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Knowledge.

With which is incorporated Hardwicke's Science Gossip, and the Illustrated Scientific News.

A Monthly Record of Science.

Conducted by Wilfred Mark Webb, F.L.S., and E. S. Grew, M.A.

FEBRUARY, 1915.

CHAPTERS IN SPECTRUM ANALYSIS.

By W. MARSHALL WATTS, D.Sc.

I.—Law and Order in Spectra.

A. Line Spectra.

" First the flaming red
Sprang vivid forth ; the tawny orange next ;
And next delicious yellow, by whose side
Fell the kind beams of all-refreshing green ;
Then the pure blue, that swells autumnal skies,
Ethereal played ; and then, of sadder hue,
Emerged the deepened indigo, as when
The heavy-skirted evening droops with frost ;
While the last gleamings of refracted light
Died in the fainting violet away."

" Science moves but slowly, slowly, creeping on from point to point."

The scientific investigator is a man with an inquisitive mind. He may possess the aesthetic temperament which can appreciate to its fullest extent the beauty of any phenomena he observes, but he is never satisfied until he can understand and explain the cause of the phenomenon he investigates ; and he is only completely happy when he has succeeded in reducing the matter to formulae. Others may be satisfied with the perception of beauty, and may regard the attempt to express the phenomena by mathematical formulae as a sort of profanation. I have known musicians impatient of all attempts to explain harmony or concord or discord, and there are artists capable of painting the rainbow with the colours in the wrong order!

Can there be anything more beautiful than a spectrum (or, at first sight, more uninteresting than a catalogue of the wave-lengths of the lines which make up the spectrum) ? Yet I venture to think that there is, so to speak, more beauty in the law and order revealed by a patient study of a dry catalogue of wave-lengths than that perceived by the mere contemplation of the harmoniously grouped colours of the spectrum visible to the eye.

" The harmonious spheres
Make music, though unheard their pealing
By mortal ears."

Even in the early days of spectrum analysis it was felt that there must be some connection between the vibrations to which the bright lines of a glowing gas are due, and the earlier attempts at tracing this connection were based upon analogy with music. In following up such an analogy we must employ numbers of vibrations instead of wave-lengths. The number of vibrations per second of the red light of incandescent hydrogen is obtained by dividing the velocity of light, 300,000 kilometres per second, by the wave-length, which is 6563 ten millionths of a millimetre for the red $H\alpha$ line. This gives 457·108 million million vibrations per second. To avoid these unwieldy numbers it is preferred to divide the wave-length into one centimetre, or 10^8 ten millionths of a millimetre,* so that we obtain the number of oscillations made while light is travelling one centimetre. This is called the " oscillation-frequency." In the visible portion of the spectrum, λ, the wave-length in tenth-metres, is represented by four figures before the decimal point, and $10^8/\lambda$, or $10^8\lambda^{-1}$ is

* One-ten millionth of a millimetre is called one " tenth-metre."

represented by five figures before the decimal point. For example, the four lines seen in a hydrogen-vacuum tube are given thus :—

	Wave-length.		Oscillation-frequency.
H_α	6563·042	......	15236·84
H_β	4861·49	......	20569·82
H_γ	4340·66	......	23038·0
H_δ	4101·89	......	24379·0

Professor Johnstone Stoney, guided by musical

Table 7.

	Observed. (I.A.)	Calculated from the formula $O.F. = 27419{\cdot}805 - \frac{109679{\cdot}22}{(m+0{\cdot}0_569)^2}$
H_α	6562·793	6562·793
H_β	4861·326	4861·327
H_γ	4340·467	4340·466
H_δ	4101·738	4101·738
H_ϵ	3970·075	3970·075
H_ζ	3889·051	3889·052

analogy, endeavoured to explain the rhythmical arrangement of lines on the theory that they were overtones of a very low fundamental vibration, since $H\alpha$, $H\beta$, and $H\delta$ might be the twentieth, twenty-seventh, and thirty-second harmonics of a fundamental vibration of oscillation-frequency 761·845. But there was no place for $H\gamma$ in this arrangement, and no reason why these harmonics only should be observed; nor does the theory account for the extensive series of lines observed in stellar spectra by Sir William Huggins and others. It is now generally admitted that such theories will not account for the facts.

The first striking success in the attempt to explain these regularities was obtained in 1885 by Professor Balmer, who found that the hydrogen lines were connected in a simple manner with the succession of natural numbers from 3 onwards, the wave-lengths of $H\alpha$, $H\beta$, $H\gamma$, $H\delta$, and so on, being $\frac{9}{5}$, $\frac{4}{3}$, $\frac{25}{21}$, $\frac{9}{8}$, and so on, of the wave-length 3646·1 of a "head" in the violet, to which the lines crowd continually closer and closer. Otherwise expressed, $\lambda = 3646{\cdot}14\,\frac{m^2}{m^2-4}$, where m is put equal to 3, 4, 5, and so on, in succession; or, if we use oscillation-frequencies, $O.F. = 27418{\cdot}75\,(1 - 4/m^2)$. We may obtain an interesting representation of the law which holds in this spectrum by measuring the distance of the lines from the "convergence-frequency" at 27418·75, which we may write C.F. We have $C.F. - O.F. = \frac{4C.F.}{m^2}$; or, if we put $y = \frac{1}{m}$, then $y^2 = \frac{1}{4C.F.}(C.F. - O.F.)$, which is the equation of a parabola.

Figure 27 illustrates this, in which the upper part shows the series of hydrogen lines which have been observed, and the lower shows the parabolic curve which connects the stars, plotted with a scale of $1/m$ along the left margin, and a scale of oscillation-frequencies along the bottom of the diagram. Along the right-hand margin is shown a scale of $1/m^2$; and, when the lines are plotted with this and the bottom scale, it is seen that all the points lie accurately along a straight line.

The formula given above, namely,

$$y^2 = \frac{1}{4C.F.}\,(C.F. - O.F.)$$

may be written

$$\frac{1}{m^2} = \frac{1}{109675}\,(C.F. - O.F.),$$

or

$$O.F. = 27418{\cdot}75 - \frac{109675}{m^2}.$$

The researches of Kayser and Runge, of Rydberg and others, have shown that in most spectra, though the lines may *appear* to be distributed at random, yet in very many cases *series* of lines,

Table 8.

	Observed.			Calculated.
Vacuum-tube.	Chromosphere.			$O.F. = 27418{\cdot}75 - \frac{109675}{m^2}$
Ames.*	Dyson.†	Evershed‡	Mitchell.§	
6563·042		6563·045		6563·07
4861·49		4861·527	4861·90	4861·52
4340·66		4340·634	4341·17	4340·64
4101·85	4101·92	4101·900	4102·00	4101·90
3970·25	3970·21	3970·212	3970·48	3970·24
3889·15	3889·15	3889·15	3889·47	3889·21
3835·6	3835·53	3835·53	3835·69	3835·54
3798·0	3798·06	3798·00	3798·15	3798·05
3770·7	3770·79	3770·73	3770·90	3770·79
3750·25	3750·32	3750·27	3750·41	3750·30
3734·15	3734·52	3734·53	3734·63	3734·52
3721·8	3722·05	3721·98	3722·20	3722·12
3711·9	3712·12	3712·13	3712·20	3712·12
	3704·00	3704·01	3704·03	3704·00
	3697·29	3697·28	3697·35	3697·30
	3691·70	3691·70	3691·78	3691·71
	3687·00	3686·96	3686·97	3686·98
	3682·92	3682·94	3682·96	3682·96
	3679·50	3679·52	3679·48	3679·51
	3676·54	3676·51	3676·48	3676·51
	3673·90	3673·87	3673·96	3673·91
	3671·46	3671·53	3671·45	3671·63
	3669·58	3669·55	3669·60	3669·60
	3667·89	3667·83	3667·91	3667·82
	3666·21	3666·25	3666·23	3666·24
	3664·78	3664·74	3664·80	3664·82
	3663·58	3663·55	3663·56	3663·55
	3662·35	3662·36	3662·37	3662·36
	3661·35	3661·31	3661·42	3661·36
			3660·47	3660·42
			3659·88	3659·86
			3658·80	3658·80
			3658·19	3658·07
			3657·40	3657·41
			3656·80	3656·83

* Ames, *Phil. Mag.*, 1890, XXX, 33.
† Dyson, *Phil. Trans.*, 1906, CCVI, 403.
‡ Evershed, *Phil. Trans.*, 1903, CCI, 457.
§ Mitchell, *Astrophys. Journ.*, 1913, XXXVIII, 407.

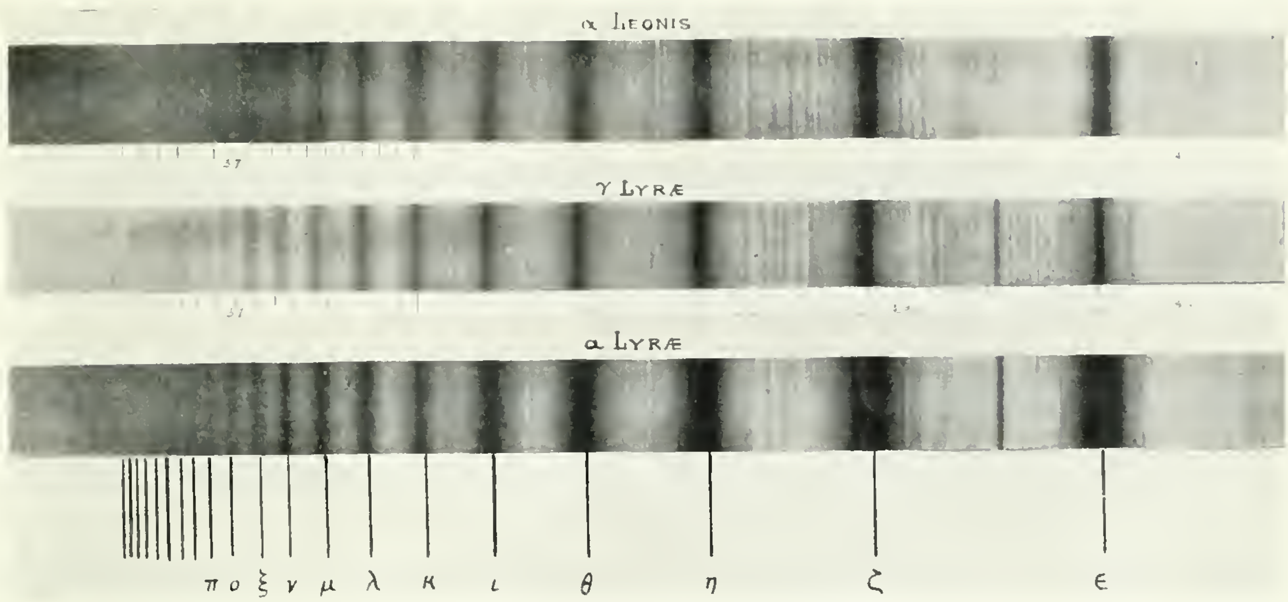
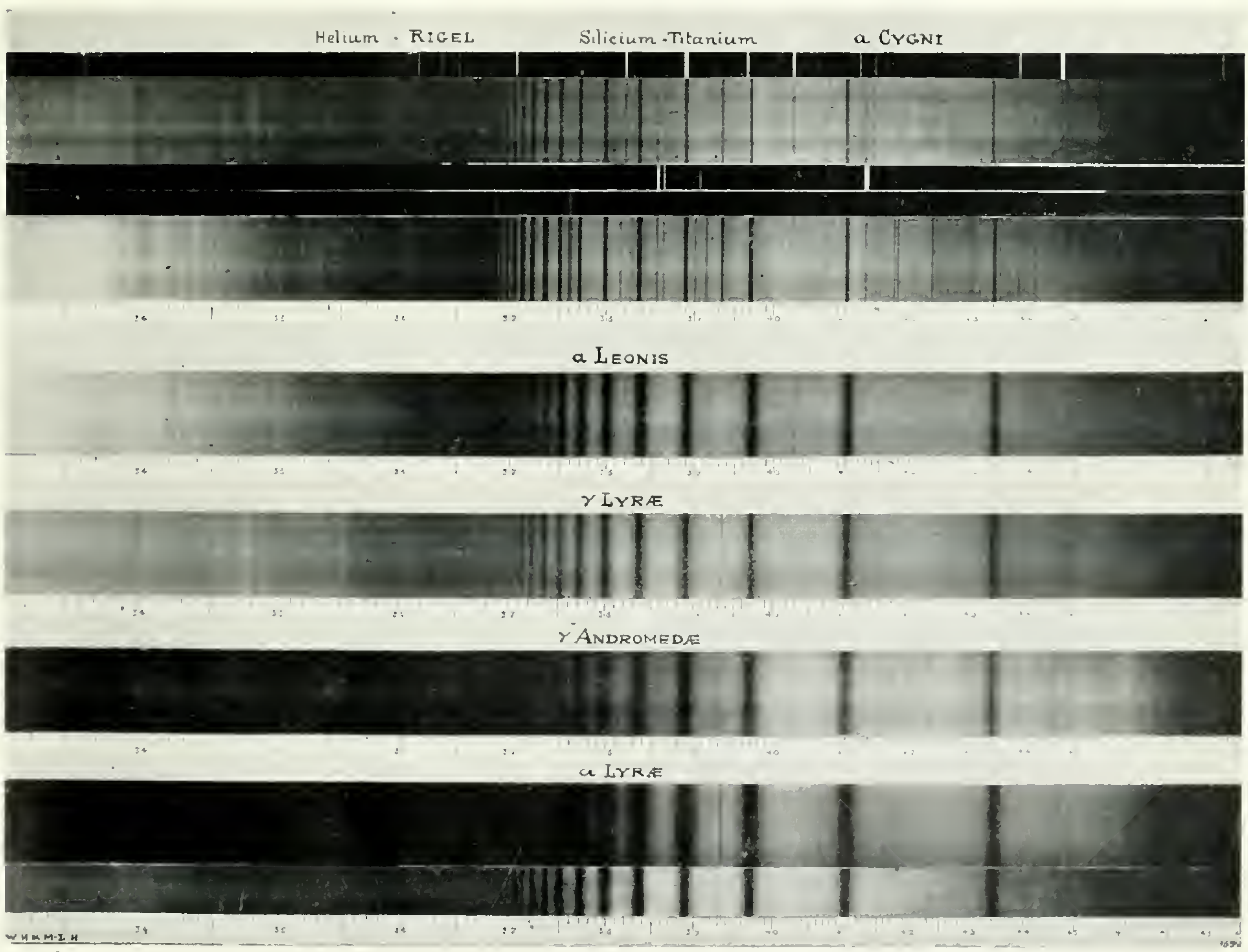


FIGURE 25.



From Spectrograms *by Sir William Huggins.*

FIGURE 26.

The Spectrum of Hydrogen as observed in the Stars.

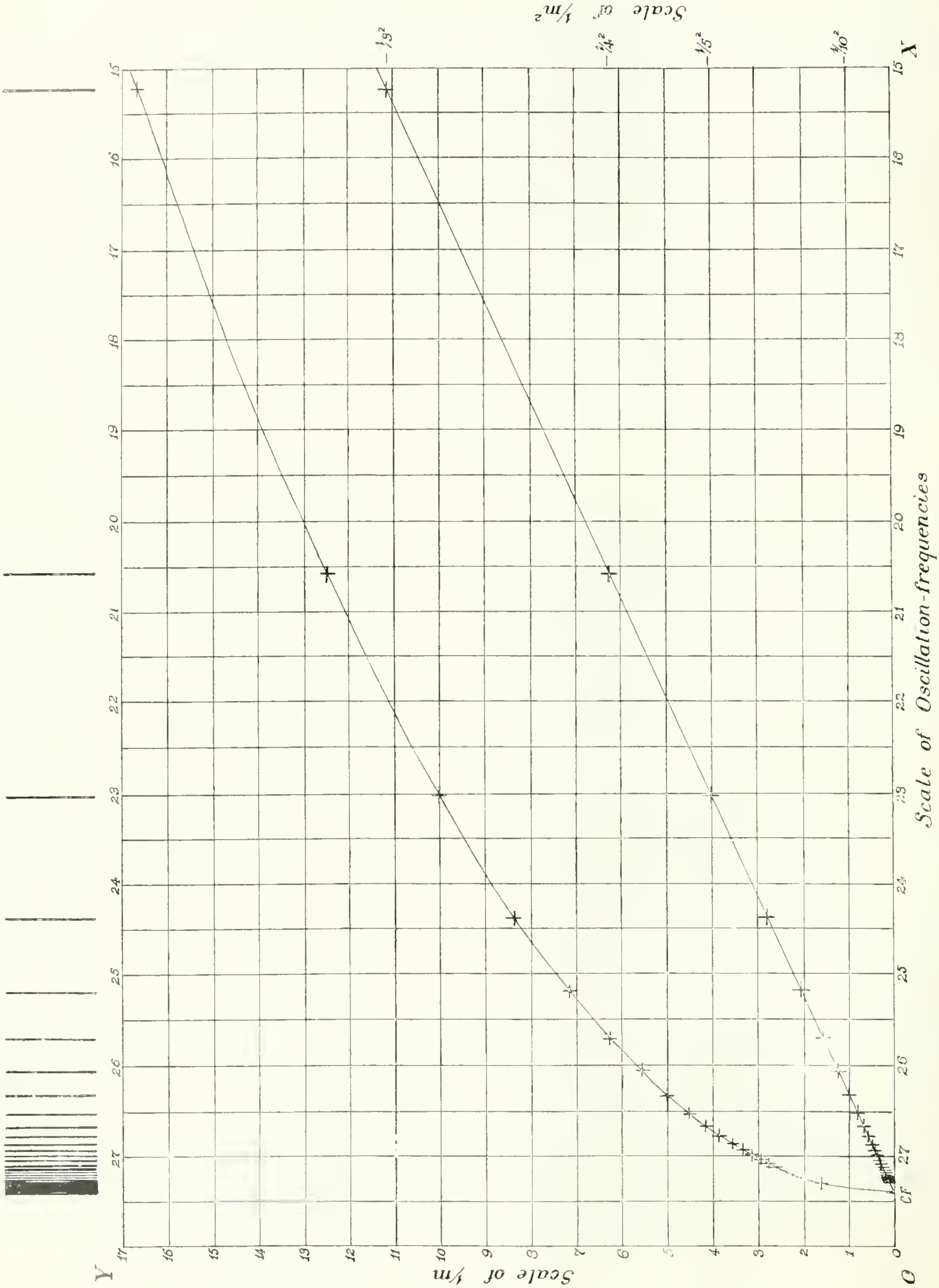

Scale of Oscillation-frequencies
Scale of 1/m
Scale of 1/m²
X
Y
O
CF

FIGURE 27.

similar to the hydrogen series, can be traced. In each series the lines succeed each other with great regularity, becoming closer together and diminishing in intensity as we pass from red to violet, thus approaching a "head" or limit. Several series may coëxist in the same spectrum. These series may be represented by formulae. It appears probable that the number 109675 is the same for all spectra and all elements, so that it is a "universal constant" of Nature. Rydberg's general formula is $O.F. = C.F. - \frac{109675}{(m+\mu)^2}$, which differs from the simpler formula for hydrogen only by having another term, μ.

The complexity of a spectrum is found to depend in some way upon the position of the element furnishing it in the Periodic Table of Mendelejeff, or, in other words, the lower the atomic weight of an element, the simpler its spectrum. Thus hydrogen, with atomic weight 1, has the simplest of all spectra. Probably μ is not really zero, but has some very small value. Curtis* has recently shown that the wave-lengths of the first six hydrogen lines are given with extreme accuracy by giving to μ the value 0·0000069, as shown by the following comparison (see Table 7), in which the wave-lengths are given in terms of the International Unit.

The series of hydrogen lines now known consists of thirty-five lines: of these only the first thirteen have been observed as bright lines in the vacuum tube; the rest occur as dark lines in the spectra of stars, as seen in the reproduction of Sir William Huggins's photographs (see Figures 25 and 26), or as bright lines in the spectrum of the Sun's chromosphere. The latest determinations are brought together in Table 8.

The series of stellar lines observed by Pickering in ζ Puppis (see "KNOWLEDGE," 1914, Volume XXXVII, page 59) is given approximately by the formula $O.F. = 27418{\cdot}75 - \frac{109675}{(m+{\cdot}5)^2}$. But it is more probable that these lines are due to helium.†

* Curtis, *Proc. Roy. Soc.*, 1914, XC, 605.

† Fowler, *Phil. Trans.*, 1914, CCXIV, 256.

CORRESPONDENCE.

HIGH TIDES AT FREMANTLE.

To the Editors of "KNOWLEDGE."

SIRS,—The following information about the Fremantle tides, Western Australia, may be of value to your correspondents on this subject. I have been engaged upon an analysis of these tides, and am therefore in a position to give (H) the semi-range in feet and (K) the phase-constant for the various tides.

In Table 9 appear the H and K of those components that evidently are the chief controlling factors of the Fremantle tide. It shows very clearly that the Luni-solar and Lunar declinational are the two main ones to be considered.

portion of the Swan River extends past Perth, about fifteen miles from Fremantle, and beyond that the river is of very small extent, and there is no current to speak of; in fact, ten miles farther on it dwindles to quite a small stream. The Darling Range, where it takes its source, is only a comparatively low elevation, and consequently there is no head of water. As to ocean currents, there is certainly one passing along the coast from south to north, but its rate is only of small account. The chief cause of irregularity in the Fremantle tides is, I think, to be looked for in the prevailing winds.

This peculiarity can very probably be accounted for by the disturbing influences of the wind and weather on the comparatively small range of tide prevailing at Fremantle,

TABLE 9.

Title.	Name.	Period.	Mean of Years 1911–12.*	
			H.	K.
			Ft.	°
K_1	Luni-Solar Declinational	Diurnal	0·431	310
O	Lunar Declinational	,, ...	0·320	319
P	Solar Declinational	,, ...	0·130	284
Q	{Greater Lunar Elliptic ...} Declinational	,, ...	0·079	325
M_2	Mean Lunar	Semi-diurnal	0·112	319
S_2	,, Solar	,, ...	0·109	318

* Figures for 1908, 1909, 1910 analysed by Mr. Cooke are as follows (the agreement is good):—

	H	K		H	K
	Ft.	°		Ft.	°
K_1	0·445	319	Q	0·083	333
O	·322	324	M_2	·116	325
P	·144	313	S_2	·109	318

Of the long-period tides the Solar Annual is probably of most importance, but the values for different years for these tides do not agree very well, and therefore I have not included them.

One of your correspondents suggests, as causes of irregularity, strong river flows or strong ocean currents. In this connection I would point out that the estuary or salt-water which, except at certain short periods during each month, when it exceeds two feet six inches, rarely averages more than eighteen inches; thus, should a strong easterly or nor'-easterly wind be blowing, the theoretical time of high water is almost certain to be delayed, and the height also diminished. On the other hand, the sou'-wester or sea breeze banks up the water to a greater or less degree, dependent upon its intensity, accelerating the time of high water, augmenting its height and prolonging its duration. This would be especially noticeable during a westerly blow, and the exceptional height often reached by the tides during the winter months is almost solely due to the banking up of the water against our western coast line; although in this connection it must be remembered that the great tide-wave which travels along the south coast of the continent from east to west is retarded by a westerly wind, and its height necessarily increased, and consequently there occurs an additional banking up of the water of the ocean off Cape Leeuwin, which makes its effect felt to a greater or less extent northwards.

"Thus, when the Moon is in Perigee, the tides are invariably higher and the range greater than in Apogee. This is only to be expected, for its attractive force is then at a maximum. So in this respect, at all events, the Fremantle tides conform to the generally recognised law. On the other hand, we might expect to find some regular sequence of change existing between the tides and the phases of the Moon, but a comparison between the times and heights of high and low water with the age of the Moon fails to disclose any existing connection ; in fact, it only still further serves to emphasise the complications present in the tide-governing forces, and to demonstrate the difficulties likely to be met with in an attempt to accurately explain them. For the greatest and least ranges occur both at the change and full of the Moon alike.

"It should be noted in this comparison that at about the time of first quarter, and again at last quarter, the diurnal tide, namely, one high and one low during the day, is almost invariably in evidence. It also may be taken as a general rule that the highest tides and greatest range occur about the time of Moon's first quarter, although this sometimes breaks down. At the time of full or new Moon the semi-diurnal tides often make their appearance, marked by small range and great irregularity. But it sometimes happens, as mentioned above, that the highest tides and the greatest range take place at these times, with the almost certain prevalence of a diurnal tide.

"A comparison, however, with the Moon's position in declination shows that, when the Moon is on the Equator, the least range occurs, the variation in water-level being about one foot, and also great irregularity in the times of high and low water is apparent. Very little reliance can be placed upon the tidal predictions at this period. Often, for quite a considerable length of time, the water remains unchanged in level. The semi-diurnal tides, namely, two highs and two lows during the twenty-four hours, are also in evidence, but the secondaries are sometimes barely perceptible, the difference between the heights of this inferior high and low water being only a few inches.

"As the Moon moves north or south of the Equator, the range gradually increases, and the tidal curve becomes regularly diurnal in character. More dependence also may be placed upon the predicted times as the Moon's distance from the Equator increases.

"Contrary to what might be expected, the highest tide and greatest range happen when the Moon is at its farthest north point, and not at its greatest south declination, when the Moon would be almost directly over Fremantle, and would thus be in a position to exercise the maximum attractive force on the water.

"It may be stated, therefore, with some degree of certainty, that the Fremantle tides depend to a large extent upon the Moon's declination, and from its position the range of tide may be gauged fairly accurately; but the irregularity in the occurrence of successive highs and lows, although most marked when the Moon is on the Equator, is still to be expected when the Moon attains her greatest north or south declination."

H. B. CURLEWIS,
Acting Government Astronomer,
Western Australia.
The Observatory,
Perth, W.A.

FLORA SELBORNIENSIS.

February, Second Month (*Continued*).

22nd.—For the Primrose the Linnean name is used, which still stands at the present day. In a similar way Gilbert White first wrote the name of the Thrush, by which we now know it, but afterwards replaced the specific name by a phrase. He likewise takes out the specific name of the Chaffinch, and corrects the name of the Titmouse from *ater* to *major.* The Skylark is now *Alauda arvensis.*

March, Third Month.

As the Spring is now beginning to come on, the number of entries naturally very much increases.

3rd.—*Torquilla* is now the specific name of the Wryneck. The Wood Laurel is *Daphne laureola.* The Black Hellebore is *Helleborus foetidus.* The Long-tailed Titmouse is now *Acredula.* Lady-cows are presumably Lady-birds.

4th.—Chickweed Speedwell is *Veronica agrestis.*

5th.—The Common Chickweed (*Stellaria media*). This plant, with the Common Groundsel and the *Veronica* just mentioned, are among the plants which may be found in flower during every month in the year. The Missel Thrush is *Turdus viscivorus.* The Peziza is possibly *P. aurantia.*

6th.—The Red Dead Nettle is *Lamium purpureum.* The Common Wren is *Anorthuria parvula.* The Clothes Moth is *Tinea pellionella.* The Yellow Hammer is now *Emberiza citronella. Geum urbanum* is the Common Avens ; Wild Cicely, *Anthriscus sylvestris* ; Herb Gerard, *Aegopodium podagraria* ; Fool's Parsley, *Aethusa cynapium* ; and Goose Grass, *Galium aparine.*

7th.—We now call the Wood Lark *Lullula,* the Rook *Trypanocorax frugilegus,* and the Jackdaw *Coloeus monedula.*

8th.—The first-mentioned Butterfly is the Brimstone (*Gonepterix rhamni*), and the others are presumably small Tortoise-shells (*Vanessa urtica*). We know the Blackbird now as *Merula merula*).

9th.—The Hedge Sparrow is *Accentor modularis.* Dog's Mercury we call *Mercurialis perennis.* The Wood Strawberry is *Fragaria vesca.* The Ringdove is *Columba palumbus.* There is an interesting observation with regard to the Field Cricket (*Gryllus campestris*).

10th.—Wormwood is now *Artemisia absinthium.*

2. blowing, with vast numbers of their male cat:
:kins opening, which give the hedges a yellowish
tinge: the primrose, primula veris, is also
blowing.

simpliciter dictus,
The thrush, turdus ~~musicus~~, the chaffinch, frin
:gilla, ~~coelebs~~ & the skie-lark, alauda vulgaris,
[illegible] ~~ater~~ major.
sing: the ^ titmouse, parus ^ makes his spring note
Soft grey weather, & the ground in fine order.
March 1. Soft, grey weather with a sinking glass.
Groundsel, senecio, in bloom. 3rd Month.
3. The wry neck, Iynx, pipes: alias Torquilla.
This was only the black-headed titmouse, parus major.
The Elder, Sambucus; honey suckle, caprifolium,
begin to shoot.
Crown-imperials, hyacinths, tulips, Narcissuss,
Jonquils begin to peep: polyanths begin to blow.
Wood laurel, laureola, buds for bloom.
Great black Hellebore, bear's foot or setter-wort,
maximus, sex consiligo, enneaphyllon Plinii,
Helleboraster, ^ in flower in Selborne-wood.
The flies in the ^ dining-room begin to come forth out
of their lurking-holes.
The long-tailed titmouse, parus caudatus, chirps.
scarabaei subrotundi,
Lady-cows ^ & earwigs appear, forficulæ.

March 4. In flower ~~little henbit, alsine vulgaris,~~ 3.
~~seu morsus Gallinae minor,~~ veronica flosculis
singularibus, ~~hederulae folio.~~ cauliculis adhaerentibus.
(speedwell-chickweed.
5 In flower common chickweed, alsine vulgaris, seu
morsus gallinae.
Bees, apes ~~mellifera~~ domestica, are busy in the flowers, crocuss.
Sunny spring weather. Some ants, formicae,
appear.
The missel-bird or shrite, turdus viscivorus major,
(in Hants the storm-cock) sings.
The gooseberry-tree, grossularia, shoots.
White hellebore, helleborus albus, begins to shoot.
The fungus membranaceus, seu coriaceus, acetabuli
modo concavus, colore intus coccineo is now
common on rotten sticks under every hedge;
& is one of the earliest funguss. A peziza.
Columbines, aquilegia, emerging.
Spiders creep forth.
Foreign asters begin to shoot.
The bay-tree, laurus, budding for bloom.
6. Red dead-nettle, lamium vulgare rubrum, flowers:
folio subrotundo.
The wren, passer troglodytes, regulus, sings.
The moth, tinea vestivora, appears.

4. March 6. The partridge, perdix cinerea, pairs.
The yew-tree, taxus, buds for bloom.
The buds of the apricot, malus armeniaca, swell.
The buds of the peach, malus persica, swell.
The yellow-hammer, emberiza, sings: scil: flava.
Common avens, Caryophyllata vulgaris, has leaves very large.
Cuckow-pint, Arum, emerges: called also wake-Robin.
Wild Cicely, or cow-weed. Cicutaria vulgaris, much advanced in growth.
Herb Gerard, gout-weed, or ash-weed, angelica sylvestris minor, s: erratica, peeps out.
Less hemlock, or fool's parsley, cicutaria tenuifolia, much grown.
White dead-nettle, lamium vulgare album, much grown.
Cleavers, or goose-grass, Aparine vulgaris, growing from the beginning of the year.
7. The wood-lark, Alauda arborea, sings.
The rook, cornix frugilega, begins to build.
The jack-daw, monedula, comes to churches, & steeples.
Sallow, salix, flowers.
The mullein, verbascum, grown to a great tuft.

March 8. Saw ye first butter fly, papilio sulphureus, a brimstone-coloured one: some people saw several of these, & several that were coloured with black spots; these are, I believe, papiliones Urticæ. 5.
Spiders, lupi nigri, begin to dart their webs.
A beautiful summer day.
Blackbird, merula vulgaris, sings.
9. Hedge-sparrow, curruca, sings.
Vipers come forth.
Dogs-mercury, cynocrambe, buds for bloom.
Very hot sun shine, & a steady barometer.
Wood strawberry, fragaria, blows
~~Wood pidgeon~~ The ringdove, or queest, palumbus torquatus, cooes.
Field-cricket, gryllus sylvestris, appears at ye mouth of it's hole, which it has rounded out very elegantly. Those that I saw had only rudiments of wings: from whence I should suppose that ye old ones of last year do not survive ye winter.
10. The daisey, bellis, blows.
Teasel, dipsacus, emerges.
Pear tree, pyrus, buds for bloom.
Wormwood, absinthium, peeps out.

SOLAR DISTURBANCES DURING DECEMBER, 1914.

By FRANK C. DENNETT.

Notwithstanding the poor meteorological conditions which prevailed during the month, only three days (December 6th, 11th, and 28th) passed on which no telescopic examination was made, and the Sun appears never to have been free from spot disturbance. The longitude of the central meridian was 139° 28′ at noon on December 1st.

Nos. 43 and 44 of the November list were visible until December 9th and 10th respectively, and therefore reäppear upon the present chart.

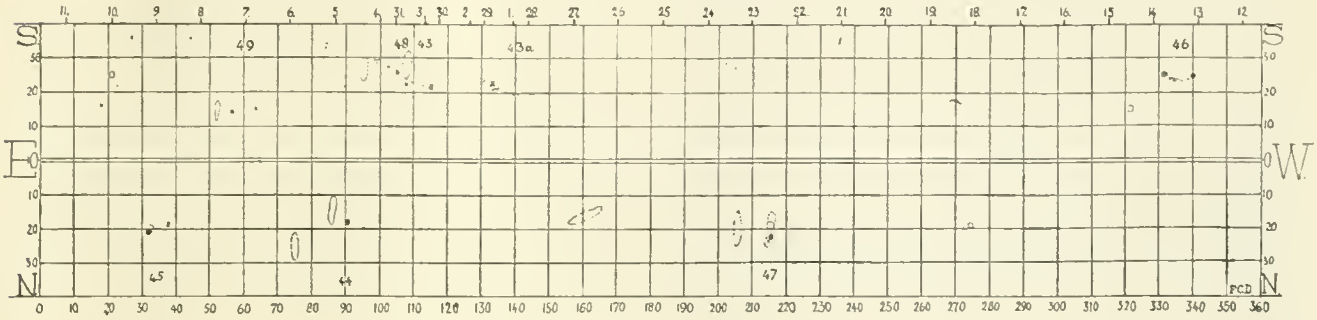
No. 43*a*.—A group of pores, which broke out on December 2nd in front of No. 43, and continued until the 21st and 22nd, and one was situated a little to its south-west on the 23rd. The spot was last seen on the 24th.

A pore, not measured, but estimated to be in the position shown by a tiny cross, near longitude 134°, S. latitude 22°, was only visible on the 24th.

No. 48.—A faculic disturbance was seen coming round the south-eastern limb on December 24th, and on the 25th was found to be connected with a spot nine thousand miles in diameter, which was last seen by the writer on January 2nd.

No. 49.—Two pores, only observed on December 31st, separated by some fifty thousand miles.

DAY OF DECEMBER, 1914.



5th. Its greatest length, on the 3rd, was seventy-two thousand miles.

No. 45.—A group first seen as two considerable spots just round the limb on the 3rd. The eastern spot was the largest, with three or four umbrae. Some pores helped to make up the group on the 8th. The length of the group was sixty-four thousand miles, and the greatest diameter of the spot eleven thousand miles. It was last seen on the 14th, when it appeared as a group of five pores in a faculic disturbance.

No. 46.—A fine group, which was found to have broken out on the 12th, consisted of two considerable spots about ten thousand miles in diameter, with some pores between them, fifty-six thousand miles in length. It was last seen near the limb on the 19th.

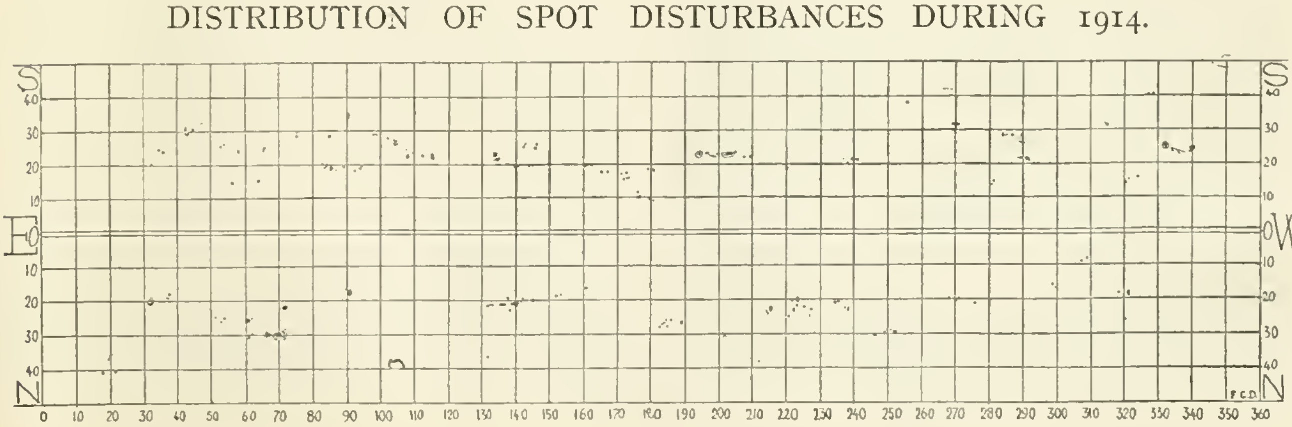
No. 47.—A spot ten thousand miles in diameter, first seen on the 18th a little within the limb. Two pores followed it

Faculic disturbances were near the north-western limb on December 1st (215°, 19° N.), 5th (160°, 16° N.), 14th, 24th (274°, 19° N.), 26th, 27th (216°, 20° N., and 204°, 18° N.), and 29th; north-east on December 1st (75°, 24° N.), 16th, 27th (86°, 13° N.), and 31st; south-west on December 5th, 16th (21°, 25° S.), 20th (320°, 15° S.), and 29th; south-east on December 8th (in which No. 46 afterwards developed), 23rd, 27th (south of No. 48, and 96°, 27° S.), and 29th (52°, 14° S.).

Our chart is constructed from the joint observations of Messrs. John McHarg, A. A. Buss, and the writer.

A second chart is also appended, showing the distribution of the whole of the spot disturbances of the past year. As compared with previous year-charts, it will be noticed that the spots, as a whole, are much farther from the Equator, are more numerous than in the three previous years, and are more evenly distributed.

DISTRIBUTION OF SPOT DISTURBANCES DURING 1914.



THE AMATEUR IN ASTRONOMY.

By W. F. DENNING, F.R.A.S.

(*Continued from page 11.*)

In cases where affluent amateurs have not personally undertaken researches, they have provided the opportunity for professional men, and America furnishes some prominent examples, among which we may instance the great observatories of Yerkes and Lick.

Of course, there are certain investigations which are far more fittingly conducted at well-equipped observatories. The determination of star positions and a great universal work like that of the astrographic catalogue are far beyond the capacities of ordinary amateur effort.

There is an idea that all the objects discoverable by small telescopes are now known, and that the great instruments recently erected must be left to grapple with the miniature orbs remaining unknown. This is only partly true. The brighter minor planets have been found, the more prominent double stars, variable stars, the brighter nebulae, have all been detected and catalogued. But in regard to certain other objects of an inconstant character the case is entirely different. I refer to solar phenomena, to new stars, to meteors and aurorae. There are constantly recurring supplies of these, easily observable, and often awaiting detection by the acute and vigilant observer, be he amateur or professional.

On walking out into my garden a few nights ago, to do a little observing work on a beautifully starlit sky, I hesitated a moment in contemplation of the vast conclave above; and I could not help thinking what a vast amount of useful observation there remained still to be done by systematic effort. Ordinary amateurs, with good telescopes and practised eyes, might accomplish it. Double stars might be measured or new ones searched for, Mars and Saturn examined and drawings made, sweeps made for new nebulae or new comets, the position of visible comets determined; without telescopic aid the light of variable stars might be estimated, new variables looked for, the heavens scrutinised for new stars, a watch maintained for meteors, and their paths recorded. These form a few items of the work suggested by the inviting firmament: it has been inadequately performed in the past; let it be more thoroughly effected in the future. Let amateurs realise that their rôle is still a most important one, and that splendid work ever awaits able and well-directed effort.

They should certainly not be discouraged by the supposition that they are now too heavily handicapped to collect any valuable contributions to the science.

I have often thought that there is not a wide difference between the amateur and the professional. In some cases the distinction is certainly a very trifling one. In one sense assuredly, men like J. F. W. Herschel, R. A. Proctor, W. R. Dawes, and C. Flammarion can hardly be regarded as merely amateur astronomers, but it is obvious that in every case the amateur studies the stars out of pure love for the subject. He admires the wonderful pictures the heavens afford, and marvels at the mysteries involved. There is a sublimity and infinity about astronomy which attract the intellectual mind and induce a feeling of reverence and awe. The peer and the plebeian alike are tempted to "lift up their eyes on high," for there is often found identity of feeling amid wide differences in social status in the great brotherhood of humanity. With regard to the professional, he ostensibly devotes himself to the study, not exactly as a way to wealth, but as a means of earning a livelihood. In very many cases, however, this is not all. Many professionals work at astronomy *con amore*. They have selected it because they have a deep regard for it. There must be really very few professional astronomers but who feel an intense interest in their subject, and whose labours are prompted by inclination. Abundant evidence of this has been afforded by them in recent years, for they have performed heavy work of honorary character quite outside their official duties. For instance, the British Astronomical Association, which is understood to provide encouragement for and useful coöperation amongst tyros and amateurs, has been assisted in most material degree by professional men who, after their heavy routine work, have freely devoted much time and attention to the assistance of mere beginners in the science.

THE ZOÖLOGICAL SOCIETY.

THE registered additions to the Zoölogical Society's Menagerie during the month of December were fifty-two in number. Of these twenty-seven were acquired by presentation, eighteen were received on deposit, three in exchange, and four were born in the Gardens. The following, which are new to the Collection, may be specially mentioned: A Peter's Dwarf-Mongoose (*Helogale undulata*), from Wangi, Tanaland, E. Africa, deposited; and a Golden-eared Honey-eater (*Ptilotis chrysotis*), from New Guinea, presented by Alfred Ezra, F.Z.S.

From a photograph by *Lafayette.*

FIGURE 28. Mrs. Fiammetta Wilson.

From a photograph by *J. Russell & Sons.*

FIGURE 30. The Rev. T. E. R. Phillips, M.A., F.R.A.S.

From a photograph by *Hills & Saunders.*

FIGURE 29. William Lassell.

From a photograph by *Maull & Fox.*

FIGURE 31. G. F. Chambers, J.P., F.R.A.S.

FIGURE 32.
The right half of the lower jaw of a Beaver, showing the molar teeth standing high out of their sockets, which are above that of the incisor.

FIGURE 33.
The left half of the lower jaw of a Beaver for comparison with Figure 34.

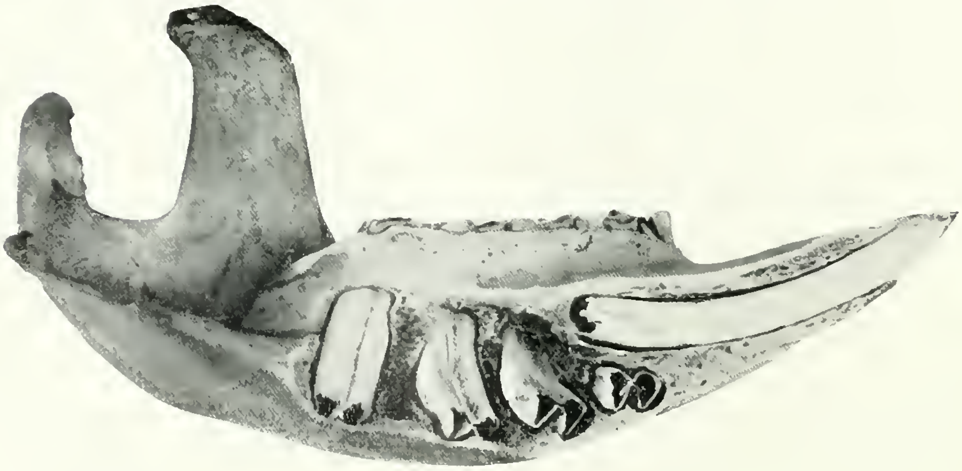


FIGURE 34.
The left half of the lower jaw of a Wombat, showing the molar teeth sunk very deeply in their sockets, which curve, while the first actually runs under that of the incisor.

THE TEETH OF THE WOMBAT AND THE BEAVER.

It is everyday knowledge to naturalists that, among the marsupials of Australia, we have types which correspond with the various higher orders of old-world mammals, and present features analogous to theirs, owing to their getting their living in the same of several ways. For instance, the Tasmanian wolf is carnivorous, the kangaroos are herbivorous, and the wombat gnaws like a rodent. The matter which concerns us here is connected with the teeth of the last-mentioned animal. In Figures 32 to 34 the lower jaw of a wombat is compared with that of a true rodent, the beaver. The lower incisor of the latter is exceptionally large, but the corresponding tooth in the wombat is also very well developed (see Figure 34). It will be seen that it is necessary to find room for the large incisors in both cases. In the beaver, as shown in Figures 32 and 33, the molar teeth, which are the only ones developed in addition to the incisors, stand high out of the jaw, and their sockets are above that of the great incisor. In the wombat, in the anterior part of the jaw at any rate, there is just the same need for accommodating the incisor socket; but it will be seen that the surfaces of the molar teeth in this animal project but little above the jaw, and it is by the curving of the molar teeth that the difficulty has been got over, the sockets ending below the level of the incisor, and in the case of the first grinding tooth coming directly underneath it. The interest lies in the fact that the same necessity has been met in two very different ways in a rodent and in a marsupial. The specimens from which Figmes 32 and 34 were taken are exhibited at the Eton College Museum, to which Sir Edmund Loder kindly presented the beaver jaw.

W. M. W.

THE FACE OF THE SKY FOR MARCH.

By A. C. D. CROMMELIN, B.A., D.Sc., F.R.A.S.

Table 10.

Date.	Sun. R.A.	Sun. Dec.	Moon. R.A.	Moon. Dec.	Mercury. R.A.	Mercury. Dec.	Venus. R.A.	Venus. Dec.	Saturn. R.A.	Saturn. Dec.	Neptune. R.A.	Neptune. Dec.
Greenwich Noon.	h. m.	°	h. m.	°	h. m.	°	h. m.	°	h. m.	°	h. m.	°
Mar. 2	22 49·3	S. 7·5	11 21·2	N. 1·9	21 42·7	S. 11·0	19 48·4	S.19·3	5 40·0	N.22·4	8 0·2	N.20·2
,, 7	23 7·9	5·6	15 56·7	S. 25·8	21 40·5	12·4	20 11·9	18·6	5 40·3	22·4	7 59·8	20·2
,, 12	23 26·3	3 6	20 56·6	S. 18·7	21 48·1	12·9	20 35·5	17·6	5 40·8	22·5	7 59·5	20·2
,, 17	23 44·7	S. 1·7	0 49·1	N. 9·5	22 2·8	12·6	20 58·9	16·5	5 41·5	22·5	7 59·2	20·3
,, 22	0 2·9	N. 0·3	4 51·8	N.27·5	22 22·5	11·6	21 22·3	15·1	5 42·3	22·5	7 59·0	20·3
,, 27	0 21·1	N. 2·3	9 18·7	N.16·5	22 45·5	S. 10·0	21 45·4	S.13·6	5 43·4	N.22·5	7 58·8	N.20·3

Table 11.

Date.	Greenwich Noon. Sun. P	Greenwich Noon. Sun. B	Greenwich Noon. Sun. L	Midnight Moon. P
	°	°	°	°
Mar. 2	− 21·8	−7·2	21·0	+22·1
,, 7	23·0	7·3	315·1	+ 9·4
,, 12	24·0	7·2	249·2	−16·4
,, 17	24·8	7·1	183·3	−21·5
,, 22	25·5	7·0	117·4	− 4·8
,, 27	− 26·0	−6·8	51·5	+17·7

P is the position angle of the North end of the body's axis measured eastward from the North Point of the disc. B, L are the helio-(planeto-)graphical latitude and longitude of the centre of the disc.

For the future the data for the Moon and Planets in the Second Table will be given for Greenwich Midnight, *i.e.*, the Midnight at the end of the given day.

The letters *m*, *e* stand for morning, evening. The day is taken as beginning at midnight.

The Sun is moving Northwards at its maximum rate, crossing the Equator $21^d\ 4^h\ 51^m$ *e*. Its semi-diameter diminishes from 16′ 10″ to 16′ 2″. Sunrise changes from $6^h\ 50^m$ to $5^h\ 42^m$; sunset from $5^h\ 36^m$ to $6^h\ 28^m$.

Penumbral Eclipse of Moon. — There will be a Penumbral Eclipse of the Moon on March 1st about 7^h *e*. A slight smokiness will be discernible on the Northern portion of the disc.

Mercury is a morning star in W. elongation, 27° 43′ W. of Sun on 20th. Semi-diameter diminishes from 5″ to 3″. Illumination increases from $\frac{1}{7}$ to $\frac{2}{3}$.

Venus is a morning star. Illumination increases from $\frac{3}{5}$ to $\frac{7}{10}$. Semi-diameter diminishes from 10″ to 8″.

The Moon.—Full $1^d\ 6^h\ 33^m$ *e*. Last quarter $8^d\ 0^h\ 28^m$ *e*. New $15^d\ 7^h\ 42^m$ *e*. First quarter $23^d\ 10^h\ 48^m$ *e*. Full $31^d\ 5^h\ 38^m$ *m*. Perigee $5^d\ 3^h$ *m*. Apogee $21^d\ 1^h$ *m*, semi-diameter 16′ 19″, 14′ 46″ respectively. Maximum librations 7^d 7° N., 12^d 5° W., 20^d 7° S., 27^d 7° E. The letters indicate the region of the Moon's limb brought into view by libration. E., W. are with reference to our sky, not as they would appear to an observer on the Moon (see Table 12).

Mars is invisible, having been in conjunction with the Sun on Dec. 24th.

Jupiter was in conjunction with the Sun on Feb. 24th, and is therefore practically invisible this month.

Saturn is between Taurus and Gemini. In perihelion Feb. 21st. Stationary Feb. 26th. In quadrature Mar. 17th. Polar semi-diameter 9″. Major axis of ring 42″, minor 19″. Angle P−5°·7.

Table 12. Occultations of Stars by the Moon visible at Greenwich.

Date.	Star's Name.	Magnitude.	Disappearance. Time.	Disappearance. Angle from N. to E.	Reäppearance. Time.	Reäppearance. Angle from N. to E.
1915.			h. m.	°	h. m.	°
Mar. 4	75 Virginis	5·7	—	—	10 17 *e*	237
,, 5	WZC 871	7·0	—	—	1 55 *m*	345
,, 8	BAC 5603	6·0	3 38 *m*	140	4 37 *m*	245
,, 10	WZC 1243	7·4	—	—	5 15 *m*	229
,, 24	39 Geminorum	6·1	5 0 *e*	85	6 20 *e*	296
,, 24	40 Geminorum	6·3	5 29 *e*	116	6 49 *e*	267
,, 25	52 Geminorum	6·0	1 46 *m*	108	2 38 *m*	284
,, 25	WZC 498	6·9	1 56 *m*	162	—	—
,, 26	μ^2 Cancri	5·4	2 5 *m*	173	2 30 *m*	230
,, 26	BAC 2991	6·1	8 8 *e*	106	9 22 *e*	312
,, 27	WZC 618	7·1	3 0 *m*	177	—	—
,, 27	11 Leonis	6·6	5 23 *e*	86	6 24 *e*	327
,, 29	76 Leonis	6·0	5 36 *e*	151	6 26 *e*	269
,, 30	BAC 4119	6·6	7 39 *e*	153	8 33 *e*	275

From New Moon to Full disappearances occur at the Dark Limb, from Full to New reäppearances.

Eastern elongations of Tethys (every 4th given) $3^d\ 7^h \cdot 7$ *m*, $10^d\ 8^h \cdot 9$ *e*, $18^d\ 10^h \cdot 2$ *m*, $25^d\ 11^h \cdot 5$ *e*; of Dione (every 3rd given) $8^d\ 10^h \cdot 1$ *m*, $16^d\ 3^h \cdot 3$ *e*, $24^d\ 8^h \cdot 4$ *e*; of Rhea (every 2nd given) $7^d\ 11^h \cdot 1$ *m*, 16^d Noon, $25^d\ 1^h \cdot 0$ *e*.

For Titan and Japetus E., W. stand for East and West elongations, I. for Inferior (North) conjunction, S. for Superior (South) conjunction. Titan $4^d\ 6^h \cdot 8$ *m* S., $8^d\ 9^h \cdot 1$ *m* E., $12^d\ 9^h \cdot 1$ *m* I., $16^d\ 6^h \cdot 3$ *m* W., $20^d\ 6^h \cdot 0$ *m* S., $24^d\ 8^h \cdot 5$ *m* E., $28^d\ 8^h \cdot 5$ *m* I.; Japetus $1^d\ 2^h$ *m* W., $20^d\ 7^h$ *m* S.

Uranus is invisible. In conjunction with Sun on February 1st.

Neptune was in opposition January 20th, diameter 2″.

Double Stars and Clusters.—The tables of these, given three years ago, are again available, and readers are referred to the corresponding month of three years ago.

Variable Stars.—Stars reaching their maxima in or near March, 1915, are included. The lists in recent months may also be consulted.

Meteor Showers (from Mr. Denning's List):—

Date.	Radiant. R.A.	Radiant. Dec.	Remarks.
	°	°	
Mar. 1-4	166	+ 4	Slow, bright.
,, 1-14	175	+ 10	Slow.
,, 18	316	+ 76	Slow, bright.
,, 24	161	+ 58	Swift.
,, 27	229	+ 32	Swift, small.
Mar.—May	263	+ 62	Rather swift.

Table 13. Long-period Variable Stars.

Star.	Right Ascension.	Declination.	Magnitudes.	Period.	Date of Maximum.
	h. m. s.	° ′		d.	
U Persei	1 53 57	+54 24	7·0 to 10·9	317	1915—Feb. 23
W Andromedae	2 12 11	+43 55	7·0 to 13·8	395	,, Feb. 9
T Camelopardi	4 31 48	+65 59	7·0 to 13·5	370	,, Apr. 19
R Aurigae	5 10 25	+53 30	6·5 to 13·3	448	,, Apr. 4
R Ursae Maj.	10 38 42	+69 13	5·9 to 13·1	299	,, Feb. 27
T Ursae Maj.	12 32 33	+59 57	5·5 to 12·7	257	,, Jan. 28

Night Minima of Algol $1^d\ 7^h \cdot 2$ *e*, $4^d\ 4^h \cdot 0$ *e*, $16^d\ 3^h \cdot 4$ *m*, $19^d\ 0^h \cdot 1$ *m*, $21^d\ 8^h \cdot 9$ *e*, $24^d\ 5^h \cdot 7$ *e*. Period $2^d\ 20^h\ 48^m \cdot 9$.
Principal Minima of β Lyrae March $1^d\ 6^h$ *e*, $14^d\ 4^h$ *e*, $27^d\ 3^h$ *e*. Period $12^d\ 21^h\ 47^m \cdot 5$.

REGENERATION.

The regeneration of "arms" in starfish, claws in lobsters, and tails in lizards exemplifies the replacement of lost parts in animals; and, although we cannot get a new lizard from an old tail, or a new lobster from a discarded claw, yet it is possible to grow a new starfish from a detached arm. In the vegetable kingdom this kind of regeneration is more common, and is put to practical uses. The making of a cutting may not seem so striking as the growing of a new starfish, for roots only have to be formed (see Figure 40), and this underground; but many leaves can produce, not one young plant, but quite a number. This is the case in *Bryophyllum*, and in Figures 35 and 36 a leaf is shown which has been lying on the moist ground for a little time. The edges of it are bounded by quite a clump of young plants. Figures 36 to 39 show other leaves, which will reproduce the whole plant, and the begonia is commonly propagated by gardeners in this way. Figures 40 to 49 also bear on this question, and it is possible to obtain a geranium from a leaf-stalk.

W. M. W.

FIGURE 35. Seen from above.

FIGURE 36. Side view.

Two Views of a Leaf of Bryophyllum, showing the young plants which it produces when broken off and laid on the ground.

FIGURE 37.
A Saintpaulia Leaf with roots springing from the petiole.

FIGURE 38.
Leaves of *Tolmeia Menziesii* sending out buds where the stalk joins the blade.

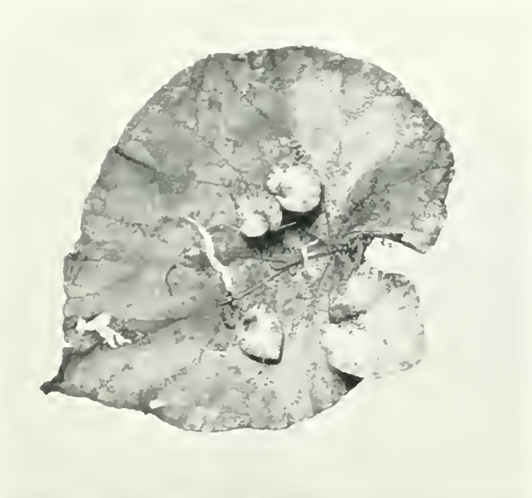


FIGURE 39.
A Begonia Leaf producing new plants.

FIGURE 40.
Pieces of the thick stem of an Aroid (*Dieffenbachia Bausei*) used as cuttings, and sending out roots and shoots.

Figure 43.

Figure 41. A Leaf of Peperomia which has sent out roots from its stalk.

Figure 42. A Peperomia Leaf that has rooted and produced a number of shoots.

Figure 44.

Figure 45.

Figure 47.

Figure 46.

Figures 43 to 47 represent the succulent leaves of such plants as Kleimia and Echeveria sending out roots and acting as nurses to buds at their bases.

Figure 48. A Pelargonium Cutting. Only a few leaves are allowed to remain on the shoot, so that it may not lose all its water supply.

Figure 49. A Carnation Layer. It has sent out roots, and is still connected with the parent plant.

NOTES.

ASTRONOMY.

By A. C. D. Crommelin, B.A., D.Sc., F.R.A.S.

THE ORBIT OF DELTA ORIONIS.—This star, the right-hand member of the belt, lying almost exactly on the celestial equator, is an interesting spectroscopic binary. A discussion of its orbit, by Frank C. Jordan, appears in "Publications of Allegheny Observatory," Volume III, part 15. He uses both his own and earlier photographs of the spectrum, and thus has observations available extending over ten years. The spectrum is of Type B1 (helium type). No secondary spectrum can be traced; so evidently there is great disparity in the light-giving power of the components.

The most probable value of the period is 5·73257 days; the eccentricity, 0·09; the orbital velocity, 100 kilometres per second; longitude of periastron, 5° in 1902, 20° in 1910; the recessional velocity of the centre of gravity, 23 kilometres per second in 1902, 15 kilometres in 1910; $a \sin i = 7,850,000$ kilometres.

Also, if m_1, m_2 denote the masses of primary and secondary stars (the Sun being unity),

$$\frac{m_2^3 \sin^3 i}{(m_1 + m_2)^2} = 0{\cdot}588.$$

The change in the longitude of periastron is doubtful, as there is considerable uncertainty in the determination; it is, however, in accord with what tidal action would lead us to expect. The change in the rate of recession of the c.g. may only arise from the different personality of the observers; it may, on the other hand, indicate revolution round a third member of the system, such as is believed to take place in the case of Algol.

There are many spectroscopic binaries for which our ignorance of the value of i is complete: this is not the case with Delta Orionis, for Mr. Joel Stebbins found some years ago, with the aid of his sensitive selenium photometer, that it is an Algol variable, though the change of light is too small to detect by ordinary methods. Hence we see the system nearly edgewise, and a partial eclipse occurs in each revolution.

If we assume for the companion a mass half that of the primary, and conjecture for the radii of the two one and a half and one million kilometres, also taking the amount eclipsed as one-quarter of the diameter of the primary, i comes out 86°. It is unnecessary to know it very accurately, since the sine of an angle near 90° changes slowly. Under these assumptions the masses come out $10\frac{2}{3}$, $5\frac{1}{3}$, that of the Sun being 1.

If we assume equal masses, and take $i = 83°$, the mass of each is two and a half times the Sun's. The total mass of the system probably lies between ten and twenty times the Sun's. From the minuteness of the star's proper motion it is believed to be very distant; hence the luminosity of the primary is, presumably, very great in proportion to its mass; in other words, its density is small, and its radius may not improbably be considerably greater than that assumed above. This would diminish the value of $\sin i$, but not enough to seriously affect the masses.

This star is one of those in whose spectra the H and K lines of calcium do not share in the periodic displacement. No very satisfactory explanation of this peculiarity has been arrived at, but it is supposed to indicate an extended calcium cloud enveloping the system Mr. Jordan finds 18·5 kilometres per second as the velocity of this calcium cloud away from the Sun. This is 3·5 kilometres greater than the velocity of the c.g., but the difference is not large enough to lay great stress upon. He notes that the Sun's own speed is about eighteen kilometres per second away from the star; hence the calcium cloud is practically at rest with reference to the sidereal system—at least as regards the radial component. This is in accord with the fact that the stars of early spectral type have in general small velocities. It will be of great interest to follow this star fairly continuously, both with the spectroscope and photometer, to ascertain whether the motion of the periastron and change in the speed of the c.g. are verified. It is quite likely that an analysis of the light-curve during eclipse would give further information about the diameters, but I have not at present access to the details.

MOULTON AND CHAMBERLIN'S PLANETESIMAL HYPOTHESIS.—Mr. T. C. Chamberlin gives an interesting exposition of this hypothesis in *Scientia* for October. The theory does not deal with the birth of the Sun, which is supposed to have formerly existed as a solitary orb. Another Sun is supposed to have passed fairly near it (according to the authors, a distance of a hundred million miles, or even more, would not be too great to produce the effects they postulate: approaches within this distance would be vastly more frequent than actual collisions). The result is tidal distortion of each star, protuberances being raised on opposite sides of them. These are supposed to have reached such a height that a large quantity of matter on each side broke off from the parent star and commenced to describe orbits round it, the moment of momentum required for this revolution being derived from the attraction of the other star. This acquirement of extraneous moment of momentum is the leading motive of the theory: "The Sun holds about seven hundred and forty-five out of seven hundred and forty-six parts of the total matter of the solar system, while it only carries about two per cent. of its moment of momentum. This leads to the conviction that a new agency came in, after the original formation of the Sun, and gave to a very small fraction of the solar matter, after it had been drawn out from the Sun, a special endowment of momentum." The two streams of matter would form a double spiral, of a form that we meet with in numerous nebulae. The argument from analogy is used by the authors to support their theory Another argument, not used by them, seems to me to be the constitution of meteors, which frequently contain a large quantity of hydrogen. This would be explained if they had once formed part of the crust of the Sun, on the hypothesis that this crust had already solidified before the approach of the other Sun, but was then disrupted by tidal action.

I shall continue this note next month.

BOTANY.

By Professor F. Cavers, D.Sc., F.L.S.

EFFECTS OF ELECTRIC DISCHARGE ON PLANTS.—Many experiments have been made during recent years in which plants, otherwise under normal conditions, have been subjected to an electric discharge from an overhead system of wires during a considerable portion of their growing period, and, as a result, acceleration of growth and increase in yield have been invariably reported. Since this treatment must considerably alter many factors in the plant habitat, and in the plant's reäction to this habitat, it is difficult to ascribe the effect, apparently due to the electric discharge, to any particular physiological cause. Priestley, who has taken a prominent part in this line of investigation, records in a recent paper, in collaboration with Knight (*Annals of Botany*, Volume XXVIII), some of the first attempts to analyse the effect of the discharge upon the plant by investigating under laboratory conditions the effect produced by such discharge upon one physiological function, namely, respiration. Experiments were made with small direct currents at a relatively low voltage and with electric discharge at high tensions. The results show that direct currents have no effect on the respiration of peas other than that due to accompanying changes of temperature; but the proportion of these currents actually traversing the peas was probably very small, the majority being taken by the water films of the seeds. Overhead discharge of low density has no effect on respiration; but with higher currents a definite increase of the carbon dioxide output was observed, this increase being wholly attributable to the rise of temperature caused by the discharge. In the field, where the currents are too small to produce any appreciable rise in temperature, electrification will have no effect on respiration, and an explanation of the acceleration of growth must be sought in other functions of the plant. The gaseous products of the discharge in air have no effect on germinating peas, but are injurious to young seedlings. These results do not, of course, mean that the acceleration is inexplicable, for one result of electrification may be increased transpiration, which alone would account for a more rapid attainment of maturity by the plant; while various observers have found that electrification produces increased activity of constructive metabolism—the processes of building up food materials in the plants.

STATISTICAL METHODS IN PLANT GEOGRAPHY. —For many years the Swiss botanist Jaccard has been investigating in great detail the distribution of plants in certain definite areas in alpine meadows, and has obtained some interesting results, which appear likely to be of general application. His latest paper (*Rev. gén. Bot.*, Volume XXVI) deals with the vegetation of some alpine gravel areas, but a fuller account of his earlier results is given in an English paper (*New Phytologist*, Volume XI). Having made a census of the flowering plants growing in the areas to be compared—similarly situated localities of about the same area in different parts of the Alps—he applies to the analysis of his results what he called the "coëfficient of community," that is, the percentage ratio between the number of species common to two district and the total number of species in the two districts. For alpine meadows he found that (1) the value of this coëfficient does not depend on floral richness, but upon the ecological characters of the areas studied; (2) the alpine flora is extremely diverse in floristic composition; (3) the rare species are most numerous and the common species least numerous [This does not apply to individuals, but to species]; (4) the coëfficient is usually higher for contiguous than for distant areas. He also uses what he terms the "generic coëfficient," that is, percentage ratio between number of genera and number of species, and finds that this coëfficient varies inversely with the variety of ecological conditions in the areas compared. For instance, in alpine areas its value increases with altitude; while in the Belgian sand-dunes (from data given by Massart) it is greatest (100) under the excessive and narrow ecological limits of the moving dunes, and least (73) under the more varied conditions of the *pannes* (salt marshes). From his analyses Jaccard draws the following general conclusions. The distribution of plants, at any rate in the alpine zone, is a resultant of the combined action of three kinds of factors: ecological biological (degree of adaptation), and sociological (competition between species). The action of these factors has resulted in two kinds of selection: an eliminative selection of species and a distributive selection, determining the number of individuals and the nature of associated species. Readers interested in the subject should consult the *New Phytologist* paper for details of Jaccard's interesting investigations.

A DARK-GROUND ILLUMINATION STUDY OF PLANT CELLS.—Until about ten years ago the method of dark-ground illumination with the microscope was regarded simply as a means of exhibiting objects with pretty and striking effect, and even now much less use has been made of the method in the investigation of the plant cell than might have been anticipated. In a recent paper Price (*Annals of Botany*, Volume XXVIII) gives the results of his examination of various plant cells, made with the object of seeing whether, by this method, more facts might be obtained concerning the colloid structure of the living and the dead cell and the reäctions of the colloid. He gives a brief account of the necessary procedure, suitable objects for study, and so on, and the paper will be found very useful by others wishing to examine plant cells by this method. The objects used were chiefly filamentous algae, spores, and hairs; and in his summary the author points out that the method often reveals new structural features, and is useful in establishing the presence of minute particles, which are difficult to see or are unresolved in direct illumination, though the method is restricted in application, owing to the difficulty of selecting suitable material for examination. It is generally recognised that protoplasm is a colloidal complex existing both in the hydrosol and the hydrogel state, a hydrosol being a colloidal solution—differing from an ordinary solution essentially in consisting of particles suspended in a continuous medium —while a "gel" is a sponge-like body in which the continuous phase encloses the other phase in a mesh of cavities. To a certain extent, these states are spontaneously reversible. The process of germination of certain fungus spores showed the gradual conversion of the gel-contents of the spore into a hydrosol on absorption of water, while later on a formation of a gel may occur again. The nucleus and chloroplast are evidently specialised parts of the plasma, with a hydrogel structure; particles and vesicular bodies ("sap particles"), usually present in the cell-sap and showing a continuous Brownian movement, were found to increase in number with decreasing vitality of the cell. The effects of plasmolysis were studied with different reägents, and it was found possible to distinguish an outer layer with much finer structure than the rest of the protoplasm, this layer being apparently the part concerned in the formation of the fine fibrils, which often connect the plasmolysed protoplast with the wall of the cell. A similar layer was also recognised on the inside of the protoplast against the vacuole. The action of fixing and coagulating agents was studied, and it was found that during fixation a change to an opalescent hydrogel takes place, the rate of formation and the structure of the gel differing in different plant material and with different agents.

CHEMISTRY.

By C. Ainsworth Mitchell, B.A. (Oxon), F.I.C.

GERMANY'S MOTOR FUEL.—Three recent issues of the *Zeitschrift für angewandte Chemie* which have recently come to hand by way of a neutral country show the straits to which Germany has already arrived from the shortage of petrol.

According to Dr. Hempel (page 521), Germany, in 1913, produced 179,800 tons of petrol and 160,000 tons of benzene (benzol), nearly a third of which was exported to France, while in the year 1912–13 the country's production of alcohol—mainly from potato starch—reached 3,753,265 hectolitres. Alcohol thus appears to be the natural substitute for petrol, and Dr. Hempel states that, by order of the Kaiser, all motor-cars in Berlin have been adapted to use alcohol as well as petrol.

The relative heats of combustion of the various possible fuels are as follows: Petrol, 9500 to 10,500; pure benzene, 10,260; commercial benzene (benzol), 9550 to 10,000; pure alcohol, 7402; ninety-five per cent. alcohol, 5875; and pure naphthalene, 9628·3 calories per kilogramme.

In practice a mixture of four parts of ninety-five per cent. alcohol with one part of benzene, containing two hundred grammes of naphthalene per litre, gave the same results as ordinary petrol; whereas the use of alcohol by itself tended to rust the tubes of the carburettor.

Dr. Dieterich (page 543) describes various mixtures of alcohol with benzene, commercial acetone, and petroleum oil as being suitable for motor engines, but points out that in each case preliminary heating of the carburettor and reduction of the supply of air are necessary.

Dr. Mohr (page 558) discusses the suitability of the various mixtures suggested by Dr. Hempel and Dr. Dieterich. In his experience only the simplest mixtures of alcohol with hydrocarbons have given satisfactory results. Thus he has found suitable for the purpose a mixture of alcohol and benzene in equal parts; or of alcohol, one half; benzene, a quarter; and petrol, a quarter. Naphthalene is an unsuitable ingredient owing to its forming crystalline deposits. Attempts have been made to use alcohol containing about one half per cent. of ammonium perchlorate, but these were unfavourable owing to the chlorine compounds formed in the explosion attacking the metal. All three chemists express their confidence that Germany will be able to produce sufficient alcohol for their motor engines, and that all mechanical difficulties can be overcome. They mention that about a dozen firms are now manufacturing carburettors specially adapted for burning alcohol and mixtures of alcohol and benzene. The addition of a small amount of motor oil is suggested as a means of preventing rusting of the tubes by the alcohol.

PROPERTIES OF NAPHTHENIC ACIDS.—The waste alkaline lyes from the refining of petroleum oils contain a large proportion of compounds which are known as "naphthenic acids." They can readily be separated by treating the lyes with a mineral acid, and, owing to the increasing scarcity of coconut and palm oils, are of growing importance for the manufacture of soaps, especially for such as will give a lather with salt water. Unfortunately, their use in this direction is restricted by their unpleasant odour, and attempts are being made in many directions to obviate this drawback.

In the last issue of *Les Matières Grasses* (1914, VII, 4115), M. E. Schmitz gives an account of his systematic experiments upon the deodorisation of the acids. He found that, by repeatedly treating them with dilute sodium carbonate solution, an insoluble compound of phenolic character, which showed the characteristic odour in an intensified degree, could be separated, while the final product had only a very faint odour. The dark, insoluble "oil" gave an intense bluish-green colour with copper salts, and could be used as the basis of a lacquer for wood. Attempts to deodorise the naphthenic acids by hydrogen were unsuccessful, but treatment with ozone for about two hours reduced the odour to some extent, and could be used as a practical process after removal of the evil-smelling phenolic substances by means of sodium carbonate as described.

GEOGRAPHY.

By A. SCOTT, M.A., B.Sc.

MAPS AND PHYSICAL GEOGRAPHY.—In the *Geographical Journal* for January Mr. Alan Ogilvie discusses the utility of our available maps from the point of view of the physical geographer, and makes a number of suggestions regarding the ways in which they might be made more useful. As it has not been found possible, so far, to combine the virtues of the different editions of the Ordnance Survey maps, all editions should be kept on sale. Similarly, atlases of land-form types, on one-inch and six-inch scales, would be of great service to teachers. The chief defect of geological maps, from the geographer's point of view, is that it is often impossible for the non-geologist to determine from such maps the lithology of the district, and this can only be remedied by the preparation of lithological maps. Other things which might be indicated on these maps are the porosity and comparative resistance of the various strata. In the investigation of land forms, much useful information could be obtained from maps showing what processes have been most effective, and also the stage of maturity at which the various features have arrived. In connection with water supply, it is suggested that not only might the different types be cartographically indicated, but also the variation of headwaters and river volumes. Other phenomena which might lend themselves to more accurate mapping than they have hitherto received are meteorological conditions, vegetation, and oceanographical and soil-survey data.

GEOGRAPHY AND STRATEGY.—There are two principal ways in which geographical conditions affect strategy: one with regard to lines of advance and the other with regard to obstacles. The former are determined by the occurrence of level country or of "defiles," such as river valleys. According to Hilaire Belloc (*Geographical Journal*, January, 1915), obstacles are of five types: rivers, including canals, forests, hill country, deserts, and marshes. Rivers are never permanent obstacles, though they may have a great tactical value temporarily, such as the Ourcq had during von Kluck's retirement. Forests are serious obstacles unless there are numerous defiles, an example in the present war being the Forest of Argonne. Hills vary in importance, and at one period those along the Aisne proved invaluable to the German Army. As campaigns have seldom been carried out in deserts, there are few data from which to deduce the value of such country. Marshes provide the greatest obstacle of all, as it is practically impossible to entrench in them. This has been well shown by the campaign in the Yser district.

GEOLOGY.

By G. W. TYRRELL, A.R.C.Sc., F.G.S

PERMO-CARBONIFEROUS BRECCIA OF ENGLISH MIDLANDS.—The chief exposures of this deposit occur near Birmingham. It consists of sandstones and marls, with occasional sheets of very angular breccia, which is formed of blocks of volcanic rocks, grits, slates, and limestones identical with rocks from the Welsh border. This puzzling deposit has been variously ascribed to volcanic, glacial, or lacustrine agencies; but H. T. Ferrar, in a paper read before the British Association, Australia, 1914, shows that it closely resembles certain desert formations. He instances especially the material which partially fills the wadis, or steep-sided gorges, of the folded mountain-chain forming the watershed between the Nile and the Red Sea. "The climate is arid, with occasional heavy thunderstorms, causing temporary currents, which sweep forward all rock material loosened during the prevailing dry climate." This material is very angular and fresh, and, in slipping down the hillsides, or in course of violent water transport, the blocks are frequently scratched, grooved, and even shattered by mutual impact. Huge blocks may be carried as much as a hundred miles down the wadi channels by water, and hence it is not necessary to invoke the agency of ice to explain the occurrence of large blocks in similar deposits. The valley-fill of most wadis in the Eastern Desert of Egypt is an unconsolidated breccia, so similar to that of the Permo-Carboniferous in the English Midlands that there can be little doubt that the two originated under similar climatic conditions.

METEOROLOGY.

By WILLIAM MARRIOTT, F.R.MET.SOC.

THE WEATHER OF FEBRUARY.—February is the last month of winter, and extremely variable in character. There is an old proverb:

> "February fill dyke, be it black or be it white;
> But, if it be white, it's the better to like,"

but more recent observations tend to set aside the old proverb. In severe winters the frosts of the two previous months continue, or return with great intensity; while on several occasions the greatest cold of the year has occurred in this month. It was a very cold month in the years 1845, 1855, 1886, and coldest of all in 1895. It was a very mild month in the years 1850, 1867, 1869, 1872, 1877, 1903, and 1914.

The average mean temperature at Greenwich for February is 39°·5; in 1869 it was as high as 45°·6, while in 1895 it was as low as 29°·1. The average maximum temperature is 45°·2; the highest mean was 51°·8, in 1869, and the lowest 35°·2, in 1895. The average minimum temperature is 34°·3; the highest mean was 39°·7, in 1869, and the lowest 22°·8, in 1895. The absolute highest temperature recorded was 63°·9, in 1899, on the 10th, and the absolute lowest 6°·9, in 1895, on the 8th. The average number of days on which the temperature falls to or below the freezing-point is ten. In 1895 the temperature was continuously below the freezing-point for seven days, from the 5th to the 11th.

The average rainfall for the month of February is 1·52-in.; the greatest amount was 4·03-in., in 1866, and the least 0·04-in., in 1821. The heaviest fall in one day was 2·89-in., in 1831, on the 7th. The average number of "rain days" (*i.e.*, on which 0·01-in. fell) is 12·4; the greatest number of days was twenty-two, in 1893, and the least three, in 1857. Snow falls on the average on three days. The average amount of bright sunshine in the City of London is thirty-one hours, but at Kew Observatory, Richmond, the amount is fifty-six hours.

The average barometric pressure for February is 29·972-in.; the highest mean was 30·473-in., in 1891, and the lowest mean was 29·499-in., in 1776. There is thus, in the neighbourhood of London, a variation of nearly an inch in the monthly means. The highest recorded reading in the British Isles was 31·007-in. at Gordon Castle, Banff, in 1808, on the 24th.

From a discussion of the results of the observations in England and Wales during the thirty years 1881–1910 it appears that when the barometric pressure is high in February it is usually followed by low pressure in March, and *vice versa*; and that a wet February is usually followed by a dry March.

"If Candlemas Day * be fair and bright,
Winter will have another flight;
But if Candlemas Day bring clouds and rain,
Winter is gone and won't come again."

* February 2nd.

RELATIVE HUMIDITY IN ENGLAND AND WALES.—At the December meeting of the Royal Meteorological Society Mr. W. F. Stacey read a paper on "The Distribution of Relative Humidity in England and Wales." He had prepared mean monthly and annual maps of relative humidity based on the 9 a.m. dry and wet bulb thermometer observations made at over ninety stations during the ten years 1901–10. An examination of the maps shows that in winter the air over the interior of the country is more moist than that over the coastal regions; that the minimum relative humidity occurs earlier in the year in the western parts of the country than in the eastern; that in summer the air over the interior of the country is drier than that over the coastal regions; and that the smallest range of humidity is found in the west and the greatest in the interior towards the east. The distribution of temperature is the chief determining factor in the distribution of relative humidity; while sea influence, the direction and character of prevailing winds, the configuration of the country, all have important effects on temperature, and therefore on relative humidity.

MICROSCOPY.

By J. E. Barnard, F.R.M.S.

THE MICROSCOPE AND THE WAR.—That there is any connection between the microscope and the present disastrous European War is not immediately apparent. A little deliberation, however, will show that both the use and the production of microscopes commercially are seriously affected. If we consider the matter from the point of view of production, it is quite clear that the number of instruments available at the present moment is not so great as formerly. A very large number were previously imported from the Continent—principally from Germany—and these are not now obtainable. On the other hand, the use of the instrument has been restricted, so that the demand in general is not so great. British manufacturers have no doubt, to some extent at least, stepped into the breach, and are producing to the utmost of their capacity. This, however, does not mean very much, as nearly all manufacturing opticians are fully occupied in making optical instruments of various sorts for Army purposes. In some respects the position of the microscope industry is analogous to the aniline dye trade. The microscope in its earlier days was almost entirely a British production, whereas it has, to a large extent, especially on its optical side, passed into the hands of Continental makers. If we read through the earlier numbers of *The Journal of the Royal Microscopical Society*, it is evident that about thirty to forty years ago, when the microscope was in course of development, British makers were in the very front rank. The influence of their design and method of construction is still largely felt; in fact, it is not too much to say that at the present time, if a microscope of the very finest construction is wanted, it is still possible, and perhaps even advisable, to get one of British manufacture. One of the features of the Continental instrument has been its simplicity; and in this respect there is something to be said for it; but in evolving such a type, Continental makers have striven more for cheapness than to provide an instrument that is thoroughly efficient. If we take the outstanding characteristic, for instance, of the Continental stand, the horseshoe foot, we are at once confronted with a design which has nothing much to recommend it; whereas the British type of tripod foot is in every respect more stable, and a better method of support in whatever position the instrument may be used.

The sub-stage, which is now recognised as of primary importance, the Continental makers have reduced to its simplest proportions, and in some respects have made it almost a useless feature of the instrument owing to the lack of centring adjustment. The British manufacturers have never been behindhand in this particular, and their instruments of the better class have been such that one might use them for the most exacting work.

That most of the improvements in microscope design have been of British origin is a matter of common knowledge, and it is only necessary to consult the earlier literature of the subject to realise this. It is hoped, therefore, that British makers will not lose the opportunity that has presented itself, of recovering at least a large part of the trade that they have lost, and that they will set themselves to so deal with the matter that when competition arises again there will be real strength behind it to meet every possible contingency. That the Continental makers, particularly those of Germany, have not relied on cheap labour, but on specialisation and systematic methods of production, is beyond question; and unless the British makers are prepared to launch out and do their part in this direction there is perhaps little hope for them in the future. So far as the optical side is concerned, Continental makers have been very much to the fore. It is no uncommon thing for a microscope of best British design and manufacture to be fitted with objectives of Continental make, and that, not because they are cheaper, but rather because they are better in quality, the price in some cases being substantially higher than those of British origin. In this respect it is somewhat reassuring to know that at least two British firms are making a feature of apochromatic objectives, and there is little doubt that these will be in every respect equal to those from the Continent. When the apochromatic objective was first brought out there was a very definite distinction between it and the achromatic object which had been in general use up to that time. Even now the difference between the true apochromatic objective and the ordinary objective is a fundamental one, although there are many objectives which do to some extent bridge the gap. A lens may be very well corrected, in the sense that some are described as semi-apochromatic, but it does not give it those exact qualities which the apochromatic objective should possess. That British makers are able to comply with the conditions is beyond question, and it is to be hoped, now that the Continental supply is stopped, users in this country will realise that the production of the best optical firms here is likely to be equal in every respect to that of Continental origin.

THE CARE OF A MICROSCOPE.—It is no uncommon thing, particularly in laboratories, to see an ordinary duster or some other dirty cloth used for cleaning lenses or other optical parts of a microscope. This is a most pernicious habit from every point of view. Nowadays the polish on optical surfaces is of a high order, and anything which tends to destroy this polish interferes with the perfection of the image, and causes loss of light. If linen is used for cleaning purposes, it should be old, and must be thoroughly washed before use, so that it is cleansed from all dirt and grit. A better method, particularly when working with oil-immersion objectives, is to use Japanese rice paper, which is now easily procurable, and is very soft and clean. A small piece of this may be torn off, and the lenses carefully wiped with it and the piece thrown away. This will be found less expensive, less troublesome, and more effective than using linen or cloth of any description. Any optical parts, even if temporarily out of use, should not be left uncovered on the working bench. For this purpose an ordinary glass may be inverted and placed over the lens, or a small bell jar, purchasable for a few pence, may be used. The brass cases for objectives should always be laid on the bench with both bottom and top inverted, so that no dust can enter.

THE QUEKETT MICROSCOPICAL CLUB.—The five hundred and fourth ordinary meeting of the Quekett Microscopical Club was held on Tuesday, January 26th, at 20, Hanover Square, W.; the President, Professor Arthur Dendy, D.Sc., F.R.S., in the chair. Three gentlemen were elected members, and four others were nominated for election. The names of officers nominated by the Committee for the ensuing year were read, being substantially the same as at present, with Professor Dendy again as President. The members proposed the names of gentlemen to serve on the Committee to fill the vacancies caused by the retirement of senior members. The ballot will take place at the annual meeting.

Vice-President Professor E. A. Minchin, M.A., F.R.S., then gave a paper, " Notes on Flea Anatomy." He said that, although the main purpose of his researches was to trace the development of the Trypanosomes found in the rat flea, having with the help of a friend dissected about one thousand seven hundred fleas, it was inevitable that an intimate knowledge of the minuter structure should be acquired. He then described the instruments and the methods employed, and gave a full account of the anatomy and histology of the internal organs, comprised under the following heads: (1) Notes on the abdominal nervous system, showing the curious difference between the male and the female; (2) on the male reproductive system; (3) on the female reproductive system; (4) on the stellate muscle-cells of the oesophagus. The lecture was of a most interesting character, especially to the audience to whom it was addressed, appealing particularly to microscopists. It was illustrated by lantern diagrams thrown on the screen, and by a series of beautiful micro-preparations exhibited under microscopes on the table. These slides Professor Minchin has presented to the Club, and they will be added to the cabinet for the future use of members. Professor Dendy made a few appreciative remarks, and proposed a vote of thanks to the lecturer, which was heartily accorded by acclamation.

The next ordinary meeting will take place on Tuesday, February 23rd, when, after the usual business of the annual meeting, Professor Dendy will deliver the Presidential address, his subject being " The Biological Conception of Individuality."

J. B.

PHOTOGRAPHY.

By Edgar Senior.

THE ELIMINATION OF THE SOLUBLE SALTS AND " HYPO " FROM THE GELATINE FILM.—In these days of hurry and scurry there is a growing tendency to give but little attention to the fixing and washing of negatives and prints. With the idea of saving time, they are often imperfectly fixed, and still more often imperfectly washed. Many workers appear to lose sight of the fact that it is false economy to withdraw either negatives or prints too soon from the fixing bath, as, when properly fixed, they can be freed from soluble silver salts and " hypo " much more rapidly than otherwise would be the case. As already pointed out in these columns, it is a good plan to use two fixing baths, the second one ensuring a complete conversion of the silver salts into the soluble variety, which readily diffuse out in the washing water. Of the various processes through which a negative passes it can be said that there are few of greater importance than thorough washing, for unless this be properly done endless trouble will arise in any after treatment that may be found necessary. Then, again, although there are many excellent washers on the market, the amateur often makes use of some domestic utensil, which is quite unfitted and unsuitable for the purpose. In any case, whatever kind of appliance be employed for washing, it should be borne in mind that, as the " hypo " and silver salts leave the film, their weight causes them to sink to the bottom of the vessel, whence they should be rapidly syphoned away.

FUGITIVE SILVER PRINTS.—It is often stated that silver prints made years ago were more permanent than many produced of late, some of which show signs of fading after a few months. As an explanation, the class of negative used has generally been taken into account, as in the early days the negatives employed were much denser, the printing paper (albuminised) was salted in a strong bath, and the printing carried to a greater depth and more gold deposited in toning. Then, again, the washing was more thorough, and performed more quickly. Long washing degrades the brilliancy of the prints. The old method of working was to wash the prints in large dishes alternately in cold and warm water, well draining between each change, the prints by this method being practically freed from " hypo " in about twenty minutes. Then the prints were made from denser negatives upon paper sensitised with a strong silver bath, and fixed in a stronger fixing bath—in many cases in two fixing baths—and then quickly washed; and to treatment of this nature has been ascribed the secret of their permanence. It has also been found that prints which are thoroughly fixed, but imperfectly washed, are more permanent than those that have received a thorough washing, but have been imperfectly fixed. There is little doubt, however, that the mounts employed have, in many cases, been the cause of fading: among prints in the possession of the writer, made upon albuminised paper, some mounted and others unmounted, it is usually the mounted ones that have faded the most. When gelatino-chloride paper was first introduced we were told that, in a very short time, it would entirely displace albuminised paper, and that the prints made upon it would be permanent; the latter claim, however, has not been realised in practice. Prints made upon gelatino-chloride papers when carefully worked do appear to be more permanent than those made upon the older albuminised papers, but it would be incorrect to call them permanent. The degree of permanence appears to depend to a considerable extent upon the method of toning adopted. In our own practice we long ago discarded the combined bath, and always resort to separate toning and fixing, making up the toning bath the moment before it is wanted, being careful not to be too sparing of gold, as it is in the use of this in sufficient quantity that the secret of obtaining good tones lies. If, after toning, the prints are fixed in two separate fixing baths, consisting of three ounces of "hypo" dissolved in twenty ounces of water, and afterwards rapidly washed, good prints should be obtained, possessing a reasonable amount of permanence.

RESTORING FADED SILVER PRINTS.—According to an account by Professor Namias, recently published in the *Photographische Korrespondenz*, faded silver prints may be restored by means of the following treatment. The prints are first bleached in a solution of—

Copper Sulphate	5 grains
Common Salt	25 ,,
Water	1 ounce

The bleached image, consisting of silver chloride, is then well washed, and may be darkened by redevelopment with any of the ordinary developers. The greatest vigour is, however, according to Professor Namias, obtained by the use of sodium stannate. For this purpose a one-per-cent. solution of stannous chloride is taken, and a ten-per-cent. solution of caustic soda added until the precipitate first formed is just redissolved. The print is then placed in this until darkened, after which it is well washed.

PHYSICS.

By J. H. Vincent, M.A., D.Sc., A.R.C.Sc.

FABRY AND PÉROT'S INTERFEROMETER.—This instrument is of exceedingly simple construction, and consists essentially of a pair of flat pieces of glass. The glass plates are placed with two surfaces separated from each other by a layer of air, the opposed surfaces being partially silvered. The silvering can be best carried out by cathodic deposition. The surfaces of the plates, which are to be silvered and placed facing each other, must be absolutely true planes, and, when mounted, adjustments must allow them to be brought accurately parallel to each other. In the interferometer the distance of the glass plates from each other is capable of adjustment, while in another form of the apparatus this distance is fixed. When truly monochromatic light passes through the plates, the layers of silver, and the air gap, it does so in a number of ways. One portion goes straight through, another is reflected from the second layer of silver, then from the first layer, and then goes on to join the first portion. The second part of the light has thus been reflected twice; the first has suffered no reflection. A third portion comes through the plates after four reflections, a fourth after six reflections, and so on. The different portions into which the light is divided will conspire together if the increase in length of path for the successive parts is an exact whole number of wave-lengths, so that, if the plates be viewed with a telescope focused on infinity, a system of circular interference bands will be seen. The bands are due to the obliquity of the paths of all the rays except those striking the plates normally. If now the light is nearly, but not quite, monochromatic; if, for instance, it consists of light of two different but closely approximating wave-lengths, two systems of fringes will be formed, one for each kind of light. Thus the apparatus is a true spectrometer, and can be used to separate the components of spectral lines.

APPLICATIONS OF FABRY AND PÉROT'S INTERFEROMETER.—The instrument has been used by Fabry and Pérot in the investigation of the intimate structure of spectrum lines. Thus they showed that the green line of thallium was triple, the main line having two weak companions towards the red end of the spectrum, and measured the differences between the wave-lengths accurately: the red cadmium line was proved to be simple. Another application was for the exact comparison of widely differing wave-lengths; in these experiments the half-silvered plates were separated by as much as 3·2 centimetres.

THE ÉTALON INTERFEROMETER.—In 1902 Fabry and Pérot began to use a modified form of their interference apparatus, which they term an "étalon," or standard. This is derived from the more elaborate form by removing the facilities for altering the distance between the plates, which are held at a fixed distance apart by three pieces of invar. This material is practically inexpansible by heat, so that, when once the distance separating the plates has been measured, it is capable of being treated as sensibly constant. The fine adjustment for parallelism of the silvered plates is made by springs, which can be pressed down by screws on to the plates over the distance pieces, which, by their compression, enable their effective thickness to be varied. One method of calibrating the étalon is by comparison with the air film of an interferometer whose plates can be gradually separated. The measurement of the thickness having been carried out, the étalon can be used to determine an unknown wave-length. By its means many lines in the spectra of the metals and in the solar spectrum have been accurately measured, these results being now regarded as more reliable than those found by other methods.

DIATHERMY.—An interesting series of articles on the use of high-frequency electric currents for the production of heat in the body of a patient appears in recent numbers of the *Archives of the Röntgen Ray*. The author (Dr. Cumberbatch) is in charge of the electrical department at St. Bartholomew's Hospital, and thus the information may be regarded as authoritative. The electric current provides a unique method of supplying heat to the deep tissues of the body; other methods of heating the body act on the skin. When high-frequency current is employed no pain is felt, no muscular contraction is produced, and no sensation other than warmth is perceived, even when the current reaches the root mean square value of from two to three amperes. D'Arsonval showed in 1891 that a current of three amperes could be passed through the human body with impunity, provided that the frequency of alternation was great. Currents of such strength had not been used previously in electro-therapeutics; and, as they became better known, it was soon evident that the curative effects which followed their use were due to heat; hence the term "diathermy," to distinguish the method from the older ways of applying high-frequency currents in medicine. The apparatus for the production of the currents used in diathermy consists of two transformers, the first to raise the alternating current from the mains to a few thousand volts. The secondary current from this first transformer charges a condenser, which is discharged through a spark gap and through the primary coil of the second transformer. The oscillations of the current in this condenser circuit have a frequency of the order of a million a second, and produce in the secondary of the second transformer the current (of the same frequency), which is passed through the patient. The design of the apparatus is such that the current which heats the tissues is, as measured on a hot-wire ammeter, adjustable from zero up to two or three amperes. The spark gap is of a very special construction. It has, in one form of the apparatus, a double gap, each a quarter of a millimetre in length, the spark occurring between the opposed faces of polished silver plates. The sparks take the form of blue films that occupy the air space between the discs. The intervals between the successive trains of high-frequency oscillations are very small, so that the blue film appears to be continuous to the eye; the discharge is accompanied by a hissing sound. The diathermy current is led to the electrodes, which are in contact with the patient by short, well-insulated, flexible leads, the contacts made with the body by the electrodes being moistened with salt solution. The frequency of the oscillations is not exceedingly high; and, since the resistance of the tissues is great, the current is not confined to the outer parts of the conducting tissues, as would occur with better conductors and higher frequency. The electrodes and currents can be arranged so as to cause a rise of temperature of a few degrees only, or the electrical heating may be concentrated on a portion of tissue which it is desired to coagulate and destroy. When the former method of application is employed the whole body is heated, and the skin becomes bathed in sweat, owing to the convection of the heat by the blood. Some interesting experiments are described, in one of which albumen is coagulated in the space between the electrodes connected to the diathermy apparatus, and in another a cube of raw meat is charred. Two disc electrodes, one inch in diameter, are placed on opposite sides of the cube. A central bridge of meat is soon cooked, and is finally charred.

RADIO-ACTIVITY.

By Alexander Fleck, B.Sc.

MEDICAL USES FOR RADIUM.—Early in the history of radio-activity it was discovered that the rays produced by atomic disintegration had some effect on the tissue of organisms, and in recent years many in the medical profession have turned their attention to directing such effects to alleviate and cure various diseases. In some forms of disease, such as rodent ulcers, a cure may be confidently expected, provided that sufficient quantities of radium are used. In other and more serious diseases, as, for example, cancer, it is not yet possible to say that a complete cure can be looked for. It seems, however, that the malignancy of the disease is mitigated by the application of radium, and often a cure lasting for a number of years has been obtained. Although the disease may recur, it does not necessarily follow that it will do so. The position taken up by the London Radium Institute and most medical men is that, whenever the cancer is at all operable, an excision is made, and the radium treatment reserved for inoperable cases. Considerable hope is entertained that, by judicious combination of radium treatment and excision, cancer will soon cease to be the terrible scourge that it is at present.

London, of course, has had for some years now a large quantity of radium available for medical purposes, and several other cities in the United Kingdom have recently purchased quantities to be set aside for use in the treatment of disease.

RADIO-ACTIVITY AT THE BRITISH ASSOCIATION.—In the issue of *Nature* for November 26th a report is given of the proceedings of Section A (Physical) of the meeting in Australia, and it seems that pure radio-activity occupied a minor position, while the allied subject of radiations in general was discussed in a number of important aspects. From the point of view of the radio-active chemist, the most interesting was a joint discussion with the Chemistry Section on the structure of atoms and molecules. Professor H. E. Armstrong seems to have been the chief representative of chemistry, and contributions were made by Sir E. Rutherford, Professor Nicholson, Mr. Moseley, and others. Professor Hicks dealt with the subject from the spectroscopic point of view, and stated that neither by the Thomson nor the Rutherford atom is it easy to explain the spectra of the elements. The real atom seems to be something more complicated than either of these models. The meeting is said to have been more of a symposium than a discussion; and, while no new facts or principles of importance have been enunciated, the full report which it is promised will be published in the annual British Association volume will be awaited with interest.

FORMATION OF ACTIVE DEPOSITS.—Very shortly after the discovery of radium emanation it was found that if two metal plates, one positively and the other negatively charged, were placed for a few hours in a space available to this gas, the negatively charged plate became intensely active, whilst the positive plate had only a very small activity. The material that produces the activities so obtained is called the "active deposit."

It is easily proved that the emanation itself is not affected by the electric field, and that therefore it is electrically neutral. The emanation in its disintegration gives off an α-particle, carrying two positive unit charges, and therefore we should expect that the remaining part of the emanation atom (*i.e.*, after taking away positive electricity from a neutral body) would be negatively charged. If this were a complete explanation of the disintegration of the emanation, then the active deposit material would be attracted to the positive plate in place of being, as it actually is, collected on the negative plate. This anomaly is explained by the liberation of a number of low-speed negatively charged δ-rays by the α-particle in its passage through the atom. There remains, however, the question as to how the small quantity of active deposit is obtained on the positive plate, and this problem has been attacked in a number of papers which have recently appeared in the *Philosophical Magazine* (papers by Wellisch, Walmsley, and Lucian). The main conclusion in all cases is the same, namely, that when the A member of the active deposit (*i.e.*, the first disintegration product after the emanation) is formed, it always carries a positive charge, but that, just as in the case of an ordinary gas ion, in the course of diffusion it may recombine with another negative ion to become electrically neutral. When this happens this neutral particle will be deposited on the first surface that it meets. The small quantity of active deposit material referred to is therefore obtained from those particles rendered neutral by recombination which have chanced to come into contact with the positively charged surface.

SEPARATION AND PURIFICATION OF RADIUM.—In a uranium-bearing mineral the greatest possible amount of radium (except in very rare circumstances) that may be present is 3·23 parts of radium for every ten million parts of uranium, and the task of separating this very small amount of material is one that demands a considerable amount of chemical skill. As it is first separated, the radium is contained in a mixture of barium, lead, and other substances, of which the sulphate is comparatively insoluble. The concentration at this stage is usually about 0·2 to 0·5 of a milligramme of radium per kilogramme of material. This sulphate has then to be converted into some soluble salt, usually the chloride, sulphuretted hydrogen, and then ammonia added to the solution so obtained in order to remove elements of the lead and iron groups respectively. Finally, the radium is obtained in the filtrate from these elements along with the barium. At this stage the procedure is transferred from the works to a chemical laboratory, and the long process of fractionation is commenced. This consists in making a hot concentrated solution of the barium-radium chlorides, which is allowed to cool. It is found that the crystals that separate out are richer in radium than the material that remains in solution (usually in the ratio of 5 to 1). This process is repeated a great many times until finally pure radium is obtained. The physical chemistry of the process is very interesting, because it is usually taught that by crystallising a substance from solution a small quantity of impurity will remain in the liquid, and that the crystals will be pure. In the above case the exceptionally small quantities of radium present are concentrated in the crystals. It is found by experience that lead also accumulates in the crystals, and it has to be separated frequently by sulphuretted hydrogen or some other means.

In some Australian works this process is considerably modified, and an account was given during the course of last year by Radcliff to the Sydney Section of the Society of Chemical Industry, in which pure barium-radium chloride was obtained by saturating the solution obtained from the crude sulphates with hydrochloric-acid gas.

ZOOLOGY.

By Professor J. Arthur Thomson, M.A., LL.D.

CATERPILLARS' SETAE.—It appears that the description of "aërostatic hairs" on the caterpillars of the Gipsy Moth and Nun Moth was mistaken. The globular swellings at the bases of the hairs were supposed to be air reservoirs, facilitating dispersal by the wind. Riley showed some time ago that the swelling does not contain air, but fluid, and that there is a large glandular cell opening into it. It is probable that the fluid is poisonous, and protective against insectivorous birds.

FORMER CONNECTIONS OF ANTARCTIC CONTINENT.—In giving an account of the fishes collected by the British Antarctic ("Terra Nova") Expedition, 1910, Mr. C. Tate Regan, of the British Museum, has taken occasion to examine the evidence in support of the view held by many authorities that in the Early Tertiary the Antarctic Continent was connected with Australia and with South America. He comes very definitely to the conclusion that neither the freshwater fishes nor the marine fishes, whether Antarctic or South Temperate, support the theory that Antarctica has connected Australia with South America in Tertiary times. The evidence from other groups of animals seems to Mr. Regan to confirm the conclusion which he reached from his study of the fishes.

SHORE MITES.—Professor L. A. L. King's recent observations on some littoral mites on the shore near Millport Biological Station show how much interesting material is available to keen eyes. Thus, as to the feeding of *Gamasus* (*Eugamasus*) *immanis*, it is noted that the mite plunges its chelate chelicerae into the body of living Oligochaetes, tears out a piece, and sucks it dry. As Michael showed, the male inserts his mandibles into the genital opening of the female, and empties the contents of a spermatic capsule into the vagina. Of *Gamasus* (*Halolaelaps*) *glabriusculus* it is noted that it survived complete immersion in water for forty-eight hours. The large red Bdellid (*Molgus littoralis*) was seen feeding on a small living Dipteron. The smaller, more vivid, more gregarious *Bdella longicornis* probably feeds on the Collembolan *Anurida maritima*, common on the shore. This species of Bdella, as Mr. T. J. Evans, of Sheffield, has also noticed, spins a silken tent in autumn.

NUMBERING HAIRS.—Evidence of the definiteness of individuality is always interesting. We know of some simple animals which have always, or almost always, the same number of cells in particular parts of their body, and in their body as a whole, and Mr. Phineas W. Whiting has shown the same sort of specificity in the bristles on the back of the Green-bottle Fly (*Lucilia sericata*). He studied a group of twelve dorsal bristles, and found that the number is hereditary and the distribution likewise. There may be a few less or more, but only a few. Reduction rarely goes beyond the loss of two bristles in a single fly. Out of five thousand three hundred and sixty-seven flies bred, there was a reduction of 748·5 in the males and of 455·5 bristles in the almost equal number of females. There were two hundred and ten bristles added in the males, and three hundred and forty-three added in the females.

FREQUENCY OF PARASITES IN FISHES.—The clean and wholesome nature of the flesh of fishes is well known. Its relative freedom from parasites is noteworthy and of practical importance. But the number of parasitic worms found in the intestines, and in other parts of the food-canal, is enormous. Dr. W. Nicoll, one of the foremost helminthologists, has examined eight hundred and forty-five fishes (one hundred and two different kinds) from around our coasts, and has found eighty-one per cent. with parasites (of over fifty different kinds). Of four hundred and seventy-five fishes from Plymouth, three hundred and eighty (eighty per cent.) were infected: fifty-six per cent. with flukes, forty-four per cent. with tapeworms, forty-eight per cent. with threadworms, and two per cent. with Echinorhynchs. Millport fishes yielded the same percentage, St. Andrews fishes eighty-three per cent., and Aberdeen fishes ninety-one per cent. This large incidence of parasites is remarkable: it throws some light on the stern character of the struggle for existence. In most cases, probably, the parasites do little harm unless they reach a host unaccustomed to them.

THE MAN-OF-WAR INFUSORIAN.—A glimpse into the intricacy of things is afforded by E. Penard's description of a ciliated Infusorian, which he found in a marsh near Geneva, and names *Legendrea bellerophon*. The genus was established by Fauré-Fremiet, but the species, *bellerophon*, which we have translated "man-of-war," is new. It is from 120–180μ in length, and about a third as broad: it has a slit-like mouth, a horse-shoe-shaped nucleus, a large contractile vesicle, and many other features with which we are familiar in ciliated Infusorians. But the remarkable feature is that on each side of the somewhat man-of-war-shaped creature there project about ten papillae at regular intervals, like the guns from a frigate. Each of these papillae bears at its blunt extremity a group of stinging threads, or trichocysts, from which, again, very delicate, probably poisonous filaments can be protruded. Each papilla is like a mitrailleuse, and a very effective weapon. There are trichocysts on other parts of the Infusorian, but they explode only on the projecting papillae. In a very striking way they move or are moved to the bases of the papillae, and accumulate there, "waiting their turn" to pass up, or to be passed up, to the tips of the papillae. When the delicate filament is protruded from the exploded trichocyst a minute viscous drop of poison appears at its ruptured end. The well-armed Infusorian swims slowly, and is carnivorous. It is wont to attack a minute Rotifer called *Diplax trigona*.

ANIMAL HYPNOSIS.—When a Snake becomes a stick, or a Hen lies immobile on the floor with a chalk line in front of its eyes, or a Crayfish stands on its head, or a Ground-beetle (such as *Scarites buparius*) feigns death on being shaken, we have to deal with animal hypnosis. In a recent investigation Professor Mangold defends the position that animal hypnosis is analogous with human hypnosis, and on the physiological side the resemblance is certainly close. Mangold's definition of animal hypnosis is as follows: A reflex tonic inhibition of locomotion and position-adjustment, induced by a sum of afferent stimuli, resulting in a sleep-like state in which there may be great changes in muscular tonus (first increase, and then decrease) and decrease of sensitiveness to many kinds of stimulus, *e.g.*, of a painful sort. One of the many difficulties concerning animal hypnosis is its relative uselessness. It may perhaps be of service when a ground-bird, hotly pursued, squats motionless, or when a mammal "plays 'possum"; but even this has not been proved to be "hypnosis" in the strict sense, and in most cases among backboned animals the capacity is known only in the laboratory. Among Arthropods it is of great service in stick-insects, which pass into hypnosis under the stimulus of light, and simulate in their pose the twigs which they resemble in colour and shape. But in many cases the hypnotic state is readily assumed under various stimuli without any resulting utility being obvious. Very interesting is the case of the female Galeodes—a fierce and unapproachable creature—which passes into hypnosis when suddenly seized by the smaller and weaker male. It looks as if we had to do with a widespread capacity which persists as a concomitant of an effective nervous constitution, but is only now and again itself brought within the sphere of utility.

ADAPTATIONS OF THE PLANKTON.—Professor J. Graham Kerr discussed in a recent lecture the adaptations of the drifting animals of the sea. Macroplankton animals, illustrated by jelly-fishes, pelagic annelids, like Tomopteris, and Salps, often show transparency, or some coloration, which is a garment of invisibility. In the

Leptocephalus stage of the Eel the haemoglobin of the blood is actually suppressed. (It is noted, in passing, that red prawns from the deep dark waters are not " red " in their ordinary habitat, but simply dark. No red rays of light penetrate through the upper fifty fathoms, and an object cannot look red unless red rays of light are falling upon it.) Many of the macroplankton animals are phosphorescent, and the pattern of the lights may sometimes help in recognition. Sense-organs, *e.g.*, balancing organs, are well developed. Flotation is assisted in many ways, *e.g.*, by the gas in the internal shell of Sepia, or by the swim-bladder of fishes. Part of the lining of the swim-bladder can secrete oxygen, and another part can absorb the gas ; thus increasing or decreasing, as occasion demands, the internal pressure. Thus the fish is able to float at one level without effort.

In the microplankton, such as Radiolarians and Copepods, the problem of flotation may be solved by lessening the specific gravity of the animal, *e.g.*, by accumulating gelatinous material in jelly-fishes. Or there may be arrangements for giving increased effect to the viscosity of the sea-water. This may be brought about merely by diminution in the size of the creature, the ratio of surface to volume increasing with diminution of bulk, or by the development of spiny or feathery outgrowths. The viscosity is lessened with rise of temperature, and thus the arrangements just alluded to are especially well marked in the plankton of the warmer seas.

SEX RECOGNITION IN WOOD FROG.—Arthur M. Banta (*Biological Bulletin*, Volume XXVI) has tried to discover the method of sex recognition in *Rana sylvatica*, the wood frog. The males distinguish the females (from other males) at a short distance. There may be something in the differences of the sexes in swimming and in behaviour when approached, and possibly something in the differences in colour. But dead females are distinguished from dead males, and it is suggested that a chemical sense in involved. This should be made a subject of experiment. The males test every frog or moving object within a radius of several feet, and their cold-blooded ardour leads to a good deal of fatal " disharmony."

SHORE FAUNAS.—Professor A. S. Pearse distinguishes, at Nahant, Massachusetts, the rock beach, the sand beach, and the mud flats. The mud flats are marked by the lack of suitable objects for attachment (therefore no sponges, hydroids, and so on), and by the comparative impurity of the water (therefore adaptations for respiration, as in Mya, with its long siphon). The fauna of the sand beach is composed largely of burrowing animals and those which are continually being swept in. The rock beach is divided into : (1) the rocks above high-tide mark ; (2) the *Balanus* zone ; (3) the *Ascophyllum* zone, with *Sertularia pumila*, anemones, *Purpura*, *Littorina*, and so on ; (4) the *Fucus* zone, with *Mytilus*, *Balanus*, *Acmaea*, *Purpura*, *Littorina*, *Asterias*, and so on ; and (5) the *Chondrus* zone, most thickly peopled, with *Idothea*, *Acmaea*, *Asterias*, *Cancer*, *Metridium*, and various Bryozoa.

" Probably no other animal habitat is subject to such a wide range of fluctuations in environmental conditions as the rock beaches along the ocean. The flora and fauna must endure the frigid span of winter and the blistering sun of summer. There is no escape : the tide keeps up its eternal rhythm, and the organisms are left exposed to the elements every time the water recedes. The exposure of the hard substratum to sun, wind, and wave has developed a fauna which consists largely of animals that are : (1) attached permanently or have well-developed clinging organs ; (2) active and hard-shelled or (3) small and ubiquitous ; and (4) mostly very hardy, and able to stand considerable exposure." The animals that have these characteristics most developed have the widest distribution.

" The surface of the rock is a veritable sieve through which the microscopic organic content of the water disappears. The barnacles sweep it constantly with their fishing nets ; the carpets of clams siphon food into their depths from the turbid water ; Littorinas search every square inch, and sweep it clean ; wherever there is sufficient moisture the Coelenterates and Bryozoans spread their delicate tentacles to seize their share." There is keen competition for food and foothold ; it is a crowded battle-ground ; it has been a great school. It is interesting to compare Pearse's survey at Nahant with that made by Russell and King at Millport, on the Clyde.

REVIEWS.

BOTANY.

Practical Field Botany.—By A. R. Horwood, F.L.S. 193 pages. 22 plates. 26 figures. 8-in. × 5-in.

(Charles Griffin & Co. Price 5/- net.)

Mr. Horwood is doing a great deal to popularise the study of botany and to direct those who take it up into the right way. At the same time, his energies are being devoted to preserving, so far as is possible, our native flora from undue diminution or extermination. The present book will cater for those who are led to study plants through the now far-reaching nature-study movement. It deals with the scope, object, and aims of botany ; it describes the various methods of mounting plants ; it touches on wild flower tables, on museums which are stationary and peripatetic. It shows what is being done to encourage the study of botany ; and, after dealing with the life-history of a plant, occupies itself with ecology, or the association of plants together into what the author calls " formations " according to soil and situation. This is the kind of botany which appeals most strongly to the general lover of nature, and broadens the outlook of the systematic botanist. No one who reads Mr. Horwood's book can fail to find some suggestion of use and of interest. We heartily wish the work the success which it deserves, and commend it specially to the notice of nature-study teachers.

W. M. W.

CHEMISTRY.

Essays and Addresses.—By the late James Campbell Brown, D.Sc. 208 pages. 23 illustrations. 8¾-in. by 5¾-in.

(J. & A. Churchill. Price 5/- net.)

The work of Dr. Campbell Brown included both the academic and the professional side of chemistry ; for, in addition to holding the chair of chemistry in the Liverpool University, he was also a public analyst and a consulting chemist. The practical aspect of his work is reflected in the whole of these essays and addresses, which are for the most part of a utilitarian character. They include addresses to the Society of Chemical Industry on such subjects as " Technical Chemistry " and the " Ethics of Chemical Manufacture " ; biographical sketches of great chemists ; and historical papers, such as " Chemistry in Liverpool in 1801."

All of these papers are very readable, even by those without any knowledge of chemistry, especially the last two on " Analytical Chemistry as a Profession " and " Science Applied to the Detection of Crime," which are characterised by their sound common sense and keen humour.

Some of the opinions, however, are open to criticism. For example, it seems to us that there is some justification for the public attitude towards mistakes made by an analyst, against which Dr. Brown protests in several places ; as, for instance, on page 202 : " The public cannot forgive a mistake in an analyst. A doctor makes a mistake, and buries it. A lawyer makes a mistake, and is paid for it as highly as if he had not. A clergyman makes a mistake, and it is discovered only in the next world. But if an analyst makes a mistake, he is condemned. He has committed the unpardonable sin."

The difference between the analyst and the other professional men cited is that he makes assertions as to matters of fact, whereas the physician, lawyer, and clergymen may express opinions. If the analyst can be shown to be wrong, this mistake is regarded by the public as of the same kind as that of the dentist who pulls out the wrong tooth, or the surgeon who makes a cut in the wrong place. In both of these instances a court would award damages to the victim.

C. A. M.

The Elements of Chemistry.—By H. L. Bassett, B.A., B.Sc. With an introduction by Professor W. J. Pope, M.A., F.R.S. 368 pages. 32 illustrations. 7-in. × 5-in.

(Crosby Lockwood & Son. Price 4/6.)

Professor Pope points out very cogently in his introduction that most scientific professions demand some elementary knowledge of chemistry in more than one of its divisions, although a student's work may subsequently have only an indirect connection with the science. It is with the needs of the medical student more especially in view that this book has been written, and it should prove of the greatest service to those who are preparing for the examinations of the Conjoint Board. It is divided into the four sections: General and Physical Chemistry, Inorganic Chemistry, Organic Chemistry, and Practical Chemistry. Obviously it is impossible within so limited a space to go very thoroughly into any of these branches, but the book gives a useful summary, and for those who are not working for examinations it could well serve as an introduction to larger treatises. It would be an advantage, from one point of view, if the practical work were distributed throughout the other sections, instead of being put at the end of the book. The theory of chemistry should be supported, not crowned, by experimental work.

C. A. M.

The Chemistry of the Radio-Elements (Part I).—By Frederick Soddy, F.R.S. 151 pages. 3 figures. $8\frac{3}{4}$-in. × $5\frac{3}{4}$-in.

(Longmans, Green & Co. Price 4/- net.)

Part II of this book was issued in 1914, as a result of important advances then made; to supply the demand consequent on the interest created in the subject by those advances, it has been necessary to publish a new edition of Part I. The new edition has not only been brought up to date, but has been enlarged, and almost completely rewritten. The fact that this new edition of Part I has been called for is testimony that the scientific public has realised to a great measure the advances that were outlined in Part II.

The book may be roughly divided into two halves, the first of which deals with the general principles involved. In the latter half the chemistry of the radio-elements is described systematically. With regard to the first half, we feel sure that, to any reader who wishes to become acquainted with the broad facts and principles of radioactivity from the physical as well as the chemical standpoint, no better summary could be recommended, provided that he possesses a knowledge of chemical laws and of the elementary facts of general science. The second half of the book will be of greater use to the person engaged practically in radio-active work, and the author's great experience in this direction has enabled him to make this section of the greatest value for use in the laboratory.

The chapter on the "Adsorption, Electro-, and Colloido-Chemistry of the Radio-Elements" is exceptionally interesting, and contains a number of suggestions for further work.

A. F.

EVOLUTION.

Mutual Aid: A Factor of Evolution.—By P. Kropotkin. Popular Edition. 240 pages. $7\frac{1}{4}$-in. × 5-in.

(William Heinemann. Price 1/- net.)

The issue of a cheap popular edition of Prince Kropotkin's well-known book, "Mutual Aid," is particularly to the point at the present moment. It has been suggested that the wholesale destruction of life among non-combatants and the pillage of their means of subsistence in the present war is part of the ordinary "struggle for the existence." Prince Kropotkin's book, dealing as it does with mutual aid amongst human beings, supports the protest which has been made against such an abuse of Darwin's terminology.

For those who are unfamiliar with "Mutual Aid" we may add that it describes co-operation among animals, among savages and barbarians, and with the craft guilds of the mediaeval city, in addition to more modern instances.

W. M. W.

FARMING.

Impurities of Agricultural Seed, with a Description of commonly occurring Weed Seeds and a Guide to their Identification.—By S. T. Parkinson, B.Sc., and G. Smith, B.Sc. 105 pages. 152 illustrations. $7\frac{1}{2}$-in. × 5-in.

(Headley Brothers. Price 3/- net.)

In few walks of life is the necessity for organised knowledge at the present time greater than in farming. The agriculturist has learnt, or is beginning to learn, that in the case of many plant diseases there is no cure, and that he must rely entirely upon prevention. Though weeds can be got rid of, the task is often a difficult one, and here it is possible to avoid one common cause of their introduction. This is by taking care not to sow seed which is impure. Before, however, a farmer can tell what weed-seeds occur among those which he is buying, he must have some knowledge of the subject. Messrs. Parkinson and Smith are therefore to be congratulated warmly on having produced a very useful book. The introduction is very concisely and simply written, while the large number of reproductions of photographs of weed-seeds, of which we are courteously permitted to reproduce a few in Figures 50 to 58, will be a very great help, not only to the farmer, but to the seed specialist. There are one hundred and fifty-two of them in all, and each is accompanied by a brief description giving the size of the seed in fractions of an inch and in millimetres.

W. M. W.

GEOLOGY.

Engineering Geology.—By H. Ries and T. L. Watson. 672 pages. 104 plates. 225 figures. 9-in. × 6-in.

(J. Wiley & Sons, New York; Chapman & Hall, London. Price 17/- net.)

Geological conditions affect many engineering operations, especially in railway construction, tunnel driving, reservoir building, and works for the prevention of coast erosion, improvement of rivers, and water supply. Geological considerations also affect the selection of building stones, road metals, cement materials, and clays, as well as the materials such as coals and ore deposits, the mining of which has long been recognised to have a geological basis. There has long been a need for a work dealing with geology from this practical point of view in its relation to various phases of industrial activity. The book under review supplies this need very satisfactorily. The authors throughout emphasise the practical application to engineering of all the topics treated. The book is intended primarily for civil engineers, but it will be found of considerable value to others interested in applied geology.

The first three chapters deal compactly but quite effectively with the mineralogy and petrology necessary to complete comprehension of the subject. They are followed by chapters dealing with structural features and meta-

Figure 50. Charlock. (*Brassica sinapis.*) × 10.

Figure 51. Hare's Ear. (*Bupleurum rotundifolium.*) × 10.

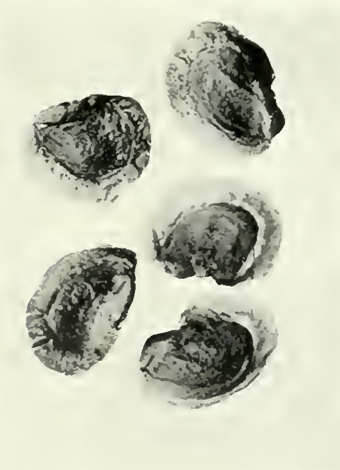


Figure 52. Yellow Rattle. (*Rhinanthus Crista-galli.*) × 4.

Figure 53. Wild Radish, Runch, (*Raphanus raphanistrum.*) × 4.

Figure 54. Ox-tongue. (*Helminthia echioides.*) × 10.

Figure 55. Cat-mint, Cat-nip. (*Nepeta Cataria.*) × 10.

Figure 56. White Campion. (*Lychnis alba.*) × 10.

Figure 57. Ivy-leaved Speedwell, (*Veronica hederaefolia.*) × 4.

Figure 58. Curled Dock. (*Rumex crispus.*) × 10.

THE SEEDS OF COMMONLY OCCURRING WEEDS.

(From "Impurities of Agricultural Seed," by S. T. Parkinson and G. Smith. By the courtesy of Messrs. Headley Brothers.)

From a photograph *by Alfred E. Tonge, F.E.S.*

FIGURE 59.

Six-belted Clearwing ♀ on flower of thrift. (*Sesia ichneumoniformis.*)
Natural size.

By the courtesy of *Wild Life.*

morphism of rocks, and with rock weathering and soils. Chapters V to X deal more directly with the practical aspects of geology in relation to surface and underground waters, land slides, waves and shore currents, lakes and glacial deposits. The remaining chapters demonstrate the importance of geological principles in the winning and selection of building stones, limes, cements, plasters, clays, coals, petroleum, road metals, and ore deposits.

The book is illustrated with one hundred and four excellently selected and well-executed plates and two hundred and twenty-five figures, some of which are open to criticism. Thus Figure 73, which, according to the designation, is intended to show monoclinal attitude of strata, shows simple dip, and is, moreover, not referred to in the text. In Figure 74 the shading does not correspond in the two drawings. The plan and section do not correspond in Figure 116, whilst in Figure 64 there is an extraordinary lack of deformation in the strata adjacent to a broad fault-breccia zone.

Since the book has been written for the American student, we can hardly be surprised that American examples abound in the text, and that American literature is mainly cited in the concise lists of literature at the end of each chapter. Nevertheless, the plan of the book is so good that European engineers will find its methods and principles adapted to all their problems, although it is to be hoped that this book will stimulate some worker with the necessary qualifications of engineer and geologist to summarise the extensive but scattered British literature on the same subjects.

G. W. T.

MATHEMATICS.

A First Course in Mathematics for Technical Students.—By P. J. Hales and A. H. Stuart. 125 pages. 7½-in. × 5-in.

(University Tutorial Press. Price 1/6.)

The material in this little book is practical and much condensed. It will probably be found useful to the type of student for which it is intended. The explanations seem to be full in some cases and meagre in others; but those who have had experience in practical work with artisan students must know that their difficulties are not the same as those of the ordinary schoolboy.

W. D. E.

Elementary Mathematical Analysis.—By C. S. Slichter. 490 pages. 7½-in. × 5¼-in.

(Hill Publishing Company. Price 10/6 net.)

A textbook in which efficiency (in Lord Rosebery's sense) appears to be the watchword. Everything is standardised, even to the size of the paper on which the student works in pen and ink It almost comes as a surprise that a typewriter is not insisted on, and that no American standard of pronunciation of the letters of the Greek alphabet is set up. The author lays stress on the possibilities and responsibilities of character-building in a mathematical course, and we find occasional hints, amounting to commands, intended for the instructor. Although the inspiration of Professor Klein of Göttingen is freely acknowledged, the book should prove innocuous, and even beneficial, to English-speaking teachers of mathematics dispersed throughout the world.

W. D. E.

Plane Trigonometry.—By C. I. Palmer and C. W. Leigh. 288 pages. 9¼-in. × 6¼-in.

(Hill Publishing Company. Price 6/3 net.)

The treatment of the subject in this book is not at all that which has been adopted in many recent textbooks. The authors begin with the measurement of angles, positive and negative, and make use at once of Cartesian coördinates. There is something to be said for this method of procedure; for most boys are made familiar with graphs nowadays before beginning trigonometry, and it is just as well to make use of this familiarity. The trigonometrical ratios are defined at the outset for the general angle, and then specialised for the acute angle. Many teachers have done this in times past, and with success in the case of intelligent boys. The clear diagrams in this book seem to indicate that the authors have themselves found this plan successful. The second part of the book consists of a very good set of tables, with full explanations, the angles from 0° to 360° being all included. Altogether the book merits the attention of teachers, and can be recommended without hesitation for intelligent students who wish to obtain quickly a practical knowledge of the subject. By way of criticism, it may be said that the saving of time involved in writing csc θ for cosec θ must in practice be very small, and may cause confusion.

W. D. E.

NATURAL HISTORY.

Wild Life: An Illustrated Monthly, Vol. VI, No. 1.—Edited by Douglas English. 32 pages. Numerous illustrations. 12-in. × 10-in.

(The Wild Life Publishing Co. Price 2/6 net.)

An editorial in *Wild Life* for January frankly states that its issue was delayed until it had been ascertained to what degree the war had affected its subscription list. The fact that once more the magazine has made its appearance shows that the thanks offered to the readers is not an empty compliment. The number contains, as usual, some excellent photographs, of which we may mention Mr. Oswald Wilkinson's picture of the male willow warbler cleaning its nest. Mr. Alfred E. Tonge concludes his illustrated account of "British Clearwing Moths." The first part of this appeared in the December number, and from it we are here permitted to reproduce Figure 59, which is an exceedingly good representation of the six-belted clearwing (*Sesia ichneumoniformis*). Another picture in the current issue, which is very striking, is Mr. D. Seth Smith's photograph of a Guinea baboon, used to illustrate Mr. E. G. Boulenger's monthly "Notes from the Zoölogical Gardens."

W. M. W.

PETROLOGY.

Textbook of Petrology: The Igneous Rocks.—By F. H. Hatch. 429 pages. 164 illustrations. 7¼-in. × 5-in.

(George Allen & Co. Price 7/6.)

According to the preface, the seventh edition of this well-known textbook on Igneous Rocks has been prepared in order that it may constitute the first volume of a general work on petrology, the second volume being the recently issued "Petrology of the Sedimentary Rocks," by Hatch and Rastall. While the general arrangement is the same as in the fifth edition, much of the text has been revised, and new chapters on the pyroclastic and the metamorphosed igneous rocks have been added. The book is divided into four parts, the first being concerned with the physical characters of rocks, the second with the rock-forming minerals, the third with the classification and description of the various rock-types, while in the fourth an account of the distribution of these types in the British Isles is given. The first two parts are eminently satisfactory, and the facts are presented in a most lucid and readable form. The introductory chapters in the third part are not so satisfactory, chiefly owing to the fact that the classification adopted is that of silica-percentages, and that the graphical methods of indicating the relation of rock-groups, which are described, are the "oxide" methods of Iddings and Brögger. No mention is made of quantitative classification, either on the basis of norm or mode, nor of the exceedingly useful graphical methods based on these factors.

It is somewhat strange to find that most of the ultra-basic rocks are relegated to the hypabyssal division, as many of these are commonly plutonic. This also tends to obscure the close relationship which sometimes exists between diorites and hornblendites. The fourth part should prove of great use, as it is very complete, though in places it appears to be not quite up to date. Thus, no mention is made of the great variety of alkalic rocks described by Tyrrell from Ayrshire, nor of Shand's elaborate investigation of the Loch Borolan complex. The reproduction of the map of the Loch Garabal area has the same inaccuracies as in the fifth edition. The value of the book is enhanced by a large number of excellent microphotographs, illustrative of rock types. The figure of a teschenite on page 233 apparently contains no analcite. As a whole, the book is admirably got up, and misprints are rare; one, however, occurs at the foot of page 185 and another on page 107, where "hydronephelinite" is used instead of 'hydronephelite." In a future edition more references to papers containing the original definitions of rock-names might be given. From the point of view of the readers for whom the book is intended, these defects are of small importance, and do not detract from the merits of an edition which should prove as useful to students and teachers now as previous editions have done in the past.

A. S.

YEAR BOOK.

Penrose's Annual.—Edited by William Gamble, F.R.P.S. 148 pages. 92 illustrations. 10-in. × 7-in.

(Percy Lund, Humphries & Co. Price 5/- net.)

Penrose's Annual, which is the twentieth volume of the "Process Year Book," is one which should be in the hands of all who are interested in modern printing and illustration. The letterpress is a very fine example of printing, though perhaps to some the lines of the heavy old-faced type are a little too close together to do full justice to it. As usual, the illustrations are exceedingly good, and their subjects very varied. There is still a tendency, especially among those used for trade purposes, to have heavy borders of various widths and tints, which detract much from the effectiveness of the print, in so far as they take the attention of the eye from it. As the plates are not numbered nor paged, it is difficult to refer to any particular one; but we think the frame round the portrait of Mademoiselle Gina Palerme, with its eye-dazzling corners, is an example of what should be avoided. The frontispiece is a portrait of Sir William Crookes, P.R.S., in colour. His academic gown, however, appears flat and unnatural; and even here we cannot get away from ornamental borders. One of the features of the year mentioned by the Editor is the development of rotary photogravure. The article by "Maçbeth," on "Efficiency in Press Advertising," is well worth reading. Among many articles of practical utility is one on "Harmonic Vibrations" by Mr. Douglas Cowley, following up the suggestion that harmonographs should be used in connection with bank-note engraving by proposing that they should be also used for the borders of cheques or name-plates, or as the headings of various kinds of commercial paper. There are still some who think that simplicity is bad taste. We fancy that more is being done in the way of coloured collotypes than Mr. Yerbury seems to imagine. Mr. J. R. Riddell asks the question, "Is a scientific training necessary?" and says that, when one is in a reminiscent mood, and compares the conditions and requirements of the crafts to-day with those in vogue some twenty years ago, the answer must be a most emphatic "Yes." We are glad that the Editor did not (owing to the war) break the continuity of twenty years' consecutive publication, and decided "to carry on."

W. M. W.

NOTICES.

THE BRITISH JOURNAL PHOTOGRAPHIC ALMANAC, 1915 (fifty-fourth issue), has just been published by Messrs. Henry Greenwood & Co., Ltd. (price 1/- net, paper; 2/- net, cloth). In addition to the usual guide to processes and the handy tables of value for reference, two long articles appear, one on enlarging and the other on photo-micrography.

ANTI-VIVISECTION.—*Nature* has a scathing article on the action of the anti-vivisectionists, who are inveighing against protective treatment for typhoid fever. The success of the treatment and the help which it must give to this country in the war are very great. We wonder whether it would not be possible to show that the anti-vivisectionists are prejudicing enlistment, and should be dealt with under the Defence of the Realm Act.

THE STAR ALMANAC.—Messrs. Simpkin, Marshall and Co. have issued the Star Almanac for 1915 by Mrs. H. Periam Hawkins (price 6d. net). This contains much information, and should appear on the wall of every astronomer's study. Two other publications by the same authoress are invaluable for reference: The A B C Guide to Astronomy (price 1/6 net), now in its third edition; and the Revolving Star Map (price 1/- net), an excellent planisphere with a movable declination scale.

THE ALCHEMICAL SOCIETY.—At the sixteenth meeting of the Society the first of a number of papers forming a symposium on mediaeval philosophy was read by Lieutenant-Colonel Jaspar Gibson, V.D., LL.B. (Lond.), on "An Interpretation of Alchemical Symbolism with reference to the Works of Edward Kelly." In this there were dealt with certain analogies between the speculations of the mediaeval alchemists, the doctrines of ancient Indian philosophy, and the theories of modern science. At the seventeenth meeting on January 8th the subject of "Alchemical Tradition" was discussed by Mr. Gaston de Mengel.

THE ROYAL COLLEGE OF SURGEONS IN IRELAND.—The President, Vice-President, and Council of the Royal College of Surgeons in Ireland have decided to place in the College a permanent record of the names of all the Students, Licentiates, and Fellows of the College who are at present serving with His Majesty's Navy and Expeditionary Forces; and, further, to erect a suitable memorial to all such as fall in the war. The President, Vice-President, and Council will be glad if the relatives and friends would communicate the names of such Students, Licentiates, and Fellows to the Registrar of the College.

ENGLISH FILTER PAPERS.—We are glad that Messrs. Balston, Ltd., the makers of the celebrated Whatman drawing paper, are making filter paper to replace that which previously came from Germany. The specimens which they have sent to us have been tested, and have been found to be rapid in their action, while they effectively retain fine precipitates. For commercial analysis and school work they are all that could be desired. For the most accurate scientific work, however, the amount of ash is too high, but filter papers washed with acids are in course of preparation to meet the demand for "ash-free" paper. We hope that our readers will take advantage of Messrs. Balston's work.

SHIPLEY & MACBRIDE'S ZOÖLOGY has been thoroughly revised, and the third edition will be published shortly by the Cambridge University Press. The science of Zoölogy has made such advances in the eleven years which have elapsed since the publication of the second edition of this textbook that it has become necessary to rewrite considerable portions. The newer discoveries in the laws of inheritance are dealt with in the Introduction, the chapter on Protozoa has been radically changed, a chapter on Gephyrea has been added, the chapter on Arthropoda has been largely rewritten, and many changes have been made in the section dealing with Vertebrata. There are many new illustrations.

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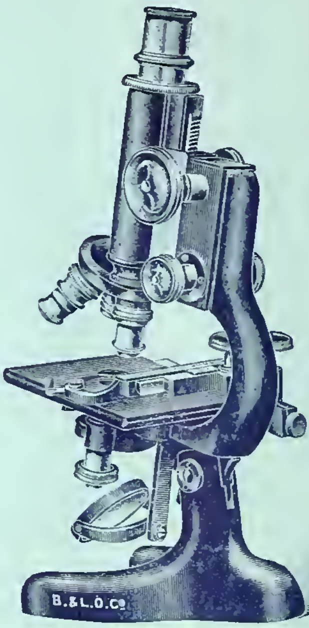

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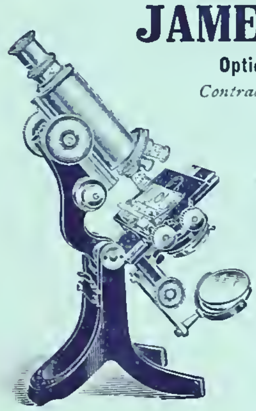

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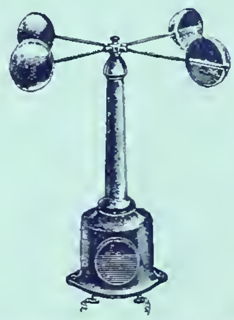

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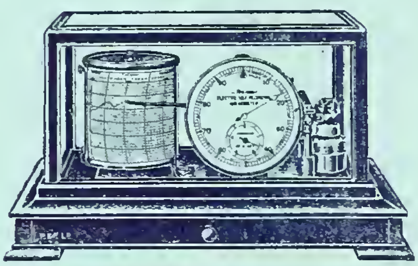

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