rhomboidal prism D E F G, so arranged that when adjusted very nearly in contact (i.e. separated by only a thin stratum of air) the faces B C and D E are parallel, and consequently between D E and B E′ they act together as a thick parallel plate of glass through which the drawing-paper is viewed. The rhomboidal prism is so constructed that when the face G F is applied at right angles to the optic axis of the Microscope the axial ray H passes without refraction to I on the internal face E F, whence it is *totally* reflected to J in the face D G. At J a part of the ray is reflected to the eye by *ordinary* reflection in the direction J K, and a part transmitted to J′ on the face A C of the right-angled prism. Of the latter a portion is also reflected to K by ordinary reflection at J′. The hypothenuse face A C is cut at such an angle that the reflection from J′ coincides with that from J at the eye-point K, thus utilizing the secondary reflection to strengthen the luminousness of the image. The angle at G is arranged so that the extreme marginal

Fig. 152.

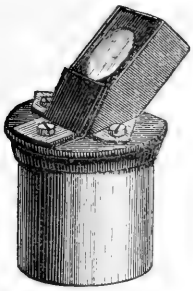
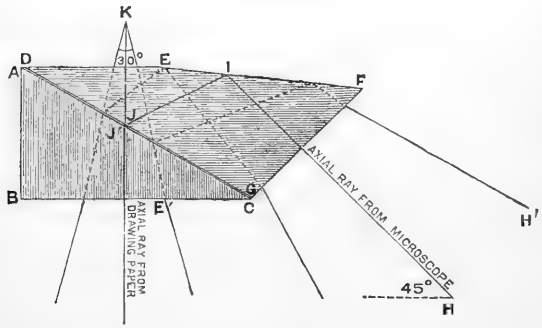


Fig. 153.



ray H′ from the field of the B eye-piece strikes upon D G at a point just beyond the angle of total reflection, the diffraction-bands at the limiting angle being faintly discernible at this edge of the field. This angle gives the greatest amount of light by *ordinary* reflection short of *total* reflection.

By this arrangement the Ramsden circle over the eye-piece comes just above the camera lucida, and the field of view is not in any way reduced; all that can be seen directly through the B eye-piece (say 30° of field) is perfectly depicted in the camera lucida,

whilst the drawing being viewed direct is of course not cut down in field.

In practice the Microscope should be inclined about 45°, and the image accurately focused through the eye-piece as usual. The camera is then slid on the eye-piece and pushed down more or less until the microscopical image is seen distinctly and the illumination of the field is equal throughout. The drawing-paper is placed on the table immediately under the camera. The observer will then see the microscopical image projected on the paper, at the same time viewing the pencil-point directly. The *whole* pupil of the eye is available for both images, the diaphragm on the apparatus being considerably larger than the pupil. It may be necessary to balance the illumination either by subduing the light in the Microscope or by increasing it on the drawing-paper. It will generally be found that when the object is in a luminous field the light on the object (especially with lamplight) may be advantageously subdued by ground glass or similar means. The eye may be removed as often as required from the camera and the work recommenced without the slightest shifting of the image; and with properly balanced illumination, fully shaded drawings can be made with very little practice. The drawing-paper should in every case be placed at the distance of distinct vision, either using spectacles or not. If the vertical position of the Microscope be preferred the drawing-paper may be inclined 45° either in front or at the side of the instrument. For very accurate drawings, in all azimuths, the drawing-paper should of course wholly coincide with the plane of the optical image, as with every other form of camera lucida. A spring clip is provided in which a screen of black paper may be put to shade the eye not in use.

This form of camera lucida can be modified so as to project the image at any desired angle. It can be used with the dissecting Microscope or hand-magnifier, also on a stand for architectural or mechanical drawings.

XVII.—*On "Optical Tube-length"; an Unconsidered Element in the Theory of the Microscope.*

By Frank Crisp, V.P.L.S., Sec. R.M.S.

(*Read* 14*th November*, 1883.)

It is not a little strange that at this late period in the development of the Microscope, an element of capital importance both from a theoretical and a practical point of view should have been left entirely unconsidered, and indeed unknown; and the fact that it is so, illustrates the disadvantages which English-speaking microscopists have always been under in having no text-book dealing with the theory of the Microscope.

In a letter written more than a year ago in reference to the Table of Magnifying Powers published in the Journal, Professor Abbe called my attention to the erroneous notions which prevailed on the subject of the magnifying power of the Microscope, and which he had been the first to clear up,* and I ought then to have published the explanation now given here, but the pressure of other engagements diverted my attention, and I confined myself to explaining the matter verbally to those who attended the meetings. Finding, however, that the Committee on Eye-pieces of the American Society of Microscopists have been misled by the Table in question, it is obviously desirable not to delay the explanation any longer.

Microscopists have always recognized that the length of the tube of the Microscope is a factor in determining the amplification of the image, that the amplification is generally greater with a 10 in. tube than with one of 6 in.; and that we obtain an increase of power by pulling out the draw-tube. Here, however, all exact notions as to the function of the tube-length have practically stopped, so much so that there has not been any agreement even as to how the length of the tube is to be measured, whether from the front or back lens of the objective to the field lens, the diaphragm, or the eye lens of the eye-piece.

In particular, no view of tube-length has been held which would explain the following apparently paradoxical statements:—

That two objectives of precisely the same focal length used with the same tube and the same eye-piece may nevertheless give different magnifying powers.

That two objectives of different focal lengths used with the same

* Professor Abbe also communicated it to Dr. Dippel, by whom it was embodied in the last edition of 'Das Mikroskop,' 1882.

tube and eye-piece will not give magnifying powers in proportion to their focal lengths; thus a 1-2 in. will not necessarily give double the power of a 1 in.

Conversely, two eye-pieces will not amplify in proportion to their focal lengths, though used with the same tube and objective.

Indeed, the true magnifying powers may differ from the powers which would be obtained on the ordinary assumptions by more than 100 per cent., and Prof. Abbe records the existence of objectives (of somewhat exceptional construction it is true) which exhibit this paradoxical behaviour: that one of longer focal length amplifies much more than one of shorter focal length; that one gives the same amplification with a long and a short tube, and that one gives a higher amplification with a short tube than with a long one.

What then is the explanation of these paradoxes?

The explanation is not to be found in any question of the length of the objective or eye-piece, or the character of their respective settings, but depends upon the fact that hitherto microscopists have regarded the outside only of the tube and have left out of consideration the optical action which goes on within it.

To properly understand the matter it will be necessary to consider the principles on which the action of the Microscope in regard to magnifying power is founded.

The magnifying power of a lens depends of course upon its focal length and varies inversely with it; the ordinary mode of obtaining the power being to divide the distance of distinct vision l (assumed as 10 in.) by the focal length, or expressing it by a formula $N = \frac{l}{f}$. Thus if the focal length f of an objective is 1-8th in. $10 \div \frac{1}{8} = 80$. The same applies to the action of the Microscope as a whole, that is with eye-piece and objective combined; when we have determined its focal length we similarly obtain its magnifying power.*

We have therefore to ascertain the proper mode of determining the focal length f of the entire Microscope, having given the focal length f^1 of the objective and the focal length f^2 of the eye-piece.

The usual assumption hitherto has been that f is determined by multiplying f^1 and f^2 together and dividing by the length of the tube 10 in., or

$$f = \frac{f^1 f^2}{10},$$

* The quotient obtained by dividing 10 in. by the focal length gives the linear amplification of an image—real or virtual—which is projected by an objective to a distance of 10 in. *from its posterior focus*, and not from the objective, as has been so commonly assumed.

so that if we had an objective of 1-8th in. and an eye-piece of 2 in. the focal length of the Microscope

$$f = \frac{\frac{1}{8} \times 2}{10} = \frac{1}{40}.$$

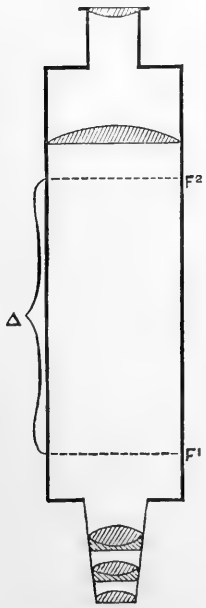
A Microscope of a focal length of 1-40th in. would magnify 400 times, so that if this method of arriving at the focal length of the Microscope were correct, we should only have to multiply the power of the (1-8th in.) objective (80) by that of the (2 in.) eye-piece (5) to have the total magnifying power (400), the brass tube being assumed to be constant at 10 in.

The fallacy of this method lies in the fact that the true formula is not

$$f = \frac{f^1 f^2}{10}, \qquad \text{but} \qquad f = \frac{f^1 f^2}{\Delta},$$

Δ *being the distance between the posterior principal focal plane of the objective, and the anterior principal focal plane of the eye-piece,* or, as Professor Abbe terms it, the rational or *optical tube-length,* in contradistinction to the mechanical or physical length.*

Fig. 154.



The accompanying fig. 154, where F^1 is the posterior focal plane of the objective and F^2 the anterior focal plane of the eye-piece, will illustrate this more clearly.

As Δ is the divisor of the fraction which represents the focal length, the latter is of course larger or smaller according as Δ is smaller or larger, that is, it varies inversely as Δ; and as the magnifying power is inversely to the focal length, the magnifying power varies directly as Δ, which is therefore seen to be a fundamental factor of microscopic amplification.

We can now see how it is that two objectives of the same focal length may yet give different magnifying powers with the same tube and eye-piece. By the different methods of construction adopted by their makers, the focal plane of the one objective may be further off the back lens than is the case with the other. The distance Δ between the focal planes of the objective and eye-piece will be correspondingly

* The principal focal planes are the planes passing through the point on the axis in which parallel rays coming from the *opposite* side of the lens are brought to a focus. "Anterior" and "posterior" are used in reference to the direction in which the rays come to the observer.

diminished, and the focal length of the whole Microscope increased. The magnifying power will therefore be diminished.

Again, take the case of two objectives of say 1-8th in. and 1 in. focal length used with the same eye-piece (2 in.) and tube. If the distance Δ remained constant, say 10 in., the total focal length would vary with that of the objectives,

$$f = \frac{\frac{1}{8} \times 2}{10} = \frac{1}{40}, \qquad \text{or} \qquad f = \frac{1 \times 2}{10} = \frac{1}{5}.$$

But the posterior focal planes of the two objectives, instead of coinciding, may have different positions, every variation producing of course a change in the value of Δ. With the 1-8th in. objective the posterior focal plane may be very near the back lens, and we have a long Δ: with a 1 in. objective its posterior focal plane may be further from the back lens (higher up the tube), and we have a diminished Δ. We might have with the 1-8th in. objective $\Delta = 10$ in., and a power of $(80 \times 10 =)$ 800, but with the 1 in. objective we should not have $(10 \times 10 =)$ 100, or a total power in proportion to the powers of the objectives. Δ might be 8 in. only instead of 10 in., and the total power would be only 80.

The converse case of different eye-pieces with the same objective is similarly explicable. The anterior focal planes of the eye-pieces may be at different points of the tube, and we shall have a varying Δ.

As to the general character of the variations in Δ, it may be noted that the position of the anterior focal plane of the eye-piece does not vary much in the Huyghenian form; a substantial difference is, however, found in this respect between the Ramsden and Huyghenian, the former having its anterior focal plane at some distance below the field lens, and the latter above it. With the objective, however, a very wide range is possible. Its posterior focal plane may be (1) some distance above the last surface of the objective; (2) close to this surface outside or within the objective; or (3)—though a more exceptional case—as a virtual focus below the stage or even below the table. Practically, however, with objectives of ordinary construction, the difference in position of the posterior focal plane is not great with powers higher than 1-2 in., and it is only when we come to the lower powers that the difference is a substantial one.

Greater differences in the power will also be found with short tubes than with long ones. With a 10 in. tube a difference of 2 in. reduces the 10 to 8, but with a 6 in. tube from 6 to 4, quite different percentages of variation.

The process, therefore, of multiplying together the powers of the eye-piece and the objective to obtain the total power of the

Microscope is a fallacious one, as it supposes a constant tube-length; whilst, as we have seen, the true tube-length varies with the different objectives and eye-pieces used.

To determine the power of the Microscope from the powers of the eye-piece and objective, it is necessary, in addition, to know the position of the focal planes of each of the latter. How these may be readily determined must be deferred for a subsequent occasion.

SUMMARY

OF CURRENT RESEARCHES RELATING TO

ZOOLOGY AND BOTANY

(*principally Invertebrata and Cryptogamia*),

MICROSCOPY, &c.,

INCLUDING ORIGINAL COMMUNICATIONS FROM FELLOWS AND OTHERS.*

ZOOLOGY.

A. GENERAL, including Embryology and Histology of the Vertebrata.

Development of Muscle-fibres and their Union with Nerves.† —Although very numerous researches have been made on the differentiation of striped muscles, and on the termination of their motor nerve-fibres, yet the multifarious observations have often been too incomplete to lead to any but conflicting and unsatisfactory theories. An important contribution towards reducing to order this unfortunate and excessive confusion is made by L. Bremer, who has studied the post-embryonic changes in lizards, frogs, and mice. The nucleus of the muscle-fibre, together with the protoplasm surrounding it, constitutes the so-called muscle-corpuscle; the corpuscle is much more prominent in young than in old muscles, for its protoplasm is gradually differentiated into muscular substance; a small number of corpuscles enter into the formation of each fibre; the substance of the muscle forms a network, which was first partially recognized by Heitzmann.‡ The meshes of this network appear polygonal in transverse, rectangular in longitudinal sections. The network is a modification of the protoplasmatic network of the corpuscles, and is so arranged that there are alternating rows, both transverse and longitudinal, of fine knots and large knots (corresponding to the fine and broad striæ); the fine knots are connected by fine threads, and the large knots by coarse threads; hence there is a fine and a coarse net.

The post-embryonic multiplication of fibres takes place by means

* The Society are not to be considered responsible for the views of the authors of the papers referred to, nor for the manner in which those views may be expressed, the main object of this part of the Journal being to present a summary of the papers *as actually published*, so as to provide the Fellows with a guide to the additions made from time to time to the Library. Objections and corrections should therefore, for the most part, be addressed to the authors. (The Society are not intended to be denoted by the editorial "we.")

† Arch, f. Mikr. Anat., xxii. (1883) p. 318. Abstract by C. S. Minot, Science, ii. (1883) p. 411.

‡ SB. Akad. Wiss. Wien, xvii. (1873) Abth. 3.

of the structures described by Margo * under the name of "Sarcoplastin"; there are lines or chains of muscle-corpuscles, united by the protoplasm net, and derived by proliferation from the corpuscles of the original fibres; the sarcoplast gradually separates from the parent fibre, undergoing muscular differentiation meanwhile, and also becoming connected with the nerve. The growth of the fibre is initiated by a multiplication of the corpuscles; the sarcolemma is not present at first, but appears later, being probably formed by the fused cell-membranes of the corpuscles, to which appears to be added a coat of connective tissue, and also around the motor plate between the two sarcolemmic coats, an extension of Henle's sheath of the nerve.

The motor nerve-plates are formed as follows. When the sarcoplast begins to change to muscle, the nerve grows towards it until the two meet and unite. In lizards only a single nerve-fibre, in the frog and mouse several together, thus approach the future muscle. At the point of contact the muscle-corpuscles change, so that an accumulation of protoplasm and a proliferation of nuclei occur there. These accumulations were first described by Kühne under the name of "Muskelspindeln," † and are mentioned by many subsequent writers. Bremer now shows that they are young "end-plates." Into these the ramifications of the nerve penetrate, after the medullary sheath has been lost. The details of the process, of course, vary in different animals, as do also the final forms of the motor plates.

Besides the motor terminations there are others which the author believes to be probably those of the sensory nerves. The fibres running to them are either small and medullated or naked, and end in ramifications upon the muscle, without any conspicuous collection of nuclei and protoplasm at the place of junction. The smaller nerve endings occur on the same fibres with the motor plates, and probably both exist on every fibre. The smaller endings Bremer designates as "Enddolden," in contradistinction to the "Endplatten." (Sachs's paper on the sensory nerves of muscles is not cited by Bremer.)

Hensen has advanced the view that the connection between the nerves and the peripheral cells exists from the first in the embryo, and that, as the cells divide, so do the nerves. Bremer's observations show that with muscles this is not the case. Moreover, Kleinenberg's theory of the evolution of muscle and nerve must be at least modified, if not set aside. That the union of the nerve-filament with the peripheral organ is secondary is shown also by His.

Cell Theory.‡—P. Geddes, in 'A Theory of the Life-history of the Cell,' says, "Our current conceptions of the groups of the Protozoa are apt to be based upon their most prominent and permanent characters only. One thinks of an infusorian as a ciliated or flagellated organism of permanent form, of a radiolarian as a highly differentiated rhizopod, with two layers of protoplasm, a gelatinous envelope, and a siliceous skeleton, while in the description of a Heliozoon special atten-

* SK. Akad. Wiss. Wien, xxxvi. p. 229.
† Virchow's Arch. f. Path. Anat., 1863, p. 116.
‡ Zool. Anzeig., vi. (1883) pp. 440–5.

tion is paid to the radiating pseudopodia with their axial filaments. In lower forms, however, more attention is paid to the whole life-cycle. In the *Amœba* the encysted state is almost as familiar as the active, in the Gregarine sometimes more so, while in such a remarkable Moneron as the *Protomyxa* of Häckel it is hard to say whether the encysted, the amœboid, the flagellate or the plasmodial is the most prominent stage. For here is no single permanent highly differentiated form, but an eventful life-history in which one protean mass of protoplasm passes through the cycle of at least four distinct phases.

Such discoveries as those of the life-history of Monads, of the ciliate embryo of *Acinetæ*, of the multiplication of Radiolarians by zoospores, or of the union of several *Actinosphœria* or Gregarines into a plasmodium, point in the same direction—in fact the whole progress of recent research has largely lain in revealing the existence, in even the most highly differentiated forms, of a life-cycle almost as complete as that of *Protomyxa*.

In other words, if we make a diagram of *Protomyxa*, exhibiting the encysted, the ciliated, the amœboid, and the plasmodial stages, an essentially similar life-history may be sketched out for all the higher groups of Protozoa, with blanks it is true, but blanks which the progress of discovery is constantly diminishing, and seems likely indeed wholly to fill. In short, a Heliozoon differs from *Protomyxa* (over and above its possession of a nucleus) merely in the excessively high differentiation and relative permanence of the amœboid stage of its life-cycle: the Monad or the Infusor has similarly developed its ciliated stage, the Myxomycete its plasmodial. In the Protophyta the resting or encysted stage certainly predominates, but they too show phases of the same life-cycle, as the naked motile zoospores of so many Fungi and Algæ (which as "a transition from plant to animal life" so perplexed the elder botanists) and the amœboid stage into which these so often collapse, bear witness.

This view at once demonstrates the thorough unity and naturalness of the Protista, and affords a basis for their classification into series corresponding to the stages of the life-cycle. In the Palmellaceæ or Schizomycetes the resting and motile stages are almost equally prominent, while in the Desmids and Diatoms and the Saccharomycetes the encysted stage predominates. The Protoplasta, the Foraminifera, the Heliozoa, and the Radiolaria, are of course referable to the preponderatingly amœboid type, while the Infusoria represent the ciliated. The Myxomycetes, far from having any relations to the fungi, stand on the whole nearest to the Moneron or Protomyxoid type, despite the excessive differentiation of their plasmodial stage."

Mr. Geddes proceeds to point out that an intimate connection exists between the changes undergone by such cyclical forms as those referred to, and the conditions under which they live; "the amœboid state, as every observer knows, varies extremely with food and temperature." The morphological importance of cellulose, he cogently indicates, has been greatly over-estimated; and it is not surprising to find it

common to both the organic kingdoms, when it is considered that it is the chemical equivalent of the waste products which are the result of the contractility which is common to all cells, whether vegetable or animal: "the plasmodial stage which terminates the cycle seems an almost mechanical union of exhausted cells." This position is further supported by an experiment which tends to show the convertibility of one morphological stage into another, by mere physico-chemical agencies, viz. the conversion to an undifferentiated condition of an *Actinosphærium* treated with dilute ammonium carbonate. The origin of plants and animals respectively, from the alleged Protistan substratum of form-cycles is thus explained:—"If division takes place continuously in the encysted stage, the resultant multicellular aggregate is a vegetable; if in the amœboid or the ciliated a more or less distinctly animal organism arises. In plants the cell-cycle is represented almost solely by the resting-stage, though the ciliated phase lingers on here and there in the antherozooid, and the amœboid in the oospore." As undisguised examples of the cell-cycle, he cites *Magosphæra* and the gastrula of sponges, but he considers that the tissue-development of all the higher animals should be interpreted in the same manner. He finds the theory to have a bearing on the physiology even of the most compound and individualized animals, inasmuch as the functions of the body are the result of the aggregate functions of its cells, and are explained by variations or phases of the activities of them; pathological phenomena are referred to the same source.

Of the various modifications and variations which cells present, and of the physiological phenomena exhibited by cells as units, Mr. Geddes attempts an explanation, based on the observations of Darwin, on the aggregation of protoplasm in the cells of insectivorous plants under certain conditions. For example: "On this view the granules of an amœba or torula are (disregarding, of course, sap-vacuoles and fat-globules) aggregation-products, the clear ectoplasm when present being merely a portion of the homogeneous protoplasm in which aggregation is not occurring. The more or less granular character of the *Amœba* would thus depend on the state of nutrition and the quality and quantity of external stimuli, and would naturally be least evident in the resting-state." This he applies to the cells of higher animals, and reconciles it with that view of their granules which regards them as intersections of a network of filaments by the fact of Darwin finding linear aggregation-masses as commonly as spherical ones. The radiate arrangement of granules accompanying the development of ova and the striæ of the "Kern-spindel" are both treated as dependent on aggregation. The motions of the Amœba are dependent on the same circumstance; and from this the contraction of muscle can be understood in connection with its minute structure and the variations which this exhibits in different states of contraction, the different sets of granules and globules being aggregation-elements the sum of whose tendencies to aggregation, exerted most fully during contraction, when they are massed together and render the fibril homogeneous, being expressed by the shortening and broadening of the muscle and the overcoming of resistance.

Xanthochroism of Parrots.*—C. F. W. Krukenberg has studied † chemically and spectroscopically the different pigments that he extracted from the feathers of birds. Most of these are red or yellow; green pigments are rare. A. B. Meyer has also taken up the subject, *à propos* of a Moluccan parakeet (*Eclectus polychlorus*), which, though certainly undomesticated, had some citron-yellow plumes where the usual colour is green, blue, or black—a peculiarity which can be produced artificially upon birds kept in captivity. Thus the Indians of South America pluck out the feathers of parrots, and treat the new roots with the milky secretion from the skin of a small batrachian, with the result that the new growth of feathers is yellow. The aborigines of Gilolo, by giving animal food to *Lorius garrulus*, transform its plumage into that of the *Lori rajah*. The natural colour returns after an exclusively vegetable diet. The green colour so common in birds is due to an admixture of a yellow pigment (psittacofulvine Krukenberg) with a dark-brown one; and Krukenberg states that no blue, white, or green pigment can be found among the parrots. He believes that all the darker pigments are derived from one substance, probably identical with coriosulphurine, which is thus the most widely spread pigment in birds' feathers.

Origin of the Individuality of Higher Animals.‡—H. Fol discusses the question of the physiological origin of the individual, and what is the first fact of personality. To obtain the desired criterion we cannot content ourselves with following the normal succession of embryological events, but must have recourse to experiment and to the observation of pathological processes. The study of double monsters derived from the development and gradual union of two embryos comprised within the same yolk may lead to some suggestions.

In answer to the question, what are the factors which determine the formation of one or more embryos at the expense of a single yolk? the author gives an account of some observations chiefly conducted on the ova of *Strongylocentrotus lividus*, which appear to be especially well adapted for investigations of this kind. One or two spermatozoa may enter the ovum without affecting the course of its development; if three do so, the future of the egg is endangered; the spermatozoon does not act as an individual, it merely represents a certain dose of nuclear substance.

Ova which are improperly matured or altered allow of the entrance of a much larger number of spermatic filaments; the author, in his experiments, has subjected perfectly fresh and mature ova to a momentary narcotization by carbonic acid; these will receive three or four spermatozoa each; at first there are no distinct indications of any deviation from the ordinary method of development; but when the first act of fission is about to be effected, a complex caryolitic figure—a triaster, a tetraster, or two parallel amphiasters, appear in the place

* SB. K. Preuss. Akad. Wiss. Berlin, 1882, pp. 517–24. See Amer. Natural., xvii. (1883) p. 891.

† Vergl. Physiol. Stud., ii. (1882) pp. 213–20.

‡ Comptes Rendus, xcvii. (1883) pp. 497–9.

of the ordinary amphiaster. The number of dividing cells is at least double that which is found in normal ova of a corresponding age, and, later on, the larvæ are irregular in form, and frequently have two or three gastric cavities.

By more complete asphyxiation the ova may be made to allow of the entrance of from five to ten spermatozoa; those which receive a still larger number may be regarded as being dead. After discussing the results of experiments on such eggs as these, Fol expresses his belief that individuality cannot be regarded as being determined by the egg, the female pronucleus, or the spermatozoon taken separately, but that the number of amphiasters which are found at the time of the first cleavage afford the earliest criterion for the number of individuals.

Occurrence of Chlorophyll in Animals.*—C. A. MacMunn bases his conclusions as to the identity of animal and vegetable chlorophyll on the fact that the wave-lengths of the centres of the bands of the same solutions of animal and vegetable chlorophyll are the same, and that the wave-lengths of the centres of the bands are the same when the same reagent is added to the respective solutions. Without committing himself to accepting the views of Kraus or Sorby, he applies the term chlorophyll to that colouring matter, or mixture of colouring matters, which can be extracted out of green leaves, such as those of *Primula*, by means of alcohol or alcohol and ether. The colouring matter, to which the writer has given the name "enterochlorophyll," and which can be extracted from the liver or other appendage of the enteron of invertebrates, was shown to be probably produced by, and in, the body of the animal, and not food chlorophyll. The absence of parasitic algæ in sections of the livers of certain mollusks which yield enterochlorophyll shows that this pigment cannot be due to their presence. The writer further showed that Pocklington's observations, published in the 'Pharmaceutical Journal' in 1873, on the presence of chlorophyll in the wing-cases of Cantharides beetles, could be verified, and he had succeeded not only in verifying the presence of the principal chlorophyll band in the ether, chloroform, and alcohol solutions of the wing-cases; but the changes produced in the spectra of these solutions on the addition of certain reagents showed the presence of a body indistinguishable from vegetable chlorophyll. Hence Leydig's conclusion as to the presence of that colouring matter in insects was proved to be correct. However, in the case of green larvæ the occurrence of a band in the red when a strong light is concentrated on the integument may be merely due to the presence of food chlorophyll in the intestine, for, on squeezing out the contents of the latter, the green colour and the band both disappear. It was then shown that chlorophyll could hardly be of much use in respiration, as oxidizing and reducing agents do not affect it; that for protective purposes or in mimicry a body of less complex chemical

* Proc. Brit. Assoc. Adv. Sci., 1883. Cf. Nature, xxix. (1883) pp. 581–2. See also *infra* p. 860.

composition might answer equally well, except that the eyes of some invertebrates may be more susceptible to rays of light of a certain wave-length than our own, especially as Sir John Lubbock has shown that ants perceive the ultra-violet rays of the spectrum which are invisible to us. It may possibly be the persistence of a pigment which was once useful in a remote ancestor in some cases, perhaps at a time when the atmosphere contained much more carbon dioxide than at present. Or again, it may be of use in absorbing the chemically active rays of the spectrum when occurring on the surface of an animal, especially as Zimiriazeff had shown that Langley's observations with the bolometer have proved that the point of maximum energy of the solar spectrum corresponds with the principal chlorophyll band between B and C. In the case of enterochlorophyll this colouring matter may be of use in furnishing material for the construction of other colouring matters, especially as this body and hæmochromogen exist side by side in the bile of some mollusks; and in the bile of the sheep and ox a body exists which fluoresces red and resembles chlorophyll closely, but possesses at the same time some properties which show that it is a hæmoglobin derivative, as proved by the writer. The conclusions which have been arrived at gave support to the view which Prof. Lankester has maintained, namely, that chlorophyll may occur quite independently of the presence of parasitic algæ, as in *Spongilla* and *Hydra*, and that it is in some cases produced synthetically by and in the bodies of animals.

Klein's 'Elements of Histology.'*—The student of the elements of histology should have his attention directed to Dr. Klein's little work, in which he will find a clear account of the leading facts of the science, illustrated by a number of excellent woodcuts. Most of these are taken either from the well-known figures prepared by the author for Klein and Noble's 'Atlas of Histology' or the 'Handbook for the Physiological Laboratory,' which was edited by Prof. Burdon Sanderson, while a few are new, or are taken from well-known writers, such as Frey or Schultze.

B. INVERTEBRATA.

Colouring Matters of Bile.†—C. A. MacMunn is led by his observations to dispute a generally accepted view that the liver of Invertebrates is nothing more than a pancreas in function; the most striking outcome would seem to be the discovery of the wide distribution of a colouring matter, which is beyond doubt a chlorophyll pigment; this it is proposed to call enterochlorophyll. The author has chiefly relied on the evidence afforded by the spectroscope, for, as he points out, it is useless to expect that the chlorophyll in the state in which it occurs should be capable of developing oxygen in the presence of sunlight in the livers of Mollusca, or in the pyloric

* E. Klein, 'Elements of Histology,' 8vo, London, 1883, 352 pp. and 181 figs.
† Proc. Roy. Soc., xxxv. (1883) pp. 370–403.

cæca of star-fishes, &c. The new body would appear to differ from plant-chlorophyll in that treatment with nitric acid makes the solution slightly greenish, although previously it may have been yellow. This is explained by the view that the pigment is in a more or less reduced condition, "probably due to the action of a ferment on the chlorophyll, or to the fact that it is sometimes present in the form of a radical or chromogen."

Spectroscopic measurements show that the liver of the oyster contains a colouring matter which, when treated in alcoholic solution with nitric acid, gives the same spectrum as a similar solution of leaf-green when treated with that reagent. A large number of other Mollusca have been examined.

Among the Arthropoda, Crustaceans have alone been studied; in the common crab enterochlorophyll was rarely, but lutein constantly found; in the crayfish there was abundance of hæmatin in the bile.

The pyloric cæca of starfishes were found to function as a so-called liver; that is to say, they not only seem to prepare a digestive ferment, but they serve as organs for the storing and probably for the actual production of pigments for surface coloration; enterochlorophyll is here also found.

Hæmochromogen, which is found in the bile of the crayfish and of the Pulmonate Mollusca, is apparently due to an animal's mode of life, and does not seem to be "distributed according to morphological considerations."

It is as yet too early to speak definitely, but there is much evidence to show that enterochlorophyll is synthetically formed in the body of its animal possessor.

The second and third portions of this important paper deal with the Vertebrate bile pigments, and some unusual urine pigments; the latter should be of interest to the physician as well as to the physiologist.

Mollusca.

Anatomy of the Marine Rhipidoglossa.*—B. Haller here gives his "first study" on these Mollusca; treating first of the nervous system and commencing with *Fissurella*, the author describes four nerve-cords as being given off, on either side, from the œsophageal commissures, viz. the antennary nerves, the cerebro-pedal commissure, the commissure of the anterior visceral ganglia, and the cerebro-pleural commissure. The heart has a double innervation, the auricles and the branchial veins being supplied from the branchial ganglion, while the auricles and the aortæ receive their nerves from the abdominal ganglion. The unpaired pedal nerve of *Fissurella* is shown to be the homologue of the lateral internal pedal nerves found in *Haliotis* and other forms. The pedal nerves of *Haliotis*, the form next dealt with, are very long, and are connected together by transverse commissures; these are not always equally developed, and it is frequently found that on one side the commissure has two roots, while on the

* Morphol. Jahrb., ix. (1883) pp. 1–98 (7 pls.).

other it has only one. Two commissures may also become connected, and it frequently happens that they lie quite close to one another, so that the distance between two commissures does not seem to be always the same but to vary within wide limits. The pedal nerve-cords of *Turbo* resemble those of *Haliotis* and have the same histological disposition of a cortical layer of ganglionic cells, and an internal nerve-plexus.

The author defines the branchial ganglion as a nervous enlargement placed at the base of the anterior gill, which receives its commissure either from the sub- or supra-intestinal ganglion (*Fissurella*) or, in the absence of these, directly from the similarly named commissures (*Haliotis*, *Trochidæ*); the presence of the subintestinal ganglion appears to be a very primitive character, and when there is a greater concentration of the nervous system, it becomes fused with the supra-intestinal ganglion (Muricidæ, Dolidæ). These intestinal ganglia were erroneously regarded by Simroth as pallial ganglia; where they seem to have disappeared the author imagines that they are replaced by the scattered ganglionic cells found in the commissures.

The views and descriptions given by v. Ihering of the pedal nerves are discussed and criticized, and the conclusion is arrived that at first these cords were not, in the oldest Gastropoda, placed on the foot, but were situated deep in its musculature; the difference between the Placophora and the Rhipidoglossa would appear to be due to the atrophy of the inferior and the greater development of the upper muscles of the body-wall, which became the strong shell-muscles. Haller is of opinion that the transverse commissures between the pedal cords of the Gastropoda, which are so well seen in *Fissurella*, and erroneously described by v. Ihering in the Placophora, are not primitive structures, which have been inherited from a Vermian ancestor, but are more recent acquirements; the plexiform arrangement found in the Chiton must have preceded the more regular commissural arrangement which obtains in Zeugobranchiate Mollusca.

After describing the details of the structure of the lateral organs of this group the author proceeds to institute some comparisons between them and the Vertebrata; in both we find sensory organs which are essentially formed of two kinds of cells—sensory and supporting. The former are short clear structures (Mollusca) with a basal nucleus and long sensory hair, or their contents are strongly granulated (Fishes). Basally, these cells lead to nerve-fibres, which either arise from separate ganglionic cells, which lie beneath the sensory organ (Mollusca), or from nerve-trunks without ganglionic cells (Vertebrata). The supporting cells are long, clear, and cylindrical (Vertebrata, *Fissurella*), or their bodies are pigmented (Trochidæ); and they are never connected with a nerve-fibre. The number of cells may be small (Vertebrata), or large (Mollusca). The absence in molluscs of the protective organs which are developed in fishes may be explained by the presence in the former of the superjacent tentacles.

After a full account of the innervation of the heart, the author passes to the buccal cavity, the minute structure of which is described in detail; different areas of the mucous membrane were found to differ in reaction, that of the floor of the mouth being always acid, while the lips are neutral, and the lateral processes in which are found the orifices of the buccal glands are always alkaline. Especial attention is directed to the goblet-shaped cells, and the characters of the buccal glands.

Existence of a Shell in Notarchus.*—Vayssière has demonstrated the existence of a minute internal spiral shell in *Notarchus*. Taken into consideration with a similar discovery by Krohn in *Gasteropteron*, the author thinks it very probable that both are persistent embryonic shells (in *Notarchus* it is about one-fiftieth as long as the animal itself), and that an analogous appendage will be found eventually in most Tectibranchs which up to the present time have been considered shell-less.

Differences between the Males and Females of the Pearly Nautilus.†—A. G. Bourne bases his observations upon the dissection of two specimens, male and female respectively—both adult and well preserved—of *N. pompilius* obtained by Prof. Lankester for the museum at University College, and a specimen of *N. macromphalus* placed in his hands for examination by Prof. Hubrecht, of Utrecht University. The author regards the tentacular lobes as homologous with the arms of a Dibranch, while the tentacles probably represent the suckers, this view, which has already gained considerable ground, receiving very strong support from the hectocotylized condition which the author describes. Eight tentacular lobes may be recognized: four internal, two superior, and two inferior, the latter two being fused together, and four external, the two superior being fused to form the "hood," and the two inferior completing the external ring. In the male four tentacles of the left superior internal lobe become hectocotylized, while the corresponding four upon the opposite side exhibit an exactly similar modified condition, though in a very slight degree, forming a most interesting example of a "rudimentary organ." In the male the inferior internal lobes are present in a very much reduced condition.

Molluscoida.

Structure of Tunicates.‡—L. Roule discusses especially the views of Prof. Herdman on the hypophysis cerebri of the Tunicata; he doubts the renal nature of the hypoganglionic gland, in the lobules of which he has never found any trace of urates. Moreover, he believes that a true kidney is present in these forms. Roule is of opinion that the gland in question is charged with secreting the mucus which agglutinates the bodies brought in by the current of

* Journ. de Conchyl., xxii. (1883) p. 4. See Science, ii. (1883) p. 206.
† Proc. Brit. Assoc. Adv. Sci. 1883. Cf. Nature, xxix. (1883) p. 580.
‡ Comptes Rendus, xcvii. (1883) pp. 864–6.

respiratory water, and which is directed towards the œsophageal mouth. In structure, the gland is altogether similar to those small glands which are scattered over the buccal walls of higher Vertebrates, and which secrete mucus. Yet again, the author finds additional support for his view in the fact that mucus-filaments may often be seen attached to the edges of the gland, or within the cavity of the vibratile canal. On the other hand there is no evidence to support the view that the cells of the raphe or of the pericoronal groove secrete the mucous filaments. The observations here recorded were made on adult specimens of Phallusiidæ, and the author purposes to make embryological investigations to see if they support the homological views to which he at present inclines.

Alteration of Ascidian Ova.*—We have here another essay from A. Sabatier in which he studies the characters of the yellow cells which he has already noted in the follicular cells of the ova of some Ascidians. When an ovary of *Phallusia mamillata* or *P. cristata* is teased out on the slide we find a large number of ova which are provided with an amorphous capsular envelope, a single layer of follicular cells, and a mass of yellow substance, which varies in form and lies in the centre of a clear, hyaline, and altogether colourless substance.

The follicular portion is clearly arrested in development, while that which most attracts the observer is the variable yellow mass within. This last is not dissolved by caustic potash or coloured characteristically by Millon's reagent: nor does it seem to be of a starchy nature. When, however, the granules are treated with strong acids they give off carbonic acid, and further use of appropriate reagents shows that we have here to do with oxalate of calcium. No definite judgment has yet been arrived at as to the characters or origin of the yellow colouring matter.

The action of colouring matters leads to the belief that the yellow masses are formed of collections of spherocrystals of carbonate of calcium, produced by the deposition of small crystals which radiated around primitive nuclei, arising either from the original nucleus, or from centrifugal and perinuclear corpuscles. They may be compared to the cystoliths which one observes in the cells of certain plants, with the difference that the organic stroma is here formed from the nucleus, and not from the investing membrane of the cell.

The fact that these altered ova are rare in young and more numerous in older individuals leads us to suppose that we have here to do with a phenomenon of senile alteration, the effects of which increase with age, and lead, so to speak, to a gradual disappearance of the effective sexuality of the animal. At any rate, they are only found when the sexual rôle has disappeared, and their presence in an anatomical element is a sign of the disappearance of the sexuality of that element, whether that be male (follicular cells, celluloid globules) or female (nucleus, nucleoli, portions of the ovarian protoplasm).

* Rev. Sci. Nat., ii. (1883) pp. 587–95.

Arthropoda.

α. Insecta.

Flight of Insects.*—Dr. Amans in his extended paper describes his examination of the structure of the thorax in *Æschna*, *Sirex*, and *Locusta*, and discusses the views of previous authors on the subject of the flight of insects. He considers that a rational theory of flight can only be formulated after various dissections and numerous experiments on the resistance of the air; the laws of the latter are as yet very incompletely known, and as to anatomy, a knowledge of one animal hardly affords a sufficient basis for a general theory. For the investigation of preliminary problems *Æschna* is specially well adapted, as it is probably the most swiftly flying of insects, making, as it does, 28 vibrations a second.

Antennary Rods of Vanessa Io.†—J. Chatin describes the cavities found on the joints which form the tip of the antennæ of this insect as communicating with the exterior by means of a very narrow orifice, which does not open directly to the exterior, but is more or less completely closed by cuticular ridges which approximate to and curve towards one another. Some authors, indeed, report the presence of an obturator membrane, but this is an appearance only, and seems to be due to the disposition of these parts; the rod or rods found in the pit have a peripheral zone, within which is a quantity of finely granular protoplasm; it is only in the young that one can observe the nucleus, as the rapid formation of pigment obscures the relations of this body; the bodies that have been described as nucleoli are due to the granulation of the protoplasm, and the subsequent condensation of the pigment into small ovoid masses. The rod may be considered as a modified hypodermic cell of special function, and particularly characterized by the prolongations at either end; the lower of these is indicated by the nerve-branches; the upper appears to undergo a special differentiation, the exact investigation of which the author postpones for the present.

β. Myriopoda.

Studies on the Myriopoda.‡—A. S. Packard, jun., has a revision of the Lysiopetalidæ, a family of Chilognathous Myriopods, to which he was led by a study of the cave fauna of the United States. In a systematic account of the genera and species we find a description of the generic characters of a new type, for which the name of *Cryptotrichus* is proposed, in reference to the minute size of the setæ, which are difficult to detect. After a note on the genus *Cambala* the author makes some observations on the Morphology of the Myriopoda.

The Chilognaths are proved by their embryology and morphology and their close relationship to the Pauropoda to be the representatives

* Rev. Sci. Nat., ii. (1883) pp. 469–90 (2 pls.). Comptes Rendus, xcvi. (1883) p. 1072.

† Comptes Rendus, xcvii. (1883) pp. 677–9.

‡ Proc. Amer. Philos. Soc., xxi. (1883) pp. 177–209.

of the primary form of the Myriopods, while the Chilopods are a secondary, less primitive group. The two pairs of head appendages found in the latter have no representative in the former, nor indeed do their morphological similars exist in any other Tracheate; it is proposed to distinguish them as *malipedes*. A comparative table is given which may be here reproduced.

	Hexapoda.	Arachnida.	Chilopoda.	Chilognatha.
1st Arthromere (preoral).	Antennæ ..	Wanting ..	Antennæ	Antennæ.
2nd ditto (postoral).	Mandibles ..	Cheliceræ ..	Protomalæ ..	Protomalæ.
3rd ditto ..	1st Maxillæ	Pedipalpi ..	Deutomalæ ..	Deutomalæ.
4th ditto ..	2nd Maxillæ	1st pair of Bænopoda.	1st Malipedes ..	1st pair of Pedes.
5th ditto ..	.. ..	2nd ditto ..	2nd ditto	2nd ditto.
6th ditto ..	1st pair of Bænopoda.	3rd ditto ..	1st pair of Pedes	3rd ditto.

The author finds that the larval diplopod Myriopod is a six-footed Tracheate, though neither its mouth-parts nor primary legs are directly homologous with those of the Hexapoda. It would seem that the Chilopod arose from a diplopod or diplopod-like ancestor, with a cylindrical body, narrow sternites, and three pairs of legs, which represent those of the larval Chilognath. Thus the first six appendages of the embryo *Geophilus* correspond to the antennæ, two pairs of mouth-parts, and three pairs of legs of the larval *Iulus*. A complete parallel seems to obtain between the diplopod Myriopods and the phyllopod Crustacea. The Myriopod must have branched off from the tracheate stem by an ancestor much more primitive than *Scolopendrella*, a form which, in opposition to Ryder, Packard looks upon as a hexapod, earlier than but allied to *Campodea*.

Pauropus does not justify its claims to a separate order, and is best placed systematically in a second sub-order of the Chilognatha; *Eurypauropus* may be looked upon as connecting *Pauropus* with *Polyxenus*.

Development of Peripatus.*—In the existing dearth of facts relating to the early stages of *Peripatus*, Dr. J. von Kennel's observations have an especial interest. He obtained his specimens, which included upwards of one hundred of *P. Edwardsii* and a few of a new species, from Trinidad. The new species is termed *P. torquatus;* it is by far the largest yet discovered, the female attaining a length of 15 cm. and a diameter of 8 mm., the male a length of 10 cm.; it is reddish-brown above, becoming paler below, the forehead and antennæ are black, a pale band separates the head from the body; the number of pairs of feet is also in excess of those of all other forms, viz. forty-one to forty-two pairs.

The uterus of *Peripatus* is always found to contain a large number of embryos in all stages, from the segmented ovum to the mature embryo; hence the female is probably impregnated once only. The ovum contains no nutritive yolk, thus the development from the

* Zool. Anzeig., vi. (1883) pp. 531–7.

primary length of ·04 mm. to that of half the adult necessitates a remarkable provision for nutrition. When the newly fertilized ovum enters the narrow portion of the uterus it becomes almost entirely shut off from the rest of the cavity into a "brood-chamber" by the thickening of the connective tissue of the wall above and below it; the brood-cavity widens by the thinning out of its epithelium at the points of contact with the ovum, now segmented. The latter at this stage is a hemispherical mass of cells, attached by its broad base; in it a small cavity appears and increases in size. The basal cells, which have a long, narrow, dense nucleus, multiply, close up the opening of the hemisphere formed by the embryo, and unite the latter to the uterine epithelium; the remaining cells have a large, roundish, granular nucleus, and by their multiplication cause a thickening of the free wall of the embryo. This now has the form of a compressed sphere, the long diameter being 0·09 mm., the short one 0·07 mm. The basal cells increase, some in breadth, some in numbers, and form an embryonal placenta; they also give rise to a very delicate membrane, the amnion, which invests the embryo and is closely applied to the epithelium of the uterus.

Meanwhile the epithelium of the brood-cavity has developed a number of dark pigment-granules in its flattened cells. The placenta grows and forms a solid stalk for the embryo, which is now solid owing to filling of the segmentation cavity by cells from the free (ventral) side, at a point which represents the blastopore, and from which material long continues to be proliferated off into the embryo to form the inner germ-layers. The intestinal cavity originates by splitting of the central mass of cells; and the attached side of the embryo is visibly differentiated into endo- and ectoderm, the free side still appears undifferentiated. The epithelium of the brood-cavity increases in thickness, the outlines of its cells disappear, the neighbouring connective tissue exhibiting a lacuna which is perhaps a hæmal cavity. The next stage is termed the "fungiform," the embryo growing laterally outwards from the summit of its pedicle; it exhibits decided bilateral symmetry; as seen from above it is oval, rather broader at one (the head) end than at the other, and near the narrower end exhibits a shallow depression, bounded towards the broad end by a low wall, and representing on the ventral side the point of proliferation inwards of the mesoderm and endoderm. The former is detached forwards from the ectoderm as a compound layer, and lies between the two other layers; passing off posteriorly into the undifferentiated cell-mass, it receives constant additions from the ectoderm. The uterine epithelium continues to thicken and forms a central ring which divides the brood-cavity into two halves; the amnion is well developed and consists of numerous cells with large nuclei. After further increase in length of the embryo the primary anus appears as a slit in the median line in front of the point of intra-proliferation of the ectoderm, the primary mouth much further forward, as an invagination of a few cells of the ectoderm, which penetrate obliquely forwards into the intestine as a solid mass, becoming hollow later. Segmentation commences by the formation in the oldest part of the mesoderm

on each side of the anterior end of the embryo of a cavity which divides the layer into two, one of which is attached to the ecto-, the other to the endoderm; shortly after, a similar pair of cavities appear behind the first, and so on backwards—the earliest condition of the body-cavity. The embryo lengthens backwards, and becomes much folded on itself. The head-segment is the largest, and consists of two globular halves. The primary mouth and anus appear to be replaced by later developments. The segmental appendages appear as pairs of arched processes; the first pair, the mandibles, are surrounded by a number of secondary papillæ, and are withdrawn into a large buccal cavity; the second form the excretory papillæ of the slime-glands; the antennæ present dorsal processes of the two cavities in the head. After the total number of segments has been formed, the nervous system arises as a series of paired ventral thickenings of the ectoderm, soon detaching themselves, and extending along the body from the brain, which has arisen in a similar way.

After the formation of an œsophagus, the mode of nutrition by the dorsal pedicle, or "umbilical cord," and placenta seems to be replaced by prehension of uterine epithelium by the mouth.

As to the relations of the primitive and adult mouth and anus and the origin of the mesoderm, von Kennel will be seen to be widely at variance with Messrs. Moseley and Sedgwick's interpretation of Prof. Balfour's preparations and drawings, which, however, do not relate to the earliest stages of the development, and which it may be mentioned were made on a different species.

γ. Arachnida.

Pentastoma Lari.*—P. Mégnin describes a new and remarkable *Pentastomum* found in the air-sacs of *Larus glaucus*. About six centimetres long and one broad, it has at first sight the appearance of a Trematode, but a microscopic examination reveals the presence of two pairs of symmetrically placed hooks at the anterior end. The new species is remarkable for the attenuated form of the anterior extremity, and the absence of any external annulation. At the front end there are two tubercles which look like aborted antennæ, and below there is an indication of a kind of segment.

On what may be regarded as the second ring there is a pair of small appendages, formed of two joints, which call to mind the characters of larval Pentastomes. The characters of this new species resemble greatly those of the Lernæidæ, and especially of the Chondracanthidæ, and seem to M. Mégnin to raise the question of the systematic affinities of these parasites. If the resemblance to the Lernæidæ is a real one, the Pentastomidæ should be ranged rather with the Crustacea than with the Arachnida.

δ. Crustacea.

Researches on the Isopoda.†—L. Huet, among the important additions which he has made to our knowledge of these Crustacea, has

* Bull. Soc. Zool. France, viii. (1883) pp. 153–6 (1 pl.).

† Journ. Anat. et Physiol., xix. (1883) pp. 241–376 (4 pls.).

been able to prove the existence of large salivary glands, and that not only in the terrestrial, but also in the groups that are essentially marine, such as the Idoteidæ and the Cymothoidæ; this discovery is of especial importance when we remember that, with but rare exceptions, these glands are only found in land-forms; on the other hand, we must remember that in certain Decapod crustaceans small glandular masses, which have given some indications of being salivary in character, have been already observed. Indeed, the author thinks himself justified in extending to the whole group the results which he has found true for the Isopoda.

With regard to the processes of respiration the author made a number of experiments which resulted in showing him that though there is a very close resemblance in the characters of the organs by which they are effected, there are but few forms that can, without danger, exchange a terrestrial for an aquatic mode of life, or *vice versâ*. Of such we have an example in *Ligia*, but here, as in all, the air respired must be damp.

Especial attention may be given to the sympathetic nervous system, the arrangement of which is as yet only incompletely known; it is much more complex than that of the Decapoda, and the splanchnic system appears to be analogous to that of the recurrent intestinal nerves of *Limulus*, arising as the nerves do from the hindermost of the nerves of the body; on the other hand, there is a close resemblance between the minute structure of the nervous system of the Isopoda and the Decapoda.

Lereboullet has already pointed out that the silky secretion formed by the cutaneous glands of certain terrestrial forms, presents a character in which they approach the Arachnida, and M. Milne-Edwards has regarded the so-called white bodies of the opercular gills as rudiments of a tracheal system. By their external form, some Isopods, as for example, *Armadillo*, approach such Myriopods as *Glomeris;* and, taking them in the whole, the Isopoda present a certain number of intermediate characters, by which they may be justly brought into association with various other groups of Arthropods, and which, at least, give them a very special position among the Crustacea.

Moulting of the Shell in Limulus.*—Dr. A. S. Packard, jun., describes the mode of moulting of the crust or shell of the king-crab (*Limulus*).

When found in the course of moulting the shell, the creature "appears as if spewing itself out of itself," as the front edge or frontal doublure splits open around the extreme edge, the narrow rent, easily overlooked in the cast skin, ending (in a half-grown specimen six inches long including the caudal spine) a little over half an inch from the acute hinder edge of the cephalothoracic shield. Not only is the outer shell cast, including all the spines and hairs, but also the chitinous lining of the œsophagus and proventriculus, the proventriculus corresponding to the stomodæum of the embryo. What

* Amer. Natural., xvii. (1883) pp. 1075–6.

Dr. Packard calls the proventriculus corresponds to the "stomach" of authors, the true stomach not being lined with chitine. How much of the rectum is cast is uncertain, but the chitinous parts lying within the body and serving as attachments for the muscles moving the caudal spine, including two sets of slender tendon-like processes, are cast. The gill-plates are also cast, as well as the delicate hair-like setæ fringing their edges.

Moreover, and this is an interesting point, as in this respect the moulted integument or shell of *Limulus* is like that of an *Asaphus* the author examined, the seven pairs of apodemes or internal processes, six pairs of which support the six pairs of abdominal feet, are also shed. This similarity of form in the apodemes of Trilobites and *Limulus* has been, to his mind, a strong argument for the existence in Trilobites of membranous abdominal swimming feet like those of the *Limulus*.

A small specimen taken in the act of moulting, 50 mm. long including the caudal spine and 30 mm. broad, was considerably larger after casting its shell, measuring 65 mm. in length, and 40 mm. in breadth, or about one-third larger.

Vermes.

Development of Annelids.*—W. Salensky has here three further contributions to our knowledge of the developmental history of Annelids. In the first he deals with a species of *Pileolaria*, allied to *P. militaris*. The process of segmentation does not seem to resemble either that of *Psygmobranchus* or that of *Nereis*, the multiplication of the micromeres being effected either by division of the micromeres themselves, or by their separation from the macromeres. At a comparatively early period, not only the dorsal and ventral surfaces, but also the anterior and posterior ends may be distinguished; the fore-end has the ectoderm represented by a single set of cells, while the region of the body is distinguished by the presence of the mesoderm. At the boundary between these two regions there is a row of larger ectodermal cells which, forming a zone, are longest on the ventral surface; they are the rudiments of the ciliary circlet. These ciliated cells, when developed, are distinguished from the other ectodermal cells by their size, their spherical form, and their structure; within each we see a finely granular protoplasmic body, which is thickened at its periphery, and bears a tuft of cilia. This is the preoral circlet, and the post-oral is not formed till later. As compared with *Nereis* and others, *Pileolaria* seems to have a nervous system which is very tardy in putting in an appearance; the formation of the ganglionic chain is preceded by the modification of the minute structure of the ectoderm, which results in the formation of glandular elements and of the ventral ganglionic chain in the more anterior regions. The "individualization" of the endoderm which, in *Psygmobranchus*, leads to the separation of that layer into two parts, does not obtain in

* Arch. Biol., iv. (1883) pp. 143–264 (6 pls.).

Pileolaria; this difference is possibly due to the difference in the distribution of the nutrient material, for in *Psygmobranchus* the deutoplasm is chiefly collected into the five large cells of the dorsal endoderm, while, in the form now under examination, it is distributed equally through all the cells of the layer.

Among the numerous points of interest discussed in the memoir we must here limit ourselves to the nervous system. In the young *Pileolaria* it is completely differentiated from the ectoderm, and the cephalic ganglia form two considerable masses in which there is a thick cortical layer and dotted substance; the commissures have the same structure in the adult as in the embryonic stages, the ventral ganglionic chain is confined to the thoracic portion of the body; the size of the ventral equals that of the cephalic ganglia, and they have the same structure. This fusion of the ventral chain, though known among Arthropods, is quite an anomalous arrangement among Annelids.

In the next chapter the history of *Aricia fœtida* is discussed; this is a worm which, owing to the large number of its ova and the ease with which they may be cultivated, would be an admirable form for the embryologist, were they not completely opaque, and so spherical that it is difficult to know exactly in what direction the section is being taken. Here, as in the case of some other Annelids, it was noted that among the mass of eggs some did not commence to segment as soon as the rest; their future history showed, however, that they were normal eggs.* Development takes place by epiboly, and the blastopore is always a large orifice. In its earliest stages the endoderm consists of several large polyhedral cells, with their long axis turned towards the blastopore. On the fourth day the body of the embryo becomes divided into two regions, and the somatic may be distinguished from the cephalic mesoderm; the origin of the latter was not made out. In *Aricia*, as in *Nereis cultrifera*, the eye arises from a single ectodermal cell, which elongates and becomes invaginated; at its proximal end the pigment is collected, and, as in *Nereis*, the organ is formed before the cephalic ganglia become distinguished as a separate structure. As in all other Annelids the medullary groove is a temporary formation, which disappears a few days after the embryo becomes free, and leaves no traces of its existence; some of the cells become striated, and on the fifth day of post-embryonic development resemble developing muscle-cells. The ganglionic chain is not developed till very late, the dotted substance only appearing on the fifth day of larval development. In specimens of *Aricia* six weeks old, the ganglia are still connected with the ectoderm, and the connection between the cephalic and the ventral ganglia is not yet effected. The cœlom is also late, though not so late, in appearing; but the individualization of the metameres in the mesoderm obtains at a much earlier period; the body-cavity arises independently in each segment, but differs in size in different regions.

The next chapter deals with *Terebella meckelii*, which has already

* A similar observation was made by A. P. Thomas on *Distomum hepaticum*.

been studied by Milne-Edwards, Claparède, and Mecznikoff; in this form the ova present many difficulties to the student of the earlier stages. In no Annelid does one find so considerable a development of the cells of the ciliated circlet, as in *Terebella;* they occupy about a third of the surface of the body, and in section the thickest portion of the ectoderm. When the somatic region begins to increase in size the ciliary circlet loses its equatorial position and passes forwards; an anal circlet is now also to be observed, and at the anterior end there is a buccal invagination, the elongated cylindrical cells of which are sharply distinguished from the other parts of the ventral ectoderm; the cephalic ganglion has not yet begun to be differentiated. In many points of the succeeding history, the author finds himself able to accept the very accurate account given by Milne-Edwards.

The tube does not begin to be secreted at any very definite stage in the history of the animal, and, apparently, does not play an important part in the life of the animal. Many young forms secrete and then leave a tube, to lead a free life, and then form a fresh tube, to leave it, and so on. In fact, *Terebella* may be said to be distinguished by the "heterochronism of its development." The structure and form of the rudimentary cephalic ganglion of *Terebella* is exactly similar to that of other Annelids; the cerebral commissures are completely formed at the time when the animal consists of 18 segments. Here, also, the eye arises from a single cell, the proximal portion of which becomes pigmented. Though true vessels are not developed till very late, the animal is provided with blood, and with circulatory organs, in the form of a cavity which surrounds the median portion of the digestive tube.

Pleurochæta moseleyi.*—F. E. Beddard gives an account of a new genus of earthworms from Ceylon, which is about 28 inches in length, and is made up of 260 segments; the setæ are developed in all the rings of the body, but are more numerous in the post-clitellian region, being there about 140 to each segment. The large intestine is characterized by the extraordinary development of specialized glands. No segmental organs were detected.

The author describes the capillaries in the hypodermic layer, which appeared to terminate in loops; in *Pleurochæta* they are evident, and it is very possible that such are often developed in the outer epidermic layer of worms and other animals, but have been overlooked owing to their insignificant size. The glandular is separated from the hypodermic layer by a band of fibrous tissue in the region of the clitellum. The absence of segmental organs in *Pleurochæta* is to be paralleled by their absence (according to Horst) in a *Perichæta* from Java, and by their slight development or absence in other species of that genus.

From the 86th to the 101st segment there are glandular bodies, in all fifteen pairs, which lie on, but are separated from the dorsal wall of the intestine; each of these glands is faintly divided into lobules, and is kidney-shaped; the walls of the intestine are, in this region,

* Trans. Roy. Soc. Edin., xxx. (1883) pp. 481–509 (3 pls.).

very vascular; in transverse section the glands are seen to possess an outer layer of granular cells, belonging to the perivisceral cavity; below this there is a fibrous layer, which sends off trabeculæ into the substance of the gland; this last has the appearance of a compound tubular gland, "or perhaps rather of a folded membrane;" the duct opens on to the transverse fold in the intestine. The presence of these highly specialized glands is perhaps to be correlated with the absence of segmental organs.

After an account of the vascular, the author comes to the nervous system, where he directs attention to the hyaline band lying on the upper surface of the ventral cord; in the place of the three ordinary we find here four tubes, three of which follow the general plan observed in other Oligochæta, while the fourth, which is about equal in size to either of the two smaller lateral ones, lies beneath the central larger one.

The study of the generative organs naturally leads to a consideration of Perrier's well-known classification of the Oligochæta; there is some reason to think that *Pleurochæta* is intermediate between the intra- and post-clitellian groups; nor is this the only point in which the French naturalist's classification appears to be artificial—in many points *Pleurochæta* resembles *Perichæta*, but has not the two cæca on the alimentary canal nor the double spermathecæ, which are invariably found in the latter genus.

Weighing the advantages and disadvantages of regarding the existing classification of Perrier as not sufficiently elastic, or of forming a fresh fourth group, the author inclines to the latter course, and proposes to form a group of *infra-clitellian* forms for the reception of his new genus.

In a postscript the author refers to a memoir by Vejdovsky which explains the anomalous structure of the dorsal vessel in *Pleurochæta*, by describing the formation of the heart from two primitively distinct rudiments.

Anatomy and Histology of Lumbriculus variegatus.*—C. Bülow, in preparing for his investigations, killed *Lumbriculi* in very weak solutions of osmic acid, by which reagent the cuticle is not separated from the matrix, while the cilia are beautifully preserved. The specimens were carefully hardened by weak chromic acid, and then by alcohol, and coloured by picro- or borax-carmine—or, better, by a mixture of the two. After imbedding in paraffin, sections were cut, and after the paraffin had been removed by xylol, were put up in Canada balsam.

After some notes on habits and external characters, we come to an account of the digestive canal; here several well-marked divisions are to be made out. The short pharynx is protrusible, and its tissues are ciliated. The succeeding portion is divisible into an upper and a lower cavity, separated by two folds which meet but do not touch one another. The cells of the lower cavity are about as long as broad, while those of the upper are elongated. The so-called liver-

* Zeitschr. f. Wiss. Zool., xxxix. (1883) pp. 64-96 (1 pl.).

cells are not placed directly on the entire tract, but on the walls of the surrounding capillaries. The muscular elements of the body are all smooth.

The author does not find himself able to agree with Leydig in asserting the presence of a closable orifice connecting the lymphatic cavity of *L. variegatus* with the outer world, and he carries his doubts so far as to suggest a re-examination of the characters of *Enchytræus latus* and *E. galba*.

The histological processes which obtain in the formation of the various organs in the growing caudal extremity and in regenerating portions of the annelidan body are exactly the same as those which obtain in the development of the embryo. We find, that is, that the mesoderm arises from an ingrowth of cells developed at the point where the ecto- and endoderm pass into one another; this mesoderm soon forms two mesodermal bands which undergo segmentation before the neural ectodermal thickening; but no mesodermal elements enter into the formation of the nervous portion of the ventral chain, as they do in *Nais* (Semper). The "primitive nerve-fibres," "giant-fibres," or "neurochord" are not of a nervous nature, but serve as elastic supports for the body. Inasmuch as they arise from the mesoderm and not from the endoderm, they are not homologous with the chorda dorsalis of Vertebrates. The muscle-plates and the other muscular elements are of mesodermal origin, as are also the segmental organs, the "liver-cells," and the blood-vascular system. The setæ and the nervous lateral lines arise from the ectoderm. The important differences between the account given by Semper of *Nais*, and that now given by Bülow affect (1) the formation of the mesoderm, and (2) the origin of the "spinal ganglia."

The former difference is probably to be explained by Semper's sections having been about four times as thick as those of the more recent observer; for this is clearly a matter of considerable importance when we reflect that the invagination of the mesoderm may not take place along more than 1-100th mm. The same explanation will hold with regard to the ganglia, as to the exact history of which Semper himself emitted some doubts.

The author concludes with the generalization that the three layers that can be distinctly recognized in the normal growing caudal end of Annelids are the dynamical equivalents of the embryonic germinal layers, since they give rise to the same organs. The only modification is to be seen in the mode of origin of the mesoderm, which does not, as in the embryo, arise from the endoderm, but from the point where the inner and outer caudal germ-layers pass into one another.

Anatomy of the Hirudinea.*—A. G. Bourne has investigated ten genera of Hirudinea. He finds that in *Pontobdella* the external evidences of metamerism are most complete, and that they have a precise relation to that expressed by the internal organization; the normal somite here presents four annuli of varying size. The clitellum includes two reduced somites, and the nerve-cord exhibits

* Proc. Roy. Soc., xxxv. (1883) pp. 350–7.

a corresponding condensation in this region. Behind the twenty somites, which can be readily distinguished, there are indications of several others.

The epidermic cells themselves are not as in *Peripatus*, ever pigmented, but pigmented connective tissue cells and vascular capillaries may intrude upon them; and the extent to which this takes place varies in species, and even in individuals, and is the cause of the coloured pattern which is seen on the surface of the body. Some of the epidermic cells may become glandular, and those are either permanently dermic in position, when they are mucous in function, or they may become "deep" glands; the latter are salivary, clitellar, or peristomial. Other epidermal cells may become sensory, but these have already been fully described by Leydig. The muscles were found to be formed of elongated cells, which are either arranged in bundles or set singly; the cells may be much branched, and consist of a cortical and medullary substance, greatly differentiated from one another.

The histology and metamorphoses of the connective substance have been carefully worked out. In the Rhyncobdellidæ the blood is colourless, and there are very large numbers of colourless amœboid corpuscles; in the Gnathobdellidæ the blood-plasma contains dissolved hæmoglobin. There are two systems of blood-spaces, which are, however, in communication with one another; one represents the closed vascular system, and the other cœlom, vessels, and sinuses. The cœlom would appear to be a schizocœle, and this persists to some extent in all the genera; most fully developed in the Rhyncobdellidæ it is reduced in *Nephelis* and *Trocheta* to the ventral sinus and its immediate branches. In some a process has been taking place, which it is proposed to speak of as a *diacœlosis* or scattering of the cœlom—connective tissue growths having more or less completely filled it up, the remnants forming the sinus system. Different remnants remain in different genera; and the same organ may remain in each; this is perhaps best seen in the varying position of the nephridial funnel in *Clepsine*, *Pontobdella*, and *Hirudo*.

New cœlomic spaces (botryoidal tissue) may be developed, and such a process is spoken of as *pseudocœlosis*; the proof of this new space being "cœlomic" is given by its inclosing the nephridial funnel, as in *Nephelis*. The process may be explained as due to an archaic enterocœle having gradually undergone diacœlosis and been replaced by a pseudocœle. "This primary and secondary cœlom exist simultaneously side by side in all existing Gnathobdellidæ. In the Rhyncobdellidæ considerably more of the primary cœlom remains, and the secondary cœlom has not yet appeared upon the scene."

In conclusion, attention is directed to the nephridia, all of which (even those of *Hirudo*) have cœlomic orifices; the funnels are found to present a serial modification from the fairly developed condition seen in *Clepsine* to the many lobed, ciliated, spongy mass which is found in *Hirudo*. The degenerate condition of the portion of the gland which follows on the funnel is probably to be explained by its function having been taken on by the blood-vessels.

Spadella marioni.*—P. Gourret has a note on this new Chætognath, which is found in abundance in the Gulf of Marseilles, and is characterized by the quadrangular form of the terminal fin, and by the reduction of the lateral fins, which are always without rays. The new form is also characterized by the presence of a paired, flattened and quadrangular ganglionic mass, placed at the postero-lateral angle of the "brain." The peripheral nervous plexus is placed between the epidermis and the subjacent musculature. Notwithstanding the doctrine of Grassi, the author thinks that some of the nerve-fibres end in muscular fibres. The tactile prominences have no rods, and their hairs are in direct relation with the tactile cells; from the base of these latter there is a prolongation which is nervous in character, and, as a very fine process, passes between the muscular fibres and forms a fusiform swelling, which, at its inferior pole, is again continued on to a nerve-trunk. No ciliated circlet, vestibular or post-cerebral follicles were observed in *S. marioni*. Contrary to Grassi, Gourret finds that the glandular cells of the intestine are ordinarily smaller than the absorbing cells; and he looks upon the cilia as having only a relation to the passage of food, a process which may be aided, at certain points, by the external layer of the intestine, the fibres of which have some muscular characters.

New Nematoid.†—F. E. Beddard describes a new Nematoid which he found in the perivisceral cavity of *Pleurochæta moseleyi* (*supra*, p. 839), and which is of interest as approaching, in some characters, the free-living forms. The author points out that, where Nematoids are found as parasites, but have structural affinities to free-living forms, the phenomenon may be explained as being due (1) to their accidental presence in the body of their host, e. g. *Dorylamius stagnalis*, which was found by Dujardin in the intestine of the carp; (2) to a free-living form passing into a parasitic stage, e. g. *Ascaris nigrovenosa*, or the *Dionyx lacazii* of Perrier; or (3) to similarity in conditions of life, e. g. this new form, *Dicelis pleurochætæ*, which lies in a perivisceral cavity freely open to the exterior by a series of large dorsal pores, as well as by the apertures of the generative organs.

In the species described there is only a single mouth-papilla, an arrangement hitherto unobserved, and possibly explicable as being due to the retention of a boring-papilla, such as is found in the young of *Ascaris* and *Cucullanus*.

Male of Oxyuris curvula.‡—A. Railliet points out that one of the peculiarities in the life-history of Oxyurids consists in the extreme rarity of the males; not only are they always smaller and much more difficult to find, but their number seems also to be less considerable than that of the females. At any rate, the male of the Oxyurid found in the horse has, as yet, been but very slightly studied. In it the testicle has the form of a blind tube, which is somewhat coiled, and so sometimes surrounds the intestine; its first half, or testicle

* Comptes Rendus, xcvii. (1883) pp. 861–4.
† Proc. R. Physical Soc. Edin., vii. (1883) pp. 229–34 (1 pl.).
‡ Bull. Soc. Zool. France, viii. (1883) pp. 211–16 (1 pl.).

properly so called, is finely granular; the efferent portion is distinguished by the large size of the investing epithelial cells. In addition to the papillæ, which may be considered as appendages of the genital apparatus, there is a simple straight spicule, which is elongated, and unlike in character to any of those figured by Galeb. Speaking generally, we find that the male of *O. curvula* presents great affinities to the male *O. vermicularis*.

Female Organs of Ascaris megalocephala.* — E. van Beneden, after a statement of the views and descriptions of earlier authors, gives an account of what he observed in a specimen of moderate size. The vagina, which is about 7 mm. long, passes upwards and forwards, and then turns backwards. Quite close to the vulva it enlarges a little; then there follows the part common to the two uteri; this is 6 mm. long, and has the form of a truncated cone; it is continued without any line of demarcation into the uteri; these are set parallel to one another, and are found under the digestive tube, near the hinder end of the body. Where they enlarge they form a convexity directed backwards; they then pass forwards and become continuous with the oviducts; along the whole of their course we note a slight but gradual diminution in the diameter of the lumen. The oviducts are nodose and transparent; the nodal points are irregularly distributed; in the course of the duct there are two or three convolutions, and the length of each is about 9 cm. The oviduct may be distinguished from the lower part of the ovary by the following method: if a living female is opened in Kronecker's artificial serum, and the oviduct be cut through transversely at two neighbouring points, so as to isolate a piece of about 1 cm. in length, there is no contraction of the piece. If, now, a piece of the oviduct be similarly treated, the walls of the tube will contract, the segment will diminish in length, and the contained ova will be expelled.

The author treats in detail of the structure of the various parts of the female generative apparatus. In the ovary the tunic appears to be structureless, and the epithelial layer is formed by longitudinal nucleated fibres, the characters of which differ remarkably in the different regions of the organ. The oviduct is somewhat difficult to characterize, from a histological point of view, as the epithelium of the lower is very different from that of the superior portion of the tube; and, while the lower portion has an external muscular tunic, there is no such tunic in the upper portion of the oviduct. Nor, again, is the line of demarcation between the epithelial cells of the upper and lower portions a transverse line; as a matter of fact, we might make a number of sections in which we should find the two sets of cells in different parts of them. The oviduct is best looked upon as being the bond of union between the two chief parts of the generative apparatus—the ovary on the one hand, and the uterus on the other. The author describes the methods by which the cell-layers of the duct can be studied.

The uterus and the oviduct are best distinguished by the differences

* Arch. de Biol., iv. (1883) pp. 95–142 (1 pl.).

in their function, the former being the organ in which development is accomplished, and commencing at that point on the generative tract at which the characters of the contents change, where the spermatozoa are accumulated in great numbers, and where the ova undergo fertilization. In the epithelial layer there is a remarkable development of papilliferous projections, with corresponding grooves; into the latter the spermatozoa seem to make their way, and so escape from the current which would drive them outwards. The conjunctivo-muscular layer of the duct has been only incompletely studied, but van Beneden points out its great importance as being possibly the representative of the splanchnic layer of Nematodes; in other words, the brothers Hertwig are perhaps right in regarding the Nematoda as Enterocœlia. This consideration is the more valuable when we know that, in the adult, there is no trace of any fibrous intestinal layer in the walls of the digestive tube. "If the splanchnic origin of the conjunctivo-muscular tunic of the sexual apparatus is demonstrated, it is probable that the secondary disappearance of the cœlomic epithelium from the outer side of the intestine, will be established at the same time.

New Worm with Remarkable Nervous System.*—The 'Willem Barents' on her third voyage captured a worm, which A. A. W. Hubrecht describes under the name of *Pseudonematon nervosum*. He gives a general account of its structure, and promises a fuller monograph. The animal is about 65 mm. long, $1\frac{3}{4}$ mm. thick, tapering behind. The digestive tract runs straight through from end to end. On the ventral side, about 45 mm. from the head, is a disk, probably a sucker. No traces of sexual, excretory, or sensory organs were found. The epidermis is thin. The muscles form three layers, a thick external longitudinal, a middle transverse or circular, and an internal longitudinal layer, variously developed in different parts of the body. The nervous system is very remarkable; it forms a continuous layer completely around the body, and lies immediately inside the layer of circular muscular fibres. It consists (1) of a fine network of delicate filaments, appearing as if felted, barely tinged by the staining reagents, and (2) of scattered nuclei belonging partly to connective tissue, partly to ganglion-cells. The layer forms a continuous tube from the head, where there is no ganglionic enlargement, back through the body to the caudal region, where the layer is present dorsally only.

Hubrecht further discusses the phylogeny of the nervous system in continuation of his previous paper.† He points out, that (1) in its lowest forms (Medusæ), the nervous system is diffuse, and there are no nerve-fibres properly so-called; (2) in a little more advanced stage it tends to form a layer spread out under and parallel with the ectoderm; the general histological character is the same as under (1)—a felted network of fine fibrillæ, which spring from the ganglion-cells (*Actiniæ*, *Pseudonematon*); (3) the diffuse layer is still present, but certain tracts are more developed, making the primitive nerve-

* Verh. Akad. Wetensch. Amst., xxii. (1883) Art. 3.

† Quart. Journ. Micr. Sci., xx. (1880) p. 431.

cords (Chætognathi, *Chiton*, &c.); (4) the diffuse part is gradually lost, and the cords are retained. These conclusions are confirmed by citations from numerous recent researches.

On this paper C. S. Minot* says "Dr. Hubrecht has, we think, successfully established two very important generalizations (1) that in the lower animals there prevails a uniform type of nervous tissue, ganglion-cell and nerve-fibre being incompletely differentiated, and the nerve-fibres being in the form of a network; (2) that the nerves were developed by concentration of the diffuse tissue along certain pathways. His paper is certainly one of much value and originality. Systematically the position of *Pseudonematon* is uncertain, but it probably belongs somewhere near the Nematodes and Plathelminths."

Anatomy of Cestoda.†—H. Griesbach finds that in the body of Cestoid worms there is only a single kind of connective substance; this is the gelatinous tissue which is traversed by anastomosing lacunar spaces; the so-called cuticle, which would be better known as the body-wall or limiting membrane, is not of epithelial or of connective character, but is a development from the gelatinous tissue. The structures which have been hitherto known as subcuticular cell-layers do not represent either a matrix or cells of connective tissue, but are formed of living protoplasm, comparable in character and function to the protoplasmic body of certain Protozoa. The water-vascular system consists of two well and two more feebly developed canals which extend through all the strobila; the former give rise to transverse anastomoses and branches which pass into the lacunar system of the gelatinous tissue, in each proglottid; the latter open into the larger canals.

The author is of opinion that the lacunar system represents the cœlom; in this we find infundibular structures, which form the commencement of the so-called water-vascular system, and are more abundant in the peripheral regions of the body. The fluid contained in the vessels takes a centripetal direction from the funnels, passing by fine tubules, comparable to capillaries and frequently communicating with one another; these open, generally in a deltiform fashion, into the longitudinal canals of the strobila and the looped vessels in the scolex. Concretions of calcic carbonate, having a kind of protective function, are to be found over the whole body; these are not calcified cells, but are formed in the water-vascular system, perhaps by the aid of special unicellular glands. At the same time that system retains the function of a renal apparatus.

The musculature consists essentially of longitudinal, circular, and dorsoventral muscles; the nervous system is represented by four ganglia in the scolex, which are connected by commissures, and give off peripheral nerves in the *Bothridia*. In the strobila we find, externally to the water-vessels, two nerve-cords, but commissures between these were not to be detected.

The results of these observations were based on a study of *Solenophorus megalocephalus*.

* Science, ii. (1883) p. 382.

† Arch. f. Mikr. Anat., xxii. (1883) pp. 525–84 (3 pls.).

Development of the Ovum of Philodina roseola.*—A. Billet has taken advantage of the discovery of a number of these rotifers to examine the early stages in the development of the ovum. He has, it is especially interesting to note, been able to observe the formation of polar globules, the existence of which in Rotifera has been denied, while their apparent absence led the late Professor Balfour to his well-known theory that polar globules are not found in parthenogenetic forms; the author believes, with Bütschli, that the polar cells are the atavistic remnants of the globules excreted by Infusoria during the process of conjugation, which are destined for the regeneration of the nucleus. The phenomena of the appearance, disappearance, and re-formation of the nucleus, and the formation of the first segmentation-groove take place very rapidly—indeed, within the space of one hour.

The succeeding segmentation phenomena are also effected with great rapidity, and the first organ to be differentiated is the mastax. In common with preceding observers, Billet notes various points of resemblance between developing rotifers and Bryozoa, and, in conclusion he promises to direct himself to the study of the winter and summer ova, and the temporary appearance of male forms—questions which must be studied before we can get to any complete account of the embryology of the rotifera.

New Swiss Rotatoria.†—Dr. O. E. Imhoff records in a preliminary communication the following species of Rotatoria from Swiss Lakes. *Conochilus* sp. differing from *C. volvox* in having black instead of red pigment in the eye. *Asplanchna helvetica*, n. sp., most nearly allied to *A. priodonta* Gosse; resembles *Leptodora hyalina* in its transparency and invisibility. He also describes and figures what he calls *Anuræa longispina* n. sp., but which is *A. cochlearis* of Gosse and described by him in Ann. and Mag. Nat. Hist., viii. (1851) p. 202, and *A. spinosa* n. sp. which is *A. longispina* of Kellicott, found by him in Niagara water at Buffalo, U.S.A., in 1879, and described and figured in Amer. Journ. Micr., iv. (1879) p. 20 and this Journal, ii. (1879) p. 157. A species of *Triarthra* and one of *Polyarthra* are noticed but not further described.

Echinodermata.

Histology of Echinodermata.‡—So little is definitely known as to the histological characters of the organs of the Echinodermata that we may regard with satisfaction the fact that O. Hamann is applying himself to the study. In his first communication he deals particularly with the Holothurians, and has some notes on the nervous system of star-fishes.

With regard to the digestive tract he finds that the parts which are macroscopically distinguishable differ also in their structural details; thus, the œsophagus in its upper portion has only a circular

* Bull. Sci. Dép. Nord, vi. (1883) pp. 1–10, 69–84 (2 pls. not published).
† Zool. Anzeig., vi. (1883) pp. 466–71 (2 figs.).
‡ Zeitschr. f. Wiss. Zool., xxxix. (1883) pp. 145–90 (3 pls.).

layer of muscles, while hæmal lacunar spaces are abundantly found in the connective substance; at the lower portion of the œsophagus longitudinal muscular fibres are developed. In the stomach both longitudinal and circular muscles are well developed; there is a lining epithelium, an internal layer of connective tissue, an outer layer with capillaries, and an investing epithelium. In the intestine we may distinguish two regions, one of a wide and one of a narrow lumen; the muscular layers are feebly developed, and a layer of fine fibrils is interposed between them and the lining epithelium; in the upper part of the intestine cæcal structures are to be detected, which are, possibly, the homologues of organs already known in star-fishes. The connective tissue always consists of fibrils with spindle-shaped cells, and of a ground-substance.

The generative tubes are divisible into two regions; the two terminal portions (basal and distal) have the same structure, and the latter acts as an efferent duct: between the two is a region in which the tissues are better developed, the separate epithelial cells are fine and filamentous, and not always distinctly separated from one another; although this outer epithelium is so well developed, it does not, curiously enough, take any direct share in the formation of the generative products, which arise rather from the lining epithelium of the tube; the ova appear to be evacuated *en masse*.

The dorsal and ventral vessels have the form of a system of lacunæ in the connective tissue, and in these the blood circulates. In all the tissues and lacunæ of the Holothurian there are found amœbiform cells. The muscles have their fibrils arranged in lamellar fashion, like primitive muscular bundles, and they appear to be of epithelial origin.

Nervous System.—When we come to compare the topographical relations of the nervous system in Holothurians and Asterids, we are struck by the great development of connective tissue, and the feebler development of the integumentary epithelium in the former; the reverse of these relations obtains in the case of the star-fish. In the latter, as is well known, the nervous system appears to be epithelial in position, but in the former apparently, though not morphologically, the nerve-fibres lie more deeply. Owing to the alteration in the position of the nervous system we observe the following differences in the histological structure of the sucker or pedicel. In *Cucumaria* the investing epithelium is succeeded by the layer of connective tissue, in which is placed the sensory epithelium and its nerve-fibrils; then come the muscular layer and the lining epithelium. In the star-fish the epithelium and the nervous layer have the feebly developed connective tissue underlying them.

After describing in detail the characters seen in Holothurians and Asterids, and criticizing the work of previous writers, the author makes some comparisons between the nervous systems of Echinoderms and Cœlenterates.

In star-fishes we recognize four elements in the ectodermal epithelium—supporting cells, sensory cells, ganglionic cells, and nerve-fibrils; the two latter being the more deeply lying. The epithelial

sensory cells are connected together with the nerve-fibrils and ganglionic cells into a whole, which forms the nervous system. The nervous layer forms a circle around the mouth and sends out a mass into each arm or ray. This arrangement cannot but call to mind that which obtains in the Cœlenterata.

Interesting as the resemblance is, it becomes more so when we reflect on the want of genetic relationship between these two phyla; in the two cases the nervous system must have been independently developed; and we gain new ideas in confirmation of certain doctrines as to the genesis of nerves and nervous systems. The brothers Hertwig have taught us that the most primitive arrangement is that in which cells, sensory, muscular, and ganglionic cells, are also epithelial. By their position these cells are able to react directly to external stimuli; the epithelio-muscular cells have given off contractile fibrils, the epithelio-ganglionic cells have numerous connections with one another, and with the sensitive and muscular cells, while the sensory cells are specially adapted for receiving sense-impressions. Dr. Hamann thinks that this is just the very condition which is to be observed in the case of the Asteroidea. The view that the specific sensory organs have arisen from indifferent sensory cells was suggested to the Hertwigs by their study of the Medusæ; an examination of the optic organs of star-fishes leads to a similar conclusion, for in them the eye-spot consists of groups of collected sensory cells, in which a pigment is deposited; this is the simplest condition of an optic organ in the whole of the animal kingdom, not excepting even the Medusæ. When we reflect that sensory cells—the necessary foundation for the genesis of specific sensory organs—are scattered over the whole surface of the body, we shall not be astonished at the phenomena of sensory organs appearing in the most various regions of the body.

Acanthology of Desmostichous Echinids.*—H. W. Mackintosh, in his second report on this subject, commences with an account of the spines of the family Arbaciidæ; in *Arbacia* the results of his studies would lead him to take a different view of the relationships of the species to that proposed by A. Agassiz. Too few representatives of the Echinometridæ have been studied for the author to be able to regard his work as a satisfactory investigation of the group; and the same is true of the Echinidæ; some information is, however, afforded, and drawings are given of sections of spines of species of which, as yet, no account has been published. From what Mr. Mackintosh says it appears that many of the figures given in Prof. Agassiz's 'Revision' are very unsatisfactory, and it is clear that the whole subject requires to be carefully and continuously worked out, and that there is here an opening for an observer who wishes to devote himself to microscopical investigation.

In his third report† some corrections of earlier statements and some brief notes on newly discovered Diadematidæ and Echinothuridæ are to be found.

*. Trans. R. Irish Acad., xxviii. (1883) pp. 241–58 (4 pls.).

† Ibid., pp. 259–66 (2 pls.). These two reports are issued separately.

Ophiurids of the 'Gazelle.'*—Prof. Studers finds that ten of the fifty-eight species of Ophiurids collected during the voyage of the 'Gazelle' are new to science; five others have been already named and their diagnoses published; the names of the new forms are *Pectinura semicincta*, *Ophiolepis affinis*, *Ophiopyrgus saccharatus*, *Ophioglypha stellata*, *Amphiura modesta*, *A. congensis*, *Ophiochiton lymanni*, *Ophiacantha gracilis*, *Ophiothrix smaragdina*, *Ophioscolex prolifer*. Some account of *Ophiothrix petersi* n. sp. has already been given,† when attention was directed to the remarkable sexual dimorphism exhibited by it, the coloration of the sexes being very different. Some of the observations are of importance as bearing on our knowledge of the geographical distribution of the members of this group; *Ophiomyxa flaccida* was found at the Cape Verde Islands, and no specific differences could be detected between it and the West Indian specimens. The marsupial pouch of *Ophioglypha hexactis* is described as a large thin-walled sac, lined by a layer of nucleated cells; in each, two or three embryos are to be found.

Cœlenterata.

Cœlenterates of the Southern Seas.‡—The fourth of R. v. Lendenfeld's communications is devoted to an account of a new genus, *Eucopella*, the forms of which are small and ephemeral, while they are devoid of tentacles or gastric cavity. The persons of the species examined—*E. campanularia*—fall under three groups; there is the nutrient person, the blastostyle, and the medusæ. The first of these is the person which exhibits the least deviation from the original Hydroid stock; its structure is described in detail, and among the interesting points noted we find that the hypostome is described as a funnel-shaped tube, which connects the mouth with the entrance into the gastric cavity; the same definition applies to the œsophageal tube of *Actiniæ*, and, in fact, if the new polyp were to swallow its hypostome, it would possess a true œsophageal tube; the ectoderm of this hypostome is distinguished by some essential points from that of the same part in other Hydroids, for it is formed of high cylindrical epithelial cells, and contains cnidoblasts, which have within stinging capsules similar to those found in the tentacles. In the endoderm we find a large number of small ganglionic cells, connected together into a central nervous organ. In addition to these, there is a continuous layer of well-developed subepithelial circular muscles, which give to this layer a high grade of differentiation.

If we put aside the supposition that the just-mentioned ganglionic cells have been originally derived from the ectoderm, and have made their way through the supporting lamella, we must suppose that the central organ of the nervous system of the *Eucopella*-polyps has been derived from the endoderm. This offers a new support to the lately developed hypothesis of the complete equivalence of the germinal

* Fremde Abh. Akad. Berl., 1882, 37 pp. (3 pls.).
† Zool. Anzeig., iii. (1880) p. 546.
‡ Zeitschr. f. Wiss. Zool., xxxviii. (1883) pp. 497–583 (6 pls.).

layers of the Cœlenterata. In other words, we are led to believe that the layers of the gastræa from which the Cœlenterata arose were not differentiated into an animal and a vegetative series. The views of the author on this point are carefully elaborated.

It is pointed out that the distribution of the different kinds of endodermal cells differs in different Hydroid-polyps, but is constant for the species; in the present case no high degree of differentiation has been attained, and three kinds of cells are found, one with another, in the walls of the stomach.

In giving an account of the blastostyle the author points out that, if we consider the homologies of the cleft blastostyle, we come to the conclusion that they are the persons which provide us with an intermediate stage between the nutrient animal and the medusa; by supposing the oral and aboral walls of the pulsating gastric space to become fused with one another, and the central solid disk to be broken through, we arrive at the structure of a medusa. The peripheral portion of the gastric space will become the circular canal, from which arise four radial canals, which lie in transverse axes, and unite at the aboral pole. On their inner and ventral face there bud off the persons which carry the genital products. The importance of the new genus in the discussion of this question is demonstrated.

After an account of the structure of the medusoid forms, the author passes to the lessons which *Eucopella* teaches with regard to the doctrine of the germinal layers; in the first place, it is to be noted that in the differently constituted persons which make up the life-cycle of this form the two germinal layers have to perform very different functions. The nutrient animal possesses in its endoderm all kinds of cells save the chitinous, while in the ectoderm those that are devoted to digestion and excretion are absent; the mesoderm consists, in addition to the indifferent supporting lamella—of muscular, ganglionic, and urticating cells. In the female Medusa we find relations which are essentially different, for the ectoderm has here undertaken a great part of the functions of the endoderm of the trophosome, as might be supposed from the free and ephemeral mode of life; the endoderm consists of similarly constituted cells, filled with brown pigment, while in the ectoderm there are covering, supporting, and sensory cells, as well as cnidoblasts. In the male medusa the ectoderm also contains the spermatophores with the spermatozoa.

Attention is drawn to the conclusion that the Cœlenterata appear to be distinguished by the fact that in them alone the mesoderm arises at all points of the surface, instead of from one or a few definite cells. In *Eucopella* we may see the cells, which are about to become ova, pass below the epithelium, and so become mesodermal. It is further to be observed that the umbrellar cavity, which is closed in the young, is formed by the dehiscence of the cells of the central cavity; the great difference between the higher animals and the Craspedota does not lie in the complete absence of a cœlom in the latter, but is due to the primitive method in which their mesoderm is formed.

The author's concluding observations on alternation of generation are illustrated by diagrams, which explain his views; the correspondence between some Hydromedusæ and insects, where again we find a long-living and feeding larva, and a short-lived sexual form, is adverted to. Among the former there are (1) Trachymedusæ, in which all nutrition is effected during the medusoid stage; (2) *Tubularia* and others, in which food is taken in during both hydroid and medusoid conditions; and (3) those—as *Eucopella*—in which nutrition is effected only while the form is hydroid.

New Medusæ from the Red Sea.*—C. Keller commences with an account of a new genus and species, *Gastroblasta timida*, a small Craspedote form, which was found for a few days only during the month of March. The gastric cavity is a short tube with thick walls, well provided with muscles; at its base it is produced into four or more processes which receive the radial vessels. At first each medusa has only one central gastric tube, but in older forms there is more than one; the author was first inclined to think that he had to do with a pathological phenomenon, but he soon found that the process was quite normal and constant. The secondary gastric tubes form at first sinus-like enlargements on the lower part of a radial vessel, and project into the umbrellar cavity. Later on, this widens at its base, and becomes perforated at its tip. This phenomenon is to be explained as either due to an incomplete division of the Medusa, or as a lateral gemmation. The former view is to be rejected, inasmuch as the secondary gastric tubes arise without any division of the primary stomach, and are at first without any oral orifice; nor have fissive processes of the disk ever yet been observed. We have, therefore, to accept the second explanation, and to regard the gemmation as an incomplete process, which has been profoundly modified by cenogeny.

Reference to the observations of Häckel, and an enumeration of observed cases of variability in the number of important organs afford sufficient support to the position that gemmation is far from being unknown among the Medusæ.

Keller finds it necessary to form a new family of Gastroblastidæ, which he defines.

The other new form now described is *Cassiopea polypoides* n. sp.; of this five differently coloured varieties were observed. Among the points studied were the characters of the yellow cells, which the author examined with the view of deciding on their vegetable or animal nature. The following are the results: treatment with iodine indicated the presence of starch, but was not sufficient to establish the vegetable character of the cells; no blue coloration of the cell-membrane was observable after treatment with iodine and sulphuric acid; but, as this reaction is not always to be depended on, Schulze's reagent was tried, and resulted in the complete destruction of the cells; as the membranes were in time acted on by a dilute solution, the result would appear to be that we have here to do, not with cell-

* Zeitschr. f. Wiss. Zool., xxxviii. (1883) pp. 621–70 (3 pls.).

membranes formed of cellulose, but with a special form of mesodermal cell.

After describing in great detail the various organs, and giving the name of ovariostomata to endodermal passages which seem to form a kind of passage for the larvæ, the author comes to some considerations on the genetic relation of the Acraspeda to Corals.

Observations on *Xenia fuscescens* showed that (1) the margin of the mouth-disk and the pinnate tentacles execute rhythmical movements, and regularly approach and separate from one another. These contractions remind us of what may be seen in the umbrellas of Medusæ. (2) The rhythms of the two are almost identical, being 40 per minute in *Aurelia* and 30 in *Xenia*. (3) The contractions continue if the tentacles be separated at their base from the body-wall. (4) Longitudinal sections of individual polyps leave the two halves still capable of contraction. On the whole, then, there seem to be striking resemblances in the nerve-physiology of Acraspeda and Anthozoa.

In conclusion, it is suggested that the Anthozoa have possibly had a polyphyletic origin, and we are reminded of Semper's observations on the alternations of generations in *Fungia*.

Development of Obelia.*—C. de Merejkowsky has studied the mode of development of the endoderm of this Medusa, and finds that it is formed at the posterior end of the larva by the immigration of isolated blastodermic cells. This mode of formation has already been detected by O. Schmidt in the sponge *Ascetta*, and Metschnikoff, who has confirmed those observations, has extended them to *Halisarca*. Kerschner, likewise, has observed the same phenomenon in the fresh-water *Hydra*, and Metschnikoff and Claus have seen it in various Medusæ. In higher Metazoa the same process has not been detected, but in Echinoderms, Selenka has observed that the mesoderm arises from immigrated cells; while Kowalevsky, though suspecting, was not able to demonstrate the process in *Thecidium;* and Balfour has expressed the opinion that there was some error in the observation.

The first question which arises is this: Is the mode of formation seen in *Obelia* and other Medusæ a special process, having no relation to the ordinary gastrula-condition, where the endoderm is formed by invagination from a part of the blastoderm? The author thinks not, and, in support of his view, points to the fact that the cells arise from that part of the larva which, in other Cœlenterates, undergoes the regular invagination.

If we compare *Obelia* with such a form as *Pelagia*, we may say that in one the cells of the pole immigrate all together, without losing their relations to one another, while in *Obelia* they become detached, and immigrate separately. The slightness of the difference may be demonstrated by a consideration of what sometimes happens in an allied genus (*Irene pellucida?*); here, as a rule, the endoderm is formed by separate cells, as in *Obelia*, but it occasionally happens that a typical gastrula is developed.

* Bull. Soc. Zool. France, viii. (1883) pp. 98–129 (2 pls.).

If, then, there is a close relation between the formation of an endodermal layer by invagination and by immigration, we are next led to ask, which is the more primitive arrangement? Häckel inclines to favour the former, Metschnikoff the latter; for the present it is impossible to decide between these doctors, and the most pressing duty now is a renewed study of the early stages of *Thecidium*.

American Anthozoa.*—A. E. Verrill has a report on the Anthozoa dredged off the east coast of the United States by the 'Blake,' and those collected by the United States Fish Commission. A large number of species, a considerable proportion of which are either new or lately described by Prof. Verrill, were collected; *Lepidisis* is a new genus, closely allied to *Acarella*, differing only in having the external layer of small scale-like spicula, both in the cœnenchyma and on the calicles. A new family—*Chrysogorgidæ*—is instituted, the species of which are "remarkable both for the elegance of the forms in which they grow, and for the brilliant lustre and opaline and iridescent colours of the axis, which in some species has the bright emerald-green lustre of the most brilliant tropical beetles, and in others is like burnished gold or polished mother-o'-pearl." *Iridogorgia* is a new genus. The characters of the Primnoidæ are emended. Among the Gorgonidæ *Stenogorgia* is a new genus, apparently most nearly allied to *Leptogorgia*. A new genus is instituted for *Urticina nodosa*, which receives the name of *Actinauge*, and two new varieties of *A. nodosa* are described. Similarly *Urticina cellosa* is the type of a new genus—*Actinostola*.

Hard Structures of the Fungiidæ.†—Prof. P. M. Duncan, in a continuation of his previous paper,‡ deals with several of the recent genera of the subfamily Lophoserinæ, an examination of which is absolutely requisite before the classificatory position of many extinct genera of corals can be decided. The genus *Lophoseris* is taken as a typical example, then *Mœandroseris* with collines limiting series of calices is considered. *Pachyseris* follows as a most abnormal form, the collines being in excess, and the genus *Coscinarœa* is examined. Finally, the genera *Siderastrœa*, *Merulina*, and *Echinopora* are examined. This involves some classificatory changes, and the introduction of a new genus (*Plesioseris—P. Australiæ* = *Mœandroseris Australiæ*), but the importance of the synapticula as a character of the group is enhanced.

Elevated Coral Reefs of Cuba.§—W. O. Crosby describes the elevated coral reefs of Cuba, and draws from them the apparently well-sustained conclusion that they indicate a slow subsidence during their formation, and hence, further, that Darwin's theory of the origin of coral islands is the true theory.

* Bull. Mus. Comp. Zool., xi. (1883) 72 pp. (8 pls.).
† Journ. Linn. Soc. Lond.—Zool. xvii. (1883) pp. 302–19 (1 pl.).
‡ See this Journal, *ante*, p. 666.
§ Proc. Boston Soc. Nat. Hist. Cf. J. D. Dana in Amer. Journ. Sci., xxvi. (1883) pp. 148–9.

He also points out the following objections to the theory of the formation of coral atolls in deep waters out of the calcareous secretions of deep-water life: (1) It is very improbable that submarine eruptions ever make the large and well-defined craters, like those of subaerial action, which are appealed to in order to explain the lagoon feature of atolls. (2) Many coral atolls are twenty miles or more in diameter, which is vastly larger than the largest of craters. (3) The atolls are never circular, and the larger have the irregularities of outline or diversities of form characterizing other large islands of the ocean. (4) In the actual reefs and islands of the Feejee group, all the conditions, from the first stage to that of the almost completed atoll, are well illustrated, one island having only a single peak of rock within the lagoon not 1-100th of the whole area, which a little more of subsidence would put beneath the waters and leave the lagoon wholly free.

Polymorphism of Alcyonaria.*—Prof. M. Marshall directs attention to the occurrence of tentaculato-zooids in two members of the group Pennatulidæ—the first the variety of *Pennatula phosphorea*, known as *aculeata*, and the second a new species of *Umbellula*, *U. gracilis*, obtained in the Faroe Channel during the 'Triton' dredging expedition in 1882. In the first case the tentacles, which vary from one to five in number, are fused together to form a conical spine, strengthened by very stout calcareous spicules, and projecting a considerable distance beyond the mouth. In the case of *U. gracilis* the tentacle is single, and differs from that of all other pennatulid zooids in presenting a fringe of pinnules along each side identical with those of the typical polyps. The morphological importance of this unitentacular condition is discussed at some length, the single tentacle being shown to have constant anatomical relations and to correspond to the single tentacle present in the young embryos of *Actinia mesembryanthemum*. In conclusion, arguments are adduced against Prof. Kölliker's statement that *Umbellula* is one of the more primitive genera of Pennatulidæ.

Ciliated Groove (Siphonoglyphe) in the Stomodæum of the Alcyonarians.†—S. J. Hickson finds that in *Alcyonium* there is a groove lined by remarkably long cilia, situated on the ventral side of the stomodæum. This groove, which has been already referred to by O. and R. Hertwig, has important morphological relations in the group Alcyonaria which have not been previously referred to. He proposes to call it the siphonoglyphe.

The cilia of the siphonoglyphe, as seen in a living *Alcyonium*, moving in unison, produce a current from without inwards which brings particles of food and fresh streams of water into the canal-system of the colony. The cilia lining the rest of the stomodæum produce currents in an opposite direction, from within outwards.

A siphonoglyphe, varying in size and in length of the cilia, is present in the same position in all the non-dimorphic Alcyonarians

* Proc. Brit. Assoc. Adv. Sci. 1883. Cf. Nature, xxix. (1883) p. 580.
† Proc. Roy. Soc., xxxv. (1883) pp. 280–1.

(without solid calcareous or horny axes) examined, e. g. *Cœlogorgia*, *Briareus*, *Nephthya*, *Spongodes*, *Tubipora*, *Clavularia*, *Heliopora*, &c.

Amongst the dimorphic Alcyonarians the siphonoglyphe is usually absent in the autozooids, but well developed in the siphonozooids. In *Sarcophyton*, however, a feebly developed siphonoglyphe is present in the autozooids in addition to the well-developed ones in the siphonozooids.

In *Primnoa* and *Villogorgia*, the only examples of Alcyonarians with solid axes examined, no siphonoglyphe can be found, and the author is inclined to think, from the researches of other observers, and from general considerations, that it is not present in any genera in which the fleshy parts of the colony are represented only by a thin crust covering solid axes.

The paper contains some speculations to which the author has been led by these researches, concerning the probable philogeny of the group, and a diagrammatic arrangement of the Alcyonaria on these lines.

Finally, he proposes to divide the Alcyonaria into five principal groups: 1st. The Proto-Alcyonaria, including only those genera which do not form colonies. 2nd. The Stolonifera, including the genera *Clavularia*, *Cornularia*, *Tubipora*, &c., in which the young colonies spring from a creeping stolon. 3rd. The Pennatulidæ, which remains as heretofore. 4th. The Gorgonidæ, a group which contains only those genera in which there are solid horny or calcareous axes, and no siphonoglyphe. 5th. The Alcyonidæ, a large and somewhat heterogeneous group containing all the remaining genera of the Alcyonaria, which, though exhibiting many wide variations, *inter se*, agree in possessing no specially marked characters of deviation from an ideal central form from which it is supposed they must have sprung.

Porifera.

Vital Manifestations of the Sponges.*—Taking the sponges as an example of a group in which tissues, organs, and physiological divisions of labour are almost entirely absent, B. Solger makes them the starting-point in his proposed study of vital manifestations and their increasing complication in the animal kingdom. He gives a summary of facts deduced from observations by various writers.

The functions of *the endodermal ciliated chambers and cells* appear to be respiration and the prehension of nutriment, recent researches seeming to deny them the—at any rate exclusive—power of actual digestion. The mesoderm probably shares in the latter function: the claim of the ectoderm to this position is less indisputable. The occasional occurrence of lipostomy and lipogastry does not affect this question much, but relates chiefly to the manner of disposing of the used-up water; the function of exhalation is transferred in lipostomy to other canals and pores, that of digestion in lipogastry is taken up by the ciliated chambers or possibly by the ectoderm and mesoderm. The discovery of digestive ferments (pepsin, trypsin) in the body of

* Biol. Centralbl., iii. (1883) pp. 227–35.

the sponge has its importance somewhat reduced by the uncertainty which prevails as to the exact distribution of these compounds in the living animal. A reserve of nutriment occurs at certain times in several widely distinct sponges; and in some cases starch has been demonstrated between the cells, but there appears reason to regard this as derived from algæ. Oily matters have been extracted by chemical processes from sundry sponges and traces of fatty matter have been observed. Though so commonly found dissolved in fatty matters in Vertebrata, colouring matters are found abundantly in the sponges, although fats are so scanty in these organisms. They occur in the endodermal ciliated cells (*Spongelia avara*, Calcisponges) or in the mesoderm (*Euspongia officinalis*, *Chondrosia*). Some forms (*Calcarea*) from being colourless take a brown colour when placed in spirit, others (*Suberites*, *Hircinia*, and *Stelletta*, spp.) lose their colour if exposed to the light. *Aplysina aerophoba* offers a remarkable example of change of colour consequent on death, viz. from a sulphur-yellow to prussian blue; this is caused by changes in certain roundish refractive mesodermal cells with bladder-like nucleus and small surrounding granular space; the colour is preserved unchanged in solution of salicylic acid; the substance which produces it is considered to be reserve nutriment. The same body (aplysinofulvin) appears to occur in *Aplysilla* sp. and *Hircinia* sp., but changes much less rapidly in *Aplysilla* than in *Aplysina*, perhaps because the "reducing ferment" which hinders its conversion is decomposed more slowly in the latter case. The *Horny fibres* have been shown to be excreted from special mesodermal cells. No proofs have yet been given of the occurrence of a moulding of the sponge-skeleton by absorption, such as the plasticity of such forms as *Ascetta clathrus* would seem to suggest. In connection with the rearing of sponges it is remarked that Cavolini's observation that after having taken root, the pieces of sponge shed over the old parts a mucilaginous mass, in which the skeleton subsequently appeared, might be utilized as giving a hint where to look for the youngest parts, when these are sought after, and thus further the study of tissue-development.

Spermatogenesis in Sycandra.* — Although spermatozoa are described in Calcisponges by both Häckel and Eimer, yet, as Dr. N. Poléjaeff points out, these authors are hopelessly at issue as to the structures which they thus describe, and their divergence leaves the matter in as uncertain a condition as before. Carter's results are not more satisfactory. Even Keller's and Vosmaer's alleged observation of these structures cannot be regarded as conclusive. Poléjaeff experimented upon *Sycandra raphanus* at Triest, employing a large variety which grows on posts in the harbour. Oblique sections of specimens hardened in 0·01 to 0·05 per cent. osmic acid solution, stained with alum-carmine, showed large numbers of minute bodies deeply stained, refracting light strongly; these had previously been detected in motion in sections from the living sponge; sometimes they occurred free in the radial tubes and intercanals, at others in roundish and

* SB. Akad. Wiss. Wien, lxxxvi (1883) pp. 276–98 (2 pls.).

oval cavities lined with epithelium. The use of stronger magnifying powers revealed masses comparable to young sperm-balls, in the form of cells of the same size as the ordinary wandering cells, containing several nuclei but no perceptible endothelium. Thinking that the scarcity as compared with the ova of these bodies (which he henceforth regards definitely as male elements), perhaps indicated the existence of a relatively dicœcious condition, he examined a large number of specimens, and at last found a relatively male specimen, i. e. one in which ova were scarce, but in certain sections from which abundant sperm-masses in all stages were found. From a comparison of these stages, the author has drawn out what he considers to be the normal course of development. The earliest stage is an ordinary wandering cell, such as originates ova also, 0·008 to 0·02 mm. in diameter, with transparent vesicular nucleus and strongly refractive nucleolus; such are further found containing two nuclei of different sizes, placed at opposite poles of the cell; next is found a "primitive sperm-cell" inclosed in a "covering-cell," which Poléjaeff assumes, although he is not certain of the fact, to be derived from the two nuclei just mentioned and the protoplasm surrounding them. The nucleus of the primitive sperm-cell divides and subdivides—the protoplasm not being seen to take part in this process until the mass enclosed by the covering-cell is a number of very small strongly refractive granules lying in completely transparent protoplasm; the granules probably give rise to the heads, the protoplasm to the tails of the spermatozoa, but this again is not based on direct observation. The further history of the capsule is unknown; the sperm-ball does not increase in size. The mature spermatozoon may be seen under a power of 400 diameters. but usually only the round head; to detect the tail a section taken from the living sponge should be so treated as to isolate the liquid containing the elements and the latter watched as they die; the head passes into the tail abruptly; the latter has a serpentine outline when death occurs, and appears to have a length not exceeding 0·03 mm.

The differences between this mode of spermatogenesis in *Calcarea* and that which seems common to Horny and Siliceous Sponges, according to the observations of F. E. Schulze and others, are (1) the non-division of the entire contents of the mother-cell into other cells, a point which is probably merely relatively distinctive; (2) the absence of an endothelium to the capsule, probably due to the absence of that centrifugal pressure on the surrounding mesoderm-cells, which the sperm-mass exerts in those cases where it increases in bulk; (3) the incomplete separation of the sexes. The great vitality of the male elements is a striking fact, which may account for the great productiveness of this sponge; spermatozoa have been found alive in half decomposed specimens full of Bacteria and Infusoria.

Fresh-water Sponges of Bohemia.*—Dr. F. Vejdovsky reduces the previously published European species of *Spongillidæ* to five, viz. *lacustris*, *jordanensis*, *fluviatilis*, *mülleri*, *erinaceus*. He considers

* Abhandl. K. Böhm. Gesellsch. Wissensch., xii. (1883) pp. 1–44 (3 pls.).

great uncertainty to overhang the real characters of the older species.

In his special description of those species found in Bohemia he recognizes but one genus, *Spongilla*, but divides it into three subgenera, *Euspongilla* (*Spongilla* s. str. of Carter), characterized as possessing smooth skeleton-spicules and small spined parenchyme-spicules; gemmules either naked or invested in a parenchymatous coat, containing spined spicules; *Ephydatia* (Gray's genus, restricted to species with toothed rotulæ to the amphidiscs, and hence corresponding only to part of *Meyenia* Carter); *Trochospongilla*, for species of *Meyenia* Carter, with the margins of the amphidisc rotulæ entire. Dr. Vejdovsky gives lists of synonyms of the above species, which he describes, separating them in some cases into distinct varieties. As the main subject has been so lately dealt with by Carter and Dybowski,* it will be sufficient to indicate the chief novel facts and views introduced here, with notes on some species scarcely known to English students.

Euspongilla lacustris, includes *S. jordanensis* of Kusta, which Vejdovsky has examined afresh.

Two forms are distinguished by the structure of the gemmules, viz. var. *macrotheca*, the gemmule of which has a weak parenchyme-layer, devoid of a chitinous membrane, and is greenish in colour, and *lacustris* s. str., with brown gemmules, with a thin chitinous membrane to the parenchyme-layer in addition to the thick inner chitinous layer.

Euspongilla jordanensis Vejdovsky, *nec* Kusta. This species has been only hitherto described with certainty in the Bohemian language; the present full description and figures show that it is distinguished from *S. sibirica* Dybowski only by the superior thickness of the parenchyme-layer of the gemmule, and by the smoothness of the parenchyme-spicules.

A var. *druliæformis* is established for a specimen recalling the genus *Druilia* Gray (*Parmula* Carter), by having the gemmule covered with shield-like structures; these, however, appear to require re-examination.

Ephydatia fluviatilis is identified with *Meyenia* No. 1 of Dybowski.

Ephydatia mülleri Lieberkühn, includes *Ephydatia* No. 2 and *Meyenia* No. 2 of Dybowski; Vejdovsky distinguishes a *forma A*, with thick shafts and irregularly toothed rotules to the amphidiscs from *forma B*, in which the shafts are slender and the rotulæ regularly stellate; as "var. ? *astrodiscus*," *Meyenia* No. 3 of Dybowski is also placed under *E. mülleri*.

Trochospongilla erinaceus Ehrenberg. The surface is marked with curious stellate grooves. The ends of the skeleton-spicules are smooth, while all the rest of their surface is covered with large sharp spines. The rotulæ of the amphidiscs have the edges entire and usually turned up, saucer-wise.

The paper concludes with a table of the distinguishing characters

* See this Journal, *ante*, p. 378.

of the species and varieties, and a list of seventy-eight works dealing with Fresh-water Sponges. The illustrations relate chiefly to the spicules and the structure of the gemmule. Unlike Dybowski, the author does not employ positive measurements of the parts in his descriptions.

Bavarian Fresh-water Sponge.*—Mr. H. J. Carter records the discovery of spicules of *Spongilla* in the dark-brown argillaceous diluvium of the Altmühl valley, Bavaria.

African Fresh-water Sponges.†—M. Hilgendorf describes two *Spongillæ* (*S. nitens* Carter and *S. Böhmii* n. sp.) collected by Dr. R. Böhm in the River Ugalla, near Lake Tanganyika. Until now the occurrence of a fresh-water sponge from Africa had never been proved.

Protozoa.

Chlorophyll in Vorticellæ.‡—T. W. Engelmann describes the occurrence of undoubted chlorophyll in certain Vorticellinæ. Growing on filaments of *Vaucheria*, both living and dead, he found, along with *Vorticella campanula* and *nebulifera*, others of a diffused green colour, distinguished also by the narrower and more delicate circular marking of the body, and the greater transparency of their endoplasm. The colouring matter did not belong at all to the endoplasm, but entirely to the ectoplasm, and to the cuticle and the very narrow protoplasmic subcuticular layer. In fresh animals the colour was perfectly homogeneous, as in the chromatophores of plants, but somewhat paler.

In order to determine whether the colouring substance was true chlorophyll, i. e. a chromophyll with true power of assimilation, Engelmann employed the bacteria-method proposed by himself.§ Careful experiments proved beyond a doubt that these *Vorticellæ* had the power of decomposing carbon dioxide, and giving out free oxygen into the air in the presence of light. This the author regards as the first instance known of a true chlorophyll connected with the living protoplasm of an animal, and not with vegetable organisms contained within it. The quantity of oxygen given off is, however, small, partly in consequence of the small amount of chlorophyll contained in the ectoplasm, partly because a considerable portion of the oxygen is immediately again required by the animal itself for its respiration.

Spectroscopic examination again showed the spectrum of the green pigment of the *Vorticellæ* to be identical with that of vegetable chlorophyll. The reaction towards concentrated sulphuric acid and other chemical tests, led to the same conclusion.

Although this *Vorticella* is the only animal in which Engelmann has at present proved the existence of chlorophyll, he has long been acquainted with specimens of *Cothurnia crystallina* of a diffused green colour; and he suggests whether many of the bluish, brownish, violet, and other pigments which are diffused through the ectoplasm of some

* Ann. and Mag. Nat. Hist., xii. (1883) pp. 329–32 (1 pl.).
† SB. Gesell. Naturf. Freunde, 1883, May 22nd.
‡ Onderz. Phys. Lab. Utrecht, iii. (1883) pp. 147–69 (German).
§ See this Journal, i. (1881) p. 962.

Infusoria are not true chlorophylls, analogous to the xanthophyll, cyanophyll, and rhodophyll of algæ.

Action of Tannin on Infusoria.*—Referring to Mr. H. J. Waddington's paper on this subject *(ante*, p. 185), H. Gilliatt points out that the effect of the tannic acid on *Paramecium aurelia* is to cause the elongation and discharge of the trichocysts, which form a dense fringe of slender rods all round the body.

New Swiss Infusoria.†—Dr. O. E. Imhoff records in a preliminary communication the following new species of Infusoria from Swiss lakes:—

Dinobryon divergens, so named on account of the manner in which the individuals of the colony are grouped. *Ceratium reticulatum*, nearly allied to *C. hirundinella*, but carries only two horns on the posterior division of the test. *Epistylis lacustris* (no description at present). *Acineta elegans*, test pear-shaped, length 0·072 mm., maximum diameter of upper part 0·044 mm.; connected with the pedicle by a globular inflation. Suckers numerous, arising at equal distances from the feebly arched anterior surface. Imhoff remarks on the incorrectness of the view entertained by previous investigators into this subject, such as Forel, that the pelagic fauna of these lakes is scanty, and limited to *Copepoda* and *Cladocera*. Besides the above new species and six *Rotifera* (for which see *supra*, p. 847), he is able, from investigations made in the winter in the lakes of Zürich, Zug, Æger, Katzen near Zürich, Greifen, and Vierwaldstätter, to add the following known forms to this fauna:—*Dinobryum sertularia*, *Peridinium tabulatum*.

New Peritrichous Infusoria.‡—F. W. Phillips describes an Infusorian nearly allied to the genus *Gerda* (Vorticellina), and which he names *G. caudata*:—

The body is elongated, about seven times as long as broad, of an undulating contour, subject to changes; it is highly contractile, assuming a globular shape when retracted; the integument is of a reddish tint and transversely striate, annulate when contracted. The posterior extremity of the body terminates in a peculiar imbricated tail-like appendage, resembling the telescopic tail of a rotifer, but is not telescopic; this appendage is finely striate longitudinally; the body when extended, before the ciliary disk is projected, is broad and rounded at both ends and depressed in the middle. The ciliary disk is convex, the peristome border thick; cilia very fine and long; vestibular setæ distinct; contractile vesicle spherical, situated at the extremity of the vestibular cleft; minute non-contractile vesicles distributed throughout the whole of the parenchyma; the endoplast is spherical and conspicuous; endoplasm granular, and maintains a continual cyclosis or circulation. The eversion of the cilia is extremely gradual, occupying about five to ten minutes; retraction is instantaneous. W. Saville Kent points out an analogy between the tail-like

* Proc. Linn. Soc. N. S. Wales, 25th July, 1883.
† Zool. Anzeig., vi. (1883), pp. 466–71.
‡ Journ. Linn. Soc. Lond.—Zool., xvii. (1883) pp. 293-5 (4 figs.).

appendage and the telescopic tail of his *Vorticella telescopica*, and the specific title of *caudata* is bestowed in allusion to this appendage.

Abyssal Type of Orbitolites.*—Dr. W. B. Carpenter makes his observations on this foraminifer the basis of a study in the theory of descent. He commences by reminding the reader of his earlier researches into the history of the Foraminifera, where he was able to trace a pedigree from the typical *Orbitolites*, which shows no trace of spiral growth, to the spiral *Orbilucina;* want of material prevented him from carrying the pedigree back with certainty to the milioline type, though he was able to express his belief that *Orbitolites* was the most specialized of the *Miliolida*.

The dredgings of the 'Porcupine' in 1869 brought up a new form of Orbitoline disk, which completely realized the hypothetical pedigree. This disk commences as a minute primordial chamber, which first extends itself into a closely coiled spiral tube like that of a *Cornuspira*, then shows an incipient septation in the later coils of this tube, which constitutes it a *Spiroloculina;* then flattens out, and becomes camerated as a *Peneroplis;* then undergoes the subdivision of its chambers which converts it into an *Orbiculina*; and, finally, by the fusion of the lateral extensions of the chambers into complete annuli, assumes the cyclical plan of growth characteristic of *Orbitolites*.

We see then an individual passing through what, in the classification of D'Orbigny, are regarded as four different orders; while we are led to recognize that, in the Foraminifera, plan of growth is a character of secondary value.

The whole of the observations may be thus summed up:—

1. There has been a progressive specialization in the structure of the shelly envelope, which in the highest forms becomes of extraordinary complexity.

2. This specialization has followed a very definite and well-marked line.

3. It is without any corresponding specialization in the structure of the animal, whose protoplasm retains throughout its primitive homogeneousness.

4. All the ancestral forms through which the highest type has passed are still living and flourishing under exactly the same conditions (so far as can be ascertained) as itself.

After a careful consideration, the author comes to the conclusion that here a "plan" in the variations may be clearly traced out, and that "natural selection" can have had scarcely any share in determining the progressive evolution and relative distribution of the several forms of the *Orbitoline* type.

Trypanosoma balbiani.†—A. Certes refers to an article by Mitrophanow, in a recent number of the 'Biologisches Centralblatt,' on the hæmatozoa of fishes, where the two new species of *Hæmatomonas* are described; the only difference between these and *Trypanosoma balbiani* appears to lie in their possession of a long flagellum. In an earlier

* Proc. Roy. Soc., xxxv. (1883) pp. 276–9.
† Bull. Soc. Zool. France, viii. (1883) pp. 209–10.

paper Certes had referred to the presence, in the stomach of an oyster, of an amœboid hyaline substance which, at first sight, appeared to be a true *Bathybius*, but which, when treated with iodine, acetic acid, and colouring matters was found to be a colloid body. How does this get into the stomach of the oyster? The recent observations of Möbius on the rapid disappearance of the crystalline style in oysters taken out of the water suggests that these amœboid masses are nothing else than the débris of the crystalline style.

Chrysopyxis bipes Stein (Dinobryon sertularia Ehrenb).*—N. Wille has made a careful examination of the organism described by Woronin under the name *Chromophyton Rosanoffii*,† and details the history of its development as follows:—After hibernation the cells divide, and the zoospores, after swarming for a time, at length come to rest, the anterior end with its contractile vacuole resting on the substratum. Colourless protoplasm now begins to collect at the opposite end, the enveloping membrane being somewhat raised up by it and finally ruptured, a portion of the protoplasm escaping into the water; the membrane can now be compared to a flask-shaped envelope, in the mouth of which is a fine protoplasmic cilium. In this state, the organism appears to be identical with Stein's *Chrysopyxis bipes;* the same author's *Chrysomonas ochracea* being the globular zoospores which result from the division of its protoplasm.

The above is the cycle of development of one form of Woronin's *Chromophyton*, the one with many small globular zoospores, which have their vacuole in the anterior part, at the point of origin of the cilia. A second form has larger oval zoospores, and the vacuole nearly in the middle of the larger diameter. In the hibernating stage it can scarcely be distinguished from the first form; but as soon as it commences to divide, it is marked by the form, size, and position of the contractile vacuole. This form is possibly Ehrenberg's *Monas flavicans* (certainly not Stein's *Chrysomonas flavicans*). When the bulging of the enveloping membrane begins, it becomes *Epipyxis utriculus* Ehrenb. Its protoplasm divides, usually by bipartition. Repeated division, resulting in the inclosing of several individuals within the same envelope, leads to Ehrenberg's *Dinobryon sertularia;* in this stage a red eye-spot is perceptible.

All the different forms which have been named appear therefore to be stages in the cycle of development of a single organism.

* Ofvers. Kngl. Vetenskaps-Akad. Förh. Stockholm, 1882, pp. 9–22 (1 pl.). See Bot. Centralbl., xv. (1883) p. 33.

† See this Journal, i. (1881) p. 100.

BOTANY.

A. GENERAL, including Embryology and Histology of the Phanerogamia.

Fertilization of the Borraginaceæ.*—The change of colour in various borraginaceous flowers would seem to bear relation to their fertilization. Hermann Müller remarks that he has observed that insects visit exclusively those which are red or just beginning to change to blue. All the blue flowers which he examined in a locality about 2 yards broad and 20 long, where many hundred flowers of *Pulmonaria* were in all stages of development, proved to be empty of honey, and all which he observed with the aid of a lens had the stigma already supplied with pollen; so that it would appear that, as in *Lantana* and *Ribes aureum*, the change of tint serves as a guide to insects visiting the flower.

Pollination of Cypella.†—Two Brazilian species of this genus of Irideæ have been studied from time to time by Fritz Müller, who finds a number of interesting peculiarities in their flowering. The flowers are produced in abundance only on certain days, which recur more or less regularly, and apparently independently of climatic conditions. Nectar is secreted in the pockets on the three petals, which are flexible, so that when a *Xylocopa* or *Bombus*, to which the flowers seem well adapted, alights on one in quest of nectar, it bends over with the weight of the bee, whose back is brought in contact with a stigma and the underlying anther. Commonly the bee goes to another flower without trying the other petals of the one on which it has first settled, so that crossing is effected by it. One of the species studied proves to have self-impotent pollen; the other is fertile with its own pollen. The stingless bees (*Trigona*), though not necessarily excluded by structural peculiarities from the nectar, do not obtain it readily; yet their visits for the protectively coloured (pale bluish) pollen are sufficiently numerous to prevent the larger bees from visiting the flowers in numbers.

Pollination of Rutaceæ.‡—J. Urban has studied the adaptations for fertilization in a considerable number of species belonging to this order. He classifies them from this point of view as follows:—I. Monoclinous species. (A) with dichogamous (proterandrous) flowers; (B) with synacmic flowers. II. Diclinous flowers. In each class are a number of subdivisions.

Division of the Nucleus.§—For the purpose of endeavouring to reconcile the description of the mode of indirect division of the cell-nucleus given by Strasburger in the case of plants, and by Flemming

* Nature, xxviii. (1883) p. 81.
† Ber. Deutsch. Bot. Gesellsch., i. (1883) pp. 165–9.
‡ Jahrb. Bot. Gart. Berlin, ii. See Science, ii. (1883) pp. 53–4.
§ Comptes Rendus, xcvii. (1883) pp. 646–8. Cf. this Journal, i. (1881) p. 621; ii. (1882) p. 317.

in the case of animals, L. Guignard has undertaken a fresh series of observations, principally on the mother-cells of pollen-grains in both monocotyledons and dicotyledons, the embryo-sac, endosperm-cells, parenchyma of ovules, wall of the ovary, &c.

Reagents capable of differentiating the constituent elements of the nucleus and of the cell-protoplasm show that the nucleus, when in a state of rest, is composed, within its enveloping membrane, of a hyaloplasm which serves as a substratum for granulations or microsomes which present the reaction of nuclei, and which are disposed in the form of a network or of a more or less anastomosing branched filament, with one or more nucleoli in the course of, or simply in contact with, the filament. The following phases may be distinguished in the division of the nucleus:—

1. The chromatic filament existing in a state of rest in the mother-nucleus, or proceeding from a modification of the network, commences to contract and to become thicker, assuming the form of a ball.

2. It then divides into segments, the number of which varies according to the species and according to the organ of the plant, but seems to be uniform for the same organ. This is the phase of segmentation.

3. The separate segments behave in different ways in different cases before arranging themselves in the centre of the cell after the disappearance of the membrane of the nucleus. Sometimes they take the form of straight rods arranged in rays; sometimes they are bent in the middle, turning their angle towards the centre of the cell and their extremities towards the periphery. This is the phase of the nuclear plate of Strasburger, or of the nuclear star of Flemming, at the end of which the achromatic threads of the nuclear spindle usually make their appearance.

4. In each rod or segment a longitudinal division then takes place (not transverse, as has been stated in the case of plants), analogous to that which several zoologists describe in the case of Batrachians, and which consequently doubles the original number of the segments.

5. Each half-segment, before taking part in the formation of the two daughter-nuclei, turns one of its more or less bent extremities, or the angle formed by its two branches if there is a curvature in the middle, in the direction of the poles which constitute two new centres of attraction, round which the divided segments arrange themselves radially.

6. After a contraction at the poles, the segments coalesce by their extremities, in order again to form a filament, the curves of which contract and assume the globular disposition of the mother-nucleus.

Although Strasburger has described cases in which there is no longitudinal division of the elements of the nuclear plate, Guignard considers that the occurrence of such a division in all the cases observed by him establishes a fresh point of agreement between the vital phenomena in plants and in animals.

Albumen, Nuclein, and Plastin.*—For demonstration of the presence of proteids within the cell, E. Zacharias employs their property of giving a precipitate with acid solution of potassium ferrocyanide. For this purpose he employs a mixture of a solution of 1 part of potassium ferrocyanide in 10 parts of water, with 2 volumes of a solution of acetic acid of sp. gr. 1·063 in its own volume of water, washes with dilute alcohol of 60 per cent., and then places the cells in a solution of chloride of iron. The potassium ferrocyanide, which forms a compound with albumen insoluble in water, enters into mutual decomposition with the chloride of iron, and all the proteinaceous parts of the protoplasm are coloured blue. Although this reaction does not indicate with certainty the presence of albumen, failure is a certain proof of its absence. The nuclein and nucleoli of the nucleus, and the starch-generators of the epidermal cells of the leaf of Orchideæ, are coloured blue. The author concludes that a large portion of the substance of the starch-generators is composed of albumen. Albumen also occurs, though in smaller quantities, in the chlorophyll-grains of *Sambucus* and *Orchis*.

The application of this reaction to dying leaves proves, to the satisfaction of the author, that the decrease in the amount of nitrogen contained is due to the diminution of the amount of albumen, more than of the other nitrogenous constituents of the cell.

Chemical Changes in the Germination of Barley.†—K. Michel states that in the germination of barley grains there is a loss of starch to the extent of 10 per cent., a portion being converted into carbonic acid and water, and a smaller portion into dextrin and sugar. From the albuminoids two important ferments, diastase and peptase, are formed very rapidly. As the radicle developes, further changes take place in the nitrogenous constituents of the seeds, substances being produced of the nature of amides, the proportion of acids increasing at the same time.

Function of Amygdalin in Germination.‡—It has long been known that amygdalin occurs in the bitter almond, associated with a special ferment called emulsin or synaptase, which, in the presence of water, decomposes it into glucose, benzoic aldehyde, and hydrocyanic acid; while the sweet almond contains also emulsin, but only a small quantity of amygdalin or none at all. The evolution of hydrocyanic acid characterizes the germination of many other seeds; and A. Jorissen now shows that this is also the case with flax seeds under certain conditions. If soaked in warm water, then exposed for a time to a temperature of 25° C., and distilled, the water distilled off contains hydrocyanic acid. This acid does not exist as such in the seeds of the flax, any more than in the bitter almond, but is the result of the action upon amygdalin of a substance analogous to emulsin. The purpose of the amygdalin, as of other glucosides, appears to be to

* Bot. Ztg., xli. (1883) pp. 209–15.

† SB. Bot. Ver. München, May 9th, 1883. See Bot. Centralbl., xv. (1883) p. 91.

‡ Bull. Acad. R. Sci. Belg., v. (1883) pp. 750–7.

furnish the seedling plant, during the early stages of its development, with the carbohydrates necessary for the formation of its cells. The quantity of hydrocyanic acid produced in germination is, however, very small; large quantities would have a poisonous effect on the growing plant.

Galvanic Phenomena in Germinating Seeds.*—J. Müller-Hettlinger has investigated the electrical phenomena presented by the apex of the roots of germinating seeds, especially of *Vicia Faba*, *Zea Mays*, and *Biota orientalis*, from the time of the protrusion of the radicle through the testa to the appearance of the first foliage-leaves. In the case of all these plants, and in all stages of development, the galvanometer indicated a current from the cotyledons and the radicle, caused by the electronegative condition of the latter and the electropositive condition of the former. But every point of the root, and also of the secondary roots when they had made their appearance, and every point of the first foliage-leaves, and especially of the tigellum, was electronegative in relation to the cotyledons, but with decreasing intensity the nearer it was to them. The following law could therefore be formulated:—If one of the conducting electrodes is imagined constantly placed at the cotyledons, while with the other the current is successively conducted from the other parts of the seedling above and below the cotyledons, an electromotor force is always set up, caused by the electropositive condition of the testa or cotyledons contrasted with the electronegative condition of all the other parts of the seedling; and this force is less intense the nearer the movable electrode is to the cotyledons whether above or below them.

Mechanical Protection of Seeds against External Injury.†—In respect to peculiarities under this head, R. Marloth classifies seeds into five groups, as follows:—

1. Those seeds in which the testa has no protective contrivance; the endosperm is wanting, or is only rudimentary. The number of plants belonging to this group is small; their very small seeds are dispersed by the wind and germinate in damp places.

2. Protective contrivances are also wanting, or are only very feebly developed; but the endosperm is abundant, consisting of thick-walled cells, and serves as a protection to the embryo which it incloses. In some the outer wall of the epidermis is thickened. In some which bear berries, the endosperm protects the embryo in its passage through the body of birds.

3. The testa has protective contrivances, and the endosperm is wanting or is only feebly developed. A very large group in which the protective layers are developed in a great variety of ways:—as simple thickenings of the epidermis, a deeper layer of thickened cells, a simple layer of thick-walled parenchyma, palisade-cells, lignified parenchyma, sclerenchyma, and a development of prosenchyma.

* Pflüger's Arch. f. Phys., xxxi. p. 193. See Naturforscher, xvi. (1883) p. 235.

† Engler's Bot. Jahrbücher, iv. (1883) p. 225. See Naturforscher, xvi. (1883) p. 349.

4. The testa has protective contrivances, and there is besides an abundant but not thick-walled endosperm. This is the largest of all the groups, and the protective contrivances are very variously displayed, as in the last. The endosperm-cells contain proteinaceous substances, oil, or starch.

5. Those with protective contrivances to the testa and a thick-walled endosperm. This double protection occurs in only a small number of plants. The walls of the endosperm-cells are always of considerable thickness, but not so great as in the case of those which depend on this only for protection.

Lignification of Epidermal Membranes.*—Besides cuticularization, the change which characterizes epidermal cell-walls in general, the outermost wall may undergo two others; it may be converted into mucilage, thereby becoming weakened, or it may be rendered firm by the deposition or infiltration of mineral matters. To these well-known transformations of epidermal cells A. Lemaire now adds lignification, hitherto supposed to be confined to internal tissues. For the detection of lignin he uses the useful reagent suggested by Wiesner, phloroglucin. A section of epidermis is transferred from an alcoholic solution of the agent to hydrochloric acid, when the lignified membranes assume a rose colour, the other parts remaining unchanged. For purposes of control, similar sections are first treated with either nitric acid or a solution of bleaching powder, by which reagents, preferably the latter, the lignin is removed. Lemaire has detected lignin in the epidermal walls of Cycadeæ, many Coniferæ, and in the petiole of certain ferns. The stomata of Coniferæ and Cycadeæ have been found by him always to have the membranes somewhat lignified.

Protective Sheath and its Strengthenings.†—A further careful examination of this subject leads S. Schwendener to the general conclusion that a natural classification of tissues must be founded entirely on their structure and function, and not on the variable phenomena of the history of their development.

Laticiferous Tubes.‡—According to G. Haberlandt, sections through the lamina of thick-leaved species of *Euphorbia* (such as *E. Lathyris*, *Myrsinites*, or *biglandulosa*) show that the anatomical connection between the palisade-layer and the laticiferous tubes is as close as between the palisade layer and the parenchymatous sheath of the vascular bundle, and the connection is close in proportion to the looseness of the palisade-tissue. The conduction of the products of assimilation takes place, as a rule, by means of funnel-shaped or spongy parenchymatous cells. In the thin-leaved species such a mode would be superfluous. Where the laticiferous tubes are found on the upper boundary of the palisade-layer beneath the epidermis, the palisade-

* Ann. Sci. Nat., xv. (1883) pp. 297–302. Cf. Science, ii. (1883) pp. 112-3.

† Abhandl. K. Akad. Wiss. Berlin, 1882, 75 pp., 5 pls. Cf. this Journal, *ante*, p. 679.

‡ SB. Akad. Wiss. Wien, lxxxvii. (1883) (2 pls.). See Bot. Centralbl., xv. (1883) p. 35.

cells incline upwards; and the formation of fresh material must consequently take place in the opposite to the usual direction. The same occurs also in *Asclepias curassavica*.

In addition to the contact of the laticiferous tubes with the spongy parenchyma, the conduction of food-material is also assisted by special contrivances. In *Euphorbia palustris* this is effected by the extension of the spongy parenchyma in a direction at right angles to that of the laticiferous tubes; in thick-leaved species by the formation of parenchymatous sheaths resulting from the spongy parenchymatous cells being in close uninterrupted contact with the laticiferous tubes.

The laticiferous tubes ramify abundantly underneath or in the palisade-layer. Where the tubes accompany the vascular bundle of the leaf (as in *E. Myrsinites* and *Hypochœris radicata*) they put out branches in an upward direction, which often ramify or dichotomize, and the ends of which abut on the palisade-cells. The lateral branch appears to break through the sheath of the vascular bundle, and not unfrequently gives the impression as if some of the cells of the sheath were employed in the formation of the branch. But the history of development shows that they are entirely independent. The walls of the laticiferous tubes have no special structure; here and there pits were found, the thin closing membrane of which appeared to be perforated by very fine pores.

The development of the reticulation of laticiferous tubes in the leaves is in inverse proportion to that of the conducting parenchyma. The ends of the vascular bundles project directly into the air-containing intercellular spaces. When the laticiferous tubes are abundant the parenchymatous sheath is imperfect, and its cells alter their form; they become as broad as long, and of irregular outline, corresponding to their functional degeneration. The so-called parenchyma of the veins disappears with the increase of the laticiferous tubes; a transverse section of the principal vein of *E. Myrsinites* shows that it is completely wanting, or nearly so.

In *Hypochœris radicata* the lamina of the leaf always has a very strong mid-rib; but the greatly developed parenchyma appears here to fulfil a mechanical function.

Medullary Vascular Bundles of some Dicotyledons.* — An extended investigation by J. E. Weiss of the fibrovascular bundles found in the pith of a large number of dicotyledons, has led to the following general conclusions.

The later origin of the medullary bundles in comparison to that of the larger bundles of the peripheral ring, does not justify the conclusion that they are cauline (i. e. originate exclusively in the stem). In the Cucurbitaceæ, *Papaver orientale*, *Actœa fœtida*, *Cimicifuga*, and *Thalictrum*, it cannot, however, be positively asserted that they are not cauline. The bundles in the stem of *Statice* and *Armeria* are certainly of common origin.

In the so-called "endogenous" formation of vascular bundles, the

* Bot. Centralbl., xv. (1883) pp. 280–95, 318–27, 358–67, 390–7, 401–14 (1 pl.).

bundles of the peripheral ring pass in the next node above into the leaves, and the medullary bundles are arranged between bundles of the peripheral ring (*Begonia*), or in most cases, form the direct continuation of leaf-traces, which after their entrance into the stem, run through one or more internodes in the peripheral circle, before they bend into the pith. In the exogenous formation of bundles, the leaf-traces pass into the pith immediately after their entrance into the stem, and bend towards the periphery only in lower nodes. Neither the exogenous nor endogenous mode of formation of bundles is properly included under the term cauline.

The bundles which occur in some *Begonias* are not cauline; those so-called in this genus pass in the node into the peripheral ring, and bend into the leaf in a still higher node. The medullary bundles in some species of *Aralia*, as *A. edulis* and *racemosa*, run through one internode in the peripheral ring, after their entrance into the stem, before they bend into the pith in a lower node, in consequence of the entire bundle twisting through an angle of 180°. *Silaus pratensis* exhibits the same phenomena, only that there is no twisting of the bundle. In all other Umbelliferæ with a medullary system of bundles, it may be assumed that they are simply continuations of the leaf-traces.

The medullary bundle-system of *Tecoma radicans* is the immediate continuation of the median bundles of the leaf-trace, which after their entrance from the leaf, run in the peripheral ring through two internodes, before they pass into the pith in the third node, accompanied by twisting through 180°. Species of *Acanthus*, as *A. longifolius*, exhibit the same peculiarity.

The medullary vascular (often only phloem-) bundles in some species of *Campanula* are not cauline; their course is the same as in *Tecoma* and *Acanthus*. In *C. pyramidalis* there is often a closed ring of vascular bundles composed of several medullary continuations of leaf-traces, which spring partly from the median leaf-trace of the next leaf above, but mostly from those of leaves of still higher insertion. A similar course is taken by the medullary phloem-bundle of Cichoriaceæ, as in *Scorzonera*, *Sonchus*, *Lactuca*, &c. They are occasionally also accompanied by xylem, and, in the lowest internodes, become concentric vascular bundles.

The medullary bundle in Convolvulaceæ, Apocynaceæ, Solaneæ, Myrtaceæ, Gentianaceæ, &c., is never cauline, it always passes, with the vascular bundles within which it lies, into the leaves, and unites, as it expands in the lamina, with the peripheral bundle of the vascular bundles. The phloem-bundles of these families differ from those of Cichoriaceæ by their course and by the absence of xylem.

The medullary vascular bundles of Melastomaceæ are also not cauline, but are the direct continuation of the phloem-bundles which run at the margin of the pith in the higher internode, and are often accompanied by annular and spiral vessels when they pass into the node in the more central part of the pith. The arrangement of their xylem and phloem is not concentric.

In thick fleshy roots the medullary vascular bundles of the stem

may be continued in the xylem; every bundle then continues to grow at its lower end. The concentric vascular bundles in fleshy roots are continuations of leaf-traces; they can occur only in the unlignified xylem-parenchyma of the root.

The phloem-bundles in the xylem of fleshy roots of species of *Œnothera*, *Gaura*, and *Gentiana*, and of *Scopolina atropoides*, are formed out of cambium.

The cortical vascular bundles are also prolongations of leaf-traces or of parts of them. In respect to their course through the stem, they may be arranged in four classes:—(1) Cortical bundles which pass in an oblique radial direction through the cortex, and gradually enter the peripheral ring of vascular bundles; (2) Those which are in connection with leaf-traces of a lower node which directly enter the peripheral ring; (3) Those which are in connection with the cortical bundles of lower internodes in a lower node; (4) Those which have a blind ending towards the next lower node, and do not unite with other bundles.

The concentric cortical bundles have a central xylem and peripheral phloem. Those medullary and cortical vascular bundles which possess cambium are capable of increase in thickness up to a certain point.

Nutating Internodes.*—J. Wiesner and R. von Wettstein give the following summary of observations on this subject:—

1. Internodes of stems in the condition of undulating nutation show two zones of strongest growth, one in the upper curve which is directed downwards, the other in the lower weaker ascending curve.

2. In the first stage of growth, after leaving the bud-condition, they are orthotropous, and have at this time a uniform growth.

3. When dicotyledons germinate (and in many seeds even at an earlier period), the originally orthotropous internodes of the seedling acquire a simple curvature, passing into the condition of simple nutation, the maximum of growth being, while this lasts, nearly in the middle of the internode.

4. When the simple passes into an undulating nutation, the two maxima of growth are manifested; with further growth of the internode they approach one another, and finally coalesce at the time when the undulating nutation ceases. As long as the internode is growing, that maximum continues which is nearer its upper end.

5. In an internode with undulating nutation there are therefore four stages:—(1) the orthotropous condition, with cell-division and very slow uniform growth; (2) simple nutation and (3) undulating nutation, with division and elongation of cells, and an irregular growth with two maxima; (4) elongation of cells, with very regular growth.

6. Those zones of an internode which grow most rapidly in length contain the longest cells.

* Anz. K. Akad. Wiss. Wien, July 5th, 1883. See Bot. Centralbl., xv. (1883) p. 200.

Function of the Apex of Roots.*—G. Krabbe has further investigated the theories as to the cause of the motion of rootlets advocated by Darwin and Wiesner. He states that the sensitive portion of the apex of roots never exceeds 2 mm. in length, and varies greatly below this limit. Since the portion of the root capable of curvature is not included in this length, and amputated roots are still able to grow, the author agrees with Darwin that the apex receives from gravitation an impulse which it passes on to the zone of maximum growth. He supports, however, Wiesner, as opposed to Darwin, in his view that geotropism is a force entirely independent of circumnutation; and that the latter is consequently not the cause of all the movements to which roots are subject.

Transpiration and Absorption of Water by Branches in Winter.†—R. Hartig has obtained the following results from a series of observations on transpiration and absorption of water on the part of the bark or leaf-buds of a number of trees during winter:—The transpiration both from angiosperms and conifers during winter varies greatly with the species. With a normal quantity of water, i. e. during the early days of the experiment, we get the following series, commencing with the least rapidity of transpiration:—birch, oak, copper beech, beech, black spruce, spruce, larch. On rainy days the branches, especially of angiosperms, take up comparatively large quantities of water. In autumn and the early part of winter the branches remain constantly full of water, from which the tree must obtain copious supplies.

Hydrotropism.‡—H. Molisch regards hydrotropism as a phenomenon of growth, and confirms Darwin's statement that a length of from 1–2 mm. at the apex of the root is sensitive to psychometrical differences, transferring the irritation to the growing part above it, and causing curvature there. The hydrotropism of roots is only a special case of the so-called "Darwinian curvature," depending on the withdrawal of water from one side of the apex of the root; the greater dryness of the air on the side which becomes convex causes a stronger transpiration of the adjoining half of the root-tip; and this stronger transpiration gives rise to the hydrotropic curvature.

The rhizoids of Marchantiaceæ are positively hydrotropic; while both unicellular fungi, such as *Mucor* and *Phycomyces*, and many multicellular fungi, such as *Coprinus*, are negatively hydrotropic.

The tigellum is neither positively nor negatively hydrotropic, even when the action of light and gravitation on one side only is excluded; except in the case of the flax, the tigellum of which is negatively hydrotropic.

The author describes a new apparatus for observing hydrotropism. A solid clay funnel provided with a perforated cover is allowed to dip

* Ber. Deutsch. Bot. Gesellsch., i. (1883) pp. 226–36. Cf. this Journal, ii. (1882) pp. 529 and 531.

† SB. Bot. Ver. München, May 9th, 1883. See Bot. Centralbl., xv. (1883) p. 92.

‡ Anzeig. K. Akad. Wiss. Wien, July 12th, 1883. See Bot. Centralbl., xv. (1883) p. 201. Cf. this Journal, ii. (1882) pp. 74, 530.

into a glass filled with water, and its surface kept uniformly moist. If the funnel is placed in an atmosphere saturated with moisture, then the roots which project through the perforations in the cover grow vertically downwards; but when placed in an atmosphere only moderately moist, the roots are diverted from their normal direction, and become closely attached to the conical surface of the moist funnel.

Influence of Diminished Atmospheric Pressure on the Growth of Plants.*—Experiments conducted by A. Wieler at Tübingen show that, all other external conditions being the same, plants will grow more rapidly under diminished atmospheric pressure. Thus, if a specimen of the common Windsor bean (*Vicia Faba*) be grown in a receptacle in which the pressure of the air can be controlled, it will be found to grow faster until the pressure has been diminished to 100–300 mm.; the normal pressure under which the ancestors of the plant have flourished being, of course, not far from 760 mm. If, however, the pressure is reduced below the smaller figure given above, the rate of growth diminishes. Wieler found that the curve of growth of the sunflower is about the same as that of the bean. It was further shown by his experiments that growth is retarded by increased pressure until the minimum is reached at 2–2½ atmospheres, from which point there is again an increase.

The quantity of oxygen in the atmosphere may in fact be reduced to a very small amount without entirely destroying the power of supporting vegetable life. The density at which the maximum growth took place varied with different plants. This may obviously be of advantage to plants growing at great altitudes.

Effect of Radiant Heat on the Growth of Plants.†—Following out the observations of Van Tieghem on the phenomenon termed by him "thermotropism," J. Wortmann has experimented on the influence on the growth of plants of changes in temperature independent of light. He found that rays of heat act on growing parts of plants in very much the same way as rays of light. Rays of heat of a definite intensity falling on one side only cause curvatures in the growing parts of plants which turn either towards or away from the source of heat; and these are quite independent of the effects of light. The apparatus employed was a large chamber in which the source of heat was a blackened iron plate heated by a gas-burner, heliotropic curvatures being prevented by special contrivances. The plants experimented on were *Zea Mays*, *Linum usitatissimum*, *Lepidium sativum*, and fructifications of *Phycomyces nitens*. Of these, the first showed itself to be positively, all the others negatively thermotropic. In order for thermotropic curvatures to take place, the temperature must be at least 20° C., and the rapidity of the curvature is proportional to the intensity of the rays of heat.

* Unters. Bot. Inst. Tübingen, i. See Bot. Ztg., xli. (1883) p. 452. Science, ii. (1883) p. 178.

† Bot. Ztg., xli. (1883) pp. 457–70, 473–80.

Colouring Matter of Flowers.*—A. Hansen has separated the two constituents of chlorophyll by Kühne's method. He has also examined the colouring matter of flowers. The yellow pigment is lipochrome, and can be crystallized. It shows two bands in the blue and no fluorescence; that described by Pringsheim resulted from a small admixture of chlorophyll. The red colouring matter is in a state of solution in the cells. The spectrum shows a broad band between D and *b*. The shades of red are often caused by an admixture of lipochrome, as in *Papaver*, *Lilium bulbiferum*, &c. The blue and violet pigments are also in a state of solution, and show bands in the red half of the spectrum. Acted on by acids they become red. None of these pigments show spectra resembling that of chlorophyll, except when a small quantity of that substance is present.

Botanical Micro-Chemistry.†—The firm named at foot published during last year a price-current founded on Poulsen's 'Botanisk Mikrokemi'; it now publishes an exceedingly complete list (88 numbers against 64 in the previous publication), including all the more important microscopic reagents recommended by botanists up to the end of June 1883. It has been made in accordance with the suggestions of W. J. Behrens, the compiler of the 'Handbook for carrying out Microscopical Investigations in the Botanical Laboratory,' partly contained in that book, and partly, as far as the newer reagents are concerned, from his communications by letter. Special attention may be called to the fact that it includes all the means employed for colouring the nucleus, and all the more important pigments for investigations of bacteria, including that employed in the 'Koch-Ehrlich-Rindfleisch' method for preparations of tubercular bacilli. Supplemental lists will be added from time to time, to include anything fresh. Prof. Behrens recommends these reagents, guaranteed to be of the greatest possible purity, the price being also moderate.

B. CRYPTOGAMIA.

Cryptogamia Vascularia.

Vascular Bundles of the Leaf of Sphenophyllum.‡—B. Renault thus describes the structure of the vascular bundles in the leaf of the fossil genus *Sphenophyllum*. A transverse section shows the following elements:—

1. A layer of the upper epidermis, that is, of the surface facing the branch when the leaf is erect.
2. A layer of the lower epidermis.
3. A mass of fundamental tissue.
4. Some vascular bundles, the number of which corresponds to that

* SB. Phys.-med. Gesellsch. Würzburg, July 30th, 1882. See Bot. Centralbl., xv. (1883) p. 254.

† 'Botanische Mikrochemie. Chemisch reine Reagentien zum Gebrauch in botanisch-physiologischen Instituten, nach Dr. W. J. Behrens und Dr. V. A. Poulsen zusammengestellt. Chemische Fabrik von Dr. Theodor Schuchardt in Görlitz (Pr. Schlesien).' See Bot. Centralbl., xv. (1883) p. 158.

‡ Comptes Rendus, xcvii. (1883) pp. 649–51.

of the veins, and therefore varies according to the part of the leaf where the section is made.

Each bundle includes a small band of woody tissue, usually flattened and surrounded on all sides by a thin layer of liber-elements. In the deeply incised lobes of the leaves the woody tissue forms, on the contrary, a small circular mass in the centre of the liber. It is composed of from five to twelve extremely slender tracheæ. The liber-elements are in direct contact with these; they are slender tubes with very thin walls. The liber-elements compose one or two layers; their thickness is less on the exterior than on the interior face of the woody bundle.

The vascular bundle never consists of any further elements than these. There are neither centripetal ligneous elements nor an external formative zone, nor secondary wood or liber. It is surrounded by a layer of larger cells with thin walls, which separates it from the mass of the fundamental tissue; it is uncertain whether this layer is of the nature of a sheath.

The fundamental tissue is composed of large rounded cells with thin walls, and a number of passages between them; in the neighbourhood of the vascular bundles a portion of this tissue is differentiated into a hypoderma. Each bundle is in fact placed between two strings of hypodermal bundles; one superior, consisting of from six to fifteen bundles, and stretching from the vascular bundle to the upper epidermis; the other inferior, and extending from the vascular bundle to the lower epidermis. There is no break of continuity between the epidermis and the hypodermal bundles, nor between the elements of the hypodermal elements, nor between them and the vascular bundle.

The upper epidermis consists of cells somewhat rounded on transverse section, with thick walls and somewhat larger in the direction of the veins; the lower epidermis of cells with vertical walls, also somewhat rounded, but smaller, and in direct contact with the hypodermal bands.

The vascular bundles of the leaf of *Sphenophyllum* have therefore no centripetal woody tissue, and therefore no power of centrifugal secondary growth; their structure is that of the very small bundles of the leaves of vascular cryptogams; and no conclusion can therefore be drawn from their structure favourable to the alliance of *Sphenophyllum* with the Sigillarias.

Structure of Phylloglossum.*—C. E. Bertrand states, as the result of an examination of *Phylloglossum Drummondii*, that the fertile peduncle is an axis, since it presents several lines of symmetry passing through one point; that the woody mass of this peduncle represents three bicentral bundles; and that the masses diametrically opposed to one another are united like the woody masses of a bicentral bundle of *Lycopodium*, *Selaginella*, and *Tmesipteris*; that, in consequence, the peduncle is a stipes; that this stipes differs from the fertile stems of *Lycopodium* only by the presence of three bundles instead of two;

* Comptes Rendus, xcvii. (1883) pp. 504–7, 612–5, 715–7.

and that the structure which approaches most nearly to that of the fertile peduncle of *Phylloglossum* is that of *Lycopodium Jutieri*.

Under the name of the "organ of Mettenius" Bertrand describes a small bilobed or furrowed emergence on the lower part of the fertile peduncle immediately below the insertion of the pedicel of the new tubercle.

The pedicel of the new tubercle has a nearly circular transverse section, and possesses a flattened elliptical central vascular bundle, surrounded by a very thick layer of primary fundamental tissue. In this tissue, at an equal distance from the vascular bundle and from the posterior surface of the organ, is a group of small cells which represent the epidermal cells of Braun's canal. Near the surface is an epidermal layer of cells characterized by thickenings of their radial walls.

The roots of *Phylloglossum* are of endogenous origin; their single vascular bundle is bicentral and axial; they do not branch; they are very unequal in size, and vary greatly in number.

Muscineæ.

Physiological Function of the Central Bundle in the Stem of Mosses.*—G. Haberlandt shows that the central bundle of the stem of mosses, generally described as a rudimentary vascular bundle, is in fact a water-conducting hadrome-bundle. *Mnium undulatum* has a sharply defined central bundle with thin longitudinal walls which ultimately become yellowish-brown, and very thin oblique septa. When mature they contain nothing but a watery fluid without starch-grains, oil, or protoplasm. If a freshly cut unmoistened stem is immersed to the length of 1–2 mm. of its leafless lower end in an aqueous solution of eosin, the pigment rises only in the central bundle, and there with considerable rapidity. If a freshly cut stem is allowed to transpire for from ten to fifteen minutes without access of water, the cells become for the most part filled with air.

In *Polytrichum* this central bundle has a complicated structure; the longitudinal walls are thick and yellowish-brown, the septa thin. It serves also here for the conduction of water, while the tissue which surrounds it, enveloped in a thin-walled dark brown sheath, contains protoplasm, starch, and oil, and represents a rudimentary leptome. This leptome-envelope is evidently a product of the differentiation of the cortex, which is the ordinary conducting tissue for the carbohydrates and albuminoids in the typical moss-stem.

Fungi.

"Ozonium."†—S. Schulzer (of Müggenburg) describes a new hymenomycetous fungus, *Bolbitius Ozonii*, the ozonium-like mycelium of which (*Ozonium auricomum* Link) densely covers the rotten trunks of oak-trees lying on grassy land. It is noteworthy as possessing the "velum universale," absent from other species of *Bolbitius*, but

* Ber. Deutsch. Bot. Gesellsch., i. (1883) pp. 263–7.

† Hedwigia, xxii. (1883) pp. 117–8. Cf. this Journal, *ante*, p. 539.

constantly present in the nearly related genus *Coprinus*. It constitutes an addition to Roumeguère's list of hymenomycetous fungi which produce "ozonium."

Brefeld's Ustilagineæ.*—The 5th part of Brefeld's 'Botanische Untersuchungen über Hefepilze' is occupied with the Ustilagineæ. In 23 species—including nearly all that are parasitic on our corn-crops—he describes the mode of germination of the spores in specially prepared nutrient fluids; and this is followed by a discussion of the morphology and systematic position of the family.

The spores of many Ustilagineæ require for their germination a substratum rich in nutrient substances; in pure water they either do not germinate at all, or the weakly germ-plants soon perish. In many species the second form of fructification, the conidia, appears with the germination. They are either formed on a small carpophore, the promycelium and sporidia of authors, or arise directly from the spores. But in some forms the conidial fructification is entirely suppressed. The conidia have the power of reproduction in endless generations, either by means of carpophores with or without mycelium, or by direct budding; in the latter case they appear in the form of colonies of buds with independent power of growth, and altogether correspond to the structures hitherto known as "torula" or "yeast," and described as independent forms of fungi. In many Ustilagineæ the development of the two forms of fructification is dependent on the conditions of life. When they are parasites, spores only are formed on the mycelium; but, on the other hand, when living outside the host as saprophytes, conidia only are formed in an endless series of generations, if there is no deficiency of nutrient material.

It is extremely probable that the conidial fructification in the form of torula-like buds occurs also in nature in many species belonging to the Ustilagineæ; that they have therefore the power of propagating outside the host as torulæ, and develope their typical spore-fructification only when they penetrate the tissues of the host by means of germinating filaments, which takes place when the supply of nutriment decreases.

It is not, however, the Ustilagineæ only that are distinguished by the power of forming torula-like conidia. In a great variety of classes of fungi forms occur the conidia of which can propagate as torulæ without carpophores by direct budding.

These observations are obviously of the greatest importance, both as regards the systematic position and morphological value of the organisms hitherto known as torulæ, and with reference to the diseases to which corn-crops are subject. It still requires to be ascertained whether the saprophyte which has propagated itself for generations in the form of torula can return to a parasitical condition, and to the formation of spore-fructification connected with this condition; and especially whether this is the case with the yeast-fungi.

* Brefeld, O., 'Botan. Unters. über Hefepilze.' Heft v., 202 pp. (13 pls.). 4to, Leipzig, 1883. See Oesterr. Bot. Zeitschr., xxxiii. (1883) p. 267.

New Ustilagineæ.*—M. Cornu gives an account of the anatomy and germination of the spores in several new or little known Ustilagineæ. *Ustilago axicola* Berk. and Curt. is made the type of a new genus, *Cintractia*, characterized by the formation of the spores in successive concentric circles. Its diagnosis is thus given:—"Sporæ adglutinatæ, tandem liberæ quum maturæ; e stromate diu fertili pedetentim natæ et recentioribus rejectæ." The curious *Testicularia Cyperi*, and a second species, *T. Leersiæ*, are described. The genus *Doassansia*, in which the spore-masses are surrounded by a peculiar envelope, is also described and figured. There are also descriptions of the following species:—*Melanotænium maculare*, *M. scirpicolum*, and *Geminella exotica*.

Development of Ascomycetes.†—O. Kihlman has followed out the history of development of *Melanospora parasitica*, which he finds to be truly parasitic on *Isaria farinosa*; also occasionally on *I. strigosa* and *Botrytis Bassiana*. The author has observed for the first time the abstriction of the conidia in this species. As regards the development of the perithecia and asci, he states that no morphologically differentiated antheridial branch can be distinguished from the rest of the enveloping hyphæ, and that neither the host nor the hyphæ of the *Melanospora*, which do not spring from the base of the carpogonium, take any part in the formation of the fructification. The ascogenous cell produces by division a true parenchymatous tissue; the parts of the envelope which are in close contact with it become disorganized, the organic connection of the ascogenous tissue or "nucleus" with the wall of the capsule, consisting of several layers, being thus broken. The cell-walls of the basal cells of the carpogonium are resorbed, their contents coalesce, and are expelled from the young perithecium in consequence of the active production of shoots in the neighbourhood. The newly formed hyphal branches constitute the neck of the perithecium; the outer layers of the wall turn brown; the formation commences of asci and spores, and the latter are forced out in a simple coiled chain through a fissure in the ascogenous tissue and through the neck-canal by the pressure of a deliquescent gelatinous mass in the centre of the nucleus. The author is of opinion that the antheridia have completely degenerated after becoming functionless, while the archicarp has maintained a form different from that of the sterile hyphæ, together with the function of producing parthenogenetic spores. *Melanospora* is hence closely related to certain Sordarieæ, constituting a group which contrasts on the one hand with altogether apogamous forms among the Pyrenomycetes, such as *Chætomium* and *Pleospora*, and on the other hand with *Eurotium* and the Erysipheæ which exhibit a comple sexual differentiation.

Kihlman has also followed out the history of development of *Pyronema confluens*, especially the further differentiation in the weft of hyphæ which is formed very early, the purpose of the tubular

* Ann. Sci. Nat. (Bot.), xv. (1883) pp. 269–96 (3 pls.).

† Acta Soc. Sci. Fenn., xiii. (2 pls.). See Bot. Centralbl., xv. (1883) p. 65.

prolongation of the larger of the two peculiar cells of the rudiment of the fructification, of the possible passage of protoplasm through this tube, and of the part taken by these two cells in the formation of the ascus. He was able to detect that a hole is formed at the end of the tubular prolongation of the macrocyst (larger cell), after it has come into close contact with the paracyst (smaller cell) by resorption of the cell-wall; the septum at the base of this tube is formed before the perforation of the cell-wall of the paracyst, and that thus no direct coalescence of the contents of the two cells is possible. The macrocysts increase in size and become enveloped in hyphæ; the ascogenous hyphæ appear on them in the form of papillose bulgings. The author therefore regards the macrocysts as ascogenous female, the paracysts as antheridia or male cells. Although there does not appear to be any open communication between the male and female cells, the alteration in the appearance of the protoplasm in the paracyst and in the tubular elongation of the macrocyst appear to indicate some process of a sexual nature. He considers that this process points to a close relationship between *Pyronema* and the Collemaceæ, and traces a gradation from *Pyronema*, with its sharp sexual differentiation, through *Ascobolus furfuraceus*, which reproduces itself parthenogenetically, to *Peziza sclerotiorum*, with a purely vegetative production of the asci.

Aspergillus and Eurotium, and their Relation to Otomycosis.*—F. Siebenmann gives a full account of the morphology of these genera, and especially of the species *A. flavus*, *niger*, *fumigatus*, and *glaucus*, and *E. repens*. On a 10 per cent. gelatine solution a single spore can produce in four days a pellicle 3 cm. thick, in the centre of which, after 36 hours, the first conidia are ripe. Water, access of air, certain nutrient substances, and a certain temperature are required for the normal growth of the conidial forms. Ammonia and ammonium sulphide in the atmosphere kill the cultures and prevent germination; iodoform and naphthalin, on the other hand, do not materially affect growth. A very favourable nutrient fluid has the following composition:—Distilled water, 1500 parts; tartaric acid, 4; ammonium phosphate, 0·6; ammonium nitrate, 4; sugar-candy, 70; calcium carbonate, 0·6; magnesium carbonate, 0·4; ammonium sulphide, 0·25; zinc sulphide, iron sulphide, and calcium silicate, 0·07. Good solid or semi-fluid substrata are black bread, and 10 to 15 per cent. gelatine for *Aspergillus*, the juices of fruits for *Eurotium*. Specially good is the secretion from the ear that accompanies otomycosis. *Eurotium* flourishes best at a comparatively low temperature, 10–15° C., *Aspergillus flavus* at 28°, *A. niger* at 35°, and *A. fumigatus* at 40°. *Aspergillus niger* can germinate after remaining ten hours in rectified alcohol, or after twelve hours' action of a saturated aqueous solution of boracic or salicylic acid, or after remaining ten hours in 3 per cent. carbolic water; ten hours in 4 per cent. salicyl-alcohol kills it completely.

* Siebenmann, F., 'Die Fadenpilze *Aspergillus flavus*, *niger*, u. *fumigatus*, *Eurotium repens*, u. *Aspergillus glaucus*, u. ihre Beziehungen zur *Otomycosis aspergillina*.' Wiesbaden, 1883 (3 pls.). See Hedwigia, xxii. (1883) p. 132.

New Parasitic Fungi.*—Under the name *Coryneum Beyerinckii* C. A. J. Oudemans describes a fungus parasitic on the branches of Amygdaleæ, and which he regards as frequently the cause of the gummy exudation so often found on them. It is found only in the neighbourhood of the wounds from which the gum exudes, in the form of dark spots, visible to the naked eye. They consist of a light brown parenchymatous stroma, from which proceed a great quantity of shortly stalked usually 4-celled conidia, distinguished by the great facility with which they germinate when placed in water, and without paraphyses.

Discella Ulmi appears as minute swellings or internodes near the apex of elm-branches, causing the leaves to turn brown and fall. These swellings ultimately open, but are not perithecia, containing only conidia borne singly at the apex of sterigmata; they are oval or obovoid, 14–16 μ long and 8–9 μ broad, and filled with a very fine-grained protoplasm.

Chestnut-disease.†—G. Gibelli has further investigated this disease, so destructive to the chestnut-trees in Italy. The extremities of the roots of the diseased trees he finds always infested with a dense mycelium, resembling a pseudo-parenchymatous cap; and the rootlets are often enveloped by branched rhizomorphs. The smaller roots are swollen into coral- or pear-like knots. The fructification is of two kinds, conidia, belonging to *Torula exitiosa* de Seynes, and perithecia, belonging to *Sphæropsis castaneæ* Sacc. var. *radicicola*; and the author believes these to be stages in the cycle of development of the same species. The roots of sound specimens, not only of the chestnut, but also of other Cupuliferæ, were found to be infested by the same mycelium, but without any fructification; and Gibelli thinks that as long as the tree is in other ways healthy, it is able to resist the injurious influence of the parasite.

The solid granulations found in the wood of the diseased trees are not composed, as has previously been believed, of true tannin, but of a crystalline acid nearly related to it. It occurs in the form of sphærocrystals of all sizes, up to that of a pin's head. In polarized light they show a black cross. The sphærocrystals of adjoining cells are in contact with one another by their bases.

Cystopus.‡—A. Zalewski has made a detailed examination of the structure of a number of species of this genus of parasitic fungi. The mode of abstriction of the conidia and that of the formation of the zoospores have already been sufficiently described.

The oospore is inclosed in a double coat, composed of endospore and exospore, and in cultivated specimens he was able to trace the development of the exospore with great exactness. The endospore consists entirely of pure cellulose, and is not, as Cornu has stated, composed of three distinct layers. The exospore, on the other hand, is usually clearly differentiated into three layers. The innermost

* Hedwigia, xxii. (1883) pp. 113–7.

† Ann. di Agricolt., 1882, and Mem. Accad. Sci. Bologna, iv. (5 pls.). See Bot. Centralbl., xv. (1883) pp. 116–7. Cf. this Journal, i. (1881) pp. 282, 777.

‡ Bot. Centralbl., xv. (1883) pp. 215–24. Cf. this Journal, *ante*, p. 684.

layer, in immediate contact with the endospore, is always thin, perfectly homogeneous, and cuticularized; with iodine and sulphuric acid it takes a yellowish or brownish colour. The middle layer is suberized; it is rarely homogeneous, but usually finely granular, and is composed of very thin round or angular columns, placed very closely at right angles to the surface; it is sometimes altogether wanting. The third and outermost layer is composed of cellulose, and varies greatly in its development. Its outermost portion is dark brown, and cuticularized or suberized.

In *Peronospora*, on the contrary, the exospore consists (with only one exception among the species examined) of only two layers; an inner one, corresponding to the innermost in *Cystopus*, and an outer granular layer which makes up by far the larger part of it. Both the layers are cuticularized, and contain no cellulose.

The mature oospore of *Cystopus* contains a ball of protoplasm, occupying from one-half to nearly two-thirds of its diameter, which itself contains a large amount of oil; the protoplasm between this ball of protoplasm and the wall of the oospore is dense, and nearly homogeneously granular. In its outer portion are a number of bright round spots, which may be vacuoles, or possibly may consist of hyaloplasm.

The author describes the following species:—*C. candidus* Pers., parasitic on Cruciferæ and a few Capparideæ; *C. sibiricus* Zlski., on an undetermined plant belonging to the Borragineæ; *C. convolvulacearum* Otth., on *Convolvulus* and *Batatas*; *C. Portulacæ* DC., on *Portulaca*; *C. Amarantacearum* Zlski., on *Amarantaceæ* (not on *Amarantus Blitum*); *C. Bliti* Bivon, on *Amarantus Blitum*; *C. cubicus* Strauss, on Compositæ; *C. Lepigoni* dBy., on *Lepigonum*.

Zygospores of Mucorini.*—G. Bainier has studied the conditions which favour the production of zygospores in the Mucorini, and finds that the conditions vary in the different species. The absence of free oxygen or of light is not a necessary condition, nor is a deficient supply of nourishment always requisite for the production of zygospores. Bainier cites a considerable number of cases where he has cultivated different species, and gives the manipulations required in each case for securing sporangia and zygospores; and he adds some observations on the chemical action of certain species. Thus, *Pilobolus roridus* cannot be cultivated on fluids, but only on semi-solid substances; *Rhizopus*, on the contrary, grows on all saccharine or starchy fluids, on mouldy bread, but developes only imperfectly on horse-dung. *Thamnidium* and *Chætostylum* develope better on a solution of peptone or of extract of malt than in a decoction of plums; the species of *Mortierella* flourish greatly when cultivated on raw meat.

Phycomyces nitens, which usually grows on fatty substances, which it decomposes, can also be cultivated on cochineal, causing it to assume a deeper colour, and rendering it more valuable commercially. *Mucor racemosus*, and a new species, *M. tenuis*, are described and illustrated in full.

* Ann. Sci. Nat. (Bot.), xv. (1883) pp. 312–56 (3 pls.).

Zygospores were also found, under cultivation, on *Sporidinia grandis* (growing on *Lepiota procera*), *Spinellus fusiger* (on *Collibia fusipes*), and large quantities of zygospores on *Syncephalis*, parasitic on *Rhizopus nigricans*.

New Schizomycete, Leptothrix gigantea.*—W. Miller describes under this name a new schizomycete found in the teeth of a dog suffering from the disease known as *Pyorrhœa alveolaris*. He subsequently found it in the bite of other herbivorous and carnivorous animals, and was able to cultivate it. It approaches very near to *Beggiatoa alba* and *Crenothrix Kuhniana*, and was in certain cases found distinctly invested in a sheath. The chief interest of the observations was that they confirmed Zopf's † view that all the various forms of bacteria are but stages of development of the same organism. All stages of intermediate forms between the leptothrix, bacterium, and coccus form were observed; and even transformation into the spirillum, vibrio, and spirochæte forms.

Bacterium Zopfii.‡—In the vermiform appendage of two hens which had died from an epidemic disease, H. Kurth found a bacterium which he describes as a new species, under the name *B. Zopfii*. He was able to trace in it clearly not only the genetic connection of the bacilli and cocci, but also the conditions in which the one or the other form arises; the bacillus form being the reproductive, the coccus the resting form. When bred in a nutrient gelatine of one per cent. extract of flesh at 20° C., the bacilli develope from the point of infection in radial threads with remarkable power of cohesion, finally forming a ball of dense coils. In a fluid nutrient substance the bacilli disconnect themselves and acquire a swarming motion. At a temperature of 35° C. this movement gradually ceases, and short threads are formed which sway about in the fluid. When the nutrient fluid is exhausted, the threads break up into bacilli, and each divides again into two cocci, which remain united; and the same takes place also in gelatine. In a fresh nutrient substance bacilli are again produced from the cocci. This species of bacterium appears to have no pathogenous effect.

A strong confirmation of Zopf's views § with regard to the genetic connection of the various forms of Schizomycetes is furnished by the fact that we have here, as modifications of the same original form, simple globular cells, motile rods, quiescent and motile longer threads, and rigid spiral forms, as stages of development in a single species, resulting from variations in the nature and composition of the nutrient fluid; i.e. from differences in its quantitative rather than in its qualitative composition.

The distinctness of *B. Zopfii* from other forms of bacterium can be best seen by culture in a 2 per cent. gelatine extract of flesh, in

* Ber. Deutsch. Bot. Gesellsch., i. (1883) pp. 221–6 (1 pl.).

† See this Journal, *ante*, p. 688.

‡ Ber. Deutsch. Bot. Gesellsch., i. (1883) pp. 97–100 (1 pl.); and Bot. Ztg., xli. (1883) pp. 369–86, 393–405, 409–20, 425–35 (1 pl.).

§ See this Journal, *ante*, p. 688.

which it always presents the same phenomena, whether bred originally in an extract of flesh of any degree of concentration, or an infusion of hay, or whether cultivated in a breeding oven, or obtained direct from the entrails of the fowl. No transformation into any other bacterial form has been observed; it presents the nearest resemblance to the bacterium of the cattle disease. Its chief characteristics are the much smaller elasticity of its cell-wall, the rapid liquefaction of the jelly, and the formation of spores, at spots of which the cocci are formed. No "spirally coiled masses of micrococci" have been observed, as described by Koch in the case of other bacteria.

Diastatic Ferment of Bacteria.* — Recent investigations have conclusively established the universal occurrence of diastatic ferments in different parts of plants, and have thrown a new light on the processes of nutrition and fermentation.

According to earlier observations, the presence of diastase in the plant was limited to germinating wheat or barley, and knowledge in regard of its wider diffusion has been advanced by the recent works of Gorup-Besanez, Will, Kranch, and especially Baranetzky. The researches of Musculus, E. Schultze, O'Sullivan, and others, have afforded an insight into the quantitative relations and the modifying external factors of temperature and acidity concerned in the action of diastase in the transformation of starch into glucose.

Having in view the action of bacteria as causes of putrefaction or fermentation in which the destruction of the putrescible or fermentescible body is accomplished by the appropriation for the purpose of nutrition by the bacteria of constituent nitrogen or carbon, the question may be asked, Can bacteria also obtain their carbon from starch, just as by the researches of Pasteur and Cohn they have been proved to be capable of obtaining it, not only from sugar, but from ammonium tartrate? Are bacteria, by the secretion of a starch-transforming ferment analogous to diastase, or in any other, but not clearly-defined way, capable of transforming starch into soluble, diffusible, and nutrient combinations? Notwithstanding the numerous investigations into the chemical and physiological relations of bacteria, very little has been made out in regard to their action on starch—a circumstance from which it may be presumed that the solution of starch by bacteria can be effected only in certain instances. In his work, 'Ueber die niederen Pilze,' Nägeli refers to the secretion by these organisms of a special energetic ferment capable of changing milk-sugar into fermentescible sugar, starch and cellulose into glucose, and of dissolving coagulated albumin and other albuminates, and Sachsse alludes to the circumstance of starch solution undergoing no change so long as it is protected from the influence of organic germs by which otherwise it quickly undergoes transformation.

J. Wortmann has made some experiments on the subject, the results of which are:—

1. Bacteria are capable of acting on starch, whether in the

* Zeitschr. Physiol. Chem., vi. (1883) pp. 287–329. See Journ. Chem. Soc. Abstr., xliv. (1883) pp. 930–3. Cf. this Journal, ii. (1882) p. 829.

solid state, as paste, or in solution, in a manner analogous to diastase.

2. As in the case of diastase, different kinds of starch are attacked by bacteria with different degrees of rapidity.

3. The action of bacteria on starch is manifested only in the absence of other sources of carbon nutriment, and when access of air is not prevented.

4. The action of bacteria on starch is effected by a ferment secreted by them, and which, like diastase, is soluble in water, but precipitable by alcohol.

5. This ferment acts precisely as diastase in changing starch into a sugar capable of reducing cupric oxide, but not possessed of peptonizing properties.

6. The ferment itself is also capable of acting on starch in the absence of oxygen.

7. The ferment is secreted by the bacteria also in neutral solution of starch, and exerts its influence under these conditions.

8. This influence is expedited in slightly acid solutions.

Microbia of Fish.*—L. Olivier and C. Richet have determined the presence of microbes in the lymph of marine fish under normal circumstances. If the lymphatic fluid of the conger-eel or mud-fish is examined, there will almost always be found in it short motile bacilli with sharp outline, which are coloured by anilin-violet, eosin, and ammonium picrocarminate; it is impossible to confound them with any other organism. They are found principally in the lymphatic fluids; they occur also sometimes in the blood of the heart, but in smaller numbers. Their abundance varies greatly in different species, and even in different individuals of the same species; they were observed best in the carlet, conger-eel, and gurnet.

Besides the bacilli there are always in the lymph and blood small hyaline refringent spheres, some of which are probably spores and micrococci.

A diastatic ferment is present in the lymphatic fluids; the cerebral and pericardic lymph behave towards starch in the same way as the peritoneal; a mixture of starch and of these fluids, with or without the addition of ether or potassium cyanides (which kill the living ferments without altering those that are soluble), becomes rich in sugar after a few hours, though this reaction is not constant.

A series of experiments on the autogenous culture of these bacilli seems to prove, though further experiments are wanted on this point, that they do not result from the germination of germs in the air, but that they are propagated solely within the tissues of the host. Putrefaction took place in only a very small number of cases.

Dealing† with the question of their mobility, they find that, with high powers, it is, as usual, difficult to distinguish between the passive or Browniau movements, and those that are spontaneous. They confine, therefore, the application of the term mobile to an active

* Comptes Rendus, xcvii. (1883) pp. 119–22. Cf. this Journal, *ante*, p. 402.
† Ibid., pp. 674–7.

process of translation. Patience and care will be rewarded by the fact that certain *Bacilli* will be seen to start into movement, while their neighbours remain quiet; they twist on themselves, and perform movements of flexion, gyration, and rapid translation, after the fashion of vibrios; a drop of acetic acid will at once stop this.

A mode of movement was observed which the authors think to be new; the bacilli of a flocculent deposit, obtained by the cultivation of the microbia of lymph, may be seen to exhibit a slow progressive movement, due to the bending of the body, and comparable to creeping; these bodies are intensely coloured by methyl-violet.

Fermentation of Bread.*—L. Boutroux has carried out a fresh series of experiments to determine the question whether the fermentation of bread is alcoholic or not. Examination of the leaven, after being kneaded and soaked, showed the presence of large cells of starch, delicate straight or bent filaments belonging to a bacillus, and small cells with granular contents resembling *Saccharomyces*. Further cultivation produced cells belonging apparently to *Saccharomyces minor* Eng., as well as to other species, all traces of bacillus having disappeared, while the surface was covered with a film of *Mycoderma vini*. The presence in the leaven of four organisms was detected, viz. two true yeasts, *Mycoderma vini* and an organism resembling *Saccharomyces*, but without any power of fermenting. The abundant evolution of carbonic acid gas cannot have been due to the *Saccharomyces*, the quantity of which remained small; while the bacillus, on the contrary, was abundant. The conclusion at which the author arrives is that, while it is probable that a certain amount of alcoholic fermentation takes place in the making of bread, by far the larger portion of the fermentation is of the kind termed peptonic.

Algæ.

Cell-nucleus and Pores in the Walls of Phycochromaceæ.†—The only instance at present established of the occurrence of a cell-nucleus in the Phycochromaceæ is by Schmitz in *Phragnomena sordidum*. N. Wille has now proved it by the application of pigments in the case of *Tolypothrix lanata*.

In *Stigonema compactum*, the necklace-like cells of which are connected together by a sheath, the same observer states that the cells are in direct communication with one another through openings in their cell-walls. When this alga passes into its *Glœocapsa* condition, the pores disappear, in consequence of the gelatinizing of the common sheath, the separate cells then carrying on their existence as distinct individuals.

Fossil Algæ.‡—In a new work on fossil algæ, the Marquis de Saporta reiterates the view brought forward in Saporta and Marion's 'Evolution of Cryptogams,' in reply to the strictures of Nathorst,

* Comptes Rendus, xcvii. (1883) pp. 116–9. Cf. this Journal, *ante*, p. 690.

† Ber. Deutsch. Bot. Gesellsch., i. (1883) pp. 243–6.

‡ Saporta, Marquis de, 'A propos des Algues Fossiles,' Paris, 1882. See Nature, xxvii. (1883) p. 514.

that *Eophyton*, *Bilobites*, and other similar structures are of vegetable origin. The absence of carbon in these remains, a fact greatly relied on by Nathorst, is explained by Saporta on the following hypothesis:—A plant-stem of sufficient substance to resist pressure, but destined in the long run to decompose, would, if resting on the sea-bottom, become covered with sand or silt, if such deposit were taking place. As the weight increased above it, its under surface would become pressed into the bed upon which it chanced to be resting. As it decomposed, inflated sediment would replace the organic matter, until finally, the decomposition being complete, the sediment from above entirely fills in the space, leaving on the under surface a reproduction in semi-relief of the decayed organism, while the upper part is merged in the sand.

There would, on this view, be no doubt about the algal nature of the *Chondrites* of the tertiaries, cretaceous, and lias, the *Alectoruridæ*, an extinct group existing from the silurian into the tertiaries, and their extinct ally *Glossophycus;* while there is somewhat more doubt about the gigantic liassic *Laminariæ* with reticulated structure. The *Eophyton* of the lower cambrian is almost proved, by its occasionally cylindrical form and interlacing fragments, and by its being wholly confined to this most ancient formation, to be something more than mere scratches upon ooze; though the evidence does not prove conclusively that it is a plant.

A. G. Nathorst in reply * says that Saporta has occupied himself with defending stone algæ, and has somewhat exaggerated the author's views, the real fact being that he has only questioned the vegetable nature of the objects classed by Schimper in Zittel's 'Handbuch der Paläontologie' as *Algæ incertæ sedis*. He is about to combat the views of Saporta more fully in a special work.

Occurrence of Aphanizomenon Flos-aquæ in Ice.†—P. Magnus observed on ice 13 cm. thick an upper green zone about 5 cm. thick composed of this alga. The filaments were vertical to the surface of the ice, in consequence of the ascent of air-bubbles in the freezing water. When cultivated the bundles became decomposed into their separate filaments. The filaments had neither heterocysts nor spores, but otherwise showed a complete agreement with typical specimens of the alga. The locality was not one in which *Aphanizomenon* had been previously observed, but only *Polycystis*, *Clathrocystis*, and *Anabæna;* it appears to thrive in a colder temperature than these algæ.

Ovulites, a Group of Dichotomous Siphoneæ.‡ — M. Munier-Chalmas argues that the Ovulites, hitherto placed by palæontologists among the monothalamic foraminifera, are in reality Siphonaceous algæ nearly allied to *Coralliodendron*, *Espera*, and *Rhipocephalus*. The fossil Ovulites can in fact hardly be distinguished from the recent *Coralliodendron* of our warmer seas. In both we find the dichotomous branches which compose the frond inserted on a stipes

* Nature, xxviii. (1883) pp. 52–3.
† Ber. Deutsch. Bot. Gesellsch., i. (1883) pp. 129–32.
‡ Bull. Soc. Géol. France, vii. p. 661. See Rev. Sci. Nat., xi. (1883) p. 463.

composed of false articulations of very unequal length. They consist of a calcareous envelope which covers the walls of a single rounded central cell, the calcareous envelope being traversed by canals, which are nothing but intervals to allow the passage of prolongations of the central cell which bring it into contact with the surrounding medium. When the false articulations are separated, those which are simply superposed are found to have only a single opening at each end, while those which give birth to two branches have two openings at their upper end.

New Type of Algæ in Stigmaria-coal.*—In the stigmaria-coal of Kurakino in Central Russia, P. F. Reinsch found algoid structures which he refers to a new type related to the Scytonemeæ. They form filaments and flat bands of compound structure without, but less complicated within, composed of a semi-transparent orange or yellowish nearly homogeneous substance which does not polarize. These organisms may be referred to three different types :—

1. Filaments 1–1·5 mm. long and 0·077–0·09 mm. broad, indented on one side to one-third of their breadth; the segments uniform in size, 0·009 mm. broad, closely packed and slightly thickened at the extremity; the swollen end divided into a number of fine segments.

2. Plane filaments deeply indented on both sides.

3. Composed of filaments either quite distinct or only united at a few spots, but much branched dichotomously. The filaments are from 0·11 to 0·16 mm. long and 0·045–0·067 mm. broad, partly entire and partly split into segments.

The absence of any regular cellular organization, and the peculiar internal structure of the filaments, show that they cannot be paleæ or other epidermal appendages of vascular cryptogams, to which they present an external resemblance.

Parasitic Alga-like Plants in Russian Coal.† — In his microscopical examination of Russian coal (Blätterkohl), P. F. Reinsch found a number of organic vegetable structures, hitherto referred to the epidermis of *Lepidodendron*, but which he regards as much more probably an alga allied to the Enteromorpheæ. The greater number of the lamellæ of the coal are variously and irregularly perforated, the perforations having a diameter of from 0·4 to 1·5 mm.; they are circular, elliptical, or triangular. Their distance from one another varies between 2 and 4 mm. As many as eight different forms may be distinguished, varying in the size, form, and distance apart of the openings. In all the specimens examined the perforated lamellæ constitute the greater part of the coal; between the lamellæ is a carbonaceous substance composed sometimes of thin flakes of an amorphous substance inclosing large numbers of *Triletes*. All the phenomena point to the probability of the plants from which this coal was formed having been water- rather than land-plants.

* Flora, lxvi. (1883) pp 355–60 (1 pl.).

† Ibid., pp. 323–30, 339–44 (3 pls.). Cf. this Journal, *ante*, pp. 409, 537.

Of undoubtedly endoplastic organisms in this coal there are four distinct forms:—(1) Short vermiform cells rounded at the end; these present the greatest resemblance to endophytic Saprolegnieæ. (2) Elongated vermiform cells; their nature is uncertain. (3) Peculiar endophytic (?) forms of unknown nature. (4) Peculiar true filiform endophytes within separate *Triletes*-structures.

The epiphytal organisms which occur on one particular kind of the lamella of this coal present a strong resemblance to certain very simple organisms of the nature of *Zooglœa* occurring on marine algæ.

Sphæroplea annulina.*—N. W. P. Rauwenhoff gives an account of his researches on *Sphæroplea annulina* Ag., an alga belonging to the oogamic Confervoideæ. Besides confirming in great measure the results of Cohn, he has discovered many peculiarities "which appear to him to have a certain importance, because they may contribute to the elucidation and solution of some interesting problems of the day."

1st. The filaments of *Sphæroplea annulina*, long, thin, and terminating in a point at both ends, are divided at greater or less distances by transverse septa, which look like thick bars of irregular form with all sorts of excrescences and protuberances. These bars, of a very marked brilliancy and double refractive power, consist of pure cellulose, and show different layers. They originate in the form of rings or excrescences on the internal face of the cell-wall, and either remain open in the middle or close up later on, beginning either at one side only or at both, by a kind of large plug of cellulose. These bars, as much from their structure as the manner of their formation, may perhaps be considered as a proof of increase by apposition, similar to the bars of *Caulerpa*, cited by Dippel and Strasburger in support of their view.

2nd. Nuclei are not found in the cells of *Sphæroplea*, but many chromatophores with starch granules. From the time of the longitudinal growth of the cells, the chromatophores divide, and at the same time the number of rings of chlorophyll increases. In various parts of the bars a dense accumulation of these chromatophores is seen united to the bars by thin and colourless protoplasmic filaments. When the oospheres are being formed, the chromatophores and the colourless plasma are reunited in dense, irregular, granular masses, as if suspended in the cavity of the cell by slender protoplasmic threads, and separated from one another by thin, but sharply defined, protoplasmic disks which completely disappear later on.

3rd. From the time of the formation of the spermatozoids, the chromatophores lose their green colour and gradually become light brown, at the same time that they break up, together with the plasma, into a multitude of small grains. In the beginning the regular rings persist; but the whole of the protoplasm is gradually separated into a limpid liquid and numerous microsomes, which are principally

* Rev. Internat. Sci. Biol., xii. (1883) pp. 176–7. Paper read before the Amsterdam Academy on the 26th May, 1883.

applied in a thick layer on the internal wall of the cell. Afterwards, the rings disappear, and a large-meshed network of small microsomes is produced grouped together under the form of filaments, and surrounded by other microsomes, placed at a greater distance from one another. Finally the microsomes aggregate, principally on the internal face of the cylindrical wall, into masses sharply defined by a membranous layer of protoplasm, and separated by large ellipsoidal vacuoles. In these masses the microsomes are grouped in ovoid or fusiform corpuscles, provided with two cilia.

Thus are formed, in one and the same cell, a great number of spermatozoids, which at first move slowly, and subsequently with extreme rapidity, especially in the vicinity of the large vacuoles; after a few minutes they escape from the cell by an opening originating in the wall, and penetrate by a similar opening into one of the neighbouring cells, filled with oospheres, there to accomplish fecundation. This process of the formation of spermatozoids does not take place simultaneously, but successively in the different protoplasmic masses separated by vacuoles of one and the same cell. Of a cell-nucleus nothing is visible.

4th. The plants of *Sphæroplea annulina* are susceptible of being notably modified in their structure and their mode of reproduction according to circumstances. The vigorous specimens are monœcious, the weak dicœcious. Some were found which consisted only of one cell or a small number of cells, and which produced only oospheres or only spermatozoids. When fecundation is not effected, the oospheres also appear capable of developing by parthenogenesis, that is, by fission and formation of zoospores in the mother-cell.

Zoochorella.*—G. Kessler describes a fresh example of symbiosis between a rhizopod and an alga, viz. *Zoochorella* living within a heliozoon, *Acanthocystis chætophora*. He succeeded also in obtaining it from *Hydra;* and in addition, within *Amœba radiosa*, he observed diatoms as well as other parasitic and larger algæ.

Volvox Globator. Is it a Hollow Sphere? †—J. Levick maintains that whilst the idea of *Volvox* being hollow has passed as so self-evident as scarcely to have been challenged, "it is easy for microscopical students to demonstrate for themselves the certainty that those charming little globes are not hollow but solid."

"As frequently happens, little accidents lead to the discovery of facts which might otherwise seem out of one's reach; and a few years ago, when I made frequent collections of this organism, I gathered some containing the rotifer which is said to make *Volvox* its nest, *Notommata parasita* of Ehrenberg; and while watching these little fellows in the home of their adoption, was surprised to see that they were eating something of sufficiently solid consistency to keep them in position in a part of the *Volvox* where, according to the hollow sphere theory, there should be nothing to eat, or to bear

* Arch. Anat. u. Phys., 1882, pp. 490–2 (1 pl.). See Bot. Centralbl., xv. (1883) p. 257.

† Rep. and Trans. Birm. Nat. Hist. and Micr. Soc. for 1882, pp. xxiii.–v.

their tiny weight. The rotifers usually made their way to the *Volvoces* within the parent, where they appeared to take up their quarters. The next thing noted was that when *Volvox* was placed upon white blotting paper, which of course left them high and dry, they still retained a good deal of their rotundity, and became flattened much less than would be expected if they were really hollow.

However, a little experiment, which it is easy for every one to try, shows that *Volvox* is without any cavity whatever, and that the perfectly transparent contents of the globe appear to possess little, if any less firmness than the pellicle or membrane which forms its periphery. This may be shown by taking *Volvox* in good quantity and straining the water from them; by this means a little mass may be obtained. Let the *Volvoces* thus collected be taken up rather roughly by means of a syringe, and placed in water containing carmine or any fine solid matter. It will probably be found that some of the *Volvoces* have been broken, some perhaps even into fragments which still display the rolling motion. Now, if little care is used in examining the ruptured specimens, it will be seen that the carmine adheres to any surface thus exposed, at once displaying the fact of its solid consistency. This is much more easily observed if the *Volvoces* are again strained off and placed in a compressor with a little clean water.

With this elucidation it is no longer difficult to understand how, as the young *Volvoces* continue their growth within the parent, there comes a time when the overstrained envelope bursts, and, as before remarked, they escape with so much energy. The manner and means of escape of the young are often seen in a gathering of mature specimens, especially if the weather is fine and warm, but this result may be brought about much sooner by the addition of a little carbolic acid, which will often cause nearly every one to burst within a very short space of time: a fact I have noted to my chagrin when mounting slides of this beautiful organism.

Solid is too strong a word, perhaps, to apply to matter which cannot be more than gelatinous, and is here used only in antagonism to the word *hollow*; but, if the spheres be stripped of their outer green covering, this envelope collapses, while the contents retain their spherical form, as is readily seen by the displacement of the carmine."

Further remarks subsequently added by the author are as follows:—

"Since I read this note, which necessarily caused much discussion at the time, it has been confirmed by several observers, and, as it has not been published, is introduced here.

I have tried the further experiment of freezing a mass of *Volvox* upon a slide, and with a sharp knife cutting some sections, which were found to retain the matter within the green envelope, and this internal matter, whatever it may be, proved to be sufficiently dense to support particles of carmine, dirt, or any other solid matter which lodged upon it.

The contents are so perfectly colourless that they are quite imper-

ceptible in water, unless it be charged with suspended matter, and then only show their presence by displacing this matter from the space which they occupy themselves."

Sections of Pinnularia.*—W. Prinz returns to this subject.†

"In the preceding 'Bulletin' I made some remarks on a note of Mr. Burgess ‡ as to the nature of the sculpturings of *Coscinodiscus Oculus-Iridis* and *Trinacria regina*, with unpublished drawings of the late Walker Arnott, representing the structural details of *Pinnularia*.

According to these drawings the striæ, more or less at right angles to the raphe which decorates the valves of this diatom, are tubes. § These details were studied on the fracture edges placed in positions favourable for examination. By mere inspection, we can convince ourselves that these natural sections present the same drawbacks as the sections of *Pleurosigma* obtained by Dr. Flögel, to which they are compared. They are too thick and often give deceptive images particularly with penetrating objectives.

M. Pfitzer ‖ has given a very detailed description of the structure of *Pinnularia*. It is based on the examination of fracture edges, and especially of sections made with a razor, by a process similar to that of Dr. Flögel, that is to say, with diatoms cemented together with gum. This method does not appear to have given quite satisfactory results, for the drawings which accompany the paper are partly diagrammatic.

I have attempted by a different process to obtain sections of this diatom, in order to give a more faithful representation of it. I chose, in a good specimen of Franzensbad earth, some small pieces rather more coherent than the rest of the mass. They were boiled in Canada balsam to harden them. After this treatment, they can be thinned by means of emery, in the same way as minerals and rocks.

This method has, however, the disadvantage of necessitating the use of heat for fixing on the slide the fragment, already ground on one of its faces. The operation must be performed with care and rapidity, to avoid the softening of the balsam which unites the diatoms, in order not to displace or break them. In this way I have obtained thin laminæ, of about a square centimetre in surface, containing hundreds of sections at right angles to the long axis of the frustule. Contrary to my expectation, not a single one gave me a clear image of the raphe. These preparations were otherwise irreproachable and of extreme thinness, in spite of the friability of the material. At the place where the raphe and the connectives are the sections had a confused, mutilated appearance, which made their observation very difficult. I *thought* I saw the thickness of

* Bull. Soc. Belg. Micr., ix. (1883) pp. 136–42 (4 figs.).

† See this Journal, *ante*, p. 695.

‡ Micr. News, iii. (1883) p. 71.

§ This view was also maintained by Schumann ("Diatomeen der hohen Tatra," Verh. Zool. Bot. Gesell. Wien, 1867, p. 73).

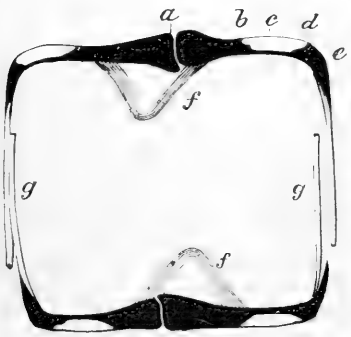
‖ Pfitzer, 'Untersuchungen über Bau u. Entwickelung der Bacillariaceen,' 1871.

the valve crossed sometimes by a broken line, like that drawn by M. Pfitzer, sometimes by a more or less oblique line.

These alterations must be due to the fact that the balsam, intended to consolidate the frustules, does not penetrate into their interior. They therefore remain empty, and their finest details not being sufficiently supported, they do not resist the polishing. Similar difficulties have probably obliged M. Pfitzer to represent diagrammatically the result of his observations on a certain number of sections.

At last, in one of the preparations, I came across a rather thick but unbroken section of an individual of great size. It is at right angles to the long axis of the diatom, and consequently gives a normal section of the raphe, taken in the neighbourhood of the central nodules, that is in the thickest and most resisting portion of the frustule, fig. 155.

Fig. 155.



a Raphe, *b c d* rib, *e* bevelled edge of the valve, *f* central nodules, *g* connectives. × 1500. (The black parts have a brown colour by transmitted light.) *Dimensions*—Height and width of the frustule (outside) 27 and 28 μ. Thickness of the valve at *a* 3·3 μ, at *b* and *d* 2·3 μ. Width of the raphe 0·4 μ. Width of the nodules at the base 7·5 μ. Height of the nodules, not including the thickness of the valve, 3·9 μ. Thickness of the connectives 0·5 μ.

The complete and minute description of the structural details of *Pinnularia*, given by M. Pfitzer, can be applied point by point to this figure, drawn entirely after nature. I refer therefore to this description, and I will only here dwell on the slight difference which may exist between my drawing and his.

The section of the raphes presents at this point the appearance of rather large slits, penetrating perpendicularly the interior of the frustule, where they terminate in two curves in opposite directions to one another.

I have already said that I have not been able to obtain satisfactory sections of this organ in a region more distant from the central nodules, and where it appears to be placed obliquely. I think, with M. Pfitzer, that the raphidian fissure is more and more inclined at this point to resume the vertical position towards the terminal nodules. The asymmetry of the central nodules is more apparent, and they are also more prominent than those which the author has drawn. I have not seen any solution of continuity in these nodules (Schumann); they appear perfectly solid. The section of the connectives and the slight displacement which they have accidentally undergone, confirms the opinions of Pfitzer on their mode of attachment, which is very common in different genera of diatoms; but I have not succeeded in finding the rather deep furrow which, in his opinion, surrounds the

connectives. Apart from these questions of detail, the concordance is complete.*

In order to elucidate the nature of the striæ or ribs of *Pinnularia*, I have examined sections parallel to the long axis of the diatom, thus intersecting perpendicularly the ribs which run along the valves. These longitudinal sections are present in great numbers in the thin laminæ of Franzensbad earth; they are rarely defective. When such a section is too thick, it includes a more or less considerable portion of the raphidian region or a portion of the edge of the valve. Sections of a thickness equal to *c a*, *c e*, *a d*, *b e*, fig. 155, would appear thus: if we look at a section of the thickness of *c a*, for instance, with a penetrating objective, the ribs invariably *appear* to be closed in their upper part by a membrane; in fact, they resemble sections of cylinders. This image proceeds from the fact that the objective shows at the same time the section of the ribs, and also the lines which represent the deeper portions of the valve.† The result is a single image, difficult to interpret otherwise than by the presence of cylinders, fig. 156 (1).

But if we use an objective without penetration, it corrects, in some degree, the too great thickness of the section, by separating the different planes which constitute it. The images, instead of being blended, succeed one another, and the cause of error is removed, fig. 156 (2).

We have thus far considered rather thick sections. In those which are thinner, the edge of the valve and the solid portions which run along the raphe are removed, and there remains nothing but the section of the ribs themselves (*b d*, fig. 155).

An image is then obtained, fig. 156 (3), which can leave no doubt as to the presence of parallel elevations separated by spaces rather wider than their thickness.

I shall not insist upon the utility of sections for the study of diatoms; it is by this means only that we can hope to have exact notions of their structure. All the methods for obtaining them are not equally good. Sections which are prepared by inclosing the frustule in gum may give rise to false interpretations. This medium not being perfectly solid, the sections are liable to break up in their most delicate parts. Suppose for a moment that the raphe is only a

FIG. 156.

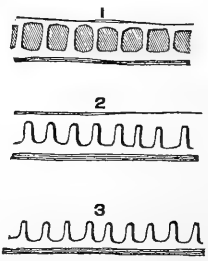


Fig. 156 (1) is seen with a Zeiss dry 1-14th in. (2) represents the *same* section seen with a Tolles homogeneous immersion 1-10th in. (3) does not change whatever the objective employed.

* Dr. Flögel has also studied sections of *Pinnularia*. His conclusions are only known to me in a very short résumé in the Bot. Ztg., 1872, p. 471. The skilful micrographer there describes some types of diatoms seen in section. *Pinnularia* shows in section, according to him, "a large empty space, which has only one passage, in the form of a short canal, towards the interior."

† The drawing by Walker Arnott, reproduced by Mr. Burgess (loc. cit. fig. 27), represents a fragment of a valve equal in thickness to *b c* of fig. 155. Perhaps it includes the whole thickness of a half valve *a e*.

gutter very deep, but closed towards the interior (as other observers admit *) by a fine membrane, the least violence will be sufficient to break the section at this point and give the image of a fissure traversing the thickness of a valve from one part to another. This effect cannot have been produced in the case of the section previously described, because it is supported by the solid portions of the valve farther off, and above all by the hardened balsam which surrounds it. An absolutely solid cement does not present these inconveniences. Balsam is only suitable for giving, to an already consistent rock, greater hardness. It could not be employed to agglutinate diatoms in powder. The other cements which I have used have given me almost negative results. There is, however, one the use of which would, I think, give some advantages; it is the solid matter deposited by certain petrifying waters. The waters of these springs, which are sometimes employed to obtain remarkably delicate copies of medals, bas-reliefs, &c., leave, on evaporating, a hard translucent substance, composed in great part of carbonate of lime. On mixing a certain quantity of the frustules with these mineral waters, we should obtain, by evaporation, a deposit in which very thin and perfectly transparent laminæ could be cut and sections of diatoms obtained. Moreover, the cement could easily be removed by a weak acid, which would enable the sections to be mounted, isolated in a medium more favourable to their study.

It is not even necessary to have recourse to these artifices of preparation. Many sufficiently hard rocks contain diatoms in more or less considerable quantity. Certain varieties of guano, for example, are very hard and give very good sections. Here is a still virgin field which will furnish many an interesting observation to those who will explore it."

MICROSCOPY.

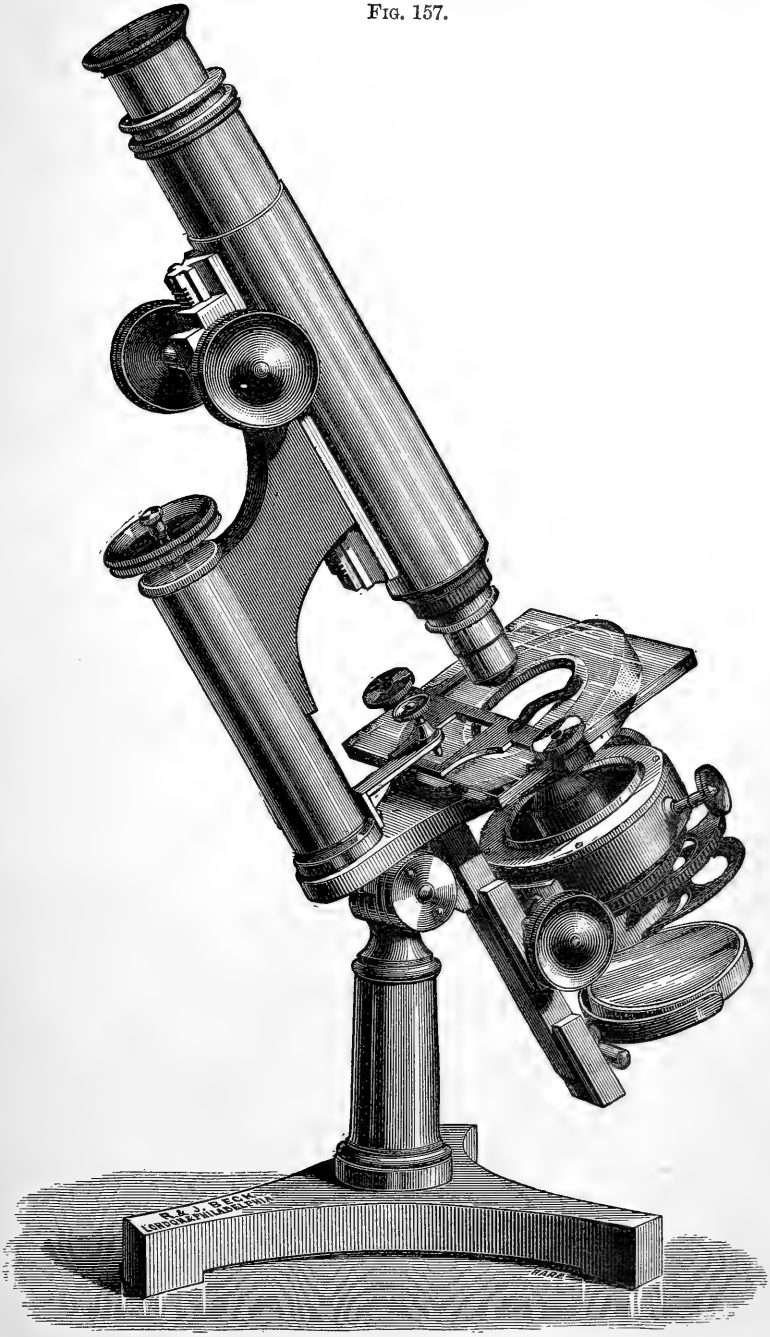
a. Instruments, Accessories, &c.

Beck's Pathological Microscope.—Messrs. Beck have designed this Microscope with a special view to delicate pathological research. The instrument is on the same model as their Economic Stand, but to it has been added a rack-and-pinion substage with centering-screws, which carries an achromatic condenser of an aperture of about 1·4 N.A. It is supplied with two rotating diaphragm-plates, the upper containing a series of blue glasses for moderating the light, the lower a series of openings of different sizes, by which the aperture can be varied to any extent, which are also placed at a distance below the lenses sufficient for accurate centering of the condenser.

Of this arrangement Messrs. Beck say, "This convenient method for rapidly varying the intensity and angle of the cone of light by means of the two diaphragm-plates will, we feel sure, be appreciated by all practical workers on minute pathology. We have made the lenses of large diameter, so that a great flood of light can be used when

* Schmidt, Bot. Ztg., 1872, p. 741.

Fig. 157.

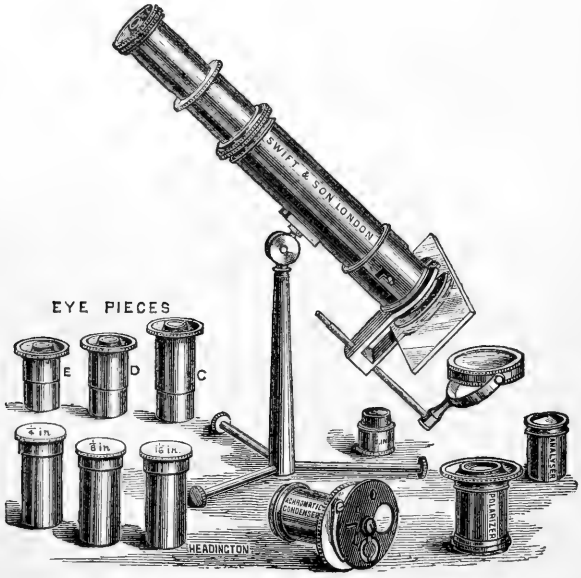


necessary, and the top lens may be taken off when a less convergent cone of light is required for low-power work."

Chevalier's Microscopes.—The Microscope figured at p. 699 (fig. 125) should, we understand, have been described as by the firm of Chevalier, who have no connection with that of Chevallier, the constructors of the instrument fig. 122.

Swift and Son's Pocket Microscope.—Messrs. Swift and Son have added a stand to their (Brown's) Pocket Microscope (figs. 158 and 159), which is one of the smallest Microscopes made having any pretensions to be a serviceable instrument and not a mere toy. As now modified, it appears to be the most complete really "Pocket" instrument yet issued. It is furnished with 1 in., 1-4th, and 1-8th in. dry objectives, and 1-16th in. immersion, three eye-pieces, achromatic

Fig. 158.

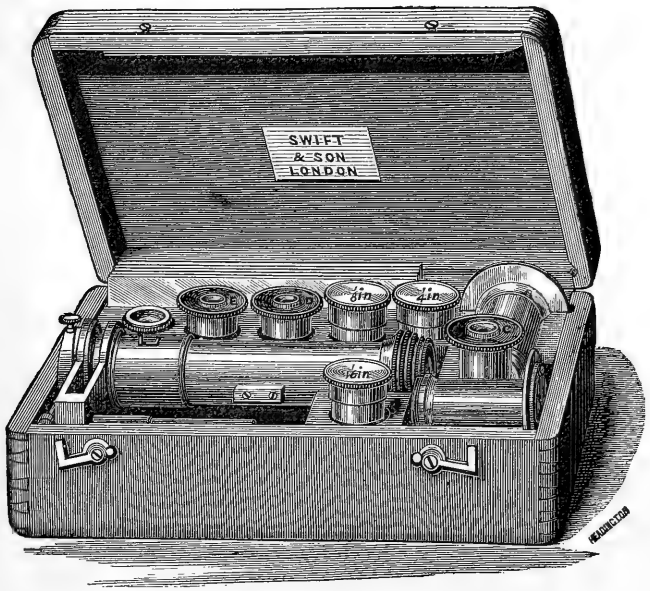


condenser with rotating disk having three diaphragms, central stop, and radial slots, together with polarizer, analyser, adjustable concave mirror in gimbal fitting, the whole (with glass slips) packing in a mahogany box $4\frac{3}{4} \times 3\frac{3}{4} \times 1\frac{1}{2}$.

The standard consists of a conical pillar, to the lower end of which three rods are screwed radially, having milled heads at the outer ends and forming a tripod foot; the upper end has a cradle-joint carrying a dovetail slide-socket, in which fits a corresponding slide at the back of the body-tube. The Microscope can be inclined on the cradle-joint as required. The slides, which can be of the usual

size, are held on the stage by a spring cylinder-clip having two lateral projecting pins which slide in right-and-left bayonet slots; the clip can be raised by the pins and keyed in the bayonet slots by a slight lateral turn when the slides are being put in or removed. The coarse adjustment is effected by sliding the tube; the fine adjustment by moving the draw-tube in or out, a plan which is far more convenient in practice than we should have anticipated. We have found no difficulty in focusing the 1-8th objective in this manner

Fig. 159.



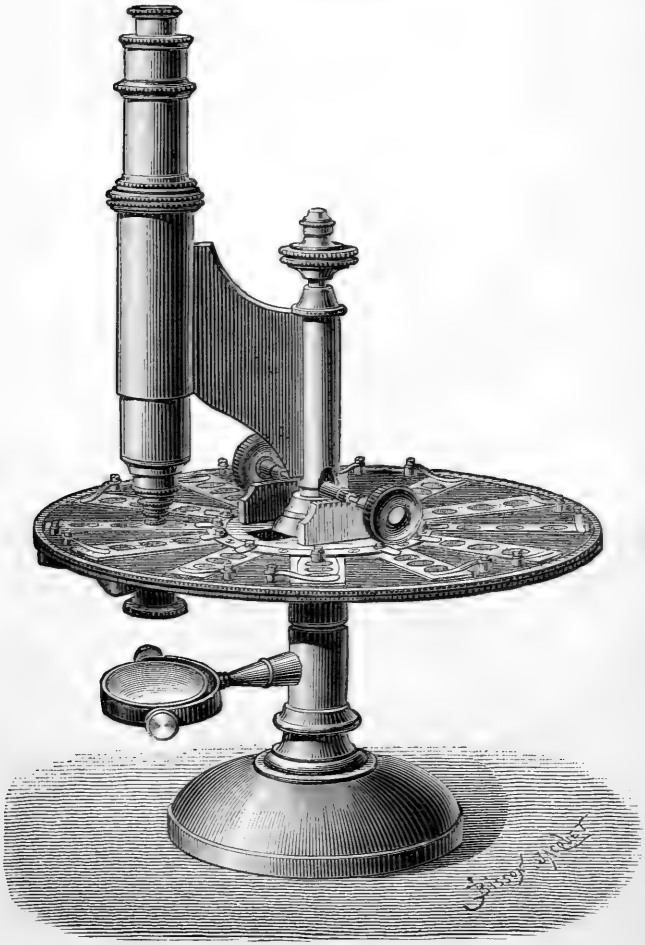
either with the Microscope on its tripod and the light reflected from the mirror, or by pointing the body-tube directly to the sky; and doubtless with a little practice the 1-16th could be used with the like facility. By the addition of adapters the objectives could of course be used on full size Microscopes. The three high powers are provided with correction adjustment. We understand that the Microscope was constructed wholly by Mr. M. Swift (fig. 158 ½ scale, fig. 159 ⅔ scale).

Mirand's Revolver Microscope.—This Microscope, by J. Mirand, jun., is a further extension of the principle on which Klönne and Müller's instrument was based (Vol. III., 1880, p. 144).

In the latter form the circular stage held eight objects on ordinary slides, which could be successively brought into the field on rotating the stage. In the new form the stage can not only be rotated on its centre, but moved from back to front and *vice versâ*, so that its centre does not coincide with that of the pillar. With this plan each of

the twelve slides carried by the stage can have three different objects mounted upon them. If then the centre object on one of the slides is brought into the field of view, all those which occupy the same relative position on the other slides will pass under the objective

Fig 160.

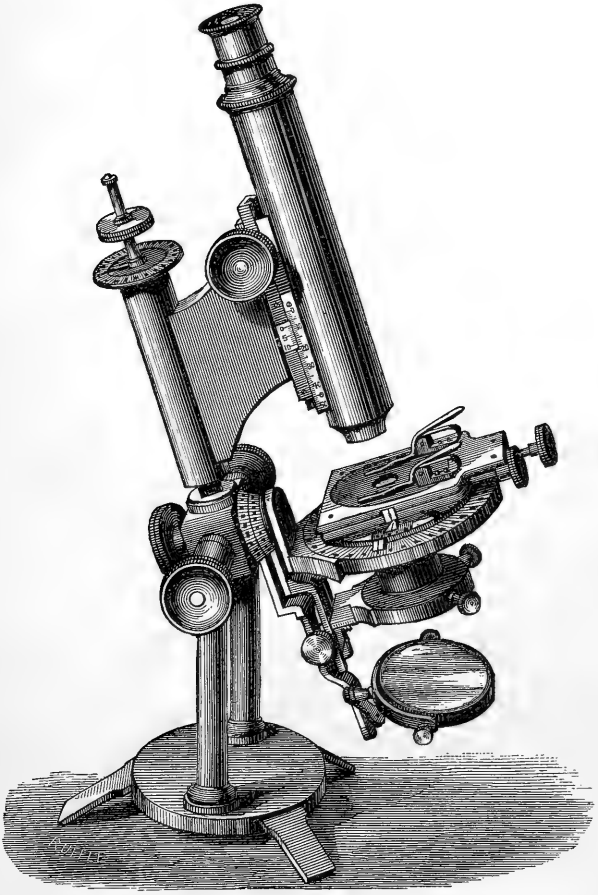


when the stage is rotated. On turning the milled heads above the stage, the pinions connected with which work in rackwork attached to the stage, the latter is moved from back to front or *vice versâ* so that the body-tube will stand over the first or third object on one of the slides. The rotation of the stage will then bring the corre-

spondingly placed objects on each of the other slides under the objective as before.

Pelletan's "Continental" Microscope.—This Microscope (fig. 161) has been issued by Dr. J. Pelletan, of Paris, and claims notice not for any distinctive feature in design, but as a combination of several points which have hitherto been confined to English or American

Fig. 161.



models, together with the focusing arrangements and connection of the body-tube with the pillar generally adopted on the Continent.

The principal novelty (to the Continental public) is the adoption of the swinging tail-pieces to carry the substage and mirror, each moving radially to the object on the stage, after the plan modified

by Bulloch,* of Chicago, from Zentmayer's "Centennial" Microscope.†

The substage with centering movements fits on the first tail-piece behind the stage, and is worked by rack and pinion. The mirror is mounted on a crank arm on the second tail-piece. The tail-pieces swing laterally either together or independently; each is provided with a graduated collar for registering the lateral rotation, and a sprung-pin drops into a corresponding notch, fixing each in the normal position when axial light is required.

The stage is circular, and rotates about 7-8ths of a turn; it has goniometrical divisions near the edge; "finders" are applied to the mechanical rectangular movements. It is attached to the lower end of the inclining column by a conical axis passing through and secured at the back by a large milled nut. This stage can be removed and a glass friction-stage substituted, which can be used reversed for oblique illumination from the mirror, &c. The friction-stage is fitted with a hemispherical lens so that its plane face is flush with the surface of the stage as in Tolles's and other Microscopes.

The focusing arrangements are of the usual Continental type. A scale is applied on the side of the body-tube working against a fixed vernier on the limb for recording focal distances by the coarse adjustment, whilst for finer measurements a graduated disk is fixed on the top of the column carrying the limb, and the fine focusing screw rotates with an index pointer, by which the number of turns and fractions can be registered.

The body-tube is much larger than is usually adopted on the Continent, and will admit an extra draw-tube (supplied with the Microscope) for the Ross gauge of eye-pieces. As arranged in the figure there are two draw-tubes, the larger one sliding in the body-tube and carrying the smaller, in which the Hartnack gauge of eye-pieces is used. The "Society" thread is applied at the nose-piece.

The suspension of the inclining column between the standards appears to have been devised without regard to the balance of the instrument. The trunnion axis is very nearly at the lower end of the column, so that the stability of the position of inclination is entirely dependent on the tension of the clamp-screws on the ends of this axis; if the unwary operator should loosen the clamp-screws without supporting the column the optical part of the Microscope falls forward or backward, in either case striking the table, as no stop-pins are provided either to mark the vertical or the horizontal position.

The Microscope is manufactured by E. Lütz, and appears to us to require thorough revision both in design and construction.

Zeiss's Mineralogical Microscope.—This (fig. 162) is based upon Dr. Zeiss's large Microscope-stand with the addition of a rotating stage, polarizer and analyser, sliding quartz-plate above the objective, and centering nose-piece.

The polarizer turns away from the stage, as shown in the woodcut,

* See this Journal, iii. (1880) pp. 1073–80.

† Ibid., pp. 1067–73.

FIG. 162.

the tubular diaphragm-holder also turning in the same way. The arm attached to the polarizer serves to rotate it.

Bausch and Lomb Optical Company's Fitting for Neutral Tint Camera Lucida.—Fig. 163 shows the fitting adopted by the Bausch and Lomb Optical Co. It is made of vulcanite, and the half ring to which

Fig. 163.

the frame holding the neutral tint glass is fixed fits on the cap of the eye-piece. The vulcanite is sufficiently elastic to obtain a good grip of the eye-piece.

Testing the Binocular Arrangement.*—Mr. J. Swift gives the following directions for testing the binocular arrangement of a Microscope.

It is of the first importance that the reflecting surfaces of the Wenham prism should be absolutely flat; as the rays passing through it are twice reflected before they emerge, the slightest error in the surfaces will seriously impair the definition. For testing the quality of the prism the tongue of the blow-fly may be viewed with a 1 in. objective, and should be equally well defined in both fields. In this testing the same eye should be used in viewing each image separately. The image in both fields should focus clear and sharp at the same time, that is to say, after adjusting the focus in the vertical tube, the other tube should not require the focus to be readjusted to make the image as distinct as in the former; this point should be tested with

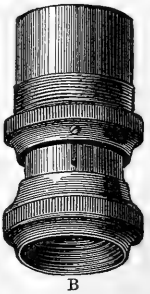
* 'The Microscope and Accessory Apparatus,' 1883, pp. 27–9.

one and the same eye-piece. After adjusting and viewing the image in one field, remove the eye-piece and place it in the other tube; if the definition is then equally good the prism may be considered satisfactory. Repeat the operation with the corresponding eye-piece without altering the focal adjustment, and if the image is not equally well defined, the eye-pieces do not match, that is to say their focal powers differ. It is absolutely essential that each pair of eye-pieces should be of equal power. Next ascertain whether the images in both fields entirely coalesce when an object is viewed through the tubes with both eyes. Place on the stage some round object large enough to nearly fill the field of the eye-piece (a good *Echinus* spine is generally sufficiently round and of the size required), adjust it in the centre of the field of the vertical tube, so as to leave a concentric ring of light around it, and then view the image in the oblique tube with the same eye-piece as before; should the image be equally in the centre of the field, it is satisfactory. If, however, the image in this tube appears a little out of centre towards the *left* of the observer, we should not reject the instrument on that account, as in the opinion of many experienced microscopists a slight lateral deviation of this kind gives an increased stereoscopic effect to the image. But if the image in the oblique tube be out of centre in the opposite direction (viz. towards the *right*), the binocular arrangement is defective. Observations prolonged for even a short time will then cause great pain to the eyes, and if continued would permanently injure even the strongest eyesight.

A reviewer of Mr. Swift's work* is sure that the above instructions "would lead the careful amateur to condemn 50 per cent. of the binocular Microscopes issued by the opticians of this country."

Bausch and Lomb Optical Company's Safety Nose-piece.—This (fig. 164) consists of two tubes; the upper A having the Society screw, and fitting into the end of the body-tube; and the lower B, also with the Society screw, receiving the objective. The lower tube is pushed out by a weak spiral spring which is inside the upper one, but a slight pressure is sufficient to press it in, and so "prevent jamming of the objective into the object." The lower tube is kept from rotating by the slot and pin seen in the figure.

Fig. 164.

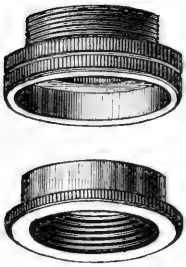


Matthews' Device for Exchanging Objectives.†—Dr. J. Matthews, referring to the fact that the joints of the stomach-pump fit together as cones and that a joint was never known to give way, suggests, as a most simple, inexpensive, and ready method for exchanging objectives, a short adapter in the form of a hollow cone which is screwed into the ordinary nose-piece, with another piece screwing on the objective and coned down exactly to

* Engl. Mech., xxxviii. (1883) p. 50.
† Journ. Quek. Micr. Club., i. (1883) p. 305.

fit inside the first. The only action required is then to push the one into the other, and as they fit accurately there is quite sufficient adherence to keep the objective in its place. The centering of the objectives is likely to be more accurate than if they are screwed on in the usual way. "It was of course just possible that a blow might cause the objective to drop out, but this in practice was hardly likely to happen."

Fig. 165.

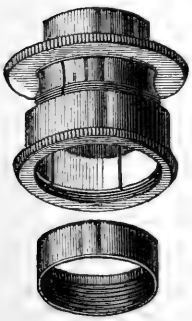


Mr. H. F. Hailes, referring to the analogy between the fitting of an objective and the chucks of a lathe, says that the proprietor of large engineering works informed him that a cone-fitting was the best for lathes that could be used, and that he had done away with screwed nose-pieces in favour of the cone. As to its power of holding, Mr. Hailes saw a 1 in. iron bolt screwed perfectly at one cut with dies held in a chuck so fitted.

Mr. E. M. Nelson, on the same subject, said that he believed the cone "to be the best fitting in the world, and for his own part he should be glad to see the whole system of screws swept away and the cone substituted."

Watson's Adapter Nose-piece.—To avoid the danger of the objective dropping out of the cone-fitting of Matthews' adapter nose-piece, Messrs. Watson have cut four slots in the coned tube of the nose-piece to give it spring, and have applied an outer screw-collar by which the tension of the cone can be increased if required. An adapter, coned externally, screws on the objective, where it may remain, as it presents no obstacle to the use of the ordinary objective-boxes. The screw-collar on the nose-piece can be regulated to give just the required amount of tension to prevent the objective from dropping out; and where additional precaution is thought desirable, a quarter turn of the collar will grip the objective as firmly as required, the reverse movement releasing it.

Fig. 166.



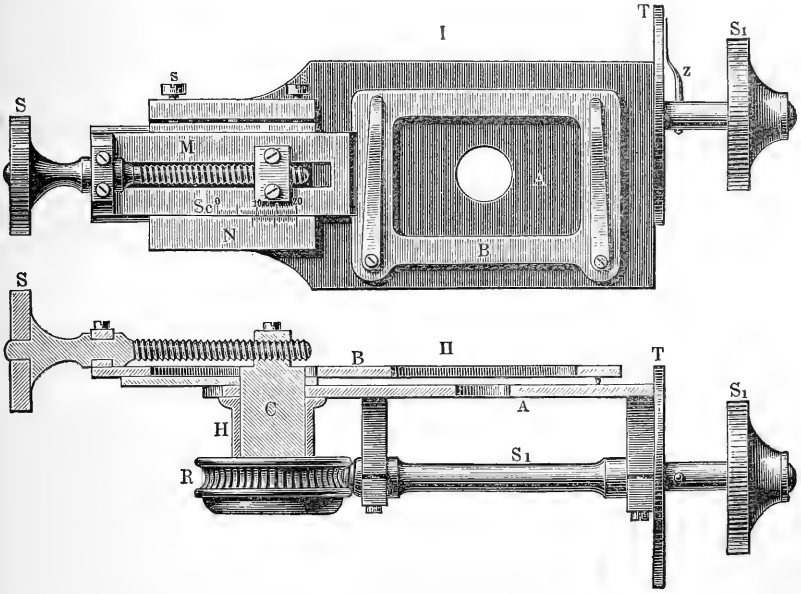
Boecker's Movable Stage.*—This (fig. 167) is yet another contrivance, of German origin, for moving an object on the stage in two directions, described with a freshness and elaboration of detail which carries one back some forty or fifty years in the history of corresponding contrivances for English Microscopes.

The lower plate A is clamped to the stage, and the upper plate B (with clips for the object) is moved by the screw S in a longitudinal direction, M and B being connected. The movement of B from back

* Dippel's 'Das Mikroskop,' 2nd ed., 1882, pp. 649–51 (1 fig.).

to front is effected by S_1, which has an endless screw working in the toothed wheel R on the axis C, which turns in the tube H attached to the fixed plate. C being connected with the movable plate B, the latter will describe an arc of a circle when S_1 is turned.

Fig. 167.



By way of apology for the latter movement not being rectilinear, it is pointed out that "since the lever-arm from the turning-point at C to the centre of the optic axis is very large in comparison with the diameter of the field, so that the arc described is a very flat one, the movement will not appear to be circular, but rectilinear."

A finder is made by graduations at Sc and N for the one movement, and on a disk at T (with an index *z*) for the other. The small screws *s s* serve to regulate the tightness or looseness of the movement of the slide M.

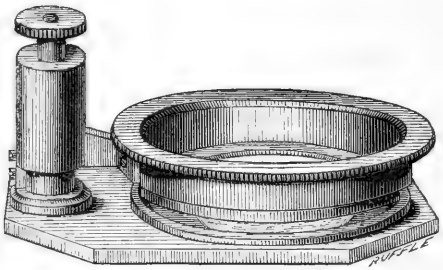
Fol's Compressor.*—Mr. J. A. Ryder writes us that he finds the compressor of Prof. H. Fol the most convenient he has tried; in fact, his studies of the development of living fish ova could not have been accomplished without it.

It consists (fig. 168) of an octagonal base-plate $3\frac{1}{4}$ in. by $2\frac{1}{2}$ in., with a circular aperture closed by glass disk $1\frac{1}{2}$ in. in diameter. A raised rim round the disk gives a depth of 1-6th in. for fluids. Over the aperture is a sprung brass ring attached to an arm, which is moved

* Morph. Jahrb., ii. (1876) pp. 440–4 (1 fig.).

up and down on a pillar by a micrometer-screw by the same action as that of the fine adjustment of Continental Microscopes. In the ring slides a piece of tubing with a thin glass plate cemented to the bottom. By pushing it more or less through the ring, a "coarse adjustment" of the compression is obtained, whilst the micrometer-

Fig. 168.

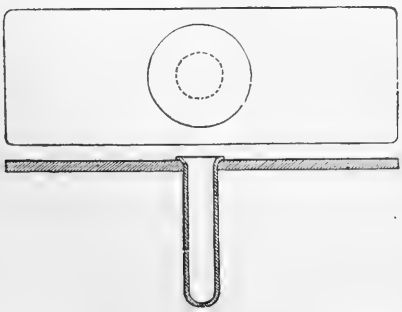


screw furnishes a "fine adjustment." If in place of the adjustable ring two pieces of tubing were used, sliding one within another, uniformity in their movement and the parallelism of the two glass surfaces could only be insured if the height of the tubing were not less than a third of the diameter, which would make large compressors very unwieldy.

Mr. Ryder mentions that the apparatus has the merit of being almost immediately applicable to any sized ovum, by having a supply of metal rings of different thicknesses to confine ova of different sizes between the cover and the glass of the base-plate.

Slack's Tubular Live-box.*—Mr. H. J. Slack has been led to construct a tubular live-box, to facilitate showing the action of the blue-bottle's mouth-organs, and that of similar insects. It does not answer for bees. At this time of the year many large flies are driven indoors by the cold, and this little apparatus may assist in studying some of their interesting peculiarities. When an ordinary live-box is used to hold a blow-fly captive, there is some difficulty in holding him tight enough, with the under side up, and yet not so squeezed as to injure him, or interfere with his comfort. The tube live-box is made with a small tube bottle, such as is used by

Fig. 169.



* Knowledge, iv. (1883) pp. 267–8 (1 fig.).

homœopathic chemists, about 1 in. long and 1-4th in. wide at the mouth. This is inserted into a hole cut in a wooden slide, and its rim prevents its falling through. Another wooden slide has a hole cut through it of rather larger diameter, and on the top side a thin glass cover is fastened with shellac glue. This slide is laid on the other. The glass cover forms a lid, which closes the tube bottle, and is held in its place by an elastic indiarubber band. A little cotton wool is put into the bottom of the tube to shorten the space, to suit the length of the fly, which must be inserted mouth uppermost, and kept moderately near the glass cover, upon which a drop of syrup is placed. Flies will readily feed in this position, and they are sufficiently limited in the power of lateral motion to be easily kept in view with $1\frac{1}{2}$ in. or 1 in. objective.

Wenham's Reflex Illuminator.*—Mr. Wenham devised this apparatus for the illumination of balsamed objects, and also pointed out that, with dry-mounted objects on the cover-glass, specimens are frequently met with which have dropped on the surface of the slide itself, and may be seen "self-luminous" with the reflex illuminator as with the immersion paraboloid; but the direction of the light is limited to one azimuth, which may be varied by rotating the illuminator. Mr. J. Swift "cannot, however, express a favourable opinion of either of these methods of illumination, on the ground (1) that objects such as diatoms, mounted in balsam, are too transparent to be viewed by light reflected from their surface only; and (2) the viewing objects as 'self-luminous' by means of light deflected or scattered within their substance has not led to any useful result, though the method has been known to microscopists since Mr. Wenham's publication of it in 1856. It appears to the author that the reflex illuminator may be used effectively to illuminate balsamed objects by transmitted light of great obliquity—i. e. of obliquity within the balsam, which can only be obtained by immersion or equivalent means; it is then as an oblique illuminator for *transmitted* light that he would recommend its use. This action of the apparatus can be utilized only in conjunction with an immersion objective whose aperture exceeds 82° measured in crown glass."

It should be noted that this action of the reflex illuminator was first utilized by Mr. Samuel Wells, of Boston, U.S.A. So far as our experience goes, the use of the reflex illuminator as an oblique transmitter is a very cumbersome method compared with the admirable simplicity of the oil-immersion condenser, or as compared with the simple hemispherical lens placed in immersion contact with the base of the slide.

Practical Benefits conferred by the Microscope. — Prof. E. Ray Lankester in his Presidential Address to the Section of Biology at the Southport meeting of the British Association for the Advancement of Science, strongly advocated the endowment of research, especially in Biology. Referring to the Microscope he said, "I need hardly remind

* 'The Microscope and Accessory Apparatus,' 1883, pp. 50–2 (1 fig.).

this audience of the almost romantic history of some of the great discoveries which have been made in reference to the nature and history of living things during the past century. The Microscope, which was a drawing-room toy a hundred years ago, has, in the hands of devoted and gifted students of nature, been the means of giving us knowledge which, on the one hand, has saved thousands of surgical patients from terrible pain and death, and, on the other hand, has laid the foundation of that new philosophy with which the name of Darwin will for ever be associated. When Ehrenberg, and later, Dujardin described and figured the various forms of *Monas*, *Vibrio*, *Spirillum*, and *Bacterium* which their Microscopes revealed to them, no one could predict that fifty years later these organisms would be recognized as the cause of that dangerous suppuration of wounds which so often defeated the beneficent efforts of the surgeon, and made an operation in a hospital ward as dangerous to the patient as residence in a plague-stricken city. Yet this is the result which the assiduous studies of the biologists, provided with laboratories and maintenance by Continental States, have in due time brought to light. . . . The amount of death, not to speak of the suffering short of death, which the knowledge of bacteria gained by the Microscope has thus averted is incalculable. . . . One other case I may call to mind in which knowledge of the presence of bacteria as the cause of disease has led to successful curative treatment. A not uncommon affliction is inflammation of the bladder, accompanied by ammoniacal decomposition of the urine. Microscopical investigation has shown that this ammoniacal decomposition is entirely due to the activity of a *Bacterium*. Fortunately this *Bacterium* is at once killed by weak solutions of quinine, which can be injected into the bladder without causing any injury or irritation. This example appears to have great importance, because it is the fact that many kinds of bacteria are not killed by solutions of quinine, but require other and much more irritant poisons to destroy their life, which could not be injected into the bladder without causing disastrous effects. Since some bacteria are killed by one poison and some by another, it becomes a matter of the keenest interest to find out all such poisons, and possibly among them may be some which can be applied so as to kill the bacteria which produce phthisis, erysipelas, glanders, anthrax, and other scourges of humanity, while not acting injuriously upon the body of the victim in which these infinitesimal parasites are doing their deadly work. In such ways as this biology has turned the toy 'magnifying glass' of the last century into a saviour of life and health."

Bale's Eye-piece Micrometer.—Mr. W. M. Bale writes that the following lines should be inserted in his description of a simple eye-piece micrometer, viz. after "central one," in line 27 of p. 571, "but on the other side of it, also two others on opposite sides, each measuring a space of 5-1000ths in. from the central one."

ABRAHAM, P. S. See Hayes, R. A.

BACHMANN, O.—Unsere modernen Mikroskope und deren sämtliche Hilfs- und Nebenapparate für wissenschaftliche Forschungen. Ein Handbuch für Histologen, Geologen, Mediziner, Pharmazeuten, Chemiker, Techniker und Studierende. (Our modern Microscopes and their auxiliary and accessory apparatus for scientific researches. A handbook for histologists, geologists, medical men, pharmaceuticists, chemists, technicians, and students). xv. and 344 pp. and 175 figs. 8vo, München and Leipzig, 1883.

BAKER'S Seaside Microscope.
Amer. Mon. Micr. Journ., IV. (1883) p. 190–1 (1 fig.).

BLACKBURN, W.—Address to Manchester Microscopical Society on the Annual Soirée of the Mounting Section.
["A few remarks upon the objects and aims of our Society."]
Micr. News, III. (1883) pp. 301–4.

Brass, dead black colour for. *Amer. Mon. Micr. Journ.*, IV. (1883) p. 177.

BRITTAIN, T., presentation of an Address to, by the Manchester Microscopical Society. *Micr. News*, III. (1883) pp. 299–301.

BULLOCH'S Biological Microscope.
[Quotation of remarks, *ante*, p. 554 last 3 lines, and p. 555 first 2 lines:—"This is praise from high quarters of which Mr. Bulloch may be justly proud."]
Amer. Mon. Micr. Journ., IV. (1883) p. 197.

CURTIES, T.—Nose-piece Adapter.
[*Ante*, p. 572.] *Journ. Quek. Micr. Club*, I. (1883) pp. 299–300.

DAVIS, G. E.—Our Verification Department.
[Nos. 115–30.] *Micr. News*, III. (1883) p. 318.

ERRERA, L.—Rapport sur la participation de la Société [Belge de Microscopie] à l'Exposition internationale de Photographie. (Report on the participation of the Belgian Society of Microscopy in the International Exhibition of Photography.)
[List of 56 photo-micrographs in different branches of natural history, exhibited by the Society, and for which they obtained one of the seven diplomas of honour.]
Bull. Soc. Belg. Micr., IX. (1883) pp. 160–4.

FLÖGEL, J. H. L.—Mein Dunkelkasten. (My Dark Chamber.) [*Post.*]
Zool. Anzeig., VI. (1883) pp. 566–7.

HAYES, R. A.—Four Microphotographs, with Description by P. S. Abraham. 6 pp. and 4 microphot. 8vo, Dublin, 1883.
[Microphotographs of preparations of transplanted teeth by the oxy-hydrogen lamp, the light being by a special arrangement of lenses condensed so as to furnish an evenly illuminated disk of about 1-2 in. in diameter. No eye-piece or correction for difference in visual and chemical foci.]
Sep. repr. from *Trans. Acad. Med. Ireland*, I.

HITCHCOCK, R.—A Microscopist rambling.
[Description of a visit to New Brighton.]
Amer. Mon. Micr. Journ., IV. (1883) pp. 166–7.

„ „ Divisions of Micrometer Eye-piece.
[Reply to inquiry as to the parts of an inch in which an eye-piece micrometer should be ruled. "On the whole it seems best to adopt some divisions which shall give sufficient accuracy without confusing the mind in counting the lines or in any wise obscuring the view of the object. It is on these grounds that we have ventured to recommend the spacing of 1-100th in."]
Amer. Mon. Micr. Journ., IV. (1883) p. 179.

„ „ Testing Objectives.
[Exhortation to use Prof. Abbe's method, *ante*, p. 120.]
Amer. Mon. Micr. Journ., IV. (1883) p. 194.

„ „ Developing Photo-Micrographs. [*Post.*]
Amer. Mon. Micr. Journ., IV. (1883) p. 198.

International Bureau of Weights and Measures (*concld.*).
Nature, XXVIII. (1883) pp. 592–6 (2 figs.) from *La Nature*.

J., C.—The Microscopic Glasses. (A chapter in advance.)
[Describes the examination of the insectivorous powers of *Drosera* "about the year 1900," with spectacles "of such a power as to enable the wearer at a distance of a few feet to distinguish the minutest object as clearly as with a first-rate Microscope."]
Sci.-Gossip, 1883, pp. 243–4.

Kellicott, D. S.—The American Society of Microscopists.
[Account of the Chicago Meeting.]
Amer. Mon. Micr. Journ., IV. (1883) pp. 172–4, 185–90.
The Microscope, III. (1883) pp. 145–51, 160–1.

Knauer, J.—Das Mikroskop und seine Anwendung. (The Microscope and its use.) *Naturhistoriker*, V. (1883) pp. 409–12.

Koch.—Ueber eine Methode die Mikrometer-schrauben zu prüfen. (On a method of testing micrometer-screws.)
Ber. Verhandl. Naturf. Ges. Freiburg, VIII. (1882) Heft 1.

Lankester, E. R.—Presidential Address to the Section of Biology at the Southport Meeting of the British Association for the Advancement of Science.
[Advocating the endowment of research, especially in Biology. *Supra*, p. 907.]

Lasaulx, A. v.—Ein neues für petrographische und mineralogische Untersuchungen bestimmtes Mikroskop. (A new Microscope intended for petrographical and mineralogical researches.)
[Made by Nachet under E. Bertrand's directions. Apparently the same as *ante*, p. 413.]
Verh. Naturhist. Ver. Preuss. Rheinl. u. Westf., XXXIX. (1882) SB., p. 82.

Lockyer, J. N.—The Movements of the Earth. (In part.)
[Contains "How Optics enables us to read fine verniers.
" " " to replace the vernier by a micrometer."]
Nature, XXVIII. (1883) pp. 598–604 (17 figs.).

Mason, J. J.—Minute structure of the Central Nervous System of certain Reptiles and Batrachians of America. Illustrated with 113 permanent photo-micrographs. Series A, viii. and 32 pp. [*Post.*] 4to, Newport U.S.A., 1879–82.

Matthews, J.—Device for facilitating the exchange of objectives.
[*Supra*, p. 903.] *Journ. Quek. Micr. Club*, I. (1883) pp. 299, 305.

Nelson, E. M.—New method of fixing objectives to the Microscope.
[*Ante*, p. 572.] *Journ. Quek. Micr. Club*, I. (1883) pp. 298–300.

Nunn, R. J.—The Pillar Slide. A new slide for the Microscope. [*Post.*]
Sep. repr. from *Trans. Med. Assoc. Georgia*, 1883, pp. 21–2.
Amer. Mon. Micr. Journ., IV. (1883) p. 178.

" " Chemical.—New slide for the Microscope. [*Post.*]
Sep. repr. from *Trans. Med. Assoc. Georgia*, 1883, pp. 22–4.

" " Slides with hollows for chemical reactions. [*Post.*]
Sep. repr. from *Trans. Med. Assoc. Georgia*, 1883, p. 24.

Officer, W.—Another reading table.
[A piece of board covered on one side with American leather-cloth (for tables with cloth covers), and on the other with green baize (for polished tables).]
Sci.-Gossip, 1883, p. 232.

Ollard, J. A.—Zoophyte Troughs.
[Directions for making.] *Engl. Mech.*, XXXVIII. (1883) p. 224 (1 fig.).

., W. G.—Doublets for the Microscope.
[Deals with the reduction of spherical aberration with 2 lenses.]
Engl. Mech., XXXVIII. (1883) p. 223.

Pippet, W. A.—A substitute for a revolving table.
[Cover of stout oil-cloth to a small table with a round top, drawn underneath the table by strings like the mouth of a bag: the "cover will then revolve with the greatest ease even when it has a considerable weight upon it."].
Sci.-Gossip, 1883, pp. 232–3.

PUMPHREY, W.—The Application of Photography to the delineation of microscopic objects.

[Brief directions for photographing microscopic objects, with drawing of a camera.]

Journ. Post. Micr. Soc., II. (1883) pp. 201–6 (1 fig.).

ROGERS, W. A.—Studies in Metrology—First paper.

[Contains a description and 7 figs. of the Rogers-Bond Universal Comparator, with two comparing Microscopes, Micrometers, Tolles's opaque illuminator, &c.]

Sep. repr. from *Proc. Amer. Acad. Arts & Sci.*, 1882–3, pp. 287–398 (7 figs.).

SLACK, H. J.—Tubular Live-box. [*Supra*, p. 906.]

Knowledge, IV. (1883) pp. 267–8 (1 fig.).

SLOAN, J.—A good Objective.

[Spencer's 1-10th hom. imm. 125° B.A. resolves *Amphipleura pellucida* "with daylight above or beneath the stage, with concave mirror alone, in homogeneous fluid or in glycerine. By lamplight and concave mirror with bull's-eye condenser with either fluid. It also resolves them readily by central sunlight."]

Amer. Mon. Micr. Journ., IV. (1883) pp. 198.

SMITH, J. Lawrence.—Obituary.

[Inventor of the inverted Microscope.]

Amer. Journ. Sci., XXVI. (1883) pp. 414–5.

STERNBERG, G. M.—Photo-micrographs and how to make them. 204 pp. and 47 photo-micrographs (on 20 plates) reproduced by the heliotype process. 8vo, Boston, 1883. [*Ante*, p. 720.]

[Cf. *Amer. Mon. Micr. Journ.*, IV. (1883) p. 197.]

STOWELL, C. H.—Gleanings from the Journal of the Royal Microscopical Society for August. *The Microscope*, III. (1883) p. 156.

STOWELL, C. H. and L. R.—A new State Microscopical Society.

[Suggestion for a Michigan Society.] *The Microscope*, III. (1883) p. 160.

β. Collecting, Mounting and Examining Objects, &c.

Aylward's Apparatus for Pond-Life Hunting. — Mr. H. P. Aylward has designed a set of apparatus for pond-life hunting, the novel feature of which is that the holder for the bottle is made of steel wire, one end grasping the neck of the bottle, and the other end being a hollow spiral, in which the taper end of any sized walking-stick may be inserted. The hook is similarly attached to a spiral. The dipping-bottle packs in a japanned cylindrical tin box, the upper half of which is composed of very fine copper gauze. When the bottle is emptied into this box, the organisms will be retained in the lower part, and the surplus water escape through the gauze. This operation may be repeated any number of times, and the contents afterwards returned to the bottle. For special gatherings, another japanned box is supplied, containing several large test-tubes. The size of the cylindrical box and its case containing the bottle is 5 in. × 2 in., that of the box with test-tubes, $5\frac{1}{2}$ in. × $3\frac{1}{2}$ in. × 1 in.

Capturing and Breeding Insects, Acari, &c., for Mounting.*— Mr. A. D. Michael, referring to the question of breeding insects, acari, &c., in order to get them in the best condition to mount, says that

* Journ. Quek. Micr. Club, i. (1883) pp. 241–2.

he only occasionally does so. Breeding may be advantageous when pupæ can be obtained in a late stage, or when a rare larva is found. But it is extremely difficult to imitate the whole natural conditions for any length of time; the creature is not strong and vigorous, and though the hairs and setæ are less injured, it does not necessarily make a better mount than a hardier well-developed creature born in a natural state, and perhaps caught only a short time after emerging. His own habit was, therefore, rather to rely upon capture and not breeding.

Treatment of Pelagic Fish Eggs.* — The transparent eggs of various Teleostei found floating on the surface of the sea present unusual difficulties in the way of hardening. Dr. C. O. Whitman has had recourse to all the fluids commonly used for this purpose, and failed to find any satisfactory method of hardening the yolk. Even the germinal disk cannot be well preserved by any of the ordinary hardening agents. Kleinenberg's picro-sulphuric acid, for instance, causes the cells, all through the cleavage stages as well as the later embryonic stages, to swell and in many cases to become completely disorganized. The embryonic stages can be hardened in chromic acid (1 per cent.), but the yolk contracts considerably without becoming well hardened even after three days' immersion.

All sorts of wrinkles and distortions are caused when the ova are transferred from the acid to alcohol. The best results have been obtained with osmic acid and a modified form of Merkel's fluid. This fluid, as used by Dr. Eisig, consists of chromic acid (1-4th per cent.) and platinum chloride (1-4th per cent.) mixed in equal parts. Thus prepared it causes maceration of the embryonic portion of the egg. By using a stronger chromic acid (1 per cent.) and combining it as before with the same quantity of platinum chloride (1-4th per cent.), everything may be well preserved and hardened except the yolk. Before transferring to alcohol, after one to two days' immersion in this fluid, it is necessary to prick the egg membrane in order that the alcohol may reach the egg readily, otherwise the membrane wrinkles badly and often injures the embryo.

For the cleavage stages this fluid cannot be used with success unless the egg has been first killed with another agent, for eggs placed in the fluid continue to live for a considerable time, and may even pass through one or two stages of cleavage. It is therefore necessary to use some agent that kills almost instantly. For this purpose Dr. Whitman has found osmic acid the best reagent. The eggs are placed in a watch-glass with a few drops of sea-water, and then a quantity of osmic acid (one-half per cent.) equal to that of the sea-water is added. After 5–10 minutes the eggs are transferred to the mixture of chromic acid and platinum chloride, and left for twenty-four hours or more. This fluid not only arrests the process of blackening, but actually bleaches the egg.

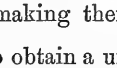
After this treatment it is an easy matter to separate the blastoderm from the yolk by needles, and the preparations thus obtained

* Amer. Natural., xvii. (1883) pp. 1204-5.

can be mounted *in toto*, or sectioned. As the blastoderm is quite thin during the cleavage stages, a whole series of these stages may be mounted and studied from the surface to advantage. After removal from the acid the preparations may be stained at once, and then treated with alcohol and mounted in balsam.

Water-bath and Moulds for Imbedding.*—A. Andres, W. Giesbrecht, and P. Mayer describe some minor arrangements which they have devised for facilitating imbedding in paraffin.

First a water-bath, the principal advantage of which is that the steam cannot reach the object, and that with a very small consumption of gas or alcohol a constant temperature can be kept up during half the day.† It is made of brass, contains a deep cylindrical and two shallow depressions with cups of brass and several deep holes, in which the glass tubes containing objects in chloroform and paraffin can be put, as well as a thermometer.‡ Difficult objects are placed with their tubes, from which the corks are previously removed, in the water-bath whilst cold, and then gradually warmed; afterwards they are put in shallow saucers, a low temperature being kept up as long as chloroform evaporates; a deeper vessel contains the paraffin for imbedding. On one side is a slit for the insertion of slides to be warmed.

The imbedding is not done in boxes of paper or of tinfoil as recommended by Kossmann, but in moulds with glass bottoms and movable metal sides, so that they can be altered in size at will. At the Zoological Institute at Leipzig they are made of type-metal. The authors have altered them a little, giving them the shape of  , and making them of brass in order to use as little metal as possible, and so obtain a uniform cooling of the whole mass. The metal walls and glass bottom were rubbed each time with glycerine, before being used, to prevent the paraffin adhering. For exactly placing very small objects the boxes are coated with thin collodion (after rubbing with glycerine), and then put into a water-bath for the evaporation of the ether-alcohol, and a box is thus obtained in which paraffin can be kept liquid for hours without running out between the metal and the glass. The imbedding then takes place quietly. The box is put in a small water-bath under the dissecting Microscope, and after the objects are placed in position it is quickly cooled by the emptying of the bath.

Fearnley's Modification of the Groves-Williams Ether Freezing Microtome.—Dr. Fearnley has devised the modification of the Groves-Williams Ether Freezing Microtome § shown in fig. 170. The

* MT. Zool. Stat. Neapel, iv. (1883) pp. 435–6.

† R. Kossmann, Zool. Anzeig., vi. (1883) pp. 19–21, recommends for the same purpose an air-bath which can be kept at 50° with a Kemp-Bunsen gas regulator.

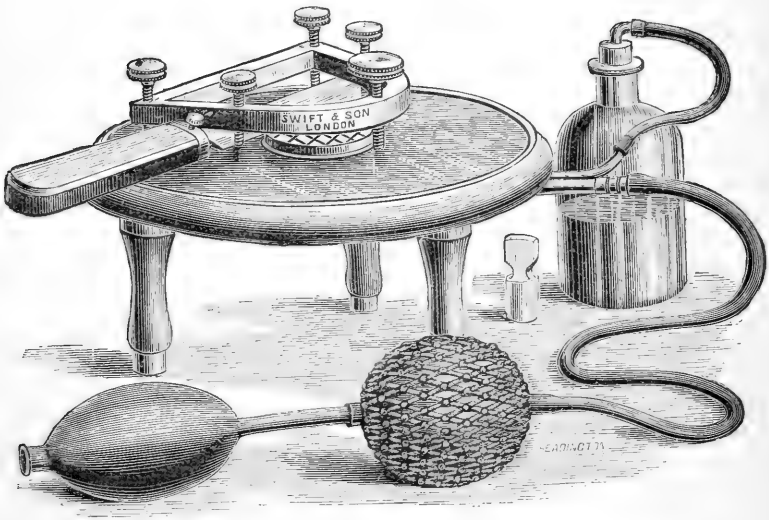
‡ This water-bath has already been described in an original and similar form by C. O. Whitman. Amer. Natural., xvi. (1882) pp. 697–785.

§ See this Journal, ii. (1882) p. 758.

bracket is removed and the glass plate is supported on a tripod, the ether apparatus being applied beneath.

The advantage claimed for the instrument over the older forms is that when only a few sections are required but little ether is

FIG. 170.



expended, as they can be frozen in fifteen seconds; whereas with the Groves-Williams instrument 1 min. to 1½ min. is requisite. The latter, however, has the great advantage of entirely conveying from the room the fumes of the ether, which in many cases cause serious inconvenience to the operator. The instrument is made by Messrs. Swift and Son.

Improvements in the Thoma Microtome.*—A. Andres, W. Giesbrecht, and P. Mayer describe some improvements in the medium size of this instrument.

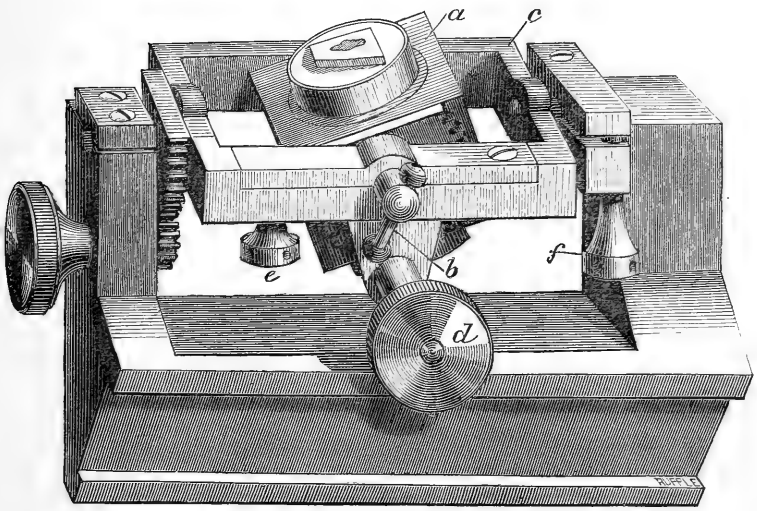
The "*clicking arrangement*" enables each turn of the micrometer-screw to be recognized by the ear, so that the eye, which is already sufficiently strained by the cutting, rests. This is of importance when working much with the microtome, especially with sections of small objects; the authors, therefore, do not agree with Prof. Thoma when he says† "such complications are useful only for very special conditions." On the author's suggestion Herr Jung has applied this arrangement to the drum of the micrometer-screw, and has further

* MT. Zool. Stat. Neapel, iv. (1883) pp. 432-5.
† See this Journal, *ante*, p. 303.

enhanced its usefulness by causing the spring to catch at pleasure either in each of the fifteen divisions of the drum or in a whole or half or 1-3rd turn of the screw.

By an improvement in the *object-holder* the object is now movable in all three directions of space. It is raised in the vertical direction and turned round the vertical axis by the hand; in the two other planes it is moved by rack and pinion, so that changes in direction can be conveniently and accurately made during the cutting. As fig. 171 shows, the piece of paraffin is at the top of a hollow metal

Fig. 171.



cylinder, which is filled inside with paraffin. The cylinder can be pushed up and down in the block *a*, and by means of six holes beneath and a small metal rod can be turned in it. It is held fast in all positions by a clamp *b*. The turning of the block in the frame *c* round the horizontal axis is effected by *d*, and it is fixed by the small screw *e* (the head of which is provided with holes for the small metal rod), which presses one bearing of the block against its axis. In the same way the frame is turned round the long axis by the rack and pinion on the left and fixed by the screw *f*. By the pressure of the bearing on the axis, the position of the object is altered at the most 0·005 mm.

The arrangement is in fact only a modification of the Cardani ring, used with ship lamps, &c. With this microtome alone is it possible to alter the direction of the object at pleasure, without at the same time raising or lowering it much. The latter disadvantage is

present in Spengel's otherwise very good microtome * so that on altering the direction of the section a considerable amount of shifting is necessary. Both axes are therefore passed through the middle of the upper surface of the block, as near as possible to the object. The attachment of the object on a cylinder which is movable in a vertical direction has the great advantage that pieces of more than 2 cm. in length can be cut. At the beginning the cylinder is placed as low as possible, and raised later on as required. Plates from 0·5 to 1 cm. deep can also be used under the knife and afterwards removed.

The latest modification relates to the *points* on which the slides run. These have now been made of ivory, and the sliding surfaces of the so-called bronze. In consequence of this the instrument is no longer subject to rust, and the movement of the knife-carrier, which when very slow, becomes irregular, is now, by the increased friction, quite regular. The durability of this new combination is of course undetermined, it seems, however, as if the wearing away of the bearing surfaces were less than formerly, when metal was used upon metal.

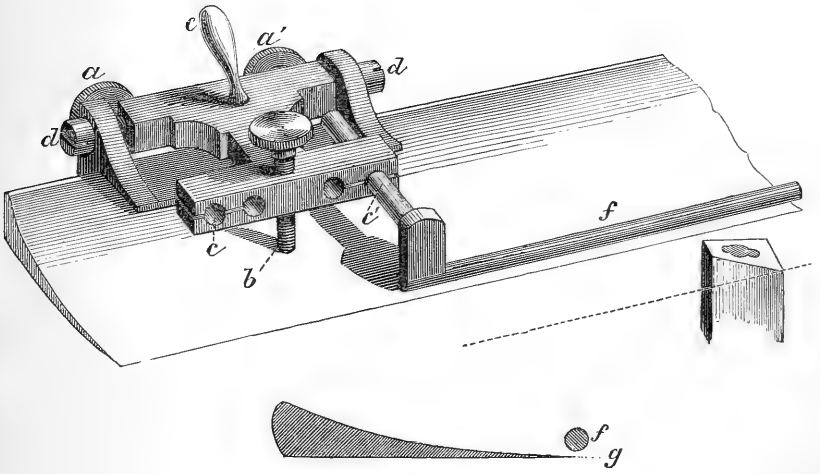
Andres, Giesbrecht, and Mayer's Section-stretcher.†—A. Andres, W. Giesbrecht, and P. Mayer describe a section-stretcher which they consider to be superior to that of F. E. Schultze.‡ The latter, consisting of a small cylinder and a watch-spring, is fixed to the object-slide of the microtome, and as the paraffin diminishes in height, the cylinder exercises a decreased pressure and will not therefore work uniformly during the whole process. Whilst the authors gave up a similar apparatus on account of the above drawback, Schultze on the other hand rejected an instrument similar to theirs in favour of his own.

The apparatus of the authors is attached to the knife itself, and during the cutting maintains the same position with respect to the section which it had in the beginning. It consists (fig. 172) of a cylindrical steel rod *f* which is exactly parallel to the knife-edge, and is just over it, and so that if further depressed the lowest line of its surface would fall exactly on the knife-edge *g*. It thus compels the section to pass between it and the edge. The position of the rod parallel to the edge of the knife in the vertical plane is adjusted by turning its arm in the holes *c* or *c'*; the parallel position in the horizontal plane by the screws *a* and *a'*, which work against the back of the knife; and the vertical distance from the edge, which must be regulated according to the thickness of the section, by the screw *b*. The whole apparatus is held on the knife by two clips pressing on the under surfaces. The hinge *d d* enables the rod and its support to be turned back by means of the handle *e* so that the edge of the knife and the rod *f* can be cleaned if necessary. For sections of great extent a very thick rod is supplied, and for very small sections a thin rod which can be easily attached.

* Zool. Anzeig., ii. (1879) pp. 641–8.
† MT. Zool. Stat. Neapel, iv. (1883) pp. 429–32 (1 fig.).
‡ Cf. this Journal, *ante*, p. 450.

If the apparatus is adjusted in the manner described it will work equally well from the beginning to the end. It cannot be used for friable sections; in such cases a section-stretcher is not applicable. The block of paraffin to be cut is to be so shaped that it presents the section shown in the figure. Some paraffin is left on the side towards

Fig. 172.



the edge of the knife, so that before it reaches the object it may find something to cut, and the opposite side is pared away so that the section (as is shown in the figure by the dotted edge of the knife) may adhere only by the posterior corner and not along the whole margin of the edge of the knife, and can therefore be easily removed by a pincette.

Cutting Sections of Probosces of Honey-feeding Insects.*— F. Cheshire recommends that the insect to be operated upon should be kept fasting for some time and then fed upon honey mixed with gelatine impregnated with some highly coloured dye. The insect should be immediately decapitated and the head rapidly cooled, and then imbedded in gelatine and the section cut by the microtome. The mouth passage is then easily seen from the presence of the dye.

By the use of this method Mr. Cheshire was easily able to make out the structure of the extreme apex ("Reaumur's bouton") of the tongue of the honey-bee, about which so much difference of opinion has existed. He has also found that the tongue is neither a tube through its entire length nor a gutter or trough, but is in reality a trough on the upper side at the apex, and a tube for the rest of its length.

* Proc. Entomol. Soc. Lond., 1883, p. xix.

Staining with Rose Bengale, Iodine Green, and Bleu de Lyon.*—Dr. H. Griesbach describes Rose Bengale as a chlorinated tetriodofluorescin, belonging to the Resorcinphtalein group; it is the bluest of all known eosin compounds and resembles fuchsin in shade. If dissolved in water it is very useful for staining chromic acid preparations, e. g. spinal cord, the grey substance of which is stained a deep bluish red, while the white substance is paler; it is also adapted for muscles and connective of Vertebrata and Invertebrata, but not satisfactorily for glandular tissues or bones.

It is especially suited for double and triple stainings, in conjunction with iodine green, and iodine green and aqueous solution of Bleu de Lyon: the nuclei of the gland cells of the organ of Bojanus, hardened in alcohol, come out emerald green, the protoplasm is unstained; cell-membranes and cilia are stained red. Transverse sections of the edge of the foot of *Anodonta*, from an alcohol specimen, should be washed in distilled water, drawn quickly through a dark solution of Rose Bengale, then washed in pure distilled water and placed for some seconds in iodine green, washed again in distilled water and placed for about five minutes in absolute alcohol, to fix the colour and remove possible excess; the sections are now drawn two or three times through a solution of Bleu de Lyon made with two parts of absolute alcohol and three of distilled water, transferred to absolute alcohol, clarified in oil of aniseed and mounted in dammar-lac; the result is very beautiful.

Carmine Staining.†—"Obersteiner is entitled to the gratitude of all neurologists who, while interested in histological researches, are unable to devote much time to cosmetic experiments. He has made the simple suggestion of heating the staining fluid containing the specimens. Previously, when large sections were to be stained in neutral carmine, one great difficulty encountered had been the fact that specimens hardened for any length of time, however well they might ultimately stain, took the colouring matter up so slowly that many days and even weeks elapsed before the process was complete, and in the meantime the carmine usually precipitated, and the finest specimens were thus rendered valueless. In the laboratory of one of the editors it has been attempted to obviate this by daily changing the staining fluid, which can be done, if proper skill be employed, without injuring the sections. But even with this many failures occur. By subjecting the staining fluid containing the sections to a water-bath heated by a spirit-lamp, the finest staining can be accomplished in from one to two hours, and in the case of hæmatoxylin in even less time. The heating of hardened sections does not injure them in the least when the precaution is used of employing a water-bath."

Stain for Fresh Tissues of Vertebrata.‡—The methods recommended by Prof. S. Mayer are intended exclusively for fresh or recently

* Zool. Anzeig., vi. (1883) pp. 172–4.
† Amer. Journ. Neurology and Psychiatry, ii. (1883) p. 579.
‡ SB. Akad. Wiss. Wien, lxxxv. (1882) pp. 69–82 (2 pls.).

dead tissues and for thin parts capable of ready examination by transmitted light. The stain recommended is Violet B. of Bindschedler and Busch (Bâle) in the proportion of one gramme to 300 c.c. of ½ per cent. salt solution.

The mesentery is very well stained by this reagent, the vascular system being very clearly brought out, while the connective tissue is rendered pale red; this is best seen in one of the *tâches laiteuses* of Ranvier. The piece should be first shaken up in a test-tube with some ½ per cent. solution of common salt, then spread out smooth on a glass plate with a brush, covered with a drop of staining fluid for ten to thirty seconds, then removed with a bristle, washed with salt-solution, and placed on a glass slip in salt-solution for examination. The method is said to be preferable to injection, from the distinctness with which the vessels are brought out, the definition of the structure of their walls, the superior rapidity and simplicity, and the prevention of misleading appearances. Specimens too deeply stained can be made paler by washing in ½ per cent. salt solution; specimens which are quite fresh require a rather lengthy staining, viz. ½ to 1 minute. Another very good object to which to apply the method is the hyaloid membrane of the frog's eye. It is also useful in the study of fat-cells in process of atrophy. Occasionally the contents of the cells are themselves stained. Certain cells, apparently plasmatic or food-cells, are brought prominently into view in the mesentery, omentum, and ligamentum uteri of the rat by this method; the granules may be coloured violet or dark blue.

It is especially useful for exhibiting smooth muscular fibres, as found in tracts in the serous membranes of the pelvis, abdomen, and thorax, and forming a netted layer in the peritoneum surrounding the vas deferens and spermatic vessels; also for elastic tissue, which may thus be well seen in the meso-rectum of the rabbit; also for the grey nerve-fibres of the serous membranes of the frog, and for the larger and smaller lymphatic vessels. No means have at present been devised for rendering permanent preparations made in the above manner. The two plates accompanying the paper contain some beautiful figures of preparations made according to the method.

Series Preparations.*—Almost the same considerations which led Dr. Giesbrecht† to his method of mounting sections in series, gave Dr. J. H. L. Flögel the idea four years ago, of using a substance for fixing in which the imbedding mass is absolutely insoluble. For this purpose he used an aqueous solution of gum arabic for objects imbedded in paraffin.

A filtered solution is prepared of 1 : 20, and, in order to protect it from mould, a dash of alcohol is added. The slide must be so carefully cleaned that it can be evenly wetted all over. The gum solution is poured over the whole surface of the slide and allowed to run off. The process can then be carried on in two ways. Either the glass is placed perpendicularly to dry, protected from dust, the sections arranged on the *dry* surface, and breathed upon so strongly that the

* Zool. Anzeig., vi. (1883) p. 565.

† Ibid., iv. (1881) p. 484. Cf. this Journal, i. (1881) p. 953.

thin layer of gum is again dissolved by the water; or the paraffin sections are laid at once in the *liquid* gum solution and, fixed in their proper place, adhere whilst drying Either modification has its advantages and disadvantages. With extremely delicate and small sections (·003 mm. thick), the dry slide is unconditionally the best; with thicker (·01 mm.) and larger sections the wet process gives the best results.

If only few and small sections are to be mounted the removal of the paraffin after fixing is unnecessary; the balsam dissolves it entirely. But if 50 or 100 sections are wanted together, the paraffin should be removed, before putting on the cover-glass, by benzine, and before it is evaporated balsam is quickly added.

After a while the gum is removed by washing from every part of the slide outside the cover-glass.

Mounting Minute Insects and Acari in Balsam.*—Mr. A. D. Michael describes his process as follows:—He first kills the creatures in hot water or spirit. Hard insects and *Acari* are best killed in hot water which causes them to expand their legs, but water rather injures minute flies, and spirit is better for them. Next wash the objects thoroughly in spirit and clean with a badger's hair, clean mechanically and by washing in spirit. Place the object on a glass slip and arrange it with the hair, leave it in spirit for such a time as experience suggests, tilt the slip so as to drain off the spirit, but not to dry the object, which should never be allowed to dry from the first process to the final mounting. Having drained off the spirit, drop on the object a little oil of cloves, which is better than turpentine; slightly warm the slide and put on a thin cover-glass, which must be supported so as not to touch the object; leave it until thoroughly soaked. If necessary remove to a clean slip for the final mount. It may be necessary to arrange the object more than once. Drain off the oil of cloves and put on a small quantity of Canada balsam, or preferably balsam and benzole. Arrange the creature on the centre of the slide. Let the balsam harden a little, then the object will not float off, as happens sometimes when a quantity of balsam is used at once. Lower the cover straight down on the object; do not try to drive out a wave of balsam as is recommended in the text-books. It is better not to put enough balsam at first to fill the space under the cover, as the balsam supports the cover if it does not reach the edge, but if the balsam reaches the edge of the cover it is apt to draw down the cover and crush delicate objects. A few pieces of thin glass to support the cover are a great protection to the object, or better still, a few tiny glass beads. Finish the slide with a ring, Bell's cement or something of the kind, but that must not be done unless the cover be supported in some way.

Collecting together Scales of Insects and other Minute Objects upon one place on a Slide.†—G. Dimmock puts the scales in a drop

* Journ. Quek. Micr. Club, i. (1883) pp. 241–2.

† Psyche, iv. (1883) p. 71.

of some quickly evaporating substance on the slide—chloroform is best for most purposes. The scales will form a kind of whirlpool, nearly all the scales finally settling down, as the liquid evaporates, in one place on the slide. Rapping the slide gently sometimes aids in the collecting together of the scales, and the tip of the scalpel used to scrape the scales from the insect can be washed in the drop of chloroform, thus saving every scale when they are from a rare specimen from which it is desired to remove only a few scales. By inclining the slide gently the mass of floating scales can be made to settle on the exact centre of the glass. One part of Canada balsam added to several hundred parts of chloroform, will cause the scales to stick firmly to the slide.

Mounting Hydrozoa, Polyzoa, &c., with extended Tentacles.*—Mr. A. D. Michael prefers to use spirit for killing the animals. Osmic acid stains too much. They should be got in good condition, placed in a watch-glass, and syringed freely, and then placed under a low power and watched until the tentacles are well extended. Then with a fine pipette run a small drop of spirit down the *side* of the glass, not on the polype. The creature will probably withdraw its tentacles. If so, leave it alone until they expand again; without disturbing it run another drop down the glass. After doing this once or twice the animal gets dull and heavy, drunk in fact, and then spirit may be added freely, and the polype mounted.

As a medium for mounting, spirit and water gives very good results, possibly the best on the whole, but Goadby's solution preserves the creatures in more natural form and keeps the sarcode harder, presenting a more life-like appearance, but it is open to the objection that it contains corrosive sublimate which produces a certain amount of discoloration of the creature after a time. Another objection is that it has a tendency to cast a sediment. For that reason it should be used weaker than the book strength, adding about three times the quantity of distilled water.

Mounting Leaves of Pinus.†—Mr. H. J. Slack writes that "Amongst the objects which yield beautiful results with [nitric] acid and chlorate of potash treatment, are the needle-shaped leaves of the pine-trees. *Pinus austriaca*, common in shrubberies, is a good one for the purpose. Quite clean leaves should be selected, of fresh growth. They should be cut into short lengths, so as not to require much acid to cover them, and treated exactly as the *Deutzia* leaves,‡ but they want a little more cooking. When finished they are quite white, and in the state of hollow tubes, all their insides being eaten out. To prepare for the Microscope, a piece of the tube must be slit open and flattened out on a slide with fine needles in a drop of water. If it curls up it must be flattened again and kept so by a cover-glass. When quite dry, mount in balsam, and view with a 1-2 inch objective,

* Journ. Quek. Micr. Club, i. (1883) p. 241.

† Knowledge, iv. (1883) pp. 130–1.

‡ The remarks above quoted are preceded by a description of the method of treating the leaves of *Deutzia scabra*.

polarized light, and a selenite film. A hand-magnifier is sufficient to show that fir needles are ornamented with rows of white glistening spots. In these the stomata of the plant are situated. Their action upon polarized light is very beautiful, and the changes obtainable by rotating the prisms very striking. Very elegant patterns that would be popular for ladies' dresses, window-curtains, &c., readily appear. So far as the writer knows, these pine needles have been generally neglected by microscopists."

Cleaning Diatoms.*—J. Y. Bergen, jun., finds the following method works well:

The diatoms are to be freed as far as possible from water, by decanting it off. Then covered with a liberal quantity of pure concentrated sulphuric acid, which is heated to boiling in a good porcelain evaporating dish. Continue the heating till the white fumes of sulphuric acid begin to escape freely, and then, while still over the lamp, add potassium nitrate (saltpetre) in bits the size of a pea, waiting after each addition till the effervescence ceases before adding more. Continue till the whole mass in the dish is white or light yellow. This will not usually take more than five minutes. Then wash the cleaned diatoms with successive portions of distilled water as usual.

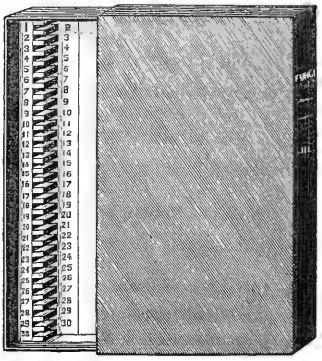
Preparation of Fresh-water Algæ for the Herbarium.†—P. Richter recommends that specimens of fresh-water algæ intended for the herbarium should be first of all placed on thin glass, or better upon mica, taking care that they dry as quickly as possible, in order that decay may not set in. When moistened for observation under the Microscope, as little water as possible should be used, and the excess removed as completely as possible by blotting-paper. They must often also be protected by a second layer of mica, which is preferable either to glass or paper. The mica can be readily split under water, but should not be too thin. To replace waste, which will necessarily take place with each moistening for observation, a quantity of the algæ should also simply be dried upon paper; and for the larger kinds this alone is necessary. Unicellular algæ which float free in the water, require no special treatment; they usually dry quickly on paper. For unicellular or filamentous gelatinous algæ, such as the Oscillatorieæ, it is usual to employ stearin-paper, in order to be able to subject them to slight pressure; but it has the disadvantage of keeping the specimens moist for some days, so that decay sets in. Richter finds the purpose answered better by ordinary yellow straw-paper with either smooth or rough surface; layers of blotting-paper may be placed between the straw-paper to dry it, and the whole subjected to slight pressure; the blotting-paper should be changed as often as possible; the first change may be after half an hour. If the alga sticks to the straw-paper, it can readily be detached by moistening. Chocolate-coloured cellulose-paper answers the same purpose as the straw-paper.

* Amer. Mon. Micr. Journ., iv. (1883) p. 198.

† Hedwigia, xxii. (1883) pp. 97–100.

Brown's Slide-box.—Mr. R. Brown, jun., of Yale College Observatory, U.S.A., has devised a slide-box (fig. 173) to stand on end like a book (and appropriately lettered on the back), the slides remaining horizontal, cover-glasses uppermost. It consists of an inner box of pasteboard, covered with bookbinder's cloth, 7 in. by 4 in. by $1\frac{1}{8}$ in., with a rack on each side 2-3rds in. deep. Both the bottom of the box and the top of one of the racks is numbered from 1 to 30, corresponding to the divisions of the rack, and the loose cover which fits on the inner box (not shown in the fig.) has corresponding numbers, against which the names of the slides can be written. This inner box slides in an outer case. Mr. Brown writes of the box as follows:—

Fig. 173.



"So far as it is an improvement upon the form employed by Prof. H. L. Smith, it is the joint work of Governor J. D. Cox, of Ohio, and myself, and has been in use three years and more, and our satisfactory experience with it seems to be confirmed by the increasing number of inquiries I receive from microscopists to whose attention it has come, without other notice than the exhibition of it before the Section of Microscopy and Histology of the American Association for the Advancement of Science at Cincinnati in 1881.

While it seems to me that the box explains itself, I will say of one or two points which might seem to be superfluous, that it was the outcome of our experience with a very smoky and sooty atmosphere, wherefore the cover to the inner box, which is also made to do duty as a table of contents. This is unattached, because it was thought to be in the way, if hinged, when the box or several of them were in use; as it is, it can lie in, on, or under the box or its cover, without occupying any of the table room. At the corresponding numbers on the index are written in pencil the names of contained objects. The column of numbers in the bottom of the box was so placed at first, but becomes superfluous when the numbers are placed on the top edge of the rack, where a slight deviation from exact conformity with the slide's position is of less consequence. Many kinds of paper were tried to find one which being correctly spaced in printing would not stretch in the process of pasting in the box, and the one which has been found to answer ('plate' paper) when printed in one direction, will stretch from 1-8th to 1-4th in. in the 7, if printed in the rectangular direction, i. e. when wet with paste.

Between the edges of the slides and the movable cover (and, if found necessary, in the bottom of the box) may be put a piece of felt, or cloth, or flannel, for the more effectual exclusion of dust or smoke, and for the greater security of the slides if to be subjected to rough

handling in carriage; but I have known of no breakage, although I have often carried boxes in my pockets without any precaution. The 7-inch racks accommodate 30 slides, except where cells of more than 1-8th in. in depth occur, and then such a slide has the space of two allotted to it. This appeared to be the practical limit of approximation of slides within our own experience, and the height of the box seemed better than if shortened for 25, giving accommodation for the additional 5 without appreciable increase of cost. As a box is seldom presumed to be filled, there is no advantage in one number over another in the way of estimating the number of slides in a collection.

In a system so inexpensive, a good deal of space may be left for estimated accessions, and a scientific classification of slides may be maintained with a minimum of trouble. When the space thus left is filled, it only remains to start a new box, which follows in order on the shelf the one which has become crowded, without any change in the succeeding boxes. Sometimes a part of the contents of the crowded box may be transferred to the new and empty one, to admit of further growth in the former; in this case the index is to be cleaned of the titles of the slides removed.

I have had these boxes (including the movable cover-index and outer case) made, in lots of 200 at a time, for 12 cents (6*d.*) apiece, the racks for 8*c.* (4*d.*) per pair, and the printing for about 2*c.* (1*d.*) per box. With smoother finished racks and glazed paper lining I think the boxes could be made for 25*c.* or 1*s.* apiece, this allowing only the manufacturer's profit. The making (12*c.*) of the boxes included the gluing-in of the racks and pasting of labels. Made on a proper scale, these ought to cost less in England than here. Of course, where the taste and the means for gratifying it co-exist, the boxes may imitate any quality of binding, and be of any degree of fineness of inside finish."

Cataloguing, Labelling, and Storing Preparations.* — Prof. S. H. Gage, in a paper presented to the Chicago Meeting of the American Society of Microscopists, says:—

"To every one possessing a microscopic slide one or more of the considerations named in the title of this paper appears of importance. All of them are, however, of especial importance to the teacher and investigator. To the investigator his specimens are the most precious of his possessions, for they contain the facts which he tries to interpret, and they remain the same while his knowledge, and hence his power of interpretation, increase. They thus form the basis of further or more correct knowledge; but in order to be safe guides for the student, teacher, or investigator, it seems to the writer that every preparation should possess two things—viz. a label, and a catalogue or history. This catalogue should indicate all that is known of a specimen at the time of its preparation, and all of the processes by which it is treated. It is only by the possession of such a complete

* 'Chicago Times,' 8th August, 1883, in advance of Proc. Amer. Soc. Micr., 6th Ann. Meeting, 1883.

knowledge of the entire history of a preparation that one is able to judge with certainty of the comparative excellence of methods, and thus be able to discard or improve those which are defective. The teacher, as well as the investigator, should have this information in an accessible form, so that not only he but his students can obtain at any time all necessary information concerning the preparations which serve him as illustrations and them as examples.

After consulting all the authorities at my disposal, and after profiting by the suggestions of as many investigators and teachers as possible, and after a careful practical test of five years in the anatomical laboratory of Cornell University, the following formula for cataloguing and labelling microscopical preparations is offered, hoping that others may find aid in the suggestions, and in return help the author to eliminate what is needless and correct what is defective:—

Formula for Cataloguing Microscopical Preparations:—	An actual Catalogue Card written according to the Formula:—
1. The general name.	1. Nerve fibres.
2. The number and date of the preparation and the name of the preparator.	2. No. 31 (Drr. 11), March 21, 1880; S. H. G. preparator.
3. The special name of the preparation; the common and scientific name of the object from which it is derived.	3. Isolated medullated nerve-fibres from the sciatic of the cat (*Felis domestica*).
4. The special object of the preparation.	4. This preparation shows well the axis-cylinder and the nodes of Ranvier.
5. The method of hardening, dissociating, &c.	5. Dissociated 24 hours in 25 per cent. alcohol.
6. The special method of preparation for the Microscope, viz. cut into sections, spread, &c.	6. Teased or dissociated on the slide with needles.
7. The staining agent and the time required for staining.	7. Stained over-night in picro-carmine.
8. The clearing agent and the mounting medium.	8. Cleared with turpentine and carbolic acid; mounted in chloroform balsam.
9. The objectives to use in studying the preparation.	9. Use 3-4ths and higher objectives (× 50).
10. Remarks, including references to good figures and descriptions.	10. See for figures and descriptions Quain's Anatomy, vol. ii. p. 141, and Ranvier, 'Traité d'Histologie,' p. 723.

Formula for Labelling Microscopical Preparations:—	Label written according to the Formula:—
1. The number and date of the preparation (No. 2 of catalogue).	1. No. 96; 1880.
2. The general name (No. 1 of catalogue).	2. Nerve-fibres.
3. The name of the object from which the preparation is derived.	3. Cat.

A very practical question arises immediately whether this catalogue shall be kept in a manuscript book or in some other form. The card form of catalogue, like that employed by Prof. Wilder for anatomical and zoological specimens, has been adopted and used during

the last five years. It has proved very satisfactory and convenient. The cards are postal card size, and each preparation has its own card. Such a catalogue has the advantage that it may be arranged alphabetically. As new preparations are made new cards may be added in their proper alphabetical order, while the cards of destroyed or discarded preparations may be removed without in any way marring the catalogue. Finally, the cards may be kept in a neat box which occupies but little more space than a manuscript book, and may be as readily carried from place to place. The ease and certainty with which the history of any preparation may be found is so evident that it hardly needs to be mentioned.

Cabinet.—A microscopical cabinet should possess the following characters:—

1. It should allow the slides to lie flat, and exclude them from dust and light.

2. Each slide should be in a separate compartment. At each end of this compartment should be a groove or bevel, so that upon depressing either end of the slide the other rises sufficiently to be easily grasped. It is also desirable to have the floor of the compartment under the object grooved, so that the slide opposite the preparation will not rest on the wood, and thus become soiled.

3. Each compartment should be numbered, and into each should be put only the slide bearing the corresponding number.

4. The drawers of the cabinet should be independent, but so close together that the slide cannot get out when the cabinet is tipped. On the outside or front of each drawer should be the number of the drawer in roman numerals, and the number of the first and last compartment in the drawer in arabic numerals."

In conclusion, it seemed to the author, both from theory and from practice, that a collection of microscopical objects, catalogued, labelled, and stored as described above, would be at its maximum value, from the ease and certainty of finding objects, while the fulness of the information concerning them would make them guides as well as models for students, and a storehouse of knowledge for the teacher and the investigator.

In the discussion which ensued, the method suggested by Prof. Gage was considered too elaborate for any but a large laboratory. In the matter of personal collections of the preparations which are generally small, "the opinion prevailed that each microscopist should be allowed to indulge his whims and have them arranged to suit his tastes."

Mr. I. C. Thompson also, in an article on the Classification and Labelling of Objects, writes * that with very few exceptions the labels of slides are almost devoid of any further information than the bare scientific or unscientific name of the object, and that often conveyed in so vague a manner as to be hardly intelligible. Slides, as ordinarily labelled, will not admit the insertion of much matter on the label, as the width must necessarily be something less than one inch; but if two labels are affixed, and placed horizontally on the slide instead of

* Sci.-Gossip, 1883, p. 251.

vertically, each can, as a rule, be a full inch or more in width, and may be arranged to contain a vast amount of information, and that of great importance. By horizontal labelling, too, the name of the object can be readily seen while upon the stage of the Microscope; a consummation usually accompanied with considerable chance of neck dislocation, should the slide be labelled in the orthodox manner.

As an experiment for his own cabinet, he recently designed some labels of this description, and has found them to answer very satisfactorily.

The kingdom, whether animal, vegetable, or mineral, heads the top of the left-hand label in bold letters, the labels for animal kingdom being further immediately distinguished by red type, the vegetable by green, and the inorganic by black type. Below the heading, follow in consecutive lines the sub-kingdom, class, order, family, genus and species, a blank line being left for the English or conventional name.

The corresponding label on the right hand gives desirable information respecting the mode of mounting and of viewing the object, naming the part mounted, the medium in which it is mounted, the name of mounter, date, and power required, and other details, concluding with the name of owner, as a corresponding finish to the "kingdom" on the other label.

The amount of information thus conveyed is most valuable, and though necessitating some expenditure of time and research, on the part of the beginner at any rate, the knowledge recorded is stored up, not only in the mind, but upon the slide. As an example, from the animal kingdom, we have, say, a slide of the wood ant.

ANIMAL KINGDOM.		
SubKingd^{m}., *Arthropoda* Class, *Insecta* Order, *Hymenoptera* Family, *Formicidæ* Genus, *Formica* Species, *F. rufa* *WOOD ANT.*		Part, *Entire Insect* Medium, *Balsam* (*dark ground illum.*) Mounter, *F. Enock* Date, 5/83. O.G., 2 *in.* I. C. THOMPSON, LIVERPOOL.

Another from the vegetable kingdom, a section of the female flowers of the yew.

VEGETABLE KINGDOM.		
SubKingd^{m}., *Phanerogamia* Class, *Gymnospermia* Order, *Coniferæ* Family, *Taxineæ* Genus, *Taxus* Species, *T. baccata* *YEW.*		Part, *Female Flowers* *long. sect. stained* Medium, *Glyc. Jelly* (*see Sachs, fig.* 388) Mounter, *C. V. Smith* Date, 9/82. O.G., ¼ *to* 1 *in.* I. C. THOMPSON, LIVERPOOL.

It is a decided advantage to have the labels printed in sheets, with (say) eight or a dozen pairs of labels on each, as being more easy

to write upon than if already cut up, and having a definite space between each the sheet is readily cut up, no trimming being required.

The use of square pieces of card of varying thickness, placed under the labels, forms a valuable protection to the object mounted between, further allowing of the slides being packed together side by side, thus obviating the necessity of rackwork during transit.

Examining Sponges.*—H. J. Carter considers that the "quickest way to examine a sponge is to soak a microscopic fragment of it in distilled water for from twelve to twenty-four hours; then tear it to pieces on a slide, drain, dry, and mount with balsam as usual; but to be *certain* of the exact form of its spicules requires that they should be boiled out with nitric acid, which may also be easily and quickly effected by placing the microscopic fragment on the centre of a glass slide and covering it with a drop or two of nitric acid, then boiling this over a spirit-lamp with low flame till it is nearly dry, after which the same process must be repeated twice or thrice; and, finally, before the last drop of nitric acid is entirely dried up, removing the slide to the table, when, through gradually increased inclination and sufficient but careful edulcoration with distilled water, the residuum may be freed from all remaining acid, drained, dried, and mounted in balsam; or, if desired, another microscopic fragment, prepared as first mentioned, may be added to it previously, when the perfect form of the spicules respectively, together with their position *in situ*, may be seen at once in the same preparation."

Exhibiting Volvox and Amœba.†—Part of Mr. J. Levick's Presidential Address to the Birmingham Natural History and Microscopical Society is occupied with the methods of "displaying" microscopic life, more especially *Volvox globator* and *Amœba*, which he describes as follows:—

"I directed my first attention to what may be called massing or crowding them together, getting them out of dirty into clean water, freeing them from other things which it was undesirable to show at the same time, and several methods succeeded very well.

Let us suppose that we have a jar with a good gathering of *Volvox*, and we wish to get them so thickly together that the whole field of the Microscope may be filled with them, nothing being more beautiful as an object of display. The most natural way to attain this is by filtering them out, and for this purpose I have made some small metallic sieves, the mesh of which is not more than 1-100th of an inch in breadth, such as the one I now have before me. This I place in a small shallow vessel, pouring the water not through, but outside the sieve, and then by means of a small syringe withdraw the water through this fine gauze, continuing the process until I get the *Volvox* at the bottom of the earthenware vessel as thickly together as I like. They may then be picked up by means of the syringe, and placed in any quantity or density upon a slide or compressor, care being taken

* Ann. and Mag. Nat. Hist., xii. (1883) p. 317.

† Report and Trans. Birmingham Nat. Hist. and Micr. Soc. for 1882, pp. xvii.-xxiii.

in showing them to allow only just sufficient depth between the top and bottom glasses to allow them to revolve freely through the water. The same result I have obtained by taking advantage of the effects of heat and cold upon these organisms. If they are freely distributed about the water in which they are stored, it is only necessary to take some ice and lower the temperature of the water to bring most of them to the bottom; or if they are at the bottom, mixed with dirt, as they often are, then to place the jar near the fire, and so stimulate them, and bring all that are living and fresh to the top, when they may be brought to one side of the vessel by directing upon it a bright light.

It is usually regarded as a difficult matter to see the cilia upon *Volvox* by even those familiar with the use of the Microscope; but these may be made so plain that the most inexperienced person may see them without the least trouble, provided that a strong light, with the *yellow* rays unintercepted, be used, and that sufficient obliquity be obtained by means of a paraboloid or other apparatus, using a compressor with a thin glass top and bottom, and just slightly flattening the largest of the spheres. The 1-2 inch is best, but when they are once seen, and all things are properly arranged, there is no real difficulty in watching their flashings with a 1-inch or even a 2-inch object-glass.

Then take another of those perplexing objects, the *Amœbæ*, which is regarded as not only hard to find, but harder still to see, and let me say that the two difficulties resolve themselves into the latter one only, there being no trouble whatever in obtaining specimens. . . . At first they seem particularly difficult to handle and isolate, being usually found so near the mud, or mixed with it; but a little study of the habits of these organisms shows a ready way to get over that difficulty.

Not being swimmers, though doubtless like the *Hydra* they possess the power to rise or fall in the water, and have besides some slight means of free locomotion, they are usually found to attach themselves to anything with which they may come in contact, generally decayed weeds or mud, and it is only necessary to take advantage of this habit to obtain them quite free from everything else.

Take up some mud and water in which they are plentiful and fill a thin trough; lay it nearly or quite flat upon the stage of the Microscope and allow it to remain there a few moments; then quietly empty out the mud and dirty water at one end while you replace it with clean at the other, and the *Amœbæ* will be found attached to the glass as clear as the noonday sun. Care only needs to be taken that the clean water shall replace the dirty without exposing the animals to the air, or they will fall to pieces in countless granules, an experiment worth noting."

Aramburu, F.—Examen Microscopico del Trigo y de la Harina. (Microscopical examination of Wheat and Flour.) 156 pp. and 50 figs., Madrid, 1883.

Aylward's (H. P.) Apparatus for Pond-Life Hunting. [*Supra*, p. 911.]
Journ. Post. Micr. Soc., II. (1883) p. 255.

Bennett, R. A. R.—Mounting Pollen.
[If small and transparent—dry. If opaque, in essential oil of lemon or glycerine.]
Engl. Mech., XXXVIII. (1883) p. 200.

Bergen, J. Y., jun.—Cleaning Diatoms. [*Supra*, p. 922.]
Amer. Mon. Micr. Journ., IV. (1883) p. 198.

Bernheimer, S. See Bizzozero, G.

Bizzozero, G.—Handbuch der Klinischen Mikroskopie. (Handbook of Clinical Microscopy.) Translated into German by Dr. A. Lustig and S. Bernheimer, with a Preface by Dr. H. Nothnagel. 44 figs. and 7 plates. 8vo, Erlangen, 1883.

Blackburn, W.—The Mounting of Pollen as an Opaque Object. [*Post.*]
Micr. News, III. (1883) pp. 297–9.

Braithwaite, R.—The Structure of Mosses.
[Report of "Demonstration." For permanent mounting glycerine jelly is preferable. Rimmington's is very pure and well made. "Immerse the moss in clean water, exactly as it is desired to mount it, quickly transfer to a clean slip, on which is dropped a little jelly sufficiently heated to melt it; place on the cover, and there will be no difficulty in making a good mount, which can be finished off with rings of gold size, and kept as long as desired."]
Journ. Quek. Micr. Club, I. (1883) pp. 290–6.

Calderon y Arana.—Nota sobre la extraccion y coleccion de las conchas microscopicas de moluscos y foraminiferos. (Note on the extraction and collection of the microscopic shells of Mollusca and Foraminifera.)
An. Soc. Esp. Hist. Nat., XII. (1883) *Actas*, p. 37.

Carter, H. J.—Contributions to our Knowledge of the Spongida.
[Contains a note on the quickest way to examine a sponge. *Supra*, p. 928.]
Ann. & Mag. Nat. Hist., XII. (1883) p. 317.

Cole, A. C.—Popular Microscopical Studies. No. 2. pp. 7–10. The Scalp. Plate of Human Scalp. Hor. Sec. × 130. Double stained.
" " Studies in Microscopical Science.
Vol. II. Nos. 3A and 5. Sec. I. Animal Histology. Chap. I. The Morphology of the Cell (*concld.*). The Blood—Blood of Frog. pp. 5–12 (pls. 1 and 2 × 75, pl. 3 × 400).
Nos. 4 and 6. Sec. II. Nos. 2 and 3. Botanical Histology. Chap. I. The Morphology of the Cell (*contd.*), pp. 5–8, 9–12. Plate I. *Frittilaria imperialis*, L.S. of scale leaf × 210. Plate 2. *Pinus sylvestris*, T.S. of stem × 30. Plate 3. *Arachnoidiscus Ehrenbergii* (recent) × 400.
" " The Methods of Microscopical Research.
Part 3. The Human Eye. pp. vii.–xvi., 10 figs. and 1 pl.
Part 4. The preparation of Animal Tissues. pp. xvii.–xxiv.

Davis, G. E.—Water, Water Analysis, and the Microscope. [*Post.*]
Micr. News, III. (1883) pp. 283–8, 309–13 (7 figs.).

Dimmock G.—The Scales of Coleoptera. [*Supra*, p. 920.]
Psyche, IV. (1883) p. 71.

Dippel, L.—Ein neues Einschlussmittel für Diatomeenpräparate. (A new mounting medium for preparations of Diatoms.)
[Abstract of Dr. H. van Heurck's paper, *ante* p. 741, with notes in commendation of Styrax.]
Bot. Centralbl., XVI. (1883) pp. 158–9.

Flögel, J. H. L.—Serienpraeparate. (Series Preparations.) [*Supra*, p. 919.]
Zool. Anzeig., VI. (1883) p. 565.

G., F.—Microscope Mounting.
[Elementary instruction on (1) Slips and micro-covers, (2) Ringing, and (3) Finishing, varnishing, labelling, and cataloguing.]
Engl. Mech., XXXVIII. (1883) pp. 194–5.

GRANT, F.—How to Mount for the Microscope. II. Preliminary examination of objects.

[Deals with crystals, with note on the different crystalline forms assumed by the same body, and directions for showing this.]

Engl. Mech., XXXVIII. (1883) pp. 222–3.

,, ,, Microscopic Mounting. III. Resinous and Air Mounting.

[1. Appliances for all mounting. 2. Materials for resinous mounting. 3. Process of resinous mounting.]

Engl. Mech., XXXVIII. (1883) pp. 243–5.

HARRIS, V., and D'ARCY POWER.—Manual for the Physiological Laboratory. 2nd Ed. viii. and 214 pp. 43 figs. 8vo, London, 1882.

HITCHCOCK, R.—Microscopical Evidence concerning Blood Corpuscles.

[Comments on evidence given at a recent trial that certain spots found upon a coat were produced by human blood. "Granting the strong probability that the Microscope does under favourable circumstances afford a means of positively identifying human blood and distinguishing it from all other blood, we must still hold to the opinion that until experience has shown such evidence to be sure and infallible, no scientific man is warranted in stating that a stain upon cloth is made by human blood from the microscopical examination alone."]

Amer. Mon. Micr. Journ., IV. (1883) pp. 175–6.

HOLMES, C. D.—Mounting Insect Organs, &c.

[Soak in liq. pot. for a day, or longer, if large. Wash and lay out upon the slip, arrange, and gently press while in the water with another slip. Remove to weak solution of acetic acid for a few hours. Wash again in clean water, and transfer to slip, and drop on spirits of wine; arrange the object and put over another clean slip; gently press and lightly fasten with thread; place end down in a small quantity of spirits of wine for a few hours. Then remove the thread and gently lift off one slip, the whole still wet with the spirit, when the object will adhere to one of the slips; drop on absolute alcohol and work object into centre of slide. Then apply oil of cloves, and in a few hours the object will be ready for the balsam to finish.]

Sci.-Gossip, 1883, p. 232.

HORN'S (J.) method of mounting very minute animals, such as embryonic fishes, in a medium which makes them transparent and causes but very little contraction of the internal parts.

[Composition of medium unknown.]

Amer. Mon. Micr. Journ., IV. (1883) p. 178.

JOHNSTON, C.—Ethyl-Æther of Gallic Acid and a New Mounting Material.

[Media for making solutions out of which the substance should crystallize —glacial acetic acid added to absolute alcohol in the proportion of from 5–20 per cent.: to this was added the ethyl-æther of gallic acid in same proportion dissolved in a test-tube. Media for mounting—boiled balsam copaiba, thickened to the consistency of molasses by best dammar resin.]

Amer. Mon. Micr. Journ., IV. (1883) pp. 192–4.

KOCH.—Testing Air, Water, and Earth for Impurities.

Micr. News, III. (1883) pp. 319–20, from *Lancet*, from *Proceedings of Berlin Medical Congress.*

LOVETT'S (E.) Embryological Slides. [Commendation of them.]

Amer. Mon. Micr. Journ., IV. (1883) p. 197.

LUSTIG, A. See Bizzozero, G.

MACDONALD, J. D.—A Guide to the Microscopical Examination of Drinking-water, with an Appendix on the Microscopical Examination of Air. [*Post.*] 2nd ed. xi. and 83 pp., 25 pls. 8vo, London, 1883.

MARKEL, J. F.—The Microscope in the Diagnosis of Diseases of the Kidneys.

The Microscope, III. (1883) pp. 163–7.

MERRILL (G. P.) has prepared 1550 microscopic slides of building-stones to be used in connection with the investigations of Dr. G. W. Hawes on the building-stones of the United States.

Ann. Rep. Smithsonian Institution for 1881, p. 110.

Nothnagel, H. See Bizzozero, G.
Nunn, R. J.—The Microscope in Medical Gynecology.
Sep. repr. from *Trans. Med. Assoc. Georgia*, 1883, pp. 8–10.
Power, D'Arcy. See Harris, V.
Quinn's (E. P.) Microscopical Labels. *Micr. News*, III. (1883) pp. 294 and 323.
Robinson, I.—Notes on a Microscopical Aquarium.
[Describes the Rotifers, Infusoria, &c., found in a bell-glass aquarium 10 in. × 10 in., kept on a hall-table.]
Trans. Hert. Nat. Hist. Soc., II. (1883) pp. 112–4.
Ryder, J. A.—On Semper's Method of making Dry Preparations.
[Vol. I. (1881) p. 706, with remarks.]
Proc. U.S. Nat. Mus., IV. (1881–2) pp. 224–5.
Slack, H. J.—Pleasant Hours with the Microscope.
[Mouth-organs of Wasps and Bees—Tubular Live-box, *supra*, p. 906.]
Knowledge, IV. (1883) pp. 216–7 (3 figs.), 242–3, 267–8 (3 figs.).
Thompson, I. C.—On the Classification and Labelling of Microscopical Objects.
[*Supra*, p. 926.]
Sci.-Gossip, 1883, pp. 249–51. Cf. also *Micr. News*, III. (1883) p. 323.
Whitman, C. O.—Treatment of Pelagic Fish Eggs. [*Supra*, p. 912.]
Amer. Natural., XVII. (1883) 1204–5.

OBITUARY.

No Obituary Notices have been received of Fellows deceased in 1882.

APPENDIX.

The publication of the Appendix referred to at p. 272 of Vol. II. (1882) is unavoidably postponed to the next volume for the sake of greater completeness.

PROCEEDINGS OF THE SOCIETY.

Meeting of 10th October, 1883, at King's College, Strand, W.C., The President (Professor P. Martin Duncan, F.R.S.) in the Chair.

The Minutes of the meeting of 13th June last were read and confirmed, and were signed by the President.

The List of Donations (exclusive of exchanges and reprints) received since the last meeting was submitted, and the thanks of the Society given to the donors.

	From
Braithwaite, R.—The British Moss Flora, Part 7. pp. 147–178, 6 pls. 8vo, London, 1883	*The Author.*
Gibbes, H.—Practical Histology and Pathology. 2nd ed., viii. and 154 pp. 8vo, London, 1883	*The Publishers.*
Penhallow, D. P.—Tables for the use of Students and Beginners in Vegetable Histology. 39 pp. 8vo, Boston, 1882 ..	*Mr. Crisp.*
Rogers, Prof. W. A.—The Micrometer described, *ante*, p. 619	*Prof. Rogers.*

Dr. G. M. Sternberg's "Photo-micrographs, and how to make them" (*ante*, p. 720), was handed to the President by Dr. Maddox, who said he wished to call special attention to it as showing a very great advance upon anything of the kind which had yet been produced. Some of the illustrations, such as Plate XII.—Möller's Typen-platte—were really marvellous specimens of the perfection to which the art had been carried.

Mr. Crisp said that Plate XVI. of *Navicula lyra* was also an admirable example, and did the greatest credit to Dr. Sternberg.

Mr. Crisp exhibited (1) Swift's Radial Microscope (*ante*, p. 704); (2) Mirand's Revolver Microscope (*supra*, p. 897); (3) Pelletan's Continental Microscope (*supra*, p. 899); (4) Fol's Compressor (*supra*, p. 905); and (5) Möller's Typen-platte with 400 Diatoms, having the name of each photographed beneath it.

Mr. Curties exhibited a simple dissecting Microscope of unknown American origin (belonging to the Rev. O. P. Cambridge), which was made exceptionally portable, and was much commended by Mr. Crouch and other opticians present.

Dr. H. Schröder's paper "On a New Camera Lucida" (*supra*, p. 813), was explained by Mr. J. Mayall, jun., and the instrument exhibited and its construction elucidated by drawings on the black-

board. Mr. Mayall exhibited the camera lucida in operation after the meeting, and it was generally acknowledged to be a marked improvement upon other forms of camera lucida hitherto made.

Mr. R. Brown, jun.'s, description of his Slide-box was read (*ante*, p. 923).

Mr. Crisp called attention to the programme of the twelfth Annual Conversazione of the Chester Society of Natural Science as being admirably arranged.

The President read the following letter from the Secretary of the American Society of Microscopists, and the President was requested to convey the thanks of the Society for the compliment.

BUFFALO, N.Y., *Sept.* 19*th*, 1883.

MY DEAR SIR,—It is my pleasure to inform you that at the late Annual Meeting of the American Society of Microscopists, a resolution offered by Dr. Geo. E. Blackham was adopted as follows: Resolved,—That the American Society of Microscopists recognizes and reciprocates the kindly fraternal feeling shown by the Royal Microscopical Society in making our President an *ex-officio* Fellow; and that as a further evidence of appreciation and reciprocal feeling we hereby elect the President of the Royal Microscopical Society and his successors *ex-officio* Honorary Members of this Society.

Yours respectfully,
D. S. KELLICOTT,
Secretary, American Society of Microscopists.

Prof. P. MARTIN DUNCAN,
President of the Royal Microscopical Society,
London, England.

Mr. Crisp said that Dr. Blackham's resolution, according to the 'Chicago Times' of the 9th August, was prefaced as follows: "In view of the fact that the Royal Microscopical Society of London has seen fit to honour this Society by making its President a Fellow of that Society, it seems fitting that there should be some formal recognition on our part of the honour thus conferred by the oldest and most distinguished national Microscopical Society upon the youngest. I therefore move, &c."

Mr. Crisp reported the decision of the Committee of the American Society of Microscopists on Standard Eye-pieces (*ante*, p. 711). He said that he was afraid that the Committee had been somewhat misled upon a point of optical theory by the Table of Magnifying Powers published in the Journal. This Table had now been withdrawn, and he had prepared a paper, which there was not time to read at this meeting, explaining the source of the error.

Mr. Squire's paper "On a Method of Preserving the Fresh-water Medusa" was taken as read, having been received during the vacation and printed in the Journal (*ante*, p. 485). Specimens of Medusæ preserved in the manner described in the paper were now exhibited.

Dr. Hudson's paper "On *Asplanchna Ebbesbornii*" (*ante*, p. 621), was for a similar reason taken as read, Mr. Crisp recalling the fact of the 'Times' having placed the letter of the enthusiastic discoverer under the leading articles and headed it "An Important Discovery."

Mr. E. Lovett read his paper "On an Improved Method of Preparing Embryological and other delicate Organisms for Microscopical Examination" (*supra*, p. 785). A number of mounted objects, as also various stages of preparation, were exhibited in illustration of the paper.

The President considered that this was a most excellent process of mounting, judging from the exceptional clearness of the preparations exhibited, which did not show any sign of leakage whatever. It was also not only a good process, but it was a cheap one, and he had no doubt that many would be only too glad to copy it.

Mr. Stewart said he thoroughly agreed with the remarks of the President as to the beauty of the slides which Mr. Lovett had exhibited. He was also satisfied as to their being proof against leakage, but he thought that it might in some instances be found useful to combine the ground-out slide with the cell, because where a plain slide was used, the object was apt to get out of the way when placed upon an inclined stage, whereas if the bottom of the cell was hollowed out instead of being flat, this movement of the object towards the side was often prevented. He should, however, like to ask if any special change had been noticed in any of the objects mounted in this fluid, such as might be due to decalcification.

Mr. Hitchcock said he had been much interested in the paper before them, and having previously seen and examined the preparations, he was able to speak to their excellence. The cement which had been described was certainly very strong. He had been using a very good cement himself for the purpose, though it was not so strong as that which had been described. It was composed simply of common shellac dissolved in alcohol, and though he knew some persons did not like it, he had found it to be most serviceable. After a time it was liable to get rather brittle, but if a mixture of asphalt and gold size in equal parts was applied, it preserved the cement, and at the same time made an excellent finish. He had found this formula very useful in preserving small specimens kept in bottles. He had also been very much pleased with the preparations of fresh-water Medusæ exhibited in illustration of Mr. Squire's paper, as there could be no doubt that one great desideratum for microscopists was some method of preserving those delicate and fragile organisms by which they could be kept in bottles as well as in slides. In preserving this kind of object at first glycerine seemed to be objectionable, because of its tendency to produce a kind of granular effect, but the alcohol appeared to harden the specimens. He should like to know if this fluid had any effect whatever on the calcareous portions of such objects, and whether the alcohol had any kind of solvent effect upon them?

Mr. Michael said he had been in the habit of using practically the same fluid for some years, and could say from experience that it was a most excellent preservative fluid, and also a very good mounting fluid when used of various strengths, according to the requirements of the objects to be mounted. If the glycerine was present in any great quantity it certainly had a decalcifying effect, and he should hesitate to use it for some objects. As to the cell material, he had occasionally used a similar cement, and though he had not used it largely he had found it very good so far.

Dr. Matthews said that in finishing cells a very good preventive against the oozing out of the fluid was a small strip of the thinnest tinfoil, painted on one side with gold size, and whilst still "tacky," applied over the junction between the cell and the cover. When this was smoothed down—and it could be done so effectually that it could scarcely be felt afterwards—the result was a perfectly tight connection which could not possibly leak. He might also mention a manner of filling cells with fluid without the possibility of getting any air bubbles inside. It was to have a small trough or cell large enough to allow an ordinary slide to be placed inside it with the cell attached in the usual way, the fluid was then poured into this trough until it filled up to a point a little higher than the top of the cell on the slide. If the object was then placed in the cell and the cover put on, there was no chance whatever of a bubble being included.

Mr. Lovett said he had now an experience of three or four years, but had not found any change of form to take place in the objects where proper precautions had been taken in mounting. If very dense fluid was used, it would of course be prejudicial to some objects; but if prepared in dense fluid and mounted in light, there would be no difficulty. It was important to have the materials good in quality and properly mixed; the best way was to get them prepared by a good chemist, and it was then very easy to mix them with the gold size. As regarded shellac, he thought it would not do at all for anything containing alcohol. The solution he had recommended would have an effect on calcareous objects if it was too strong; but in the weak form he had mentioned, it would be found to have no disadvantage. He had found bubbles in some cells which had been securely fastened down, but he was inclined to regard them as vacuum bubbles, because if they had been air bubbles some of the fluid must necessarily have got out to let the air get in. This cement was so perfectly proof against the action of alcohol, that he had used it successfully to stop the leaking of some spirit casks. When an air bubble was caused by the cover being pressed down on the cell so much as to let some of the fluid get out, it could be got rid of by pressing it out at the place where the fluid had leaked and letting the fluid run back again when the pressure was removed, and where there had been any leakage the cement would stop it at once.

The following Instruments, Objects, &c., were exhibited:—

Mr. R. Brown, jun.:—Slide-box.

Mr. Crisp:—(1) Swift's Radial Microscope. (2) Mirand's Revolver Microscope. (3) Pelletan's Continental Microscope. (4) Fol's Compressor. (5) Möller's Typen-Platte with 400 Diatoms, having the name of each photographed beneath it. (6) Fresh-water Medusæ preserved by Mr. Squire's process.

Mr. Curties:—American Portable Dissecting Microscope.

Mr. Lovett:—Slides of *Cottus quadricornis* (one day old). Ova of *Doris tuberculata*, young Diadem Spiders, various Crustacea, young of *Asteria gibbosa*, Leaf of *Drosera rotundifolia* with Insect, and *Bryum hornum* mounted by the process described in his paper.

Mr. J. Mayall, jun.:—Schröder's New Camera Lucida.

New Fellows:—The following were elected *Ordinary* Fellows:—Messrs. Charles S. Fellows, S. A. Forbes, Charles G. Fuller, M.D., Frederick Mercer, M.D., J. B. Morgan, and Charles H. Stowell, M.D.; and as *Honorary* Fellow, Dr. H. Van Heurck, of Antwerp.

Meeting of 14th November, 1883, at King's College, Strand, W.C., The President (Prof. P. Martin Duncan, F.R.S.) in the Chair.

The Minutes of the meeting of 10th October last were read and confirmed, and were signed by the President.

The List of Donations (exclusive of exchanges and reprints) received since the last meeting was submitted, and the thanks of the Society given to the donors.

	From
Badcock, J.—Vignettes from Invisible Life. (8vo, London, 1883)	*The Author.*
Bastian, H. C.—The Beginnings of Life; being some account of the nature, modes of origin, and transformations of lower organisms. 2 vols. (8vo, London, 1872)	*Mr. Crisp.*
Sternberg, G. M.—Photo-micrographs and how to make them. 204 pp. and 47 Photo-micrographs (heliotype). (8vo, Boston, 1883)	*The Author.*
Transactions of the Brighton Health Congress, 1881, with portraits, maps, and illustrative diagrams. (8vo, Brighton, 1883)	*Mr. J. E. Mayall.*
Cabinet for slides illustrating Cole's Studies in Microscopical Science	*Mr. A. C. Cole.*

Mr. C. Beck exhibited "Beck's Pathological Microscope and Condenser" (*supra*, p. 894).

Mr. Crisp exhibited (1) Microscope made by the "Société Genevoise pour la Construction d'Instruments de Physique," and movable table for drawing with the Camera Lucida; (2) Swift and Son's Pocket Microscope (*supra*, p. 896); (3) Harris's Pocket Microscope;

(4) Zeiss's Micrometer Eye-piece; (5) Millar's Multiple Stage-plate; (6) Bausch and Lomb Optical Co.'s Compressors (*ante*, p. 714); (7) Valentin's Hot Stage.

Mr. Curties exhibited Aylward's Collecting Apparatus (*supra*, p. 911).

Mr. Stewart exhibited his simple Safety-stage.

Dr. Anthony said he had for the last thirty years, in the course of his microscopical observations, attained the same result by simply having the stage of the instrument made narrower than usual, so that the slide slightly projected beyond the edge. When a high power was used all that was necessary was to tilt the slide with the finger, and it could be at once felt or heard when the objective came in contact with it whilst focusing down. Ross had somewhat improved upon this plan by having a very thin plate made, by means of which the slide could be raised in a similar manner.

The President said there was no doubt that in exhibiting objects to a class of medical students something of this kind was very necessary, and as they were not particularly careful or experienced, the plan of tilting the slides was not of so much use, but he thought the admirable little plan described by Mr. Stewart quite met the difficulty. For his own part, he could say that he had some slides which he had never ventured to show, because of the danger of getting them broken in this way.

Dr. Matthews said he had much felt the want of something of this kind, for it was only during the previous week that he had demolished a slide in that way, and this not from any particular carelessness on his part, but from inadvertence, the Microscope being shaded and the lamp turned down, so that he was almost in the dark at the time.

Mr. J. Mayall, jun., said that his objection to the use of safety-stages was based on the fact that they were for the most part only of any value when high powers were used, and as with high powers a condenser was generally necessary, it frequently happened that when the condenser was racked up and the objective down, the safety-stage was squeezed between them. Mr. Stewart's device seemed to be a very simple and efficient form, but he imagined it was only intended for use by those who were not much accustomed to high powers.

Mr. Stewart said it was intended entirely for rough purposes when exhibiting slides to students and others who were not very careful in such matters.

Mr. Crisp said it was not unusual to hear derision of these safety-stages, but it came from Fellows who were all experienced workers, and to whom any such contrivance was superfluous.

Dr. Coffin said that he had employed a similar contrivance for some time, but it was simply made of a piece of brass wire bent into a fork somewhat wider than the slide, the two ends of which were bent back again, and across which the two indiarubber bands were stretched.

Mr. Watson's Nose-piece Adapter, and that of Dr. Matthews (*supra*, pp. 903–4), were exhibited by Mr. Crisp.

Dr. Matthews, in reply to a question as to the firmness with which his adapter would hold an objective, said that as a proof of how firmly this kind of connection would grip, he might say that a 1-inch bolt could be screwed in a lathe at one operation in a chuck which was only fitted to the head-stock by a coned joint.

Mr. Ingpen thought that in the case of the lathe-chuck the screw pressed strongly against it during the operation, and that this pressure of course increased the cohesion of the surfaces, but in the case of an objective there would not only be no such pressure, but the weight would act the other way.

Dr. Anthony inquired if any provision was made as regarded the centering of the objective, supposing that it was interfered with by this mode of connection.

Dr. Matthews said that all objectives were open to the difficulty of centering, because each had its own centre, and no two of them were alike. To get accuracy they must be fitted to the instrument on which they were to be used. Those which were coned were no worse in this respect than others, possibly they were better.

Professor Abbe's Analyser was explained by Mr. J. Mayall, jun., by means of a black-board diagram.

Mr. J. Mayall, jun., exhibited and described a pocket-lens on a new formula by Dr. Schröder.

Mr. Ingpen asked if the lens was considered to be superior to those of Steinheil.

Mr. Mayall said he had recently the opportunity of comparing the two, and thought the new one was greatly superior, both as regarded length of working distance and more perfect achromatism. It was so well made that he found it worked well when used as an eye-piece.

Mr. C. Beck remarked that the working distance of the new lens was nearly an inch.

Mr. Crisp read a paper "On Optical Tube-length, an Unconsidered Element in the Theory of the Microscope" (*supra*, p. 816).

Dr. Anthony said that the important point to ascertain in future was the value of Δ, or the "optical tube-length," and he thought this was a matter which might be easily got at.

The President said it followed from the paper that in consequence of the variation in the optical tube-length they could not formulate any correct table of focal lengths.

Professor Abbe's paper "On the Relation of Aperture to Power," Part III., was read by Mr. Crisp (*supra*, p. 790).

Mr. Mayall wished to call attention to one or two practical points which had not been touched upon. With regard to the statement that

they could not use eye-piece power higher than 6 or 8, he thought they would hardly be able to agree with it from a practical point of view. In examining double stars for instance, it was well known that when an ordinary deep eye-piece failed to resolve the object, a deeper one would reveal the double star to perfection. So also with the Microscope; it was a fact that with a deep eye-piece they could often make lines visible which could not be seen with one of less depth, and he had found that with a certain eye-piece of double the C power he could see lines on Nobert's plate which were otherwise entirely invisible. He thought this was a matter in regard to which, in the face of practical experiences, mathematicians would have to step on one side. He saw that Dr. Schröder proposed to make an eye-piece of 1-4th inch focus, and he was quite sure that Dr. Schröder had it in his mind to make something that should be of some service. Therefore he could only say that he thought Professor Abbe had placed his powers at too low a figure.

Dr. Anthony said he could emphatically endorse the remarks which had been made. Every microscopist knew by experience which of his battery of eye-pieces suited his purpose the best, according as he wanted to see the relative position of the parts of a structure, and if he wished to see through several planes he would go on using his eye-pieces until his objective "broke down"; but if they had an objective which would bear the deeper eye-pieces, C, D, and so on, they knew that they were able to get a great power of separation, and then found that there were thousands of lines which could not be appreciated before because they were not grasped by the eye-piece.

Mr. J. Deby's paper "On the Mineral Cyprusite" was taken as read.

The following Instruments, Objects, &c., were exhibited:—

Mr. Beck:—Pathological Microscope and Condenser.

Mr. Curties:—Aylward's Collecting Apparatus.

Mr. Crisp:—(1) Geneva Society's Microscope, and movable Table for drawing with the Camera Lucida. (2) Harris's Pocket Microscope. (3) Swift's Pocket Microscope. (4) Millar's Multiple Stage-plate. (5) Matthews' and Watson's Adapters for Objectives. (6) Bausch and Lomb Optical Co.'s Compressors. (7) Abbe's Analyser. (8) Valentin's Hot Stage. (9) Zeiss's Micrometer Eye-piece.

Mr. J. Mayall, jun.:—Schröder's Pocket-lens.

Mr. Stewart:—Safety Stage.

New Fellows:—The following were elected *Ordinary* Fellows:—Messrs. Benjamin Braman, William Haynes, James Hulme, Edward D. Marriott, W. T. Moffat, Henry G. Plimmer, M.R.C.S., and John T. Thompson.

WALTER W. REEVES,
Assist.-Secretary.

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*** The Index includes the names of the Authors of all Papers, &c., printed in the "Transactions," or noted in the "Summary" or Bibliography, as well as those of the Designers of any Instruments or Apparatus described under the head of "Microscopy."

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THE
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The Society was established for the communication and discussion of observations and discoveries (1) tending to improvements in the construction and mode of application of the Microscope, or (2) relating to Biological or other subjects of Microscopical Research.

It consists of Ordinary, Honorary, and Ex-officio Fellows.

Ordinary Fellows are elected on a Certificate of Recommendation signed by three Fellows, stating the names, residence, description, &c., of the Candidate, of whom one of the proposers must have personal knowledge. The Certificate is read at a Monthly Meeting, and the Candidate balloted for at the succeeding Meeting.

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The Council, in whom the management of the affairs of the Society is vested, is elected annually, and is composed of the President, four Vice-Presidents, Treasurer, two Secretaries, and twelve other Fellows.

The Meetings are held on the second Wednesday in each month, from October to June, in the Society's Library at King's College, Strand, W.C. (commencing at 8 P.M.). Visitors are admitted by the introduction of Fellows.

In each Session two additional evenings are devoted to the exhibition of Instruments, Apparatus, and Objects of novelty or interest relating to the Microscope or the subjects of Microscopical Research.

The Journal, containing the Transactions and Proceedings of the Society, with a Summary of Current Researches relating to Zoology and Botany (principally Invertebrata and Cryptogamia), Microscopy, &c., is published bi-monthly, and is forwarded *gratis* to all Ordinary and Ex-officio Fellows residing in countries within the Postal Union.

The Library, with the Instruments, Apparatus, and Cabinet of Objects, is open for the use of Fellows on Mondays, Tuesdays, Thursdays, and Fridays, from 11 A.M. to 4 P.M., and on Wednesdays from 7 to 10 P.M. It is closed during August.

Forms of proposal for Fellowship, and any further information, may be obtained by application to the Secretaries, or Assistant-Secretary, at the Library of the Society, King's College, Strand, W.C.

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