case too, runs for longer periods failed to effect better separation.

Application of this technique in the identification of yeast nucleic acid has already been reported (*8*).

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Erythrocyte Mosaicism in a Pair of Sheep Twins

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Almost a decade ago Owen (*1*) reported in Science his discovery of the phenomenon of compound blood types associated with multiple births in cattle. Subsequently, this condition became known as *erythrocyte mosaicism* (*2*). Individuals with red cell mosaics are believed to have hematopoietic tissues derived in part from their own embryonal cells and in part from embryonal cells of a co-twin, or co-triplets, etc. Fusion of blood vessels between developing embryos provides the channels for the intermingling of embryonal cells with subsequent establishment of these cells in the hematopoietic beds of each individual so joined. When the autograft produces cells of a serological type different from that of the cells produced by the homograft, erythrocyte mosaicism ensues.

TABLE 1

Sheep Twins N777 and N778, and Their Parents H454 and 2955. Reactions of Untreated Cells (N777, N778) and Cells (N777/S3 and N778/S3) Recovered Following Differential Hemolysis with S3 Antibodies*

Cells	Antibodies—Readings at 3 hr												
	R	O	S2	S3	S4	S5	S6	S7	S8	S10	S11	S12	S15
H454	4	0	4	4	4	4	0	4	4	0	4	3	4
2955	0	4	4	4	4	4	0	4	4	0	4	3	4
N777 }	0	4	3	1	4	4	0	1	1	0	4	2	4
N778 }	0	4	3	1	4	4	0	1	1	0	4	3	4
N777/S3 }	0	4	3	0	4	4	0	0	0	0	4	3	4
N778/S3 }	0	4	3	0	4	4	0	0	0	0	4	3	4

* Readings 0, 1, 2, and others represent degrees of hemolysis ranging from 0 (no hemolysis) to 4 (complete hemolysis). Guinea pig complement was used in these tests.

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Although the detection of these mosaics is commonplace in dizygotic twins and higher zygotic multiples in cattle, there have been no reports of this phenomenon in species other than cattle. It is of interest, therefore, to report an example of this condition in a pair of sheep twins.

In another study (*3*) concerned with the development of blood-typing antibodies for use primarily in separating dizygotic from potential monozygotic ovine twins, we encountered a pair of twin lambs (N777 and N778) whose corpuscles reacted with certain antisera in a manner suggesting mosaicism. That is, only a fraction of their erythrocytes was hemolyzed by the action of antibodies found in three different ovine isoimmune antisera coded S3, S7, and S8 (Table 1), whereas those of their parents (H454 and 2955, Table 1) were completely hemolyzed. Unaffected erythrocytes (N777/S3 and N778/S3, Table 1) recovered following hemolysis with S3 antibodies were nonreactive in tests with S3, S7, and S8 but were hemolyzed by the other antisera (Table 1) which acted on the untreated cells. The ratio, approximately 40 : 60, of hemolyzed to nonhemolyzed corpuscles in tests with S3 was the same for each twin. There were, however, no antisera among our limited battery which would lyse only those corpuscles not lysed by S3 or S7 or S8. Although similar examples are encountered in cattle, in view of the nonreciprocal character of the evidence for mosaicism, it seemed advisable to strengthen these results by further tests. To this end absorptions were made on the S3 antiserum with the bloods of each of the twins to make certain that the hemolysis of their corpuscles with these antibodies was not nonspecific. Both bloods readily absorbed the antibodies in this serum. Although the male of this pair died a few weeks after these initial tests, the results of the differential hemolytic tests shown in Table 1 were repeatedly confirmed on samples of blood drawn from N778 at intervals of several months. There was no doubt as to the permanence of the mosaic. It was concluded that the twins N777 and N778 had exchanged hematopoietic transplants through communal choriovascular channels.

In view of the general impression that vascular anastomosis between ovine embryos occurs rarely (if at all) our results came somewhat as a surprise since we had tested only 26 pairs of twins. The idea that vascular anastomosis between sheep embryos must be very rare probably traces to the writings of Lillie (*4*). He apparently based his conclusion on the absence of any reports of ovine freemartins rather than on his own study of four pairs of fetal twins. Since the time of Lillie's paper, there have been at least two reports of ovine freemartins (*5, 6*). We have also located another report, Rotermund's doctoral dissertation (*7*), on the subject of choriovascular arrangements between ovine fetuses. Rotermund noted fusions of blood vessels in one pair of heterosexual ovine twin fetuses out of a total of 11 pairs studied, but he did not mention whether the female appeared to be a freemartin.

The ewe N778 was placed with rams in two successive breeding seasons and, if bred, never conceived. Although superficially she would have passed as a normal ewe, examination of her vagina indicated that she was very probably a freemartin. She was killed and examined by veterinarians on the staff of the School of Veterinary Medicine. Although the anatomical details of this examination are not given in this report, they left no doubt that N778 was a true freemartin.

Our data in conjunction with Lillie's and Rotermund's would suggest an approximate frequency of placental anastomosis of 5% in sheep twins. Given about one birth in three a twin birth and a sex ratio of approximately one pair of heterosexual twins to every pair of like-sexed twins (*8*), this would lead to estimating the frequency of freemartins among ewes as about 0.8%. This estimate is undoubtedly too high. Nevertheless, while the frequency of freemartinism might be low enough to escape detection by breeders, particularly if it is generally somewhat cryptic, as in the case of N778, it might nevertheless be frequent enough to explain a significant portion of nonbreeders among ewes. We are convinced that freemartinism would have gone undetected in the case of N778 had it not been for the observation of erythrocyte mosaicism.

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Photosynthesis as a Photoelectric Phenomenon

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The purpose of this paper is to propose a new mechanism for the crucial step of quantum conversion in photosynthesis. Quite recently it has been established that the prosthetic group of pyruvic acid oxidase is 6,8-thioctic acid (which may be abbreviated $\mathrm{RCH{-}CH_2{-}CH_2{-}S{-}S}$, with the first and last atoms joined in a ring), and that it is the disulfide (oxidized) form of this substance that is required in order that the oxidative decarboxylation of pyruvic acid take place (*1, 2*). It has been observed also that the presence of this compound is necessary in order that carbon dioxide be incorporated into the Krebs cycle to occur during photosynthesis (*1, 2*). Since carbon dioxide is not absorbed into the cycle in the presence of light, it is thought that the disulfide group of pyruvic oxidase must be unavailable during the light reaction of photosynthesis.

It was proposed (*1, 2*) that the chlorophyll molecule absorbs a quantum of red light and transfers the electromagnetic energy to the already strained disulfide ring, resulting in its dissociation to a dithiyl radical

$$\begin{array}{l}\mathrm{RCH{-}CH_2{-}CH_2{-}S\cdot}\\ \;\,|\\ \mathrm{S\cdot}\end{array}$$

which was then presumed to extract two hydrogen atoms from some other molecule, possibly water (*3*), yielding the reduced dithiol

$$\begin{array}{l}\mathrm{RCH{-}CH_2{-}CH_2{-}SH.}\\ \;\,|\\ \mathrm{SH}\end{array}$$

To the author it appears rather unlikely for free radicals of any type to be produced within a living cell in aqueous solution (or suspension) where ions can be formed by means of a considerably smaller expenditure of energy. The transfer of electrons can occur much more rapidly and efficiently than the transfer of relatively cumbersome hydrogen atoms, and it is not to be supposed that nature has not yet been apprised of the fact. Thus, the direct capture of two electrons by the disulfide group of pyruvic oxidase would result immediately in the reduced dithiol state:

$$\begin{array}{l}\mathrm{RCH{-}CH_2{-}CH_2}\\ \quad\searrow\quad\swarrow\\ \quad\mathrm{S : S}\end{array} \;+\; 2e^- \longrightarrow \begin{array}{l}\mathrm{RCH{-}CH_2{-}CH_2{-}S{:}^-}\\ \;\,|\\ \mathrm{S{:}^-}\end{array} \qquad (1)$$

In such an event there would be no need to search further for "the precise species from which the sulfur-free radicals snatch the hydrogen" (*2*). All that is needed to complete the molecule, if, indeed, it is in need of completion, is two protons, which, in any aqueous system, are readily available.

There is some evidence (*3*) that the reduction product of the disulfide may sometimes be a thiol sulfenic acid of the type RSSH. In that case the C—S bond is broken instead of the S—S bond, and the immediate reduction product after the electron transfer would be $\mathrm{R\ddot{C}H{-}CH_2{-}CH_2{-}S{-}S{:}^-}$

If the idea of electron transfer be accepted, the only question remaining would be "whence the two electrons?" A logical answer might be as follows: the chlorophyll molecule, on bombardment with photons of red light, absorbs one quantum, resulting in the activation of an electron to such a high-energy level that it is easily extracted by a mild oxidizing agent intimately associated with the chlorophyll molecule, namely, the disulfide group of pyruvic oxidase.

Probably the most fundamental reaction in photosynthesis is the oxidation of water:

$$H_2O \longrightarrow \tfrac{1}{2}O_2 + 2H^+ + 2e^- \qquad (2)$$

Now, instead of assuming (*4*) that chlorophyll in some way transfers its absorbed electromagnetic energy to a water molecule, which subsequently decomposes in the presence of a suitable oxidizing agent, let us assume again that chlorophyll molecules, on bombardment with photons, transfer electrons to the disulfide