A. Vibert Douglas

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DEEP-SEA DEPOSITS AND DREDGINGS

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CHAPTER XIII.

DEEP-SEA DEPOSITS AND DREDGINGS.

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(*Written in March* 1923.)

INTRODUCTION.

The monumental work of the late Sir John Murray[1] and A. F. Renard on the nature of deep-sea deposits, their classification, the methods of obtaining them and of examining them, is a compendium of information which will be the *vade mecum* of every ocean explorer. It is therefore sufficient that this memoir deal with the particular samples under consideration, referring only in the briefest manner to some of the facts appertaining to marine deposits in general.

The term " deep-sea " deposit is accepted as referring to the materials which form the ocean-bottom at depths exceeding 100 fathoms.

Deep-sea deposits may be classified very simply thus :—

(*a*) Pelagic deposits ..	Red clay. Radiolarian ooze (siliceous chiefly). Diatomaceous ooze (siliceous chiefly). Globigerina ooze (calcareous chiefly). Pteropod ooze (calcareous chiefly).	
(*b*) Terrigenous deposits	Blue mud .. Red mud .. Green mud .. Volcanic mud.. Coral mud ..	Materials brought down by rivers, worn from coasts, carried by icebergs or by atmospheric currents.

A deposit is often found to contain a mixture of two or more of the above together with some secondary or chemical products (clayey matter arising from the decomposition of pumice, felspars, and other minerals ; manganese nodules ; palagonite and zeolitic materials ; phosphatic concretions, iron and calcareous concretions, etc.), and not infrequently there can be distinguished

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[1] Murray (J.) and Renard (A. F.).—Report of the Scientific Results of the Voyage of H.M.S. *Challenger* during the years 1873–76. Deep-Sea Deposits, 1891.

planetesimal dust (cosmic spherules of iron and nickel chondrites with lamellar structure, etc.).[1]

The hydrographer and electrician[2] of the Shackleton-Rowett Antarctic Expedition obtained for the geologist[3] sixteen bottom-samples from the Atlantic and Southern Oceans. Of these fourteen were true pelagic deposits and two were dredgings of rocks and pebbles (see pp. 9-10).[4] The number is small compared with the number of soundings recorded, chiefly because of the difficulty of winding in from 1,000 to 3,000 fathoms of wire without losing either the sample from the tube or snappers, or the end portion of the wire itself carrying the tube or snappers, by sudden breaking stresses due to ice or to the high seas and excessive rolling and pitching of the ship.

The Kelvin and the Lucas sounding machines were used, the former for shallow water (up to 300 fathoms), the latter for greater depths (Brunton wire in coils of 6,000 fathoms, diameter 0·028 in., weight 12·3 lbs. per 1,000 fathoms, breaking strain 175 lbs.). It was found advisable to attach a strong flexible rope of about 10 fathoms in length to the end of the wire, and then fasten the weights and snappers or Buchanan tube to the end of the rope. This arrangement proved more satisfactory than attaching the weights, etc., directly to the wire. The length of rope was then added to the depth recorded on the drum. A point of interest arises in the attempt to find the relation between true depth and apparent depth when the ship is drifting—this will be discussed at the close of this chapter.

EXAMINATION OF SAMPLES.

The samples had been dried to some extent and placed in small glass sample-bottles with the exception of two or three which were wrapped in filter paper and put in tins. This latter method is not satisfactory as the remaining moisture produced rust, which ate through the filter paper and worked deep into the sample. The terrigenous deposits were very much embedded in tallow and before it was possible to examine them in any way they had to be simmered gently for several hours in a sodium bicarbonate solution. Only distilled water was used for this purpose in order to eliminate any deposition of lime, etc. Care was taken never to bring the liquid containing any of the samples

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[1] Fowler (G. H.).—The Science of the Sea, 1912.

[2] Commander F. A. Worsley, D.S.O., O.B.E., R.D., R.N.R., and J. Dell, C.P.O., R.N.

[3] G. Vibert Douglas, M.C., M.Sc.

[4] Geogr. Journ., 1923, vol. 61, p. 101.

to boiling point in order to prevent the finer particles from being aggregated or the larger particles from disintegrating.

The sizes of the samples of pelagic deposit varied from about 30 gms. to such small quantities that when slides had been made there was little or nothing left. Where there was 0·5 gm. or more the specific gravity was determined by means of a pyknometer.

The microscopic examination of the deposits and slides yields much information regarding the nature of their constituents, but in order to obtain the distribution curve representing the relative proportions of particles of different sizes it is necessary to employ a method of soil analysis devised by Dr. Sven Odén of Upsala,[1] and afterwards applied by him to some marine deposits sent him from the *Challenger* Office. His results[2] are of much interest, not only because each type of deposit showed a distinctive form of curve, but also because the same type of deposit exhibited definite peculiarities according to the ocean from which it had come.

Sven Odén's Method.—One pan of a balance is placed near the bottom of a vessel containing an aqueous suspension of the sample. By continuous weighing the rate of deposit on the pan is obtained and this cumulative weight, P, is plotted against the time, t, forming an " accumulation " curve. The following points were established :—

(1) If the height, h, of the water column above the pan be varied, the accumulation curve for any given sample remains practically unaltered if the values of t for the abscissa are reduced to some standard value of h—say $h = 10$ cm., by the factor $10/h$.

(2) The accumulation curve is independent of the total weight of the sample, within reasonable limits, if P be the percentage of the total weight.

(3) Care must be taken to avoid, or correct for, temperature variations since the rate of fall of the particles varies inversely as the viscosity of the liquid, and for water this changes very rapidly with temperature. [$\eta = 0{\cdot}01307$ at 10° C. to $0{\cdot}01004$ at 20° C.]

(4) The " effective radius " calculated from Stokes's law,

$$v = \frac{2}{9} g \frac{\sigma_1 - \sigma_2}{\eta} r^2$$

has a real physical significance where the number of particles dealt with is so great as to render the investigation statistical rather than individual.

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[1] Internationale Mitteilungen für Bodenkunde, 1915, vol. 4, p. 257. [Obtainable on loan from Ministry of Agric. and Fisheries, 10, Whitehall Place, London, S.W. 1.]

[2] Proc. Roy. Soc. Edinburgh, 1917, vol. 36 (for 1915–1916), pp. 219–36.

(5) From the accumulation curve, $P = f(t)$, it is possible by a mathematical analysis to obtain a function $F(r)$ such that the area $F(r)\,dr$ represents the proportion by weight of particles having an effective radius between the limits r and $r + dr$. It is found that

$$F(r) = -\frac{2t^2}{r}\frac{d^2P}{dt^2} = -\frac{2t}{r}\frac{dP}{dt}\frac{dz}{dx}$$

where $z = \log \frac{dP}{dt}$, and $x = \log t$, the auxiliary curve (x, z) being adaptable for graphic treatment.

It has been objected by Prof. C. G. Knott[1] that the use of Stokes's law may give entirely fallacious results due to the irregular shapes of the particles, many of which may be of flat flaky form. This objection is emphasized by the recent success of Dr. E. W. Wetherell[2] in photographing the tracks of flat solids falling through water. It has nevertheless seemed to the writer that it was worth while following Sven Odén's method in view of the extraordinary consistency of the results, the large number[3] of particles involved, and the fact that especially in Globigerina ooze the predominance of spheroidal forms is very marked (see ref. 1, pls. 12–15).

Experimental Arrangement.—The apparatus employed by Sven Odén depended on an automatic electrical release whereby counterbalancing weights were introduced on to the second pan of the balance as the particles were deposited on the immersed pan. The writer has substituted a very simple and apparently satisfactory method of compensation consisting of allowing one or more drops of distilled water to fall from a small orifice, at the end of a drawn-out glass tube joined to the base of an ordinary burette, into a small beaker on the second balance pan. The times when successive drops were required in order to maintain a balance were noted, also the number of drops, and these two items provide the data from which the accumulation curve can be drawn. Readings were taken at intervals over twenty-four hours at least, then the major portion of the water was syphoned off and the amount of undeposited residue obtained. To the cumulative total was added the equivalent weight of the residue which would have settled on the pan in time $t = \infty$, thus giving the total weight corresponding to the value $P = 100$ per cent.

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[1] Proc. Roy. Soc. Edinburgh, 1917, vol. 36 (for 1915–1916), pp. 237–39.

[2] Nature, 1922, vol. 110, p. 845.

[3] In a sample of deposit weighing 10 gms., whose average density is 2·6 and whose radius is 20μ the approximate number of particles is 10^8.

It was found that the drops formed a sufficiently accurate scale of weights; and by using a glass receptacle of very small diameter the correction for evaporation during twenty-four hours was so small as to be practically negligible.

Results.—The numerical work involved in evaluating $F(r)$ is considerable. It was carried out in tabular form with the following sequence of columns:—

(1) Actual time t' in seconds.
(2) Calculated time $t = 10/h \cdot t'$.
(3) First differences of (2). $t_n - t_{n-1}$.
(4) $\log_{10} t_n = x_n$.
(5) First differences of (4). $x_n - x_{n-1}$.
(6) Number of drops (cumulative).
(7) P = percentage of total weight.
(8) First differences of (7). $P_n - P_{n-1}$.
(9) $dP/dt = (8)/(3)$.
(10) $\log_{10} dP/dt = z = \log_{10} (9)$.
(11) First differences of (10). $z_n - z_{n-1}$.
(12) $dz/dx = (11)/(5)$.
(13) r (as given by Stokes's law) $= \sqrt{\frac{h}{ct}}$, where $c = \frac{2}{9} g \frac{\sigma_1 - \sigma_2}{\eta}$ and $h = 10$. The evaluation of c involves $g = 981$, σ_1 = density of ooze, σ_2 = density of water, η = viscosity of water at the temperature at which the experiment was carried out. Express r in units of μ.
(14) Mid-point of interval dr $[= \frac{1}{2}(r_n + r_{n-1})]$.
(15) $F(r) = -\frac{2t}{r}\frac{dP}{dt}\frac{dz}{dx}$.

Columns (14) and (15) then form the abscissæ and ordinates respectively of the distribution curve.

It should be remarked that it was frequently evident that a slight smoothing of the first difference columns was necessary before proceeding to the next step. This was easily effected by plotting.

In the following tables and accompanying graphs the results obtained by the above method are given for six pelagic oozes. The values of r are the mid-points of the intervals dr corresponding to the respective values of $F(r)$, and the unit of measurement of (r) is μ (= 0·0001 cm.). The figures in brackets are the percentages by weight which remain ungraded. $\Sigma F(r)\,dr$ + percentages ungraded = 100 per cent.

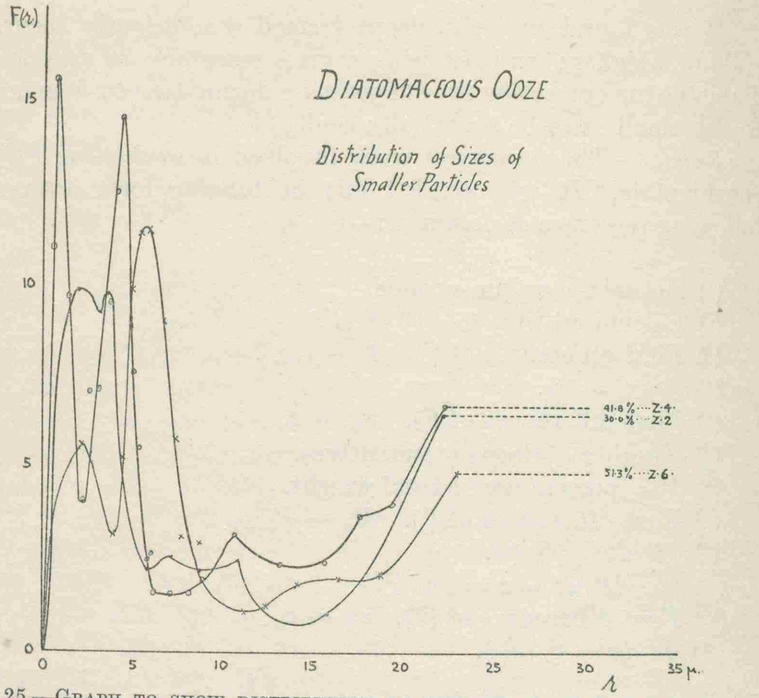

FIG. 25.—GRAPH TO SHOW DISTRIBUTION OF SIZES OF SMALLER PARTICLES IN DIATOMACEOUS OOZE.

TABLE I.

Values of r and F(r) for Diatomaceous Oozes.

Z 2		Z 4		Z 6	
r	*F*(*r*)	*r*	*F*(*r*)	*r*	*F*(*r*)
—	(1·80)	—	(3·00)	—	(4·11)
1·9	9·85	0·5	11·00	2·1	5·65
3·2	9·16	0·6	15·70	3·8	3·13
3·5	9·74	1·3	9·70	4·4	5·23
4·0	7·23	2·2	4·06	4·9	9·83
4·8	3·47	2·5	7·05	5·4	11·31
5·8	2·20	3·1	7·13	5·8	11·48
7·2	2·50	3·7	9·50	6·6	8·98
8·7	2·16	4·1	12·50	7·4	5·75
10·8	2·48	4·4	14·50	7·7	3·04
13·0	0·79	4·7	8·71	9·2	2·87
15·8	1·00	5·0	7·52	11·1	1·04
22·0	6·45	5·4	5·50	12·4	1·23
—	—	5·7	2·41	14·2	1·76
—	(30·00)	6·0	1·52	16·4	1·88
—	—	6·6	1·56	18·8	2·02
—	—	8·1	1·58	22·9	4·84
—	—	8·8	1·90	—	—
—	—	10·6	3·16	—	—
—	—	13·2	2·28	—	(51·30)
—	—	15·7	2·33	—	—
—	—	17·6	3·52	—	—
—	—	19·4	3·89	—	—
—	—	22·2	6·63	—	—
—	—	—	(41·80)	—	—

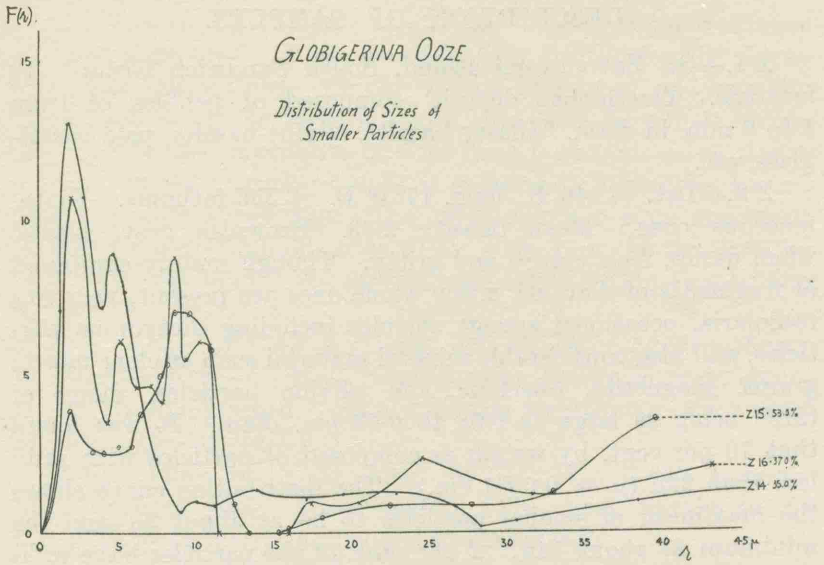

FIG. 26.—GRAPH TO SHOW DISTRIBUTION OF SIZES OF SMALLER PARTICLES IN GLOBIGERINA OOZE.

TABLE II.

Values of r and F(r) for Globigerina Oozes.

Z 14		Z 15		Z 16	
r	*F*(*r*)	*r*	*F*(*r*)	*r*	*F*(*r*)
—	(2·44)	—	(1·50)	—	(1·85)
1·3	7·10	2·0	3·88	2·1	10·65
1·9	13·05	3·4	2·53	4·3	3·48
2·8	10·70	4·1	2·50	5·2	6·08
4·0	7·12	5·0	2·72	6·1	4·54
4·7	8·85	5·8	2·73	7·2	4·67
5·5	7·64	6·4	3·73	7·9	4·06
7·4	2·35	7·1	4·26	8·6	8·75
8·9	0·65	7·6	4·96	9·4	5·45
9·8	0·97	8·1	5·24	10·1	6·06
11·1	0·78	8·6	7·00	10·9	5·92
13·8	1·29	9·6	7·00	13·6	0·00
17·0	0·94	10·9	5·80	17·2	0·90
19·4	1·21	12·4	0·88	20·4	0·83
22·7	1·19	14·3	0·00	24·5	2·26
25·9	1·09	15·8	0·04	31·6	1·08
28·2	0·16	18·0	0·42	43·1	2·07
30·5	0·24	22·4	0·78	—	—
33·4	0·49	27·6	0·83	—	(37·0)
38·3	0·95	32·9	1·24	—	—
51·2	1·28	39·5	3·52	—	—
—	(29·70)	—	(53·00)	—	—

DESCRIPTION OF SAMPLES.

Z 1.—Off Zavodovskii Island, South Sandwich Group. 19 fathoms. Terrigenous deposit[1] composed of pebbles of from 1 to 5 mm. in diam. Glassy basalts, olivine-basalts, pale basalt-glass, etc.

Z 2.—Lat. 67° 40′ S., long. 17° 0′ E. 2,356 fathoms. Diatomaceous ooze.[2] Mean density 2·53. Brownish grey, plastic when damp, feels clayey and gritty. Though mainly composed of fragments of diatoms, a few whole ones are present, very few radiolaria, occasional sponge spicules including dictyonine particles, and also considerable mineral material such as clear quartz grains, magnetite, obsidian, and olivine particles, many of these being as large as 0·08 to 0·02 cm. diam. It was found that 70 per cent. by weight is composed of particles with radii less than 22μ ($\mu = 0{\cdot}0001$ cm.). The distribution curve shows the maximum of smaller particles to be at about 2μ and the minimum at about 14μ. 2 per cent. of the particles have radii less than 0·7μ and were still in suspension after twenty-four hours.

Z 3.—Lat. 67° 48′ S., long. 16° 1′ E. 2,163 fathoms. Small rounded pebble of ægirine-granite and diatomaceous ooze. Apparently very similar to Z 2, but the amount obtained was only sufficient for two slides.

Z 4.—Lat. 69° 18′ S., long. 17° 11′ E. 1,089 fathoms. Small rounded pebble of ægirine-granite and diatomaceous ooze. Mean density of ooze 2·67. Brownish grey, plastic when damp, feels clayey, very fine-grained. More whole diatom frustules than in Z 2, fragments of sponge spicules, no coarse terrigenous particles but sprinkled with very finely divided magnetite and other minerals, and contains a large amount of excessively fine particles which keep the water opalescent even after standing for several days. 60 per cent. by weight is composed of particles with radii less than 22μ. The curve indicates maxima at 0·6μ and at 4·4μ and a pronounced minimum from 6μ to 8μ. 3 per cent. of the particles have radii less than 0·46μ and had not settled after forty-two hours. This sample came from the farthest point South that has been reached at that longitude.

Z 5.—Lat. 68° 29′ S., long. 16° 3′ E. 1,925 fathoms. Diatomaceous ooze. Very small sample, sufficient only for two slides, which resemble Z 2 and Z 3.

Z 6. — Lat. 66° 52′ S., long. 14° 27′ E. 2,341 fathoms. Diatomaceous ooze. Mean density 2·75. Brownish grey, clayey and fairly fine-grained. Chiefly diatom fragments, one irregular 2 mm. pebble of quartz with augite, otherwise very little quartz but considerable magnetite of sizes from 0·28 mm. diam. downwards. 50 per cent. by weight is composed of particles having radii less than about 23μ. The curve shows a main maximum at about 6μ and minimum at 11μ. 4 per cent. of the particles have radii less than 0·57μ and had not fallen within twenty-four hours.

Z 7. — Lat. 65° 43′ S., long. 16° 25′ W. 2,766 fathoms. Diatomaceous ooze. Mean density 2·51. Brownish grey, clayey and fairly fine-grained. Mainly diatom fragments. Very small sample. Resembles Z 6.

Z 8. — Lat. 66° 7′ S., long. 38° 11′ W. 2,622 fathoms. Diatomaceous ooze. Mean density 2·69. Very similar to Z 6 but with more quartz grains and less magnetite.

Z 9. — Lat. 64° 38′ S., long. 45° 0′ W. 2,446 fathoms. Diatomaceous ooze. Light brownish grey, sample quite small, but resembles Z 6, though with much less frequent magnetite particles.

Z 10. — Lat. 64° 29′ S., long. 45° 43′ W. 2,331 fathoms. Diatomaceous ooze. Several whole Navicula-like specimens, also whole radiolaria. Light brownish grey, fine-grained with very few magnetite or coarse mineral particles. When left in suspension the water remains muddy opalescent for over a day whereas all the others, with the exception of Z 4, clear in half a day. This sample came from near the non-existent "Ross's appearance of land."

Z 11. — Lat. 68° 3′ S., long. 16° 6′ E. 2,163 fathoms. Diatomaceous ooze. Composed mainly of diatom fragments, with radiolaria and sponge spicules and mud-like débris. Very small sample.

Z 12. — Lat. 65° 22′ S., long. 10° 17′ W. 2,762 fathoms. Diatomaceous ooze. Similar to Z 11. Very small sample.

Z 13. — Lat. 63° 49′ S., long. 44° 39′ W. 1,758 fathoms. Terrigenous deposit consisting of chips and fragments of rock. (See report of W. Campbell Smith, chapter v, p. 65.)

Z 14. — Lat. 39° 13′ S., long. 10° 28′ W. 1,880 fathoms. Globigerina ooze. Mean density 1·93. Greyish creamy white, partly caked, very hard and brittle and not easy to get into suspension in its ultimate particles. Very rich in various species of Globigerinidæ (*Globigerina dubia, rubra, bulloides, sacculifera*

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[1] Mr. W. Campbell Smith has examined and reported upon this deposit (see p. 64).

[2] Mr. R. Kirkpatrick, of the British Museum (Nat. Hist.), has kindly examined the micro-slides and identified the deposits and the various foraminifera mentioned in this report.

have been thought to be identified by the writer from pls. 12 and 13 of ref. 1). Many of these shells are beautifully preserved, and the largest ones, oval, globular, kidney-shaped, or resembling acorns, were measured under the microscope and found to range from many about 0·2 mm. to occasional ones up to 0·7 mm. in length. No magnetite or coarse mineral grains are present. 70 per cent. by weight is composed of particles having radii less than about 60μ. The curve indicates maximum distribution at 2μ and at $4{\cdot}5\mu$ and low values throughout the range 9μ to 35μ. 2 per cent. of the particles have radii less than $0{\cdot}8\mu$ and remained in suspension after twenty-four hours.

Z 15.—Lat. 35° 40′ S., long. 5° 1′ W. 1,942 fathoms. Globigerina ooze. Mean density 2·05. Very like Z 14. One pebble of arkose about 1 mm. long, with white mica. 50 per cent. by weight is made up of particles having radii less than 43μ. It is evident from the curve that there is maximum distribution between $r = 2\mu$ and $r = 11\mu$, and there appear to be no particles within the range $13{\cdot}3\mu$ to $15{\cdot}2\mu$ though the curve begins to ascend gradually beyond the latter value. 1·5 per cent., having radii less than $0{\cdot}8\mu$, had not settled within twenty-four hours.

Z 16.—Lat. 35° 41′ S., long. 5° 10′ W. 1,989 fathoms. Globigerina ooze. Mean density 2·44. Very similar to Z 14 and 15, but with noticeably more of the exceptionally large shells. 63 per cent. by weight consists of particles having radii less than 50μ and these cluster chiefly within the range 2μ to 11μ, there being apparently no particles within the region $11{\cdot}3\mu$ to $15{\cdot}8\mu$. 1·85 per cent. was found to have radii less than $0{\cdot}65\mu$ and had not fallen within twenty-four hours.

MISCELLANEOUS REMARKS.

(1) *Sizes of Particles.*—The three diatomaceous oozes, the sizes of the particles of which were determined (Z 2, Z 4, Z 6), show certain features in common: (*a*) About half the weight settles within the first forty-five seconds (when $h = 10$ cm.) and is composed of particles having effective radii greater than 23μ; (*b*) of the finer particles the majority cluster about the sizes given by $2\mu < r < 6\mu$ and within this range there are two maxima, this "kink" being a feature of all the curves and appearing also in Sven Odén's curve for "Boden 117 Kosta." (ref. 2, p. 298).

The three Globigerina oozes (Z 14, Z 15, Z 16) also show common features: (*a*) from 35 per cent. to 50 per cent. is composed of relatively coarse particles falling within the first twenty-five seconds (when $h = 10$ cm.); (*b*) of the finer particles the distribution is greatest within the range $2\mu < r < 11\mu$; (*c*) in one case there are comparatively few and in the other cases no particles recorded having radii approximately 13μ to 15μ. This result is of special interest because Sven Odén found a complete absence of particles having radii within $12\mu < r < 20\mu$ for Globigerina ooze from the Atlantic (the gap for the Pacific Ocean having slightly different limits). This range embraces that obtained by the writer and suggests that this genus of foraminifera is of two classes—"giants" and "dwarfs"—and that the former at least are not greatly affected by the dissolvent action of sea-water, otherwise such a gap as that found by Sven Odén and in part confirmed by this investigation would be most improbable.

(2) *Radioactivity.*—The radium content of certain typical deep-sea deposits has been determined by Prof. J. Joly[1] and shows the following progression: 3 to 5 $\times 10^{-12}$ for terrigenous deposits; 6 to 8 $\times 10^{-12}$ for calcareous deposits; 30 to 50 $\times 10^{-12}$ for red clay and siliceous deposits. The most slowly accumulating deposits are thus seen to be the most radioactive, as in them there is of necessity a higher proportion of the uranium which, originally brought into the sea by the denudation of igneous (or sedimentary) rocks, is gradually precipitated all over the ocean. Time did not permit of the precise determination of the radioactivity of the particular samples under consideration, but rough tests were made on Z 2, 4, 6, 7, 8, 14, 15, 16, which indicated that they were certainly not exceptionally high in their radium content.

(3) *Geographical Distribution.*—The three Globigerina oozes, Z 14, 15, 16, lie well within the extensive area of this type of ooze charted both by Murray[2] and by Harvey Pirie.[3]

The eleven diatomaceous deposits, Z 2–12 inclusive, all lie in a belt between lat. 64° S. and lat. 69° 18′ S., extending westwards from long. 17° 11′ E. to 45° 43′ W. This belt lies entirely within the region shown on Pirie's chart as terrigeneous deposits, his southern limit of diatom ooze being approximately between the 59th and 60th parallels. Murray, however, draws the limit of the diatom deposits as far south as lat. 68° between long. 0° and 16° E. Z 2, 3, 6 and 11 confirm this, while Z 4 and 5 indicate that the diatom area extends even farther south at this

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[1] Joly (J.).—Radioactivity and Geology, 1909. See also Phil. Mag., July 1908, ser. 6, vol. 16, p. 190.

[2] *Challenger* Report, Deep-Sea Deposits, 1891.

[3] Pirie (J. H. Harvey).—Scottish National Antarctic Expedition, 1902–04: Deep-Sea Deposits. Trans. Roy. Soc. Edinburgh, 1913, vol. 49, pp. 645–86.

longitude. Z 12 lies approximately on the edge of Murray's diatom area. Z 8, 9 and 10 lie within the region shown by Murray as terrigenous, his southern limit of the diatom belt being between lat. 61° and 62° at about long. 40° to 45° W., while Pirie's limit is at 59° S. approximately. Z 13, however, was a dredging composed entirely of rock chips and fragments, and as the South Orkney Islands lie in this region it is likely that much of the sea-bottom is strewn with terrigenous material, in addition to that deposited from icebergs.

(4) *Deep-sea Soundings.*—Reference has already been made to the problem of correcting for the curvature and lag of the wire when a sounding is made while the ship is drifting. If l be the length of wire indicated on the drum when bottom is reached; t the time from the commencement of the sounding until bottom is reached; v the velocity with which the wire is let out ($= l/t$); V the velocity of drift of the ship; θ the angle which the wire makes with the vertical at the ship; d the true depth; then the problem is to express d as some function of l, v, V and θ. The problem is of more than mere theoretic interest when it is considered that the correction may very probably exceed 5 per cent. under certain conditions. It is not intended to discuss the various formulæ which have been worked out,[1] as much further work is necessary and more data are required in order to test their value; but the writer desires to take this opportunity to solicit from every possible source suggestions and information, in particular reliable data for actual values of l, t (or v), V, and a series of values of θ during the time t.[2]

(5) *Acknowledgments.*—The writer has pleasure in expressing gratitude to Prof. Sir E. Rutherford for his courtesy in allowing the investigation to be carried out in the Cavendish Laboratory; to Dr. C. T. Heycock for kindly lending a balance from the Metallurgical Department; and to Mr. G. Vibert Douglas, who provided the material, drew attention to the work of Dr. Sven Odén when suggesting the investigation, and continually aided and advised in many ways.

[1] The writer is indebted to Capt. A. L. Alington, R.N., for one formula.
[2] Address to G. Vibert Douglas, Royal Societies Club, London.

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earthquake. They would rather err on the conservative side and it follows that the average geologist, who as a rule has had but little training in recognizing the evidences of activity, usually describes faults simply as faults, without distinction as to their activity.

These conditions led to a difference of interpretation of the term active as it is used in separate sections of the Fault Map. Mr. Wood, who gathered from many generous contributors much of the fault data shown on the southeast, and the southern portion of the southwest, sheets of the map, subsequently examined many of these faults in the southeast region, and some elsewhere, and found it desirable to recognize a considerable number of grades of knowledge corresponding as nearly as might be to the degrees of certainty with which the faults, and their symptoms of activity, were determined. His manuscript map shows the following distinctions: active fault well located; active fault uncertainly located; fault probably active; line probably active fault (?); fault well located; fault uncertainly located; line probably active; line including all from probably fault to very doubtful; line including all from probably fault to very doubtful and uncertainly delineated. Mr. Willis, who is responsible for the mapping in the districts north of San Luis Obispo, with the assistance of Mr. Robin Willis, made a reconnaissance survey of the area between San Luis Obispo and Santa Rosa, and extended the application of the term active to faults which he recognized as such on physiographic evidence as well as on indications more commonly employed, whenever in his judgment the facts justified that classification. He thus classified as active many faults which he would not have identified as such without personal examination.

The task of transferring the manuscript data to the copy for the printer fell to Mr. Willis and involved the adjustment of the differences of interpretation in so far as it might be possible to bring them into accord. It was not possible, however, to reach that desirable unity of statement which might have been attained if all the evidence could have been reviewed by a single observer. It was necessary also to reduce the number of distinctions to that which could be shown by a moderate number of printings on the map. The adjustments were made by Mr. Willis on the eve of his departure for Chile and an explanatory note was inserted by him in the legend of the map just before sailing, without opportunity of consultation with Mr. Wood. The note falls somewhat short of a complete statement of the facts. On the southeast sheet it reads that the faults thereon shown as active "have been active during historic time" and it should further explain that the classification as active also includes such as "exhibit specific surface indications of recent activity, such as fresh scarps and trace phenomena." Furthermore, a considerable number of the faults shown on the southeast sheet, and also on the southwest sheet, that are marked dead, would better be indicated as, "probably active, but without definite indication of recent disturbance." Were these changes made in the map itself the number of active faults shown in the southern half of the map would more nearly approximate that of the active faults delineated by Mr. Willis in the northern half.

In making this compilation we have been placed under obligations to many individuals, corporations and institutions. Some of them have wished not to be named and the list of others who have contributed to the advancement of our knowledge of California is too long to be given here. It is appropriate to state, however, that the work was done in cooperation with the Advisory Committee on Seismology of the Carnegie Institution of Washington, with the U. S. Geological Survey, represented especially by Messrs. Noble and Kew, with the U. S. Hydrographic Office, with the Navy Department, with the University of California and with Stanford University. While the Seismological Society of America is directly responsible for the publication, it could not have accomplished it without the cordial cooperation given by these organizations.

BAILEY WILLIS,
H. O. WOOD

DETERMINATION OF THE CURVATURE INVARIANT OF SPACETIME

ON January 30, 1924, and on the two following days a remarkable series of lectures was delivered by Dr. Silberstein to the Physical Society of McGill University, Montreal. Not only did Dr. Silberstein present to his audience one of the vastest problems with which the human mind can grapple, but he gave for the first time in public an exposition of his own investigations of the intrinsic properties of spacetime as the frame of the universe.

The preliminary lectures dealt with the geometries of space and spacetime; the early attempts to formulate mathematical equations which would hold true not only for terrestrial measurements but also for planetary measurements; the discrepancies which invariably occurred between theory and observation in the latter class of measurements; the great conception of Einstein whereby the universe was to be treated mathematically as a four-dimensional "spacetime" continuum, and his later inspiration, whereby he conceived spacetime as finite according to the principles of elliptical geometry; the modification of the Einstein spacetime equation by de Sitter, whose beautiful theory has overcome the outstanding difficulty of

Einstein cosmology and has prophesied not only measurable but conspicuous deviations from classical theory for measurements dealing with distances as great as those of the remote stars and nebulae.

The third lecture dealt with Dr. Silberstein's own investigations based upon the spacetime theory of de Sitter. Attention was confined to a discussion of Radial Velocity. This velocity in the line of sight is measured by the Doppler effect, that is to say, by the displacement of a spectral line in the spectral photograph of a star relative to the position of that line in the spectrum of a similar source of light on the earth.

Both de Sitter and Weyl showed theoretically that the greater the distance of the star from the observer, the greater would be the shift of the spectral line; but their theories only allowed for a shift towards the red end of the spectrum. In the case of de Sitter, this was because he limited himself to the perfectly artificial assumption of the star fixed relative to the observer; and in the case of Weyl because he introduced the quite gratuitous assumption that the world lines of all the stars belong to a unique pencil of geodesics diverging into the future. Observation, however, shows that not all the stars are receding, a considerable proportion having motions towards the solar system, while of the 42 spiral nebulae whose velocities have been measured four are approaching and likewise a large proportion of the globular clusters. Thus the spectral shift equations of de Sitter and Weyl are untenable; first, because they are theoretically unsatisfactory, being based on a gratuitous or a narrow assumption and, secondly, because they are flatly contradicted by many of the most remote celestial objects.

Dr. Silberstein has taken up the problem without introducing any limitation whatever into de Sitter's spacetime theory, thus entirely abandoning the prejudice of the universal scattering of matter. He treats the observing station and the star as two free particles and integrates the equations in their full generality. This leads him to a formula for the complete spectral displacement, a general Doppler formula containing two terms due to (1) an individual characteristic of the star considered, namely, the radial velocity which it would have at its closest approach to the observer, whether that position occurred in the past, or would occur in the future, and (2) the ratio of the distance of the star from the observer to the radius of curvature of spacetime. Although these two factors are inseparably amalgamated, yet the first dominates the result for stars near the sun, while the second far outweighs the first for stars near the boundary of our galaxy or for the spiral nebulae which are themselves probably small galaxies lying far out beyond the confines of our galaxy.

Dr. Silberstein has collected all the numerical results which are available—namely, Shapley's observational data—with regard to the Doppler displacements and distances of globular clusters and the Magellanic Clouds, and inserting these values in the equation embodying the relations above described he solves for the only unknown—the radius of curvature of spacetime. The results are so consistent from the clusters, whether approaching or receding, and from the two Magellanic Clouds, that it is impossible not to attach a tremendous importance to this achievement of Dr. Silberstein's. Thus, an intrinsic feature of the universe, the radius of curvature of four-dimensional spacetime, having a clear mathematical significance but utterly impossible of visualization in the ordinary sense of three-dimensional realization, has been evaluated numerically with a precision and weight never before approached. The consistency of the nine values obtained gives rise to a law which can be enunciated in terms of physical observable things, thus: the product of the Doppler displacement and the parallax is a constant, and this constant has the simple physical meaning of the smallest possible parallax in such a spacetime, namely, the ratio of the earth's distance from the sun to the radius of curvature of spacetime.

The figures given by Dr. Silberstein as the measure of this radius of curvature are as follows: The mean of determinations from seven globular clusters is 6.0 multiplied by 10 to the power twelve in astronomical units, and the mean value of these seven clusters, together with the Greater and Lesser Magellanic Clouds, is 6.07 multiplied by 10 to the power of twelve.

Gigantic though this figure may be, it yet implies a finite volume of the elliptical space as a section of spacetime, and the thought of "a closed elliptic cage" would be intolerable to the undaunted imagination of Dr. Silberstein, were it not relieved by this inherent property of the spacetime, strangely stimulating to what Clifford termed "cosmic emotion," that a light signal from a star near the observer's polar (the polar is a sphere around the observer of the greatest possible radius in that space) would take an almost infinite time to reach the observer, while from a star actually on the polar the signal would come—never.

A. Vibert Douglas

McGill University

SCIENTIFIC EVENTS

THE MASSES AND LUMINOSITIES OF THE STARS[1]

An important paper on this subject was read by Professor A. S. Eddington at the meeting of the

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[1] From *Nature*.

A. VIBERT DOUGLAS

Early Scientific Writing in Canada

offprint from

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Xth Congress for Hist. and Phil. of Science

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Early Scientific Writing in Canada

A. Vibert Douglas
Queen's University, Kingston, Canada.

The forthcoming *Literary history of Canada* (English language) will contain one chapter on writings in the field of science.

Prior to 1800 very little scientific writing in English was done in Canada. A few almanacs and some practical instructions in agriculture, husbandry, dentistry and public health were published. But by the 19th century well educated professional men came from the British Isles in increasing numbers as physicians, teachers, ministers of religion, army officers and surveyors. The fauna and flora and the geology of Canada presented a fresh field and a stimulating challenge to many of these men. Scholarly articles and a few books on scientific subjects began to be written in Canada.

In Nova Scotia as early as 1818, the *Letters of Agricola* appeared weekly in the Halifax *Recorder*. Their author, John Young, stimulated farmers of the Maritimes to improve their methods, studying climate, soils, manures and advocating the application of lime to the fields, describing the various types of occurrence of lime in Nova Scotia and how best to prepare it for spreading. So highly were these letters regarded and so great was their influence that they were published as a book under the same title in Halifax in 1822.

One manifestation of growing intellectual activity was the formation in Montreal, Quebec and the Maritimes of Natural History Societies or Literary and Scientific Societies. The Montreal Natural History Society was founded in 1827, shortly after the Literary and Historical Society of Quebec; a museum was established and the papers read at its meetings were published subsequently in the *Canadian Naturalist*. This magazine undoubtedly helped to form the intellectual atmosphere of those early years.

In Upper Canada a similar function was performed by the *Canadian Journal*, organ of the Royal Canadian Institute which was established in Toronto in 1849. Through its public lectures, its *Journal* (1852-78), and its subsequent *Proceedings* and *Transactions*, the Institute has richly contributed to the intellectual growth of this country. In its *Centennial Volume* (1949) are found ten essays on "One Hundred Years of Science" in Canada.

The Nova Scotia Literary and Scientific Society was established in January 1859. One of the first papers read before the Society was on the "Fossiliferous Rocks of Arisaig" by the Rev. David Honeyman.

This somewhat too comprehensive society was modified in 1863 when the Institute of Natural Science was founded and commenced publication in its *Transactions* of the papers read at its meetings. The seventh paper for that year was by R. G. Haliburton, F. S. A., (son of Judge Haliburton, satirist) on "The Festival of the Dead," afterwards published in Halifax as the first part of his book *New Materials for the History of Man* (1863). In this he showed that ancient and more recent inhabitants of four continents regulated their Festival of the Dead and their date of the beginning of the new year from the heliacal rising or the midnight culmination of the Pleiades. Haliburton communicated theses ideas to Professor Piazzi Smith which led the latter to base one of his dates for the construction of the Great Pyramid on the present altitude of the Pleiades at culmination relative to the inclination of a passage to the south face, up which, due to the precession of the equinoxes, the Pleiades might have been seen in B.C. 2170.

In 1862, the Principal of Queen's University, Rev. Dr. William Leitch, published in London a good account of the astronomical knowledge of the day with reproductions of the Earl of Rosse's drawings of galactic, elliptical and spiral nebulae. The tone of the book is set by its title, *God's Glory in the Heavens*. Published also in New York, it ran to a third edition in 1866.

H. Beaumont Small was the author of *The Animals of North America* (Montreal 1864) illustrated with many attractive woodcuts and written to meet "a growing desire for further acquaintance with... the pleasing study of Natural History."

A striking feature in our development is the early interest in Canada in the repercussions of advancing scientific knowledge upon religious beliefs. One evidence of this is the work of Henry Taylor which seems to have had considerable influence in Great Britain. Published by Coates in Toronto 1836, it bears the title "*An Attempt to Form a System of the Creation of our Globe, of the Planets and the Sun of our System.*" The author attempted "to reconcile the present Geological appearances of our Earth with the Mosaic account of creation" by taking literally "the waters" of the first chapter of Genesis and explaining them in the light of "the wonderful discoveries in pneumatic chemistry, of the gaseous bodies and... the component principles of water." Out of this "Universal ocean" sun, moon, planets are born, the "days of creation" being successive cycles of time. His manuscript, composed between 1819 and 1825, was shown to Archdeacon Mountain, and the Bishop of Quebec, who encouraged him to take it to England where he gave a copy to the Lord Bishop of London, to a theologian named Fairholme, and in 1833, to the Royal Institution in London. When he learned in 1836 that Professor Buckland and the theologians Pusey, Chalmers and Gleig were advocating these very ideas, he hastened to publish his work, fully believing that he was the originator of the ideas.

The same serious motive led Thomas Trotter, Minister of the Presbyterian Church of Antigonish, to publish in 1845 in Pictou his *Treatise on Geology*, "in which the discoveries of that science are reconciled with the Scriptures." The Rev. Moses Harvey of St. John's Newfoundland, with eloquence and many poetic references reviewed current advances in geology and astronomy in *The Harmony of Science and Revelation*, Halifax and St. John's, 1856. In this book he upheld the speculative musings of Sir David Brewster on the plurality of inhabited planets in the universe. A different treatment of this theme was T. W. Goldie's *Mosaic Account of Creation of the World and the Noachian Deluge Geologically Explained*, which ran to two editions in Quebec in 1856.

Thoughtful and scholarly men in Canada viewed with the same grave concern the great wave of new biological knowledge and speculation which swirled around the words Evolution and Natural Selection throughout the latter half of the 19th century and far into the 20th. The concern was of two kinds—unreasoned opposition to the new knowledge on the assumption that it was undermining spiritual faith; and honest acceptance leading to earnest and often ingenious efforts to reconcile new scientific knowledge with biblical cosmology. In 1859, the same year in which *The Origin of Species* appeared in London, Dr. James Bovell, M. D. published in Toronto *Outlines of Natural Theology* of which Professor Chapman wrote in the *Canadian Journal*, "It deserves the attention of all interested in the progress of Canadian literature." In this book the author, who believed "that a Being exists who through his works reveals himself, as an author in his volume," outlined the current state of knowledge in geology, zoology, and physiology, quoting numerous authorities such as Lyell, Humboldt, Darwin, Murchison, Huxley, Solly and Agassiz, stating unequivocably where he agreed or differed with their metaphysical or theological deductions. The influence of Dr. Bovell on the thinking and activities of the youthful William Osler (afterwards Sir William Osler, M. D.) continued to be a potent factor throughout Osler's life.

The proponents of reconciliation of science and religion had an eloquent champion in that distinguished and prolific Canadian scholar, Sir John William Dawson. His classical *Acadian Geology*, Edinburgh and London, 1855, is far from being in the category of an ordinary textbook. Dawson's *Archaia (Studies of the Cosmogony and Natural History of the Hewbrew Scriptures)* Montreal and London 1860, was so widely read and valued that he revised it in 1877 and it reappeared under the title *The Origin of the World according to Revelation and Science*. His prestige both in Canada and in Great Britain was indicated by the reception accorded to *The Chain of Life in Geological Time*, London 1880, 2nd edition 1885, 3rd. edition 1888.

During the latter half of the last century the official government reports of the Geological Survey and the Department of Agriculture grew in number and in range. Scientific magazines like the *Canadian Naturalist*, the *Canadian Journal*, the *Anglo-American Magazine* were providing well written articles on a wide range of scientific topics: lithology, ocean currents, fossils, the Niagara suspension bridge (1852), the Victoria bridge at Montreal (1855), the age of timber trees and ethnological investigations.

The *British American Journal* (Montreal 1845, with a new series beginning in 1860) contained articles and reviews on medical subjects both general and specific.

The growth of productive scholarship in Canada was greatly stimulated by the increase in the number of universities across the country in the latter part of the 19th century. These with their faculties of letters, social, and scientific studies attracted and encouraged able, ambitious scholars. To provide new outlets for the publication of their ideas the *Queen's Quarterly* was founded in 1893. Other somewhat similar magazines followed in the 20th century. In these Canadian periodicals much excellent writing is to be found, including expositions of current scientific ideas and achievements designed for the enlightenment of the intelligent general reader.

This century has seen an ever increasing flow of Canadian books and papers on scientific subjects, especially Natural History, geology, biology, the history of medical advances and biographies of men of science. It is a healthy sign. The chasm that too often exists between the disciplines of the literary men and sociologists on the one hand and the scientists on the other, is wholly deplorable. An urgent obligation rests upon scientist and historian of science to make every effort to bridge that chasm.

A. Richard [illegible]

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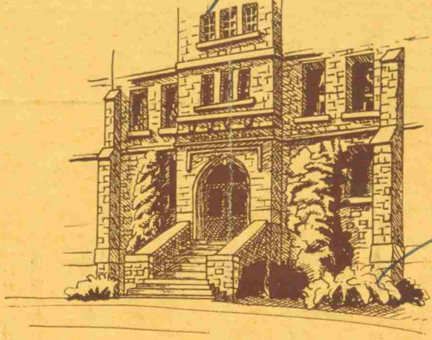
War Service 1939-45
"Doing the next thing"
ARD



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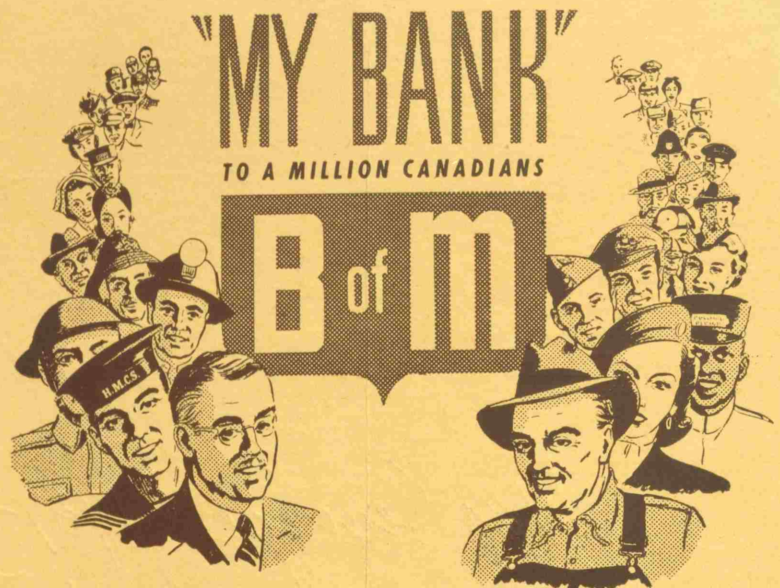

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QUEEN'S TO OPERATE NEW CANCER TREATMENT CENTRE AT KINGSTON GENERAL HOSPITAL THIS SUMMER

QUEEN'S is to operate a new cancer treatment centre at the Kingston General Hospital this summer, Ontario Health Minister Dr. R. F. Vivian announced recently. Dr. R. C. Burr, Med. '32, University radiologist, will be in charge.

More than half of the ground floor of the new Victory wing of the hospital will be made available to operate the Kingston clinic, which will serve as a pilot clinic. If it proves successful it will serve as a model for other such centres throughout the province. The laboratories and diagnostic rooms will be equipped and administered entirely by the Ontario Department of Health and the Cancer Treatment and Research Foundation.

The University will provide the medical staff. Although the number of such appointees is still undecided, a representative from each department of the Medical Faculty is expected, as the clinic is primarily for treatment. Considerable research will be done as well.

In making his announcement, Dr. Vivian said: "The fear of cost of treatment must be removed. In this first centre, and without commitment, a fixed fee for service will be established and subsidized. Half of this fee will be paid by the patient and the other half by the foundation from money which it has received from the Ontario Government. Those unable to pay anything will be treated free."

DR. R. C. BURR

The Cancer Treatment and Research Foundation, which will direct the plan, was established by the Drew administration and is under the chairmanship of Arthur Ford, of London, with a medical advisory board of cancer specialists headed by Dr. Gordon Richards of Toronto. The foundation had previously received half a million dollars from the Ontario Government.

Pointing out that cancer was the second leading cause of death in the province, and that 5,193 persons died of cancer in 1943, Dr. Vivian said reduction in the mortality rate could only be accomplished by early diagnosis and adequate treatment. Early diagnosis depended upon an educated public unafraid to seek medical advice.

The problem of making more readily available the facilities for diagnosis and treatment of cancer had been under intensive study for more than a year by the department and the foundation. Under the new plan, Dr. Vivian said, a co-ordinated system of service fully developed by specialists in cancer diagnosis and treatment would be set up. Each centre would have the most modern equipment, and consultation in all branches of medical science would be available. Scarcity of equipment and trained personnel prohibited the immediate establishment of the entire programme, but the first centre would be ready at Kingston this summer.

Dr. Vivian emphasized that the subsidy method is not state medicine. It would, he said, obtain the best possible service for the people of Ontario at a cost within their means without adding an overbearing weight of taxation.

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Mentioned In Broadcast

The activities of the Queen's Cercle Francais were mentioned in a short-wave broadcast from Montreal to France recently.

DOING THE NEXT THING

LEVANA 1939-45

by A. Vibert Douglas, Dean of Women

THE wartime activities of women undergraduates at Queen's University form a record of training, of service, and of achievement not undeserving of a place in the University archives.

With the declaration of war by Great Britain on September 3, 1939, and by Canada a few days later, it was certain that the training of university men would be compulsory and dictated by the Government, and it was almost as certain that any wartime training for university women would be left entirely to the discretion and initiative of each university.

That Queen's women undergraduates would wish to participate in some forms of war service was never doubted. Three considerations determined the variety and flexibility of the programme. One was the need for practical training of women to meet any emergency that might arise at home by reason of accident, sabotage, or air raids. Another was the realization that, as Canada's war effort took shape and developed, women would be called upon to replace men in an ever-widening range of tasks, both in and out of uniform, and from the colleges should come women capable of assuming leadership. The third consideration was that not only Red Cross and canteen work but every conceivable form of community service and any kind of training which made them more useful citizens should be regarded as war service activity.

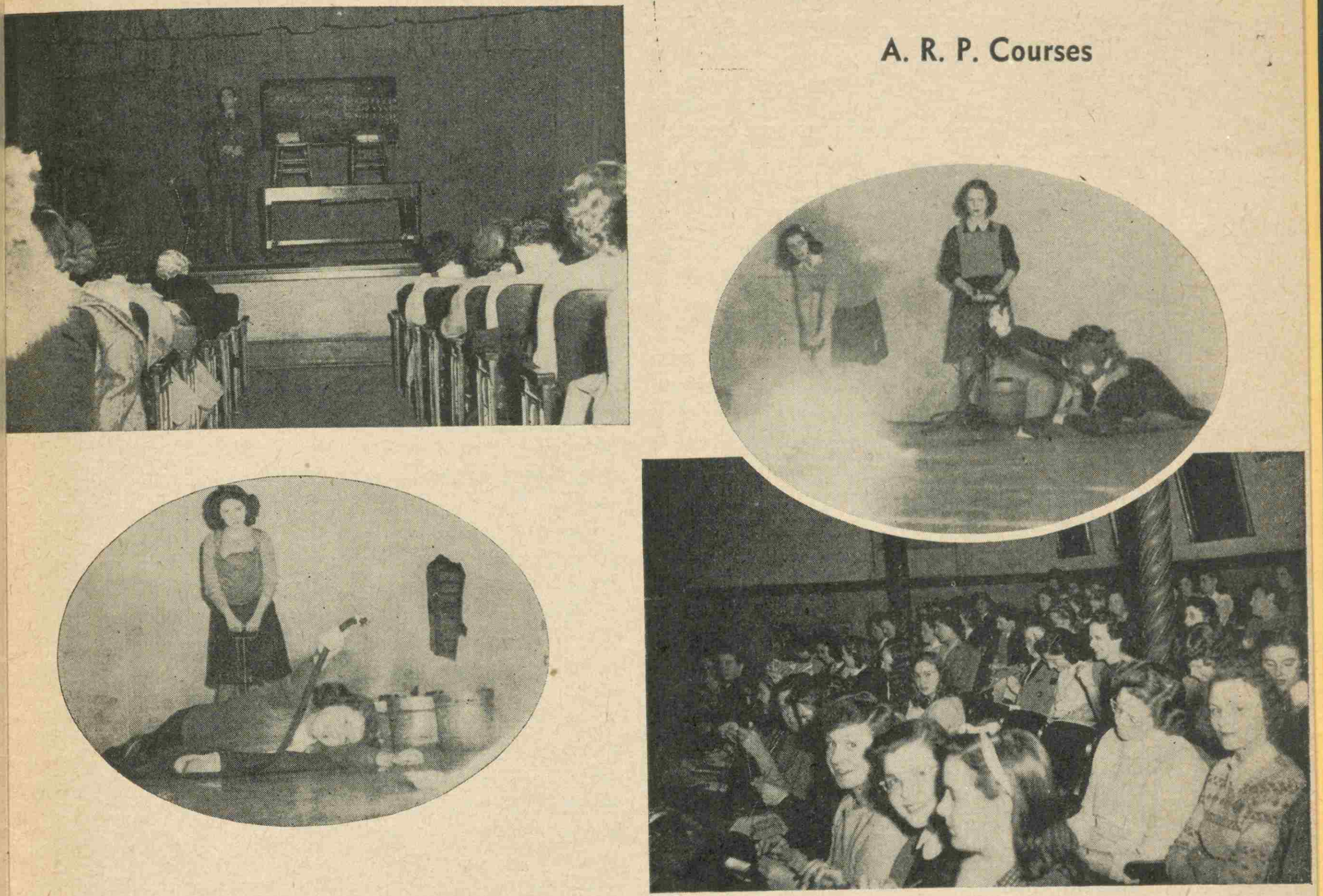
As a beginning, in September, 1939, courses in home nursing and in first aid were planned. Invaluable advice and assistance in these and in all subsequent courses were given by Dr. G. S. Melvin and Dr. J. H. Orr. Generous help was given also by other members of the Medical Faculty and by Miss Louise Acton and nurses of the Kingston General Hospital, and in the winter of 1942 by Miss Marion Crawford and nurses at the Ontario Hospital. Attendance at these courses was voluntary until the autumn of 1941 when it was declared compulsory for first year but remained optional for upper year women. The following is the record of courses and registration:

1939-40 home nursing, 183; first aid, 31
1940 Summer School, home nursing 117
1940-41 first aid, 77; home nursing, 10
1941 Summer School, first aid, 29
1941-42 first aid, 128; home nursing, 104
1942 Summer School, first aid, 27
1942-43 first aid, 99
1943-44 first aid, 51; home nursing, 62
1944-45 first aid, 32; home nursing, 103.

The total registration at these fourteen courses was 1053. By oral and practical examination 943 qualified for the St. John Ambulance Association certificate, voucher, or medallion. The cost of running the courses, supplying text-books, bandages and splints, registration of marks and issues of certificates, was met by charging each student a minimum of one dollar, and for some courses a maximum of two dollars. During the six years a total of $1,405.50 was handled in connection with this project.

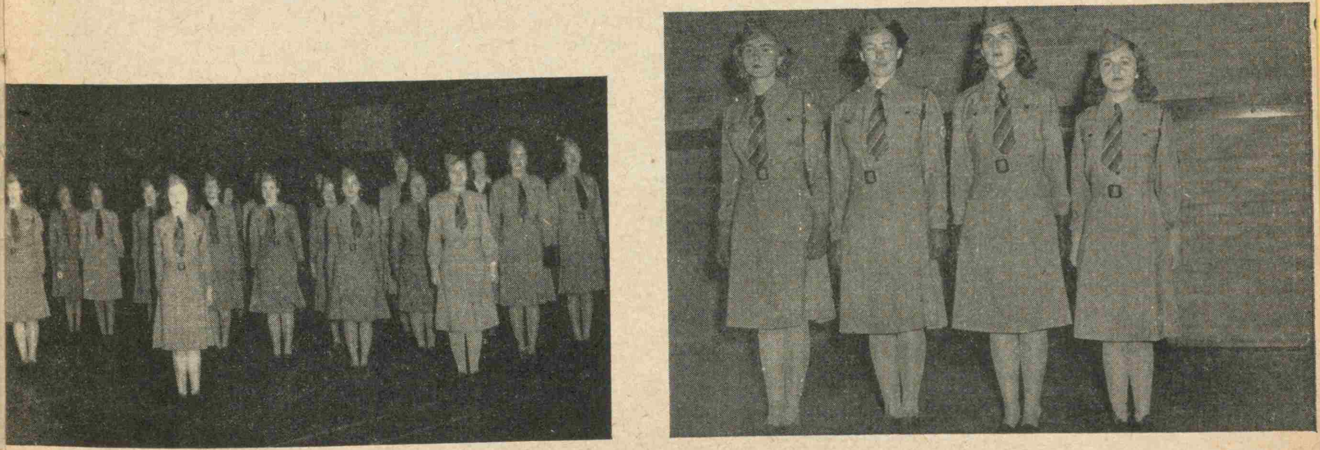
Red Cross work during the first session was confined to knitting squares for afghans, but in the summer of 1940 a Red Cross fund was begun. In September, the Queen's Red Cross Unit was authorized and a workroom established in the Old Arts Building. Two sewing machines, generously lent by Miss M. Macdonnell and Mrs. V. Williams, were in use five afternoons a week. The Levana Society appointed conveners for each period, and in second term made their only attempt to bring compulsion into what had been planned and for the next four years remained an entirely voluntary service.

A special flannelette quilt was designed for practical serviceability. It was 84 by 72 inches, contained two batts, was topped with an inset panel of some gay print, and was tufted with bright wool. In the five years, 168 of these quilts were made and sent to Britain, as well as 26 afghans. Knitted articles were made from wool issued by the Kingston Red Cross and from wool purchased for the workroom. In all some four hundred articles were made, including many children's and infants' garments, service



A. R. P. Courses

Women's Training Detachment



socks, helmets, scarfs, mitts, and pullovers. Three or four friends of Levana augmented the numbers of knitted articles by their much appreciated contributions. At the request of the Kingston Red Cross some special jobs were done, such as abdominal bandages and hospital comfort bags. The cost of quilt materials was approximately $600 and about $120 was spent on wool.

The Queen's Red Cross unit organized military hospital visiting groups in 1941 and this activity steadily grew in value and importance. The students took fruit, sweets, books, and magazines to the wards and chatted with the men. Some gave assistance with simple handicrafts. Many expressions of appreciation testified to the cheer and encouragement which the students were able to give; and many of these students, some of whom had lost loved ones, found satisfaction, comfort, and strengthening of their own spirits through this work. Approximately $170 was expended from Red Cross funds in this work. The need for hospital visiting is increased rather than lessened with the end of the war and some members of Levana are carrying on this activity into the months of peace.

Other activities made more appeal to some students — canteen work; music, drama and social evenings at soldiers' and airmen's entertainment centres; office assistance under Women's Voluntary Services; children's work at Orphans' Home or with church groups; making up ditty bags for the Navy. Some students with technical training filled gaps as these became evident in library work, in University laboratories, and at the Blood Donor Clinic. A large number took advantage of evening classes at the Kingston Collegiate and Vocational Institute to make themselves more useful by acquiring training in cooking, sewing, typing, and shorthand.

In 1940-41 Miss Marion Ross, director of physical education for women, organized a university women's training detachment as a Red Cross Corps. This corps was open to upper year students and gave excellent training in basic drill, orderly room procedure, military terminology and regulations, and in subsequent years courses in telegraphy, map reading, and a signals course under Air Force direction. In 1943-44 the scope of training was widened by having lectures from officers of the three armed services. In 1944-45 the Corps members did precision drill of high quality and directed their other efforts towards practical services as nurses' aides (266 hours in Kingston General Hospital) and at the Blood Donors' Clinic (149 hours). As commandant of this corps, Miss Ross discovered and developed the leadership abilities of a large number of undergraduate women.

SEWING CIRCLE
Red Cross Workroom in the Old Arts Building

In the autumn of 1941 an excellent course in motor mechanics and transport driving was begun by arrangement with the Royal Canadian Ordnance Corps. Members of the Canadian Red Cross Corps and a large number of other students registered for this course but after a few weeks it had to be discontinued due to pressure of military work. In subsequent sessions, under the direction of the Girl Guides organization, special short courses in youth leadership were given to small groups of interested students. Three such courses were held before the close of the war and one has been given in the 1945-46 session as youth leadership is one of the vital needs of the peace years. In 1943-44 the Hotel Dieu kindly agreed to give a recognized course of twenty lectures, followed by supervised ward work, to a small but serious group of students who thereby qualified as nurses' aides.

Three courses compulsory for all undergraduate women were arranged. The Air Raid Precautions course involved sixteen hours in the autumn of 1942. It included fire fighting and smoke rescue methods (Assistant Chief Brightman, Kingston Fire Department); chemical warfare, detection and characteristics of gases, anti-gas precautions, gas first aid, decontamination (Captain W. H. Agnew, C.O.T.C.); incendiary and high explosive bombs, A.R.P. organization and films from Britain (Captain M. McIntyre Hood, Toronto; emergency sanitation (Dr. John Wyllie); A.R.P. first aid special problems (Dr. G. S. Melvin). After this course 307 wrote the examination, 261 passed, and 126 qualified for the Provincial Civilian Defence Certificate.

The compulsory course in the autumn of 1943 was planned under the general heading of health and nutrition. Addresses on vitamins and nutrition, illustrated with films from the National Film Board, were given by Miss M. Sibley (K.C.V.I.), on infant and child feeding by Mrs. Estall, on municipal health by Dr. D. S. Puffer (Kingston Health Officer), on community health by Mrs. H. F. H. Hertzberg, on mental health by Dr. C. H. McQuaig, on hygiene by Miss A. Gibson, R.N., and on physical fitness by Miss Marion Ross. Of 289 writing the examination, 254 passed.

The autumn course in 1944 again taxed Convocation Hall to capacity and as in the previous courses, the C.R.C. Corps took the responsibility of checking attendance from prepared seating lists. Fourteen films were procured from Ottawa and the main speakers were Dr. Ursilla N. Macdonnell, on UNRRA; Dr. G. H. Ettinger, on some contributions of Queen's laboratories to wartime research; Miss R. Johns, on food problems of Europe; Principal Wallace, on some recommendations to government from the Advisory Committee on Reconstruction; and Capt. F. C. R. Chalk, on readjustment problems of returning veterans.

This record would be incomplete without mention of the fact that some undergraduate women left the campus to enlist in the R.C.A.F.(WD) W.R.C.N.S., C.W.A.C., or R.C.A.M.C. Nursing Service. Others postponed their courses in order to fill posts in laboratories, schools, civil service, nursing, or other imperative work. Many others employed the summer months in work of essential importance—farm and orchard work, laboratories, industry, office work, social welfare.

This account of the wartime activities of Levana must contain a grateful acknowledgment of the generosity of the financial support given to the Queen's Red Cross Unit. A summary of the fund is as follows:

A.M.S. & War Aid Commission	$625
Levana, L.A.B. of C., and B.R.H. Council	220
Summer School B.R.H. Committee	73
Miss Phillips' Handicrafts Exhibits	81
Grant Hall (Red Cross) Dance	27
Dr. M. M. Gibb	110
Other private donations	86
Red Cross Boxes (Red Room, B.R.H., Tech. Supplies)	40
Miscellaneous	20
	$1282

This fund is still open, campus grants are being sought and given, and some members of Levana are still doing "the next thing", carrying military hospital visiting and children's aid work into the needy and challenging postwar period.

RETIRING TRUSTEES ARE RE-ELECTED

DR. W. C. Clark, Arts '10, LL.D. '35, Ottawa, Ontario, and Dr. Alexander Macphail, LL.D. '39, Kingston, Ontario, have been re-elected without contest by the graduates to the University Board of Trustees. They will hold office for three years.

J. M. Macdonnell, Arts '14, LL.D '41, Toronto, Ontario, and A. E. MacRae, Sc. '14, Ottawa, Ontario, were also re-elected trustees by acclamation in the benefactors' elections, Mr. Macdonnell for a four-year term and Mr. McRae for three years.

PRINCIPAL WALLACE STARTS 1946 LECTURE SERIES

AN address by Principal Wallace on the UNO Educational Conference in London, which he attended in November, will be the first in the series of five public lectures sponsored by the University in January and February. The lectures are held at eight o'clock on Monday evenings in Convocation Hall, Old Arts Building. Following is the schedule:

January 14—Principal Wallace.

January 21—"Atomic Power," by Dr. B. W. Sargent.

January 28—"Allergy," by Dr. G. K. Wharton.

February 4—"The Story of the Flying Bomb," by Dr. John Stanley.

February 11—"Russia," by Dr. H. A. Innis, of Toronto.

FILL EXECUTIVE POSITIONS IN FEDERAL DEPARTMENT

OFFICIAL amalgamation of the Department of Munitions and Supply and that of Reconstruction was marked at Ottawa on New Year's Day. Included in the list of chief executives were a number of Queen's alumni:

G. C. Bateman, Sc. '05, LL.D. '44, Director General, Washington, D.C., Office.

Norman B. Davis, Sc. '11, Controller of Radio-Active Substances; Deputy Co-ordinator (Mining), Resources Development Branch.

W. A. Mackintosh, Arts '16, Director General, Economic Research Branch; member of Depreciation Committee.

Brigadier Colin A. Campbell, Sc. '22, Director General, Real Estate Branch.

Dr. C. J. Mackenzie, LL.D. '44, Director General, Research and Development Branch.

E. T. Sterne, Sc. '13, Director General, Chemicals and Explosives Production Branch.

E. P. Murphy, Sc. '10, Crown Assets Allocation Committee.

W. A. Newman, Sc. '11, President, Federal Aircraft Limited.

Paging All Bellringers!

RINGING the mythical bell in Grant Hall tower needn't remain a standard undergraduate joke, because there is a perfectly sound cast-iron bell, complete with an aura of Queen's history, lying idle in the basement of the Old Arts building.

Dean Earl recently drew attention to the bell, and the *Review* rooted out its origin. It was cast by the Kingston foundry for the Old Medical building tower back in 1859. For forty-two years its voice rang out every hour to tell the change of classes. Then another floor of classrooms was added to the two-storey building, and the tower was torn down. Homeless, the bell joined the museum in the Old Arts building, where it remained until all but biological exhibits were moved to Miller Hall in 1931. Then it was consigned to the basement of the Old Arts building to collect dust and cobwebs on its motionless handle and silent clapper.

Annual SMOKER

TORONTO
ALUMNI
BRANCH

★

Royal York Hotel
Ballroom

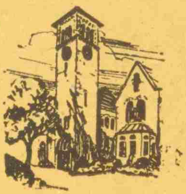
6 p.m., Thursday, February 14th, 1946

REFRESHMENTS

Queen's University

KINGSTON - ONTARIO

Incorporated by Royal Charter 1841



Situated in the oldest city in Ontario; thirty-four modern buildings; health insurance provided during session; placement office gives free service to students and graduates.

SPECIAL SESSION FOR EX-SERVICEMEN AND WOMEN

Queen's University will offer beginning *early in April* a full year of work in the Faculties of Arts and Applied Science to ex-servicemen and women. The work in Arts will include the subjects of the preparatory year, all the first year subjects for which there is a sufficient number of applicants and certain advanced courses will be made available for qualified students. The first and second years in the Faculty of Applied Science will be offered. Students who successfully complete the session will be able to proceed to a higher year in September, 1946.

University Entrance Requirements for Ex-service Men and Women as Agreed Upon by the National Conference of Canadian Universities.

FACULTY OF ARTS

JUNIOR MATRICULATION:

1. English
2. French or another language
3. Mathematics (Algebra and Geometry)
4. One of: History
   A language not already chosen: Latin, Greek, French, German, Spanish, or Italian
   A science: Physics or Chemistry or Agriculture.

If in addition to Junior Matriculation standing, the student can offer credits at Senior Matriculation level, he will be given allowance up to a total of five subjects.

FACULTY OF APPLIED SCIENCE

1. *General education*—minimum:
   Senior Matriculation in English
   Junior Matriculation in History and in French (or another language), or, alternatively,
   Senior Matriculation in one of these two subjects.
2. *Pre-requisites for first year work*:
   Senior Matriculation in Mathematics (Algebra, Geometry, and Trigonometry), in Chemistry, and in Physics.

FACULTY OF MEDICINE

1. *General education*—minimum:
   Senior Matriculation in English
   Junior Matriculation in another language (Latin advised) and in History, or, alternatively, Senior Matriculation in either of these two subjects.
2. *Pre-requisites for later work*:
   Senior Matriculation in Mathematics (two of Algebra, Trigonometry), Physics, and Chemistry.

Candidates interested in both the special session and the regular session should write for further information to the Registrar, Queen's University, Kingston, Ontario.

East Germany Through a Tourist's Eyes

by

A. Vibert Douglas

The former Dean of Women and Professor of Astrophysics at Queen's describes the frustrations and revelations of a trip last summer through East Germany from which she came away with admiration for the cheerfulness and friendliness of "a people who have been through great tribulation."

WITH a receipt for nine days' total expenses in my wallet and a three-page detailed itinerary in my handbag, I flew from Paris to East Berlin in late July with the assurance that an entrance visa would be awaiting me at the airport. There a queue had already formed at the visa wicket behind which a young woman checked and rechecked the papers submitted, handed out visa forms, and slowly released one after another at the head of the line. Some of these individuals then sat down to wait for their papers; others proceeded to the gate, showed their visas, collected their baggage and passed out of sight between two airport guards.

For me the delay might not have been unduly long had not the Canadian agent for East European travel sent to Berlin the wrong dates, shifting everything three days earlier than my planned schedule called for. "You should have been here three days ago," said the official. I showed my dated itinerary and tried out most of my inadequate German vocabulary, but three hours went slowly by before a temporary visa was given me for one night at the Berolina Hotel, cash for a day's meals and instructions to go to the Reiseburo first thing in the morning.

The Berolina Hotel, off one of the fine broad new boulevards of Berlin, is spacious and of first class quality. The bedroom closet was equipped with not only coat hangers but clamp hangers for trousers or skirts, with shoe brush and cloth, with a small sewing kit of needles threaded white and black. The dining room was large and modernistic in a subdued fashion, the menu gave wide choice of food and drink. In Canadian equivalent my room was $5.25 per night. The people in the lounge seemed to be chiefly business men and parties of East European tourists with money to spend on drinks, ices and patisserie—the terrace cafés of the Berlin boulevards were crowded with such groups happy and gay in the lovely summer weather.

Next morning I walked by flower-bordered paths to a busy street and then past three large blocks of empty devastation to an area of noisy dusty rebuilding. Near there was the Reiseburo, the government tourist office, where once more I was told I should have arrived three days before, that all reservations were cancelled and all places crowded. So for the first of many times in the course of the next eight days I insisted that the fault was not mine but their agent's, and that I had already paid for everything listed on my itinerary. Importunity prevailed and two and a half hours later, I emerged with a new itinerary in the reverse order from what I had planned before leaving Canada. I had an hour to get back to the hotel, pack my bag, pick up my railway ticket at the hotel desk and get to the 12.30 train for Leipzig.

Leipzig Station is one of the largest in Europe—30 parallel tracks come into a vast concourse with broad stairs at either end leading down to street level, a wide street noisy with many trams, full of pedestrians, a few private cars, many trucks but almost no taxis while a patient queue waited and waited. I remarked to a gentleman beside me how few taxis were available. He shrugged his shoulders and said: "This is Germany", adding that petrol was very expensive.

The three and a half hour journey from Berlin had been made in a two-decker train, very crowded, with many families obviously off for a vacation. At first the country was flat agricultural land, fully cultivated, here and again plots of reforestation with pine trees and some forestland. Then came a region of tar sands and heavy industry. The city of Leipzig was 40% demolished by bombing but in twenty years much had been rebuilt, a ring of green being retained around the heart of the old city. Facing this ring is the heavy grey stone museum once the High Court of Germany where The Reichstag trials were held. On a side street is the house where Schiller composed his "Ode to Joy". New apartment blocks are going up. New hotels and a large supermarket. The old buildings of the great market square were fortunately spared as also the Thomas Church where Bach was organist for 37 years, and where Luther preached in 1539. Adjacent to the church is its famous Music School.

My very intelligent guide drove me to the Auerbach's Keller, immortalized in Goethe's Faust, two Faust monuments at the entrance, and a statue of Goethe nearby, then out to the grounds of the world-famous Leipzig Trade Fair and beyond them to the great heavy Monument of the Nations commemorating the defeat of Napoleon in 1813. My guide spoke of the forthcoming Trade Fair when visitors from many nations, east and west, would pour into the city taxing hotel and private house accommodation to the limit. As a linguist she would be in constant demand, and when it was over she would fly to beautiful Sochi on the east coast of the Black Sea for a holiday. I sensed no enchantment with the present situation, rather a vaguely expressed hope that greater freedoms would come, albeit slowly; but when I enquired how wages compared with prices, the reply was immediate and direct—wages compare favourably with the low cost of the essential foods and clothing; rents are kept low, but all luxuries are expensive. I did not see the famous Leipzig Zoo, but was told that more lions are born there than anywhere else in captivity. They are sold to zoos all over the world, even to Africa.

Here, as wherever I went, people were neatly dressed in summer garb, most of the men wore clean white shirts, often of nylon or similar fabric, the younger women in gay prints, older ones often in a skirt and pretty nylon or frilly cotton blouse. Poverty I did not see in the five cities visited.

By dint of repeated demands for my railway ticket to Weimar, I at last was given a first class ticket, so I travelled in roomy comfort the hour and half journey in a compartment comparable to a first class coach on British Railways. The country became more hilly and wooded as we approached this little Thuringian city, once the intellectual and artistic capital of Germany. To me who had just finished rereading Emil Ludwig's life of Goethe the whole town came alive, permeated through and through with his spirit, an almost tangible presence.

With fountains and red geraniums in the centre, the old Market Square is indeed the focal point of the town. Facing it is the Elephant Hotel completely modernized behind its ancient low façade. From it my young guide led me for two hours through the old winding streets to see the grand ducal palace with its ancient gate and huge courtyard, the more modern palace of the archduke, the government buildings and in particular the part where Goethe worked as Minister of Education, the great Park which he designed and loved, his house in the park and his large town house, his theatre and the famous Goethe-Schiller monument, other monuments of Goethe, Herder, Liszt, Wieland and Carl August, and the churchyard where lie the remains of Goethe's faithful wife Christiane.

In this town I saw two or three German versions of the 'hippie', a type not encouraged according to my guide. This guide was in her early twenties, had specialized at school in Russian and English, had been an official guide for three years. That morning she had conducted a group of Russian architects around the town. Taking me about was her last assignment before leaving for the Baltic coast in charge of a group of holidaying children, a part time responsibility which would allow for vacation activities of her own. In the autumn she would enter the university taking Russian and English, receiving free tuition and about $50 a month to cover room and board in a student hostel.

The light was failing as we returned to the Elephant so I took my guide in to the hotel for dinner, and how she enjoyed this 'luxury'. I tried to draw her out a little. Cost of living? The essentials were within every worker's means; luxuries were rare. Certain things like spirits, chocolate, tobacco products, perfume, furs, were reasonable in the Tourist Shops, attached to the main hotels, but only hard foreign currency could be used. This explains why occasionally a taxi driver asked hopefully if he could be paid in American dollars offering a generous rate of exchange! I asked my guide if she hoped for a reunion of east and west Germany. The answer came slowly: only if they will come to

us as a socialist state. She spoke scornfully of the west German leaders as having been pro-Nazi. This was one of the post-war generation born and educated in the socialist state, and inculcated with Marxist doctrine. "I would not live in a capitalist state no matter how high its standard of living; I would not feel safe."

The next morning I spent in the Goethe museum, his town house, just a short walk from the Elephant. I saw the simplicity of his private rooms, especially interesting the study with its high writing shelf by the window overlooking the garden full of flowers; his library of many thousand volumes, the complete set, beautifully bound, of his own writings. The corridor and six rooms facing the front of the house are full of pieces of sculpture, pictures, family portraits, cases for 18,000 geological specimens, with many of the superb crystals and minerals on view. The adjacent museum gives further evidence of the wide spread of interests and insatiable curiosity of this amazing man. Zoological specimens, fossils, a Wimshurst machine, test tubes, an elaborate magnifier, a drafting set, and the walls covered with manuscripts and drawings of Faust.

After the usual telephone calls to Reiseburo in Berlin, which happened wherever I went, I was handed a ticket to Dresden a bare hour before the train left. The messenger was a remarkably beautiful young woman without a word of any foreign language except Russian. Five and a half hours later through interesting hilly country and finally a deep gorge between brown sandstone cliffs, I entered Dresden. This city of 500,000 saddened me as Berlin and Leipzig had not, except for the general feeilng of horror at the madness of war and its accompanying devastation wherever one sees it. But old Dresden seemed an unnecessary addition to the record of destruction. The heart of the city was destroyed. The shattered tower of the great Lutheran Cathedral near the high bank of the Elbe is all that remains of that landmark and it is to be retained, standing alone in the large space save only for the undamaged dynamic statue of Martin Luther. Much rebuilding is evident but many great grey hulks and skeletons of what were fine public buildings remain. Wide streets, squares and parks abound and statues of dukes and princes of Saxony. A wildish new park containing a small children's railway occupies a large part of the blasted heart of the old city. The famous Technical University lies beyond it, one of its buildings being the old jail which became the Gestapo headquarters. Every autumn the new freshman class is assembled in its courtyard where executions took place and a monument commemorates the victims, giving numbers of each nationality, including Germans, who died there. The present Rector of the university is a woman, a professor of nuclear physics. Two Potsdam students doing the preliminary years of a course in civil engineering, whom I had met the previous August in the Tatra mountains in Czechoslovakia, told me they might never be able to complete the course because there would be over a hundred applicants for twenty places in the Dresden University.

The tower of the Dresden Rathaus remains but most of the building is new, the palaces of the Saxon princes are impressive, but the place of greatest interest is the famed Semper Art Gallery with its many treasures of Italian, Dutch and Spanish art. Above all, hung at the far end of three salons, is Raphael's Sistine Madonna, larger than I had imagined and impressive in its majestic dignity far beyond my expectations. At the end of the war all the masterpieces had been taken away to Russia, some of them badly damaged by water and rubble during the bombardment; but later all were returned, fully restored, to the joy of the grateful citizenry.

At Dresden I was joined by a Montreal friend whose arrival from East Berlin had been delayed a day because of troop train movements towards the Czechoslovak border where the Warsaw Pact manoeuvres were to take place. The Bratislava talks had been in progress and apparently amicably, but Russian supply trucks were moving in convoys down the roads to the south. When we inquired about our scheduled visit to the nearby town of Meissen we met with a flat negative —against police orders. Vehemently refusing to take No, we were escorted to police headquarters where two policewomen with the only unpleasant faces we saw in Germany took our passports and disappeared to return after some minutes with the permission granted. Driving down the west side of the Elbe we passed many Soviet lorries before reaching the picturesque town of Meissen with its close-packed, red-tiled little houses, narrow steep streets, high perched Schloss and simple unadorned early Gothic cathedral. The famous porcelain factory and its extensive display rooms of early and present day products are a centre of attraction. A bus load of young Bulgarians with their interpreter was being conducted through the demonstration and show rooms.

An early train conveyed us in three hours to Potsdam where we found ourselves assigned to rooms in the Cecelienhof Hotel deep in a park with spectacular flower beds, by a lake dotted with sailboats. Erected about 1909 in half-timbered Tudor style as a summer palace for Kaiser William and "little Willie", (whose family lived on there until 1945), it is now a combination of hotel and historic museum where one can see the small, elegant baronial hall with lovely staircase to the musician's gallery, and the round table at which Stalin, Atlee and Truman signed the Potsdam Agreement. The city was heavily bombed; much construction is in progress but the things of interest to me were the unpretentious little house presented to Voltaire by Frederick the Great, the palace and park of Sans Souci with their associations with Voltaire, Maupertuis and Frederick, and the distant view of the Academy of Science, the Max Planck Institute, the observatory dome (all its prewar instruments were taken to the USSR in retaliation for the German destruction of Pulkova Observatory), and the other centres of learning high up above the lake.

On our return to Berlin we were accommodated in the large new Hotel Unter den Linden on the broad avenue of that name now completely rebuilt and again one of the great, handsome streets of Europe. First on the right above the Brandenburg Gate and the infamous wall, stands the massive granite USSR Embassy and beyond it the Soviet Trade Building. Some fine shops with large windows display carpets, books, paintings, and the Meissen products. The Comic Opera is there, a royal palace, a square with fountains and flowers and terrace café and the greystone Humboldt University before which are statues of the famous brothers Karl Wilhelm, philologist and statesman, founder of the University in 1809, and Friedrich Heinrich Alexander, naturalist and explorer.

The great Alexanderplatz is a scene of noisy confusion with demolition and construction, giant cranes and underground excavations. In a couple of years, perhaps, it will present a magnificent appearance, but last summer long detours were necessary; the dust and din were overwhelming and the sun shone down upon the scene where the temperature stood at 80°F in the shade. Many great apartment blocks are going up. These form a feature of every city or town I saw, and not one of them anywhere was without its rows of gay flower boxes at the edge of every balcony.

The greatest attraction for us was the Pergamon Museum of Archaeology, one of the superlative collections of Europe and the Middle East. Here we stood spellbound before the Greek altar of Pergamon from Asia Minor, the Syrian Temple of Baal, the Babylonian Tower and street approach in black brick with brown and greyish bas reliefs of animals. Here indeed one could spend hours, and unfortunately I did not even get to the Egyptian section.

By dint of more importunity at the Tourist Bureau, official transportation to the West Berlin airport was provided with a friendly driver who saw me through the formalities at check-point Charlie in less than five minutes. And so to the western airport where he refused a tip. Incidentally my Weimar guide had informed me that tips were considered demeaning in a socialist state where wages were adequate—but, she added, western tourists were accustomed to giving tips, so the waiters expected it from them. The first thing that struck me on arrival at West Berlin airport was to see at least twenty taxis in double ranks at the exit!

I came away from East Germany with many memories of a frustrating nature, but many more of friendliness and cheerfulness, and with a deep admiration for a people who have been through great tribulation. Their eastern conquerors confiscated most of their heavy machinery and rolling stock and kept thousands of their men to help rebuild the devastated Soviet cities. Slowly and determinedly, with tightened belts and with no external aid, (as had West Germany), the east Germans are recreating their country and their lives within the political and economic framework imposed upon them.

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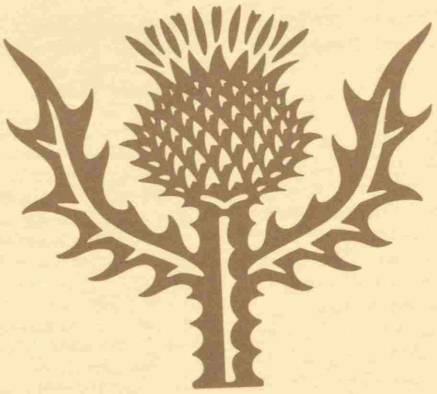

EDDINGTON, SIR ARTHUR STANLEY

by

A. Vibert Douglas

from the fifteenth edition of ENCYCLOPAEDIA BRITANNICA

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HELEN HEMINGWAY BENTON, Publisher

RAMSEY, *God, Christ and the World* (1969), places emphasis on theology as the only way towards reuniting Christianity. GEOFFREY FRANCIS FISHER, *The Archbishop Speaks* (1958), reflects an understanding of ecumenism as an invitation to an objective re-evaluation of the theology of the particular Christian churches. N. GOODALL in his *The Ecumenical Movement* (1961), records the personal feelings and thoughts of a man committed to world evangelism as a means of achieving true ecumenism. JOHN COLEMAN BENNETT, *Foreign Policy in Christian Perspective* (1966), is an analysis of the Christian perspective of foreign policy by a theologian committed to religious and political or international ecumenism. S.C. NEILL, *Towards Church Union, 1937–1952* (1952), is a record and chart of theological mores affecting, and the steps that should be taken in gaining, a clearer perspective of the theological dimensions of modern ecumenism. DENO JOHN GEANAKOPLOS, *Emperor Michael Palaeologus and the West, 1258–1282* (1959), studies in depth the political overtones and motivations of the reunions negotiated and agreed upon in Lyon and Florence-Ferrara. R. ROUSE and S.C. NEILL, (eds.), *A History of the Ecumenical Movement 1517–1948* (1954), stands out as the most scholarly work in the series of ecumenical literature to be consulted in understanding both the division and the imperative of bringing about a united Christendom. ERNST BENZ, *Geist und Leben der Ostkirche* (1957; Eng. trans., *The Eastern Orthodox Church*, 1963), gives an objective analysis of the openness of the Eastern Church, vis-a-vis the ecumenical orientation of modern times. STEVEN RUNCIMAN, *The Great Church in Captivity* (1968), reveals the abandonment of the Eastern center of Christianity, resulting from the westernization and alleged self-righteousness of Christianity, pointing to the need for a new evaluation of unity, both as a demand of God and of history.

(I.)

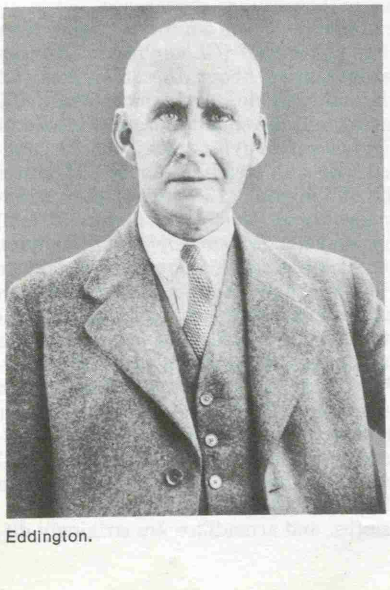
Eddington, Sir Arthur Stanley

Astronomer, physicist, and mathematician, Sir Arthur Stanley Eddington was a pioneer in the fields of relativity, cosmology, and the dynamics and internal constitution of the stars. He was also a notable expositor of new scientific ideas and their philosophic significance.

He was born on December 28, 1882, the son of the headmaster of Stramongate School, an old Quaker foundation in Kendal near Lake Windermere in the northwest of England. His father was a gifted and highly educated man who died of typhoid in 1884. The widow took her daughter and small son to Weston-super-Mare in Somerset, where young Eddington grew up and received his schooling. He entered Owens College, Manchester, in October 1898, and Trinity College, Cambridge, in October 1902. There he won every mathematical honour, as well as Senior Wrangler (1904), Smith's prize, and a Trinity College fellowship (1907). In 1913 he received the Plumian Professorship of Astronomy at Cambridge and the following year became also the director of its observatory.

From 1906 to 1913 Eddington was chief assistant at the Royal Observatory at Greenwich, where he gained practical experience in the use of astronomical instruments. He made observations on the island of Malta to establish its longitude, led an eclipse expedition to Brazil, and investigated the distribution and motions of the stars. He broke new ground with a paper on the dynamics of a globular stellar system. In *Stellar Movements and the Structure of the Universe* (1914) he summarized his mathematically elegant investigations, putting forward the thesis that the spiral nebulae, cloudy structures seen in the telescope, were galaxies like the Milky Way.

By courtesy of the University of Chicago; photograph, Yerkes Observatory, Williams Bay, Wis.



Eddington.

During World War I he declared himself a pacifist. This arose out of his strongly held Quaker beliefs. His religious faith also found expression in his popular writings on the philosophy of science. In *Science and the Unseen World* (1929) he declared that the world's meaning could not be discovered from science but must be sought through apprehension of spiritual reality. He expressed this belief in other philosophical books: *The Nature of the Physical World* (1928), *New Pathways of Science* (1935), and *The Philosophy of Physical Science* (1939).

Relativity theory

During these years he carried on important studies in astrophysics and relativity, in addition to teaching and lecturing. In 1919 he led an expedition to Príncipe Island (West Africa) that provided the first confirmation of Einstein's theory that gravity will bend the path of light when it passes near a massive star. During the total eclipse of the sun, it was found that the positions of stars seen just beyond the eclipsed solar disk were, as the general theory of relativity had predicted, slightly displaced away from the centre of the solar disk. Eddington was the first expositor of relativity in the English language. His *Report on the Relativity Theory of Gravitation* (1918), written for the Physical Society, followed by *Space, Time and Gravitation* (1920) and his great treatise *The Mathematical Theory of Relativity* (1923)—the latter considered by Einstein the finest presentation of the subject in any language—made Eddington a leader in the field of relativity physics. His own contribution was chiefly a brilliant modification of affine (non-Euclidean) geometry, leading to a geometry of the cosmos. Later, when the Belgian astronomer Georges Lemaître produced the hypothesis of the expanding universe, Eddington pursued the subject in his own researches; these were placed before the general reader in his little book *The Expanding Universe* (1933). Another book, *Relativity Theory of Protons and Electrons* (1936), dealt with quantum theory. He gave many popular lectures on relativity, leading the English physicist Sir Joseph John Thomson to remark that Eddington had persuaded multitudes of people that they understood what relativity meant.

His philosophical ideas led him to believe that through a unification of quantum theory and general relativity it would be possible to calculate the values of universal constants—in particular involving the number 137 (the fine-structure constant), the ratio of the mass of the proton to that of the electron, and the number of atoms in the universe. This was an attempt, never completed, at a vast synthesis of the known facts of the physical universe; it was published posthumously as *Fundamental Theory* (1946), edited by Sir Edmund Taylor Whittaker, a book that is incomprehensible to most readers and perplexing in many places to all but which represents a continuing challenge to some.

Eddington received many honours, including honorary degrees from 12 universities. He was president of the Royal Astronomical Society (1921–23), the Physical Society (1930–32), the Mathematical Association (1932), and the International Astronomical Union (1938–44). He was knighted in 1930 and received the Order of Merit in 1938. Meetings of the Royal Astronomical Society were often enlivened by dramatic clashes between Eddington and Sir James Hopwood Jeans or Edward Arthur Milne over the validity of scientific assumptions and mathematical procedures. Eddington was an enthusiastic participant in most forms of athletics, confining himself in later years to cycling, swimming, and golf. He died on November 22, 1944.

Contributions to astrophysics

Eddington's greatest contributions were in the field of astrophysics, where he did pioneer work on stellar structure and radiation pressure, subatomic sources of stellar energy, stellar diameters, the dynamics of pulsating stars, the relation between stellar mass and luminosity, white dwarf stars, diffuse matter in interstellar space, and so-called forbidden spectral lines. His work in astrophysics is represented by the classic *Internal Constitution of the Stars* (1925) and in the public lectures published as *Stars and Atoms* (1927). In his well-written popular books he also set forth his scientific epistemology, which he called "selective subjectivism" and "structuralism"—*i.e.,* the interplay of physical observations and geometry. He believed that a great part of physics simply reflected the interpretation that the scientist imposes on his data. The better part of his philosophy, however, was not his metaphysics but his "structure" logic. His theoretical work in physics had a stimulating effect on the thought and research of others, and many lines of scientific investigation were opened as a result of his work.

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(A.V.D.)

Edentata

Edentata, an order of mammals, includes 31 living species distributed among the armadillos, true anteaters, and tree sloths, as well as eight extinct families of ground sloths and armadillo-like animals. The living families and six of the extinct families comprise the suborder Xenarthra. A second suborder, Palaeanodonta, consists of two extinct families. The entire evolutionary history of the edentates is restricted to the Western Hemisphere and the majority of the living species occur today in South America.

GENERAL FEATURES

Edentata means lacking teeth, though in reality only the true anteaters are toothless. The majority of edentates have simple, peglike cheek teeth that lack enamel; canine-like teeth do occur in some forms. Certain armadillos may have as many as 100 teeth. Edentates possess specialized traits, such as reduced dentition, a long sticky tongue, powerful, clawed, forefeet, associated with their insect diets. They also have primitive traits, such as the possession of five toes on the hindfeet, a simple uterus, and small, uncomplicated brain, which place them close to the primitive stock that gave rise to the infraclass Eutheria, which includes all placental mammals.

A persistent myth holds that any kind of armadillo, in defense against enemies, can roll itself into an impregnable armour-plated ball. In fact, only the three-banded armadillo (*Tolypeutes tricinctus*) is able to perform this feat. Most armadillos contort themselves into a reasonable facsimile of a ball, but some only slightly increase the convexity of the dorsal shell (carapace) while flattening against the ground. Individuals of some species flee to burrows or attempt to burrow right on the spot but may freeze and feign death when flight and rapid excavation are somehow prevented. Misconceptions about other edentates also exist. The toothless, weak-jawed anteaters seem to be sucking in ants and termites through a small tube, when, in fact, it is the sticky product of the greatly enlarged submaxillary glands covering the lengthy extensible tongues that facilitates the capture of these insects. The slow-moving arboreal sloths, typically depicted as moving upside down along a branch, really spend only about 10 percent of their time moving at all.

The armadillos and anteaters are important ecologically, helping to control many kinds of abundant insects, especially ants and termites. Armadillos feed on some carrion and thus play a small part in cleaning up the environment. Although some armadillos may become agricultural pests, and the armour of several species is made into purses and other curios, edentates are generally of little economic importance. Generally, the greatest interest in edentates lies in their bizarre appearance.

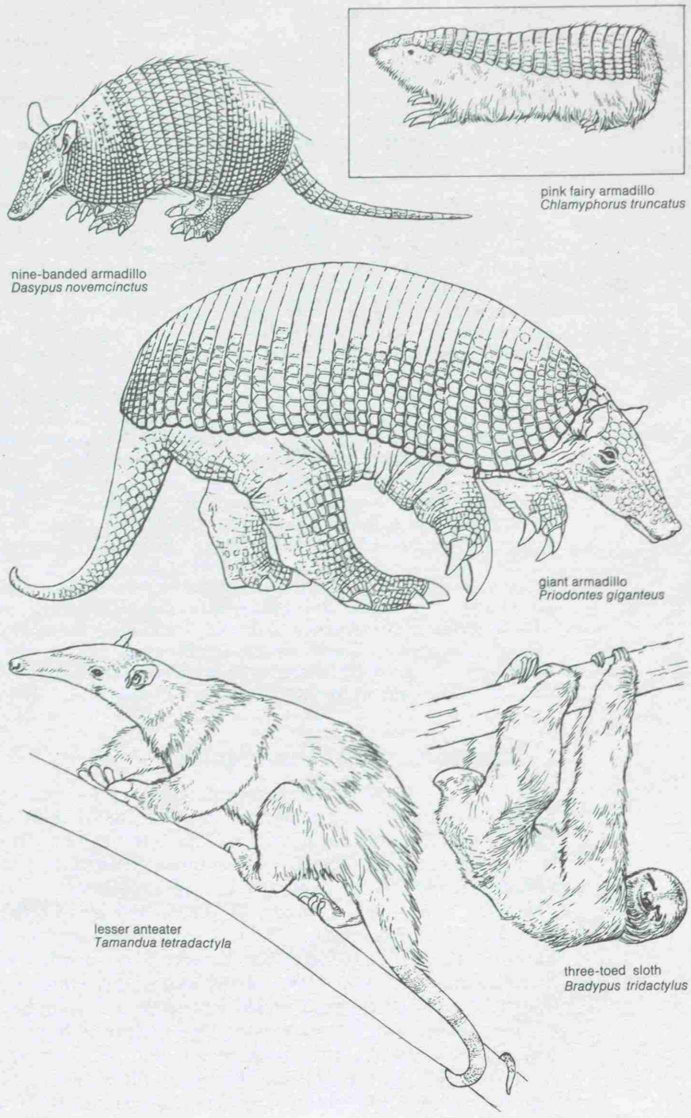

Figure 1: Edentate body plans.
Drawing by J.C. Barberis

Living edentates range in size from the tiny pink fairy armadillo or "lesser pichiciego" (*Chlamyphorus truncatus*) of Argentina, measuring about 16 centimetres (6.5 inches) in length and weighing little more than 100 grams (a few ounces), and the slightly larger two-toed or silky anteater (*Cyclopes didactylus*), just over 37 centimetres (15 inches) long and weighing about 325 grams (12 ounces), to the 60-kilogram (125-pound) giant armadillo (*Priodontes giganteus*), nearly 1.5 metres (5 feet) long, and the giant anteater (*Myrmecophaga tridactyla*), which weighs up to 25 kilograms (55 pounds) and may be over 2 metres (6 feet) in length. Among extinct forms, an Oligocene armadillo, *Prozaedyus proximus*, had a skull under 8 centimetres (about 3 inches) in length and was only somewhat larger than the smallest of the living armadillos. The Pleistocene ground sloth, *Megatherium americanum*, was 6 metres (20 feet) long and was larger than a modern elephant; a Pleistocene glyptodon (*Doedicurus clavicaudatus*) was more than 4 metres (13 feet) long and 1.5 metres (5 feet) high. Both flourished in South America about 500,000 years ago.

Anteaters, tree sloths, and armadillos are strikingly dif-

THE ENERGY OF STARLIGHT

BY A. VIBERT DOUGLAS

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THE ENERGY OF STARLIGHT

BY A. VIBERT DOUGLAS

I

THE development of science presents a dual aspect. When it is regarded, as it were, microscopically, the mind is staggered by the vision of ever-growing complexity, greater and greater diversity, whether it be of stars or stones, men or microbes, molecules or atoms — new types, new species, new affinities, new isotopes. Regarded macroscopically, however, very different is the prospect it affords — the vision of all-embracing natural law, a great underlying unity gradually disclosing itself, the intrinsic harmony of all things. This is the vision all-compelling, the vision which sends the man of science on a lifelong quest as sacred as that of the Holy Grail — the quest of Truth. And in the reality of this vision his faith is unwavering and undaunted. All faith is dynamic, and to this vital faith of men of science that there exists ultimate order in the universe Professor A. N. Whitehead has ascribed the rescue of Western thought in the later Middle Ages from the futility of 'unbridled rationalism.'

In no branch of science is this gradually emerging unity more evident than in the realm of physics. Five or six hundred years before the beginning of the Christian Era we find the Greek philosophers experimenting and speculating upon the phenomena of mechanics, sound, heat, light, electricity, and magnetism. Each of these was at first an entirely separate and distinct branch of knowledge, no connecting links being apparent. Archimedes investigated the laws of mechanical advantage and buoyancy; Pythagoras studied sound, discovering a relation between the length of a stretched string and the note which it would produce when caused to vibrate; Hero of Alexandria probed some of the mysteries of heat; Thales, in 600 B.C., knew something of the manifestations of electrostatics and of magnetism, but to him they were phenomena unrelated in any way; Aristotle, about 350 B.C., and five hundred years later Ptolemy of Alexandria, recorded their observations on the behavior of light, but of its true nature and its kinship to the phenomena studied by Thales and Hero even Ptolemy knew nothing.

Our picture is thus of six streamlets of knowledge having their beginnings in the far-distant past, each growing in breadth and depth as the centuries rolled by. But not the inspired vision of even the greatest thinkers of early times could foresee that these streams would prove to be tributaries of one mighty river — the vast, deep, broad river of energy.

The first confluence took place almost imperceptibly with the gradual realization that sound was essentially a mechanical phenomenon, produced by mechanical means and in itself a pulsation of material particles. Thus two of the streamlets had merged their waters before the time of Galileo and Newton. The momentous contributions to knowledge made by these two giants among the great thinkers of all time swelled this stream during the seventeenth century until it became a rushing torrent.

The other streamlets, meanwhile, grew each to the proportions of a river, but each maintained its individuality until the nineteenth century. With the discoveries of Coulomb, Volta, Gauss, Oersted, Ampère, Ohm, and the great Faraday, the rivers of knowledge regarding the phenomena of electricity and magnetism became merged into one, the river of electromagnetic energy. Contemporaneous with Faraday, Carnot and Joule were establishing the relation between mechanical energy and heat, and so another mingling of waters was accomplished and the comprehensive river of mechanical energy flowed on toward the present century, to be augmented from within by the work of Helmholtz, Clausius, Kelvin, Boltzmann, Gibbs, and Planck.

But what of the river of light? 'Light, the prime work of God,' as Milton has written; light, to this day the chief marvel and mystery to the natural philosopher. The stream of light grew into a river during the lifetime of Newton and Huygens. Its volume increased with the investigations of Fraunhofer, Fresnel, Foucault, and Kirchhoff, but it was the mathematical researches of James Clerk Maxwell about 1875 that brought about the union of the river of light with the great river of electromagnetic energy. The Maxwellian electromagnetic theory of light at once led men of science to search for a radiation akin to light but invisible and of very great wave length. The infectious enthusiasm and pioneer researches of Sir Oliver Lodge stimulated many to the search, but to Hertz in 1888 fell the lot of first detecting the 'wireless' waves. Gradually it was realized that to the same category of electromagnetic waves or vibrations belonged the heat rays, much shorter in wave length than the Hertzian waves, but longer than those of visible light. Thus, too, the mysterious X-rays of Röntgen found their true place among the electromagnetic waves shorter than light, shorter even than the invisible ultraviolet light whose chemical activity is so great.

Thus the great river of mechanical energy mingles its waters with those of the great river of electromagnetic energy, and even as the waters swirl together new knowledge regarding the energy of matter itself springs suddenly forth in astounding abundance to increase the already swollen river. The momentous discovery by Sir J. J. Thomson of the electron, the ultimate charge of negative electricity and the smallest known particle of matter, closed the century. Following up the work of Becquerel and the Curies in radioactivity, the present century saw the birth of Rutherford's nuclear theory of the atom and his discovery that the electron and the proton, or ultimate positive charge of electricity, are the two building bricks of all the elements of which matter is composed. On Rutherford's experiments arose Bohr's theory of the atom, which supplied for the first time a picture of the mechanism within the atom which permits of the emission of electromagnetic energy as X-rays, light, or some other form. The culminating step in this conception that there is one great entity, energy, which can manifest itself in many forms, was taken by Lorentz and by Einstein independently when they propounded the relation which links matter with energy. Matter itself, or, to think of its ultimate constituents, the proton and the electron — these are tremendous concentrations of the fundamental entity of the universe, energy. Not that this is available energy — the secret of the concentration of energy whereby matter is created and the secret of the annihilation of matter whereby its energy is dissipated into space are held tightly by Nature beyond the grasp of man. Sometime and somewhere in the space-time universe this transformation has taken place and matter has come into existence. Man can alter its form to a limited extent by bringing about chemical and physical change, but he cannot as yet make or unmake matter.

II

After contemplating this mysterious fundamental entity, energy, manifesting itself in so many ways, whether bound as in matter or freely transformable as from light to heat, from heat to mechanical energy, to electrical or chemical or any other of the well-recognized forms, the question naturally presents itself, Whence comes all this terrestrial energy with which we are familiar? The earth beneath our feet, the air we breathe, and our bodies themselves are tremendous concentrations of energy. Whence comes it? And the answer is — star dust. Our earth was once a portion of the surface material of the sun, and our sun is just a star among the stars of a great galaxy of many millions, a quite typical star in most respects, neither one of the largest nor one of the smallest, neither one of the hottest nor yet the coolest. A chance fragment of a great star is our planet; and man, as far as his physical framework is concerned, being 'of the earth, earthy,' is therefore of the stars, starry, or, rewriting a famous line of the great poet, 'We are such stuff as stars are made on.'

When we seek the source of the unbound energy of the earth we find that some of it — its gravitational energy and a very small amount of its heat — is within it; but the energy which maintains the surface temperature of the earth at a reasonable degree of warmth, the energy which makes possible the existence of life upon the earth, life vegetable, life animal, the life of man — all this energy comes from without. It is brought to the earth in the sunlight and in the starlight; but, since the latter term in its fullest sense includes the former, we may simply and with absolute accuracy say, Of star dust are we made, and by starlight we live.[1]

If astronomy be the study of the stars, astrophysics may be said to be the study of starlight. Whereas the former is the oldest of the sciences, the latter is one of the youngest, yet in the few-score years that have elapsed since the birth of astrophysics man's knowledge of the universe has expanded many fold, so almost overwhelming have been the revelations resulting from the study of the energy of starlight.

One never ceases to marvel at the achievements of the early astronomers. They mapped the heavens; they recognized that the stars are the timekeepers; that their positions give us our sense of direction; that the seven celestial bodies — sun, moon, and five naked-eye planets — which wander across the background of the 'fixed' stars move with an ordered precision which they could foresee though they could not explain. But, because they knew not the real significance of energy, they could read in the starlight only its most obvious message.

Aristotle gave his support to the doctrine that all things terrestrial were made up of four constituents, — earth, air, fire, and water, — whereas the celestial bodies were composed of a fifth substance, the perfect immutable

[1] The writer acknowledges indebtedness to Dr. A. Wilmer Duff for the idea of the river of energy developed above and to Dr. E. B. Frost for the metaphor 'star dust' as here employed.

substance; and hence, unlike the earth, the heavenly bodies remained forever unchanged. No room is here for a study of the energy of starlight, for to recognize an outflow of energy presupposes change in the radiating body. Thus the minds of men had to be freed from the shackles of this Aristotelian fallacy before the science of astrophysics could come into being. This liberation was not achieved for seventeen centuries, and then it was Galileo who severed the chains once and for all by turning his pioneer telescope upon the sun and finding there every evidence of change — change in its surface brightness, dark areas whose shapes and positions altered from day to day. By this and other evidence he proved the universality of the law of change.

There remained now no obstacle to the study of starlight as energy save only the very essential fact that the means of analyzing light was still unknown. The discovery of the prismatic separation of light into its constituent rays was one of the many achievements of Sir Isaac Newton. If a ray of starlight be made to traverse a glass prism, it emerges not as one ray but as many; the composite starlight is analyzed, and each ray corresponding to a different energy value is set out in order, so that it can be studied apart from the others; and, what is quite as important, if the incoming starlight is lacking in some of the full range of expected energy values, their absence becomes at once apparent.

The road was now paved for the birth of astrophysics, and the investigations of Fraunhofer and Kirchhoff into the spectra of starlight mark the beginning of this new branch of science.

III

When the light of a star is viewed through a spectroscope attached to a telescope, a band of colored light is seen, the sequence of rainbow colors, but crossed at intervals by dark lines. Instead of merely looking at this spectrum, a photograph of it may be taken, and thus a permanent record is obtained which may be studied under the microscope. In this way precise measurements may be made of the wave lengths of those missing radiations in the stellar spectra. Now these dark lines in the spectrum are the hieroglyphics which hold the message of starlight, and the corresponding measurements of wave lengths are the code by means of which these hieroglyphics may be interpreted.

It is well known to the physicist that the atoms of every element can be identified by the distinctive radiations which they can emit or absorb according to the conditions of temperature and pressure under which the experiments are carried out. When the distinctive wave lengths of, let us say, the hydrogen atoms are found to agree precisely with a set of the dark lines in a stellar spectrum, the conclusion is obvious and unavoidable — hydrogen is not exclusively a terrestrial element, it is a constituent of every star, it is one of the essential building bricks of the material universe. So too carbon, nitrogen, calcium, iron, silicon, and, indeed, most of the elements of terrestrial occurrence, have added their hieroglyphics to the stellar spectra. Not only do the elements impress upon the starlight the record of their identity, but also of the conditions of temperature and pressure under which they are radiating or absorbing energy. The temperatures of stellar atmospheres are found to vary from about two thousand degrees Centigrade for the cool reddish stars to over twenty thousand degrees for the hot giant stars of bluish hue. This is read directly in the message of the starlight, but to form a picture of the conditions

at the *centre* of a star is another matter. All the courage and all the insight of the mathematician are here required to reason from known surface conditions to the unknown central conditions. 'Our object in diving into the interior,' writes Professor Eddington, 'is not merely to admire a fantastic world with conditions transcending ordinary experience; it is to get at the inner mechanism which makes stars behave as they do.'

The starlight contains some valuable information regarding the motion of the star. Just as the whistle of an approaching locomotive is shrill, suddenly becoming deeper as the engine speeds away, so the hieroglyphics are displaced slightly toward the violet end of the spectrum if the star is approaching and toward the red or longer wave lengths if the star is receding. Much of what is known regarding the motions of the stars in space is learned in this way. These motions are sometimes very large, a velocity of one hundred kilometres per second being not uncommon, yet so vast are the distances between stars that 'speeding' is not a public danger! Even a 'runaway star' traveling one thousand kilometres per second would speed on through empty space for many millions of years before approaching so closely to any other star as to cause apprehension or consternation in the star world. The stars are no more crowded together than would be four or five little minnows were they the sole inhabitants of the Atlantic Ocean.

IV

Whence comes the energy of starlight? This has been one of the puzzling questions to which one answer after another has been given, only to be rejected as insufficient. Kelvin suggested a gradual contraction of the star; then radioactivity seemed to offer a solution; more recently the slow synthesis of the elements was regarded as the source of energy — hydrogen atoms in the stellar crucibles being so locked together in mutual embrace as to be transmuted into the successively more complex elements of increasing atomic weight, a process accompanied by a liberation of electromagnetic energy. But now a new and yet more startling theory holds the field, championed by some, doubted by some, unproven but not disproven — the theory of the spontaneous annihilation of matter within a star. Reference has already been made to the Lorentz-Einstein hypothesis of the intrinsic oneness of matter and energy. It is not inconceivable, then, that under the extraordinary conditions existing deep down within a star the ultimate particles of matter, proton and electron, might so collide that each unkinked the other's energy, thus producing their mutual annihilation as matter, or, expressed otherwise, thus bringing about the physical degradation of the energy of matter to the energy of radiation.

Perhaps this is the true explanation of the seemingly inexhaustible store of energy poured out continuously into space from every star that shines in the heavens. To consider just one typical star, our own sun is radiating energy equivalent to the annihilation of four million tons of its mass every second, and has been radiating thus for a million million years if we are justified in assuming that it was once as massive a star as Sirius. But, vast as is the store of stellar energy, it is not limitless. Professor Whitehead paints a majestic but a solemn picture of the universe 'passing with a slowness, inconceivable in our measures of time, to new creative conditions, amid which the physical world, as we at present know it, will be represented by a ripple barely to be distinguished from non-entity.'

'Degradation of energy, yet conservation,' is the summing up of the whole matter by the physicist; 'physically wasting, yet spiritually ascending,' is the dictum of the philosopher.

That the processes of nature are irrevocably proceeding toward a lowest ebb is a thought intolerable to some types of mind. In spite of the fact that there is no supporting evidence, there are those who would believe that somehow and somewhere radiant energy — the energy of starlight — is being re-formed into protons and electrons, these aggregating into atoms, the atoms forming nebulæ which condense into stars whose matter gradually becomes transformed again into radiant energy. Thus the whole order of nature becomes one vast cycle indefinitely repeated.

V

It would be difficult to overestimate the influence which astronomy has had upon the human mind. From the geocentric standpoint of pre-Copernican days to the heliocentric point of view was a tremendous advance and involved a revolution of thought of far-reaching consequences. But the study of starlight has not left us there; it has forced upon mankind the realization that, though the sun is the centre of the solar system, it is not the centre of the universe. Our glorious sun is but one of the lesser stars in a galaxy of a thousand million; and far out in space beyond our galaxy are the spiral nebulæ to the certain number of many million, and the probable number of a thousand billion[2] — and each spiral nebula is a galaxy of myriad stars!

Where is man in such a picture? Certainly not where Gray infers him to be when he sings of gems and blossoms unseen by mortal eye: —

> Full many a flower is born to blush unseen,
> And waste its sweetness on the desert air.

Nature has strewn her stars with even greater prodigality, but can we say they 'waste' their energy of radiant light and heat upon surrounding space because it may be devoid of little 'earths,' the habitats of human life? Is it 'waste'? That word is unknown in the economies of nature. The stars in their courses fight against our petty, anthropocentric sentimentalisms; they fight and they prevail. We must change our philosophy; we must widen our vision and sing with another poet, Robert Service, —

> A star or a soul is a part of the Whole
> And weft in the wondrous Plan.

All down the ages we find men of science and poets alike drawing inspiration from the starlight. Ptolemy of Alexandria, in terms characteristic of his period, expressed it thus: 'Mortal though I be, yea, ephemeral, if but a moment I scan the multitudinous circling of the stars, no longer on earth I stand, but sit with Zeus himself and take my fill of the ambrosial food of gods.'

Human thought has passed through many phases since Ptolemy's day. Materialism is inadequate and unsatisfying. When man endeavors to grasp the significance of the workings of nature, tries to realize the vastness of the universe and to grapple with the great mysteries still unsolved, perhaps it is a something within him akin to mysticism which sets some chord vibrating in harmony with those thoughts expressed by Pope in his pæan of praise to an Immanent Divinity, who

> Warms in the sun, refreshes in the breeze,
> Glows in the stars and blossoms in the trees;
> Lives through all life, extends through all extent;
> Spreads undivided, operates unspent. . . .
> To Him no high, no low, no great, no small;
> He fills, He bounds, connects, and equals all.

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[2] This is the English billion, equivalent to a million million. — AUTHOR

Europe's Youth Carry Moral Scars of War

By A. VIBERT DOUGLAS

Before any Canadian uses the argument of Europe's black markets and frequent lawlessness as reason to cease sending food abroad, he should ponder the explanation given here. In Europe recently the writer discussed with various professional people many of the continent's youth problems. In such matters as black market trading, deception and evasion the years of German occupation induced new concepts of morality. Our sympathy and practical help are necessary to see the people through this hang-over.

IN every country of Europe that was attacked and occupied by the German armies there are problems of readjustment which are inevitably present and call for understanding and great patience. We have had our own problem of juvenile delinquency in Canada and we can place our fingers upon various facts associated with war-time disruption of family life as partially to blame. But contrast our problem with that of countries which were four or five years under ruthless and cruel enemy domination.

Laws, orders and edicts were to be despised, and broken or evaded whenever possible. Buying on the black market, getting the necessities of life surreptitiously and stealthily, was patriotic. Food procured in that way never came to the knowledge of the enemy authorities and therefore was not subject to the deduction of that large proportion of all produce commandeered for export to Germany. And such food might make all the difference between hunger and actual starvation. In all these countries the vitality of the people reached so low an ebb that it is estimated that in some of them 40 per cent, and in Poland even higher, of all the students have tuberculosis in the advanced or incipient form. Small wonder that evasion and deception became virtues, for they were frequently the means of survival.

Patriotic Deception

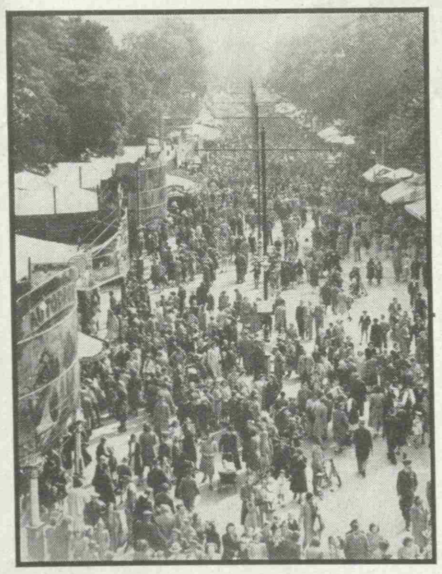
In another way, too, deception was a highly prized art. Perhaps a member of the family or of a neighboring community was sought by the enemy officials, charged, justly or unjustly, with some act of sabotage or resistance to the German authorities. To be caught meant death or deportation to a German labor camp. Deportation might mean worse than death and at best offered but a small chance of survival. (A French student in a sanitorium in Switzerland told the writer that he was one of seventeen survivors of a camp of 600 deportees.) Many a loved one was saved from capture only because an adult or a child was quick and ready with an effective lie and could carry dissimulation through with an apparent and convincing nonchalance.

Picture a child of eight or ten or twelve years living the next five years of his life under the circumstances just outlined. When suddenly the liberation came, imagine these young people being told that now to be good citizens they must respect the law and live within it, that truth and integrity are the ideals to be followed, that lying and deception are wrong, that buying on the black market is no longer respectable even though there is not enough food obtainable by legitimate means.

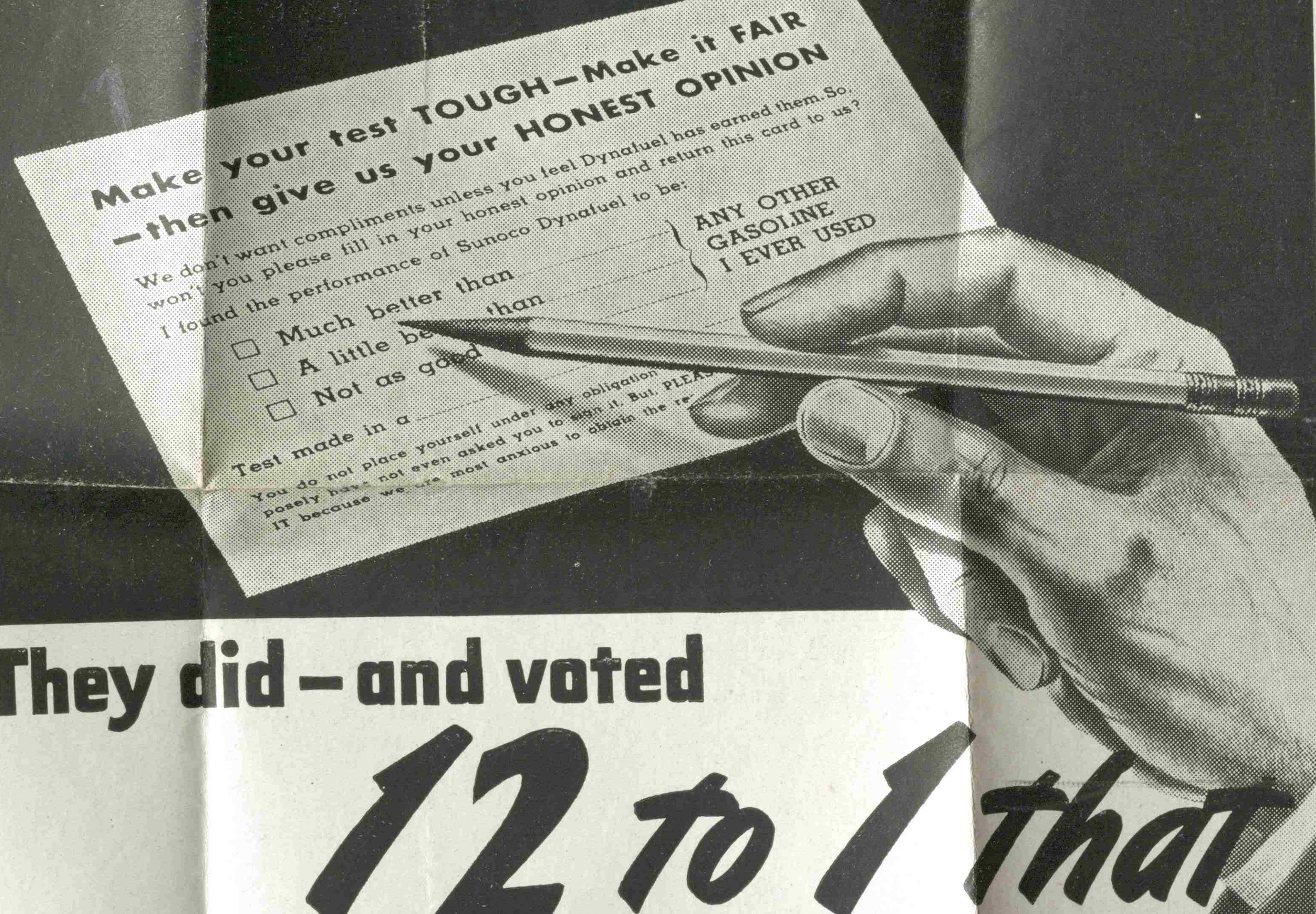
Such a readjustment cannot be accomplished overnight. It is not easy for adults; it is too much to expect of children. Patient, sympathetic and wise guidance from parents, teachers, social workers and civil authorities is needed; and it will take time.

So long as people are hungry and cold, so long as they lack many of the simplest necessities of life, there will be black markets. As long as these markets exist, the temptation to deal with them will be too strong for many people. There are those who would resist the black market for their own needs, but to whom a sick and hungry infant or a beloved parent, elderly and ailing, poses an ethical problem of another category.

We who have never gone hungry, we who have never seen enemy soldiers marching victoriously in our streets, whose homes have been unshattered by enemy bombs, and whose loved ones have never been dragged from us by brutal gestapo—we must try to understand the postwar problems facing the liberated countries. We shall then be slow to criticize or condemn, and quick to sympathize and to render help in any and every way within our power.



The university town of Oxford is also noted for its centuries-old street carnival. Called the St. Giles' Fair, it is an enormous annual attraction as the above picture shows, with a daily attendance of more than 30,000.



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FIVE FACETS OF INTERNATIONALISM

By A. Vibert Douglas, Dean of Women at Queen's, and President of the International Federation of University Women

A PROMISE to the editor of the *Review* must be honoured, and so there follows a brief account of twelve weeks in which I sojourned in six countries of Europe. I saw much that was of tremendous interest and significance, and met a wide variety of people many of whom are indeed to be ranked as amongst the highest flowering of humankind.

On June 1, I crossed by night from Harwich to the Hook in response to an invitation extended to me by the Netherlands Association of University Women. Soon after sunrise Dr. Klompe (now a member of parliament) met me and we drove across central Holland to Deventer. There we had lunch with a group of university women and then proceeded north to Groningen. A large group were gathered there for dinner in an historic moated farmhouse near the North Sea where generations of Dutchmen have slowly and arduously pushed back the sea with three successive lines of dykes. The next morning we drove westward to Leeuwarden where we had lunch with a busy group of our members. Driving on to the coast, I stood for the first time on one of the great North Sea dykes, the sea level on the one hand twelve to fifteen feet higher than the level of the fields, farms and villages on the other side.

We drove across the twenty-five miles of dyke which enclose the Zuider Zee and then for miles across the Wieringermeer Polder which had been innundated when the Germans blew up the dyke. Vast new barns had been erected and one-storey prefabricated dwelling houses beside them. The indomitable spirit of reconstruction here and in the cities to the south was something so impressive that it calls forth the highest admiration. That night we met the university women of Amsterdam, and afterwards I went on to The Hague by train. The next day I met a group at Leiden for lunch, and saw something of their oldest university and the Leiden Observatory, famed for theoretical researches in astronomy and cosmology. I met the university women of The Hague at dinner that evening and those of Rotterdam the next day. I have no words to express adequately my admiration for the spirit of the citizens of Rotterdam. With the heart of their city destroyed and their harbour so largely blasted, they are doing a job of gradual reconstruction which is a magnificent example of human faith and endeavour.

The next morning I saw masterpieces of Rembrandt and Van Gogh in Amsterdam, and visited Dr. Westerdyke and her internationally known laboratory museum of fungi at Baarn. She was the third president of the I.F.U.W.

From the Scandinavian express, crossing the British Zone of Germany with a military transit permit, I saw the desolation of Osnabruck, Bremen, Harburg, Hamburg, and the beauty of Rensburg where the railway crosses the once proud Kiel Canal, and so into Denmark. Welcomed by the university women of Copenhagen, I spent five days in that beautiful city meeting with many small groups of professional women and one large public gathering at the university. The next engagement was on the mainland of Jutland at the university town of Aarhus, justly proud of its modern university and its unique museum village of centuries-old houses, mills and shops.

Returning to England from Esbjerg, I began a tour of ten cities for the British Federation of University Women. Thus I was enabled to meet groups in London, Brighton, Oxford, Reading, Birmingham, Birkenhead, Liverpool, Bradford, Leeds and Hull. Everywhere, whether in Holland, Denmark, or Great Britain, the warmth of kindliness, and the expressions of gratitude to Canadian university women were almost overpowering.

On July 1, I crossed from Dover to Ostend and went through Belgium to the British Zone of Germany to play a small part in a great experiment in international education. This was the Summer Seminar planned and carried through by the Canadian Committee of International Student Service, with support from every university in Canada, every provincial government, the C.C.R.U. and the education authorities in the British Zone of occupation. The last-named provided accommodation for the students and administrative and teaching members of the Seminar at Schloss Plon, a

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few miles south of Kiel. This large seventeenth century princely residence, amongst the beautiful lakes of Schleswig, became the home of 135 students of sixteen nationalities having in common at least some knowledge of English and a sincere desire to learn from one another and to inquire together into the problems confronting the world in general and students in particular. To Professor Marcus Long of Toronto and Professor Anstensen of Saskatoon belong the chief credit for this amazing experiment where fifty German students and an equal number of Canadians and about thirty-five from fourteen other countries lived together for six weeks in a spirit of mutual respect and keen inquiry. My time with them was necessarily limited to ten days and I can truly say it was one of the greatest experiences in twenty-six years in educational work.

On returning to England I had the privilege of attending the Congress of the Universities of the Commonwealth at Oxford. It was an enriching experience in a multitude of ways. Amongst many events packed into a few days, *Review* readers will be most interested in a reference to the Convocation in the Sheldonian Theatre when Principal Wallace was one of six to receive the D.C.L., and to the banquet in the great hall of Christ Church given by the University of Oxford after which the thanks of all delegates were expressed to the Vice-Chancellor by the Principal of Queen's University in a speech so appropriate to the occasion that it was universally acclaimed and appreciated.

There followed for me very busy days until the end of July with committees and the Council Meeting of the I.F.U.W., a reception given by the London Association of University Women in the Senate House of the University of London and the annual dinner of the British Federation in Crosby Hall. Representatives of some twenty-four of our thirty-three member nations were able to be present at the Council Meeting held in Eastbourne. I think we all felt that something of constructive and permanent value was accomplished and that the ties were strengthened which hold our International Federation together and make it a force in the world today.

On July 31 I had an unforgettable day at the Olympic Games, one of some 82,000 spectators to see the finals of the 100-metre dash and the 400-metre hurdles; the semi-finals of the 800 metres, the long jump, the pole vault and the hammer throw; nine heats of the women's 100 metres and the women's javelin throw. What a day of blazing sunshine and excitement!

My niece, Elizabeth V. Douglas, Arts '47, had just finished a year of teaching at a school near Cambridge, and together we went to Paris on August 2. We stayed at Reid Hall, a residence for university women established by the generosity of the American donor whose name it bears. Under the wise and kindly guidance of Miss Leet it has become an international meeting ground. It houses the office of the French Federation of University Women, with two of whose officers I had several discussions. The charm of Paris captures one ever afresh but three days were all that could be spared. There followed one wonderful day at Chartres where the unbelievably beautiful twelfth and thirteenth century glass windows are almost all in place again. Then a night train to the south of Switzerland and two and a half days in Zermatt and on the Gornergrat and the high foothills of the Matterhorn—no lectures, no speeches, no immediate responsibilities — a time of utterly joyous abandonment to the spirit of the high Alps and glaciers above the upland meadows. This brought to realization a dream of many years duration. We went north through the magnificent scenery from Zermatt to Lucerne and thence to Zurich, where we settled down in that charming old and modern city to enjoy to the full the Congress of the International Astronomical Union. Astronomers from thirty-two countries attended this first meeting of the Union since 1938. It was a week of amazing Swiss hospitality, of stimulating scientific discussion and chit-chat, and of renewal of faith in the ability of people to work together and co-operate in the things of the mind, almost completely undisturbed by political differences—almost but not quite.

There followed two days in Basle, meeting with the university women there to plan for the I.F.U.W. Conference to be held in Zurich and Basle in 1950. Thence to England and two days later, on August 25, I embarked for Canada.

FROM ATOMS TO STARS

BY A. VIBERT DOUGLAS

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FROM ATOMS TO STARS

BY A. VIBERT DOUGLAS

THROUGHOUT the ages intellectual progress has been due to three attributes of mankind — a deeply implanted, insatiable curiosity; a far-reaching, unrestrainable, unfetterable imagination; and an undaunted faith that there is order in the universe, an underlying harmony in nature. Dean Inge, who is one of the few distinguished men of letters to possess a keen and sympathetic understanding of the aims, ideals, and spirit of scientific inquiry, has written these words: 'The dramatic fancy which creates myths is the raw material of both poetry and science. Curiosity, imagination, and faith — these are the qualities of mind which have led the natural philosophers of every age to search patiently amid the phenomena of nature that they might perchance discover the reality behind and beneath the appearance of things.

To every investigator there come moments when his thought is baffled, when the limits of experimental possibility seem to have been reached and he faces a barrier which defies his curiosity. Then it is that imagination, like a glorious greyhound, comes bounding along, leaps the barrier, and a vision is flashed before the mind — a vision no doubt that is partly false, but a vision that may be partly true. It stirs up new ideas in the thoughts of the investigator, it fires him with a fresh enthusiasm and his curiosity spurs him on to further endeavors. Thus is brought about the gradual growth of knowledge.

I

The greyhound imagination of the Greeks pictured the atom, the ultimate particle of matter, smaller than anything that human eye can see. Almost three hundred years ago, the greyhound imagination of Pascal saw a vision of what was within the atom: 'Consider the last least object [the atom] at which he [the scientist] can arrive. Perhaps he will think that it is the limit of littleness in nature. But I will show him within this a new abyss. I will paint for him not only the visible universe, but all the immensity of nature that one can conceive within the bounds of this epitome of an atom. He may see an infinity of universes, each with its firmament, its planets, its earth, in the same proportions as in the visible world.'

In the light of the revelations of the last twenty-five years, Pascal's vision is indeed remarkable. Overdrawn though it undoubtedly is in some respects, there is more than a germ of truth within it, and the last phrase in particular is strikingly prophetic. We know to-day the proton and the electron and how in the hydrogen atom the latter revolves about the more ponderable former, very much as a planet about the sun. We know, too, that the heavier elements are composed of atoms having a nucleus made up of some compact aggregation of protons and electrons, while outer electrons in orbits like planets and comets revolve about this massive centre.

To-day the greyhound imagination of a Rutherford is leaping the barrier of the complex atomic nucleus, while the picks and spades and battering-rams of his associates are opening for us a breach into the very citadel of the atom. Here we are dealing with the limit of smallness to which the human mind has attained.

But the human mind goes outward to the immensities as well as inward to the atom. Here, too, the imagination has played its part and astronomers have done what Ulysses longed to do—'To sail beyond the sunset and the baths of all the western stars.' Young men have seen visions and old men have dreamed dreams; these flights of the imagination have paved the way for the advance of knowledge. These visions and dreams are among the highest peaks of human achievement.

Man has looked out into space beyond the sun and solar system of planets, satellites, asteroids, comets, and meteors, out beyond the six thousand stars visible to the naked eye, beyond the thousands of stars revealed to the eye by means of a telescope, beyond the millions of stars recorded photographically and estimated statistically — and what does he see? He sees spiral nebulæ, clusters of one hundred million stars, island galaxies to the number of many thousands — possibly there are many millions. And of these myriad stars each one is a radiant sun, a sphere of inconceivably hot, glowing gas. The majority are as large as or larger than our sun, and their average distances are such that if one star were represented by a golf ball the next star would be another golf ball, or perhaps a football, or a small balloon, some thousand miles away.

II

To gain some idea of these astronomical distances let us imagine that the Golden Arrow, whose recent record of 231 miles per hour astonished the world, should travel around the earth at the equator, contenting itself with a speed of 200 miles per hour. It would complete the journey in five days. At the same speed it would cover the distance from earth to moon in fifty days. It would arrive at the sun in fifty-three years. Neptune, the outpost planet of our solar system, would not be reached until fifteen hundred years had elapsed, and then through interstellar space the Golden Arrow would speed on and on for thirteen million years ere it would reach a neighboring star. After ninety thousand million years, when it has passed through all the stars of the Milky Way and arrived at the confines of our galaxy, — like a traveler who comes to the border town of his own country, — in a sense the journey has just commenced, the exploration of the universe is about to begin.

No doubt Shakespeare thought that he was taxing the imagination of his audience to the utmost when he made Puck, the messenger of the fairies, assert his capacity for speed thus: 'I'll put a girdle round about the earth in forty minutes.' Our generation would not tolerate a fairy who could do no better than that! Have we not the radio wave that will encircle the earth in one seventh of a second?

Let us then desert the Golden Arrow for a golden sunbeam, that swiftest known messenger, the electromagnetic radiation which travels through space at 186,000 miles per second. A sunbeam comes down to the surface of the earth, hits a smooth shiny object, and is reflected outward again. At the moment of rebound, vault into the saddle, and away you go to explore the universe. In one and one-third seconds you have passed the moon, in eight and four-tenths minutes the sun is left behind, and after four years the first neighboring star looms large ahead. Thereafter, every four or five years will bring you near to some great sun, or perhaps to some binary system where two great stars revolve about one another. Less often, but nevertheless not infrequently, it will be a multiple system of three or four or more suns revolving about one another in pairs, and the pairs about the common gravitational centre of their group. Undoubtedly there will be an occasional star that you will find, as you approach closely, to be surrounded, like our own sun, by a family of planets, of comets, and of meteoric swarms. What may you not see as your sunbeam carries you close to some of these planets? Our imagination loses itself in speculative wonderings.

But you will have abundant time to ponder on the sights and the marvels of any one group of stars or solar systems ere you reach another, — several years of meditation, — unless perchance your course leads you into a dense nebulous region of interstellar space where your sunbeam is buffeted this way and that, so that it is no easy matter to avoid disaster. An oxygen atom here, a nitrogen atom there, a meteoric fragment just beyond, and your sunbeam just misses the one, collides with the other, losing some of its energy, is buffeted by the third, and swerves off obliquely. Thus on and on from one excitement to another, year in and year out, until at long last the vast nebula is traversed and you emerge into less crowded regions of space.

One hundred thousand years of journeying thus will bring you to the outermost limits of the Milky Way, the frontiers of our galaxy — and what then? It is then, and then only, as your sunbeam begins its million-year journey across cloudless, starless space, that your exploration of the universe may be said to have really begun. Looking backward upon our galaxy, you see it as a mighty aggregation of a thousand million stars not distributed evenly in a spherical volume of space, but in a volume flattened above and below into a disc or lens-shaped configuration. Looking around you in all other directions, you see what seems to be a vast void with here and there — incredibly far off — a faint, faint, hazy light. Let your sunbeam carry you toward the brightest of these phantom lights. As the centuries roll by, the great galaxy behind you recedes into the background until it too is merely a faint phantom patch of fuzzy light. More centuries come and go, and the phantom light before you grows more real, its true nature dawns upon you — it is another galaxy of many million stars.

Each one of the far-away phantom lights, and there are myriads of them, is a star galaxy, and we do not wonder that the spirit of the man in Richter's legend grew faint at the immensity of space and asked in tones of awe akin to dismay, 'End is there none to the universe of God?' 'And,' continues Richter, 'all the stars echoed the question with amazement . . . and this echo found no answer.'

III

The human mind roves through the universe exploring its mysteries from one end of the scale to the other, from the inconceivably small things — the electron, the proton, the atom — to the incomprehensibly vast things — the stars and star galaxies. Where is man in this scale of magnitudes? Man as a physical body, a quantity of matter, — as distinct from man as a mental and spiritual entity, — must be somewhere between these two extremes, the atom and the star. In ancient mythology, Astræa, the goddess of justice, is represented as a figure of commanding dignity holding in outstretched hand the scales or balance of equity. Imagine the goddess undertaking to weigh out the energy content of different material objects in the universe. In one pan she places an average man and from a cornucopia she pours individual atoms into the other pan. How many atoms will be required to bring about a true and just balance? A thousand million million million million! Next she removes the atoms from the pan and in their places she puts one average star. Now the other pan is much too light, and so she puts more and more and yet more men into it until there are ten thousand million million million million men, when the balance is reached. Here, then, is man's place in the avoirdupois scale of the universe — almost but not quite halfway between atom and star. It is from this midway point that man, because of his mental and spiritual endowments, can survey the smaller things of nature on the one hand and the greater things upon the other hand with an ever-increasing curiosity and comprehension.

Let us suppose that two young investigators, filled with the curiosity, imagination, and faith of the scientific worker, come to Dame Nature and say: We wish to give our lives to scientific research, 'to follow knowledge like a sinking star beyond the utmost bound of human thought' — what shall we do? To one Dame Nature replies: Take thou the atom. To the other she says: Take thou the star. Perhaps you think, as they do, that their paths will never cross — the one in his laboratory delving into the profundities of things so small no microscope will reveal them, the other in his observatory photographing a vast galaxy of myriad giant stars. You can imagine that possibly they will grow discontented with their lots, and, with that strange perversity of human nature, the one will come to Dame Nature and say: You told me to study atoms, but I should like to study stars! And the other returns and says: You told me to study the stars, but I want to study atoms! And Dame Nature smiles quietly as she replies: Yes, I told you to study the atom; return to your laboratory, bend all your energy to the task, and some day you will find that the walls of your laboratory are expanding and expanding until they include — the stars. And to the other young investigator she answers: Yes, I told you to study stars; return to your telescope, your spectroscope, and your measuring instruments, and lo! some day you will awaken to find that you are really studying atoms.

This is not merely a parable — it is the actual truth; and the remaining portion of this article will have failed in its purpose if it does not carry conviction that this is the case.

IV

The physicist and the astronomer have much in common and of necessity the latter owes a very great debt to the former. Since the astronomer can know nothing of the nature of the stars save what he can find written in the starlight, it is natural that he should early ask, — and he has been repeating the question at intervals ever since, — 'What is light?' At different times the physicist has made somewhat different answers. To-day, if he be in a humorous mood, his answer may be along these lines. He picks up a piece of red chalk and draws a sinuous curve to represent a wave. Above this he draws the figure of a runner striding from crest to crest with a small pack sack on his back. With orange chalk he draws another wave of slightly shorter wave length, — that is to say, the distance from crest to crest is less, — and on this is drawn an orange runner with shorter legs, since his stride is less, but carrying a larger pack sack. Then a yellow wave with a yellow runner, a green wave and a green runner, and similarly for blue, for indigo, for violet, until he has all the spectrum colors represented; but each successive wave is shorter from crest to crest, the corresponding messenger has shorter and shorter legs, and the pack sacks are larger and larger. Can you picture the Marathon Race of the Light Rays? Ninety-three million miles away, at an instant *Go!* some atoms in the sun rearrange their orbital electrons, thus liberating some energy; out spring the little messengers with the spare energy in pack sacks on their backs and race away toward the earth. Who will win the race? Surely not the little violet runner with the very short legs and the very big load? Perhaps you would stake your all on the long-legged red runner with the small pack sack? But here is the remarkable thing: for eight and a fraction minutes they race abreast and at the finish there is no final sprint — they all break the tape together. It is a dead heat.

We might watch the runners in a longer race, a race from the Andromeda Galaxy to the earth, but if so we must have great patience, for when the runners leave that distant star cluster their little legs will flash up and down, backward and forward, for a million years before the finishing line is approached. Again it is a dead heat, and if the goal be the retina of your eye turned upward toward the constellation of Andromeda, at a certain moment the runners will all arrive and lay down their burdens. Each pack sack of energy upon your retina causes an electrical current to run swiftly up an optic nerve to the brain, and your brain informs you that at that moment you are seeing the Andromeda Galaxy. Thus the physicist, with some help from the physiologist, explains the sensation of 'seeing,' but he utters a warning regarding the interpretation of the sensation. When you say that you are seeing Andromeda Galaxy, you are seeing it as it was one million years ago, not as it is to-day — exactly what it is like to-day will only be known on the earth a million years hence when the messengers now setting out from that far-off cluster have completed their long race.

But curiosity overcomes the circumspection of the physicist and provokes him to ask what that star cluster does look like to-day. To which question the astronomer makes reply that in all probability it looks very much as it did a million years ago, for in the age of a star or a star cluster a million years is no more than is one second of time in the life of an average man. It will be somewhat more spread out with less nebulous matter uncondensed into stars and it will be somewhat turned around, for the astronomer knows that this vast galaxy is slowly and majestically rotating with a period of some seventeen million years.

The picture of light which the physicist gives us is thus a dual one. We must think of a continuous undulating influence emanating from a radiating body if we are to explain reflection, refraction, diffraction, and interference of light — this the physicist calls his Electromagnetic Wave Theory of light. But if we would explain the mechanism of the emission of light by an atom, the absorption of light, photographic and photo-electric phenomena, we must fix our thoughts on the little runners and their pack sacks of energy — this the physicist refers to as the Quantum Theory of light. The essence of this theory is that to the runner associated with each different wave there is assigned a pack sack of definite size, and no runner will ever carry a pack sack either heavier or lighter than his own just, meet, and proper load, nor will he ever give up a portion of his load of energy — 'Take the whole or none' is his ultimatum to the atoms he encounters. An atom can accept a pack sack containing more energy than it can store, but after taking what it needs it must reradiate the remainder as a ray of longer wave length — in other words, a new messenger goes off whose longer legs and slower stride are just suited to the lesser load of energy.

This picture is not limited to visible light. There are invisible waves, the infra-red, the heat, and the Hertzian or radio waves, each longer in wave length than the previous one and the corresponding quantum of energy smaller. So, also, there are the unseen ultra-violet rays, the X-rays, gamma rays, and the cosmic rays of shortest-known wave length. Quantum theory associates a messenger with each of these also, and the pack sacks increase steadily in capacity as the wave lengths diminish.

The astronomer ponders often, long, and deeply over the nature of light and the individual characteristics of the light from the sun and the stars. Gradually it has dawned upon him that with the aid of the physicist he can unravel many of the riddles of the stars. What are the stars made of? The physicist produces a table of the distinctive radiations emitted by the different kinds of atoms known on the earth. It is the Rosetta stone that makes possible the deciphering of the message in the starlight, and by its aid the astronomer finds that the same elements that build the earth build the sun and all the stars. How hot are the stars? Again the physicist rises to the occasion and shows how the color of a hot body changes as its temperature increases. This method of estimating temperatures by the color of the light radiated by the glowing body is in common use by metallurgists, who speak of a mass of molten metal being faint red, cherry, bright red, salmon, orange, lemon, light yellow, and so on as the temperature changes from about 900° F. to about 2000° F. The coolest stars are not much hotter than the hottest metal obtainable in a furnace, and so the astronomer can extend the color scale farther up the spectrum to the hottest-known blue stars having surface temperatures of 20,000° F. or more.

How fast are the stars moving toward or from us? Once more the astronomer appeals to the physicist, and once more a reply is given which enables him to interpret the minute changes in positions of the spectrum lines as indicative of the velocities of the stars.

V

Astronomy owes an immense debt to physics, but the indebtedness is not entirely one-sided. The astronomer discovered in the sunlight evidence for the existence of an element unknown on the earth — helium. Physicists and chemists were at once on the alert to find it, and, when at length it had been found, helium proved to be of crucial importance in theoretical investigations in atomic structure, in radioactivity, and in spectroscopy. In fact, no atom save only the hydrogen atom has been more closely studied by physicists. The practical value of helium is well known on account of its being the best nonexplosive gas for lighter-than-air machines.

Many examples might be given of the ways in which the astronomer can throw light upon problems which at one time or another have baffled the physicist. Sometimes astronomy provides the physicist with startling new ideas of the properties of matter — properties undreamed of in the laboratory but clearly exhibited in the stars, where the conditions of high temperature far transcend anything reproducible on the earth. What physicist ten years ago would have even contemplated matter so compacted together that one cubic inch of it would weigh a ton? Yet to-day the astronomer points directly to the faint companion star of Sirius and says, 'There it is, and here is the spectroscopic evidence which proves that this is so. . . .'

For many reasons the physicist is interested to know how much energy is required to knock an electron completely out of an atom, or, as he expresses it, to ionize an atom. For many of the elements he has been unable in his laboratory to measure this directly, and so the astronomer has come to the rescue. Indian and English physicists have evolved the theory underlying the problem, and astronomers at Harvard have asked stars of various temperatures to tell their ionization stories, with the result that carbon, silicon, scandium, iron, and other elements radiating in the stars provided some of the answers. At McGill University, instead of asking many stars of differing temperatures, one star whose temperature changes periodically was asked the question: What are the ionization potentials of iron, of vanadium, of yttrium, and of lanthanum? And in the starlight the answers were found.

An astronomer and a physicist were one day walking over an English meadowland where the skylarks were continually rising from the grass, soaring upward and upward, singing their glorious song of confident aspiration, higher and higher into the upper air — and then quite suddenly, like a falling stone, each skylark returned to the ground. After watching them for some time the physicist threw himself down on the grassy slope and said, 'I wonder how long, on the average, those birds stay up in the sky.' So they began to time them. One was up ten seconds, another eight, a third nine, and so on — nine, seven, twelve, nine, ten, nine, nine, eight, nine, eleven. . . .

'Well,' said the astronomer, 'I think we have discovered something about skylarks — let us write a book on Birds, beginning thus: "The English Skylark is a little bird that flies up out of a meadow singing a beautiful song and staying up in the sky, on the average, nine seconds before he returns rapidly to the earth."'

But the physicist did not laugh. He was deep in thought. At length he turned to the astronomer and said, 'Do you know, there is a problem that has been worrying me that is just like these skylarks! We know a good deal about calcium — one electron can be dislodged, leaving the atom with nineteen electrons going about the nucleus in orbits. When the atom absorbs a little energy, the outermost of these electrons behaves just like a skylark — it flies up to a higher orbit; true, it does not sing a beautiful song, but it does something else: it emits the loveliest little ripple of violet light — and then, suddenly, down it comes again to its ground level. My question is this: How long, on the average, does the skylarking electron remain up in its higher orbit?'

'The answer to your question is one hundred millionth of a second,' replied the astronomer. 'The sunlight tells us that, but it is a long story. Here it is in brief outline. Astronomers were perplexed because calcium atoms are abundant farther out in the atmosphere of the sun than even the lightest of all gases, hydrogen. Photographs of the outer atmosphere or chromosphere of the sun taken at the time of a total eclipse show the red and the yellow light from hydrogen atoms as far out as four thousand to six thousand miles from the sun's surface, but the violet light from ionized calcium atoms proves that those atoms are out as far as nine thousand miles from the photosphere. These atoms can only stay out there if the sun's gravitational attraction, which is pulling them inward continually, is counterbalanced by the outward impulses given to the atom every time it absorbs the energy which sends its skylarking electron to a higher orbit. Thus the number of these impulses will depend upon the rate at which the electron returns to its lower orbit ready to receive another impulse upward.'

One hundred millionth of a second! To us this may seem an inconceivably brief interval, but to the electron it provides ample time for a million revolutions about the nucleus. Anyone can measure the passage of time to one fifth of a second with a stop watch, the physicist with his oscillograph measures intervals of one millionth of a second, but the timekeeping of the skylarking electrons transcends our powers of comprehension. At the other extreme is the astronomer's estimate of the age of a star, equally beyond our realization — ten million million years.

It is a solemn thought that no man liveth unto himself. It is equally true that no star, no atom, no electron, no ripple of radiant energy, exists unto itself. All the problems of the physical universe are inextricably bound up with one another in the relations of space and time.

You cannot solve the riddles of the stars without involving the aid of the atom, nor can you fully comprehend the atom without the aid of the stars. On the uplifting swings of imagination the astrophysicist roams the universe from atom to atom, from star to star, from star to atom, from atom to star. Impelled by curiosity regarding the natural universe, encouraged by the evidences for his faith in the reality of cosmic harmony, he presses on and on — a sweet and a fitting thing it is to toil for the Truth.

FORTY MINUTES WITH EINSTEIN

By A. Vibert Douglas

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I walked from the Princeton railway station to the Institute for Advanced Studies and was told that Dr. Einstein had a severe cold but would see me at his home. The Institute bus took me to the white wooden house on a quiet street of Princeton and the housekeeper showed me into the parlor. My eye was immediately caught by two inlaid cabinets containing various objects of religious art. On a canopied central shelf of one was a rather beautiful Madonna and Child; on a side table was a statuette of a Chinese philosopher beggarman; on the wall hung a picture of the period of early Italian Christian painting.

Upstairs at the back of the house was his study. The rear wall was almost entirely of glass to the floor and looked out over back gardens and fields beyond, with leafless trees making filigree patterns against the grey-blue winter sky. Along the opposite wall and one side wall were high bookshelves, a few of the shelves holding piles of offprints.

Dr. Einstein was seated in an easy chair at the angle of the bookcases, a low square table in front of him, and his secretary with notebook on knee by the table on his right. His massive head, longish white hair, powerful very dark eyes under shaggy grey-white eyebrows, caught and held attention. He wore a dark grey dressing gown and had a brown silk muffler round his throat. In spite of his obvious frailty, he insisted on rising to greet me.

He came directly to the point of my visit and paid a striking tribute to the English astronomer, Sir Arthur Eddington, who was the first and greatest interpreter of the theory of general relativity to the English-speaking world. He spoke of the literary value, the beauty and brilliance of Eddington's writing in those books aimed at giving to the intelligent lay reader at least some understanding, some insight into the significance of the new scientific ideas—but with a smile he added that a scientist is mistaken if he thinks he is making the layman understand; a scientist should not attempt to popularize his theories, if he does "he is a fakir—

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In regard to the developments in the early years made by Weyl and Eddington, the later theories of the expanding universe of Friedmann, Lemaître and Eddington, the still later kinematic relativity of E. A. Milne, and the yet more recent theories of continuous creation of matter of Jordan, Bondi and Hoyle, the comments of Dr. Einstein were brief and critical. He definitely disliked the hypothesis of continuous creation, he felt the necessity for a "beginning"; he regarded Milne's brilliant mathematical mind as lacking in critical judgment; he was not attracted by the idea of Lemaître's primeval atom; and he concluded by saying of his own and all the others, "Every man has his own cosmology and who can say that his own theory is right!"

I asked him why so many Americans were unwilling to accept the idea of the expansion of the universe and the observed red shifts of the spectrum lines of distant galaxies of stars as genuine Doppler effect of recessional velocity. His reply was very brief: "They don't understand general relativity!"

Reverting to the theory of continuous creation and the controversy in London over the legitimacy of a theory not based on observable facts, Dr. Einstein approved the warning which had been sounded by the President of the Royal Astronomical Society the previous year, but he added that we must not forget that Clerk Maxwell's fruitful theory was not laid upon a foundation of physical observation.

He then told me of his visit to Cambridge to receive an honorary degree from the Chancellor of the University in 1930, when he was the guest of Professor and Miss Eddington at the Observatory. He spoke of the quiet hospitality of their home and recalled the fact that during the time of this visit the King's Birthday Honours appeared in *The Times* with Eddington's name in the list of Knighthoods. I asked whether Eddington showed any reluctance about accepting a title and Dr. Einstein replied abruptly, "No, why should he?" I said that some members of the Society of Friends strongly disliked such marks of approval and I had wondered if Eddington had had any hesitancy in accepting this royal honour. He said not only was Eddington gratified but his sister was obviously very happy about this honour to her brother. Dr. Einstein then paid a sincere tribute to the Society of Friends and said quietly, "If I were not a Jew, I would be a Quaker."

From Eddington's knighthood my thoughts jumped to the New Year Honours just published two days previously in London and I mentioned that Epstein would now be Sir Jacob. I thought Dr. Einstein would be specially pleased, but he seemed quite indifferent. Laughingly I said that the British had compiled quite an assortment of their citizens: a sculptor, a comedian, a track champion, the organizer of international football, and the usual array of scientists, civil servants and leaders in various phases of active citizenship at home and in far parts of the Commonwealth. "Yes," he replied, "it is quite a zoological garden—lions, elephants *and* giraffes".

On the low table between us were pages of mathematical analysis, ash trays and a beautiful little carved wooden monk. I remarked upon his choice objects of religious art asking if he had any special interest in Roman Catholicism. He shook his head emphatically and said that solely as art he enjoyed these things.

Thirty years ago, I had been told that in his study in Berlin were three portraits, one was of Sir Isaac Newton to whose universal law of gravitation Einstein had made the first modification, the next was of James Clerk Maxwell, and the third was another picture of Newton. I looked to see if Newton's picture was on the wall of his study in Princeton. Instead I saw a portrait of Mahatma Gandhi and another striking portrait which Dr. Einstein told me was of a German musician whom he held in high esteem. Of Gandhi he said, "He was the greatest man of our age". I thought of Dr. Schweitzer and mentioned his name, evoking the remark, "Yes, he too is a very great man".

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