poison-gland trails that had been ignored previously. The implication seems to be that workers will follow other odor leads if there is some "knowledge" that a true (accessory-gland) trail exists. It also follows that only a small amount of the accessory-gland secretion need be in a trail to induce trail following. In fact, the venom from the true poison glands may be serving as a diluent for the accessory-gland secretion, although there is at present no direct evidence to support such a hypothesis (*3*).

The artificial trails made from accessory-gland preparations provide supernormal stimuli that attract far more workers than normal trails laid under similar circumstances by single living workers. The chemical nature of the releaser substance has not yet been precisely determined. However, the following data may be considered suggestive. A petroleum ether extract of steam distillate of whole ants prepared by M. S. Blum and his associates (*4*) produced trail-following responses of nearly comparable magnitude to those produced by accessory-gland preparations when it was tested under the experimental conditions described above. The number of workers drawn out by contact with the distillate was at least equal to the number attracted by the accessory-gland preparations, but orientation along the trails was somewhat less consistent. Blum *et al.* have shown that the infrared spectra of the distillate and of whole venom contain the same carbonyl band. On the basis of preliminary investigations, these authors have suggested that the carbonyl band is exhibited by the toxic principle itself, and that this constituent is manufactured by the accessory gland (*5*). It remains to be proved that the toxic principle and the trail-following releaser are one and the same (*6*).

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References and Notes

1. E. C. Macgregor, *Behaviour* 1, 267 (1948).
2. J. D. Carthy, *ibid.* 3, 304 (1951).
3. P. S. Callahan (as he notes in correspondence with M. S. Blum) has found that the poison glands can be closed off at the base of the poison vesicle by a pair of highly developed muscle bundles; hence it is possible for the accessory gland to release its products independently of the poison glands. The possibility that such an operation occurs during trail laying should be considered in future studies.
4. I am indebted to Dr. Blum for supplying me with the fire ant extract used in this study and for granting permission to use unpublished data pertaining to it.
5. M. S. Blum (personal communication). For a report on the nature of whole venom, see M. S. Blum, J. R. Walker, P. S. Callahan, A. F. Novak, *Science* 128, 306 (1958).
6. It is interesting to note the significant observation by G. W. K. Cavill and D. L. Ford [*Chem. & Ind. (London)* 1953, 351 (1953)] that workers of the dolichoderine species *Iridomyrmex detectus* (Fr. Smith) follow artificial odor trails made from the steam distillate of other *detectus* workers. These authors have identified the distillate as 2-methylhept-2-en-6-one.

7 October 1958

Redox Absorption Spectra from Single Pigment Cells of Squid

Abstract. Single pigment cells from the squid *Loligo forbesi* have been studied by microspectrophotometry. The absorption spectra obtained show characteristic changes on reduction and oxidation which are compatible with those found in ommochromes. The presence of melanoid substances, however, cannot be excluded.

In several cephalopods, such as *Sepia officinalis, Octopus vulgaris*, and *Eledone moschata*, and also in arthropods such as Crustacea and Arachnoidea, a peculiar group of pigments, the ommochromes, has been found (*1, 2*). One of the significant properties of most ommochromes is that there is a characteristic change in the absorption spectrum on oxidation and reduction, although a few ommochromes do not behave in this manner (*3*). Pigments closely related are the ommatins (*3, 4*) and insectorubin (*5*), the latter being found in locusts and other insects.

In contrast to other investigations reported in the literature, the studies presented in this report were carried out on single pigment cells in the cutis of a cephalopod, *Loligo forbesi*, caught in the North Sea. The tissue was fixed in 4-percent Formalin, and sections were rinsed for 2 hours and immersed for 24 hours in a (reducing) 0.05*M* solution of $Na_2S_2O_5$. Microspectrophotometric measurements were made by comparing substrate and blank at each wavelength. The single pigment cells were magnified about 150 times. The absorption spectrum obtained after reduction is shown in Fig. 1 (curve 1). A maximum is found between 525 and 540 mμ, representing, when compared with measurements by Schwinck (*2*), a slight shift toward the longer wavelengths. This shift may be due in part to light scattering (*6*) or fixation. After oxidation for 24 hours in 7-percent H_2O_2, the maximum at 525 to 540 mμ essentially disappears (Fig. 1, curve 2).

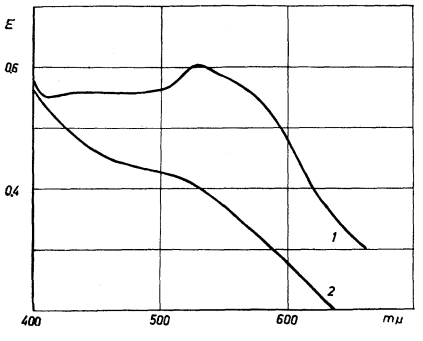

Fig. 1. Absorption spectra of a single pigment cell of *Loligo forbesi* after reduction (curve 1) and oxidation (curve 2) for 24 hours.

These results are in general agreement with bulk analyses on ommochromes reported by Becker (*1*) and Schwinck (*2*). They do not exclude, however, the presence of melanin or melanoid substances which show a gradually increasing absorption to the shorter-wavelength range (*7*); nor should it be postulated that the pigment found is identical with others already known. This study may merely show that, with suitable technique, redox absorption spectra can be obtained even from a single pigment cell and, thus, compared with analyses on extracted material.

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References and Notes

1. E. Becker, *Naturwissenschaften* 29, 237 (1941).
2. I. Schwinck, *ibid.* 40, 365 (1953).
3. A. Butenandt and R. Beckmann, *Z. physiol. Chem., Hoppe-Seyler's* 301, 115 (1955).
4. A. Butenandt and G. Neubert, *ibid.* 301, 109 (1955).
5. T. W. Goodwin and S. Srisukh, *Biochem. J.* 47, 549 (1950).
6. P. Latimer, *Science* 127, 29 (1958).
7. E. Santamarina, *Can. J. Biochem. and Physiol.* 36, 227 (1958).

17 October 1958

Blood Groupings in Marshallese

Abstract. The absence of the Diego blood factor, the extremely low incidence of the *M* gene, and the unusually high R^1 gene frequency of the Marshallese more nearly resemble the blood groupings of the people of the western islands of Indonesia than the blood groupings of the Amerindians.

During March 1958, the annual medical survey of the Marshallese people of Rongelap Island was carried out, 4 years after they were accidentally exposed to radioactive fallout (March 1954) (*1*). These annual surveys are carried out by Brookhaven National Laboratory under the direction of R. A. Conard and are sponsored by the Atomic Energy Commission with the collaboration of the Department of Defense. During the course of these studies it became of interest to determine the blood groupings in the Marshallese people as an index of their origin and homogeneity. Blood samples were obtained by the survey team for this purpose.

The frequent movement of the Marshallese people among the various islands of Micronesia and, to a lesser extent, of Melanesia and other adjacent areas precludes any such concept as "pure" Marshallese. However, these people have lived for an estimated 2000 years on these islands with fewer outside contacts, perhaps, than most other groups. The findings presented consist of the

Table 1. Results of blood grouping of 129 Marshallese.

Group	No.	Percentage	Gene frequency*
		ABO system	
O	75	58.1	.762 (r_c = .789)
A_1	24	18.6	.114 (p_c = .116)
A_2	0	0	
B	19	15.0	.093 (q_c = .095)
A_1B	10	7.4	
A_2B	1	0.8	
		M-N system	
M	8	6.2	.14
MN	20	15.5	
N	101	78.3	.86
		Rh-Hr system	
Rh_1Rh_1	126	97.7	.985
Rh_1rh	3	2.3	

* r_c, p_c, and q_c = corrected gene frequency for genes *O*, *A*, and *B*.

Table 2. Blood group frequencies among Marshallese and Polynesians.

Item	Marshallese		Polynésians
	This report (N = 129)	Simmons' report (*4*) (N = 678)	Simmons and Graydon's report (*6*) (N = 138)
	ABO system		
Group (%)			
O	58.1	52.2	39.1
A	18.6	21.4	60.9
B	15.0	21.1	0
AB	8.2	5.3	0
Gene frequency			
r_c	.789	.723	.626
p_c	.116	.135	.374
q_c	.095	.134	0
	Rh-Hr system		
Phenotype (%)			
Rh_1Rh_1	97.7	90.6	19.6
Rh_1rh	2.3	.7	.7
Rh_2	0	.3	29.7
Rh_1Rh_2	0	8.0	50.0
Gene frequency			
R^1	.985	.951	.449
R^2	0	.04	.543
R^0	.015	.006	.007
	M-N system		
Type (%)			
M	6.2	10*	19.6
MN	15.5	19*	47.8
N	78.3	71*	32.6
Gene frequency			
m	.14	.22	.435
n	.86	.78	.565
	Duffy system		
Fy^a + (%)	89.2	100	74.6
	Kell system		
K + (%)	0		0
	Diego system		
Di^a + (%)	0		0

* These values were calculated from published data.

blood groupings and gene distribution of 129 Marshallese and cannot be considered as characteristic of any special group, but rather a sampling of the gene distribution in the area. The results, by the ABO, M-N, and Rh-Hr systems, are shown in Table 1 and are compared with the results of other studies in Table 2.

ABO system. In the ABO system the high frequency of the B group which almost equals that of the A group is in sharp contrast to the absence of B or AB among the Polynesians. An unusual finding was one Marshallese of group A_2B. This was verified by testing with several absorbed B antisera, as well as with the lectin from *Dolichos biflorans* (*2*). The total absence of A_2 genes in Eastern Asia, Australia, and Indonesia has been repeatedly noted (*3*). Inquiry into the family background of the single A_2B native failed to reveal any significant information to lead one to suspect admixture.

M-N system. The low frequency of the *M* gene has been noted in this area by many investigators (*4*). The frequencies obtained in this study are among the lowest encountered and are in sharp contrast to the figures obtained among the Polynesians.

Rh-Hr system. A most unusual distribution was noted in the Rh-Hr system. Tests were performed with anti **Rh_0**(D), **rh'**(C), **rh''**(E), **hr'**(c), and **hr''**(e) sera.

A completely different set of results from those reported for Polynesians was obtained. In particular, the latter were reported as being of group Rh_1Rh_2 in 50 percent of the persons tested, whereas not a single individual of this grouping was found among the Marshallese. The gene frequency of 98.5 percent for R^1 is the highest reported for any ethnic group. The complete absence of any rh negative persons in these and related series makes one suspect that the true genotype of the bloods giving a positive reaction with anti-**hr'**(c) serum is most probably R^1R^0. The occasional finding of an Rh_0 person by Simmons *et al.* (*4*) supports this interpretation. In the present series of 125 samples there were no bloods that reacted with **rh''** (E) antiserum.

Duffy system. In the Duffy system there were found 89.2 percent Duffy (Fy^a) positive bloods. A previous report of 100 percent Duffy (Fy^a) positive reactions (*4*) (performed on 30 specimens that had been stored for 16 months) indicates a need for verification and clarification.

Other systems. Kell tests were 100 percent negative, as was previously reported. Diego tests were 100 percent negative (*5*).

The failure to demonstrate the Diego factor in any of the studies conducted in this area of the world is noteworthy. To date its absence in Polynesians (*6*), Maoris (*7*), and now in Marshallese becomes a significant finding in view of its occurrence in Mongoloids, Eskimos, and Amerindians (*8*), to whom Heyerdahl (*9*) credits the population of Polynesia.

The present findings (*12*) indicate a rather homogenous population of the Marshall Islands with extremes of gene frequencies. With some reservations, because of the relatively small sample, the following facts are of interest in the blood groupings of the Marshallese: (i) the extremely high frequency of the *O* gene (78.9 per cent); (ii) the extremely low frequency of the *M* gene (14 percent); (iii) the highest incidence of the R^1 gene yet reported (98.5 percent); (iv) the presence of 10.8 percent of Duffy (Fy^a) negatives; (v) the absence of the Kell and Diego blood factors; (vi) a single example of A_2B.

The investigations of numerous authors, compiled and summarized by Mourant, relate these blood groupings most nearly to those found in Southeast Asia and Indonesia, where relatively frequent *B* genes, a high *N* frequency, and a similarly high frequency of the R^1 gene are found.

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References and Notes

1. R. A. Conard, L. M. Meyer, W. Wollins, W. W. Sutow, J. S. Robertson, A. Lowery, H. C. Urshel, J. M. Barton, "Medical survey of Marshallese four years post exposure," in preparation.
2. W. C. Boyd and R. Shapleigh, *J. Lab. Clin. Med.* 44, 235 (1954).
3. A. E. Mourant, *The Distribution of the Human Blood Groups* (Thomas, Springfield, Ill., 1954), p. 123; L. N. Sussman, *Am. J. Clin. Pathol.* 26, 471 (1956).
4. R. T. Simmons, J. J. Graydon, N. M. Semple, J. B. Birdsell, J. D. Milbourne, J. R. Lee, *Am. J. Physical Anthropol.* 10, 31 (1953).
5. We are indebted to Dr. Philip Levine, who supplied the anti-Di^a serum, and to Dr. Miguel Layrisse, who supplied the Di^a-positive cells for control.
6. R. T. Simmons and J. J. Graydon, *Am. J. Physical Anthropol.* 15, 357 (1957).
7. H. Lehmann, A. North, J. M. Staveley, *Nature* 181, 791 (1958).
8. P. Levine, M. Layrisse, E. A. Robinson, T. Arends, R. D. Sisco, *ibid.* 177, 40 (1956); M. Layrisse and T. Arends, *ibid.* 177, 1083 (1956);
9. M. Lewis, H. Ayukawa, B. Chown, P. Levine, *ibid.* 177, 1084 (1956).
9. T. Heyerdahl, *American Indians in the Pacific: The Theory Behind the Kon-Tiki Expedition* (Allen and Unwin, London, 1952), p. 821.
10. We acknowledge the technical assistance of Hannah Pretshold.

5 August 1958