a razor blade) to expose the immature tassel for measurement. Test plants from each planting were used to estimate the stage of plant maturity for the remaining plants.

Gibberellin-induced male sterility, ranging from tassels barren of all floral parts to tassels which approached normal pollen shedding, was found. Most sterile tassels developed all floral parts except stamens (pollen and pollen sacs). On partially fertile tassels the upper portion of the central spike or the terminal portions of the lateral spikes, or both, developed staminate spikelets and shed pollen. The number of anthers extruding from staminate spikelets during flowering was recorded as trace, light, moderate, and normal as a measure of relative fertility of the tassel. Silks were functional, and open-pollinated seed from male-sterile plants produced plants with fertile staminate flowers.

The early flowering line planted 1 June showed no gibberellin-induced male sterility in any of the treatments, and the data are not presented. The immature tassels of this earlier flowering line, being considerably more than 1 in. in length when treated, had apparently passed the stage of development for chemical induction of male sterility.

Data from field experiments are presented in Table 1. The late-flowering line planted 1 June showed sterility in varying percentages of tassels, depending on the time of application and the concentration of gibberellin applied. Application of both concentrations (500 and 1000 parts per million) of gibberellin 56 days after planting induced fewer sterile tassels on the main stalk, but it was observed that there were more sterile tassels on the "suckers" (lateral shoots) than when the same concentrations were applied 48 days after planting. Data for the "suckers" are not included in the percentages in Table 1. Gibberellin in concentrations of 100 parts per million at both times of spraying induced only an occasional partially sterile tassel, and no data were recorded.

Applying the gibberellin near the suggested critical stage of plant development and increasing the concentration of gibberellin 2½ times induced male sterility in the early flowering line planted 1 July. Both treatments resulted in sterility in 87 percent of the tassels. Similar treatments on the late flowering line in the 8 July planting induced sterility in 100 percent of the tassels.

In the two later plantings, flowering occurred in early September, when temperature and day length were less favorable for optimum pollen development and shedding. It is impossible to separate environmental effects present during the late plantings from the effect of increased concentrations.

Moore (*2*) and Naylor (*3*) reported chemical induction of male sterility when young maize plants were sprayed with maleic hydrazide. Wittwer (*4*) used maleic hydrazide effectively to induce male sterility in cucurbits. In this study, gibberellin effectively induced male sterility in two maize inbreds. This effect has not been reported in previous papers on gibberellin-treated maize.

Further investigations are needed to determine the reliability of this chemical (gibberellin) "sterilization" and its large-scale application in the production of maize hybrids. If consistently effective, chemical induction of male sterility would be a valuable method for reducing or eliminating detasseling of seed fields. (*5*)

Table 1. Chemical induction of male sterility in two inbred lines of maize by foliar applications of gibberellin.

Time of spraying (days after planting)	Gibberellin (ppm)	Male sterile tassels (%)	Partially fertile tassels			Normal tassels (%)
			Trace†	Light‡	Moderate§	
Late flowering line planted 1 June						
	0	0	0	0	0	100
48*	500	32	13	32	23	0
48*	1000	46	18	15	21	0
56	500	15	10	20	10	45
56	1000	25	3	7	15	50
Early flowering line planted 1 July						
	0	0	0	0	0	100
39* and 46	1000 each	87	5	6	2	0
39*	2500	87	10	3	0	0
Late flowering line planted 8 July						
	0	0	0	0	0	100
36* and 43	1000 each	100	0	0	0	0
36*	2000	100	0	0	0	0
43	1000	33	13	35	19	0

* Immature tassels were approximately 1 in. in length.
† Trace: from one extruded anther to 1 in. of extruded anthers on any part of the central spike or one lateral spike.
‡ Light: more than 1 in. of extruded anthers on any part of the central spike or one lateral spike, or a trace on two or more spikes, central or lateral.
§ Moderate: more than 1 in. of extruded anthers on two or more spikes, central or lateral.

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References and Notes

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5. The suggestions and advice of Dr. S. H. Wittwer in connection with this study are appreciated.

27 December 1957

Electrophoresis of Free Sugars in Blood

A convenient method, described in this report, for the qualitative identification of free sugars in blood provides a useful complement to data obtained from nonspecific oxidation methods. Thus, in the development of a micromethod for the quantitative determination of galactose, in which a Somogyi oxidant was used (*1*), definite confirmation of the presence of galactose was required as proof that the reduction was not due to other sugars or to nonsugar reducing substances.

A method for determining this, based on the electrophoretic behavior of the sugar-borate complexes (*2, 3*), is easy to perform and is more rapid than chromatographic methods. In developing it we used a Spinco model R apparatus, although, with suitable adjustment of voltages and times, any strip-type electrophoresis apparatus may be used.

Differentiation of glucose, galactose, fructose, and lactose in deproteinized human blood is facilitated by the use of borate solutions at two different *p*H's—an extension of the techniques of Consden and Stanier (*2*). The method will indicate concentrations as low as 4 mg per 100 ml of any one of these sugars in blood, equivalent to less than 4 μg per spot (*4*). It is satisfactory up to a total sugar concentration of about 125 mg per 100 ml; above this concentration the sample should be diluted to prevent streaking.

Reagents. Buffer A (*p*H 9.2) consists of a 2 percent aqueous borax ($Na_2B_4O_7 \cdot 10\ H_2O$) solution. Buffer B (*p*H 7) consists of 24.8 g of boric acid (H_3BO_4) and 5.8 g of sodium chloride, dissolved in water and diluted to about 700 ml. Borax solution (0.05*M*) is added, with stirring, until the *p*H reads 7.0. The solution is then diluted to 1 liter with water (*2*). Standard sugar solutions consisting of 1

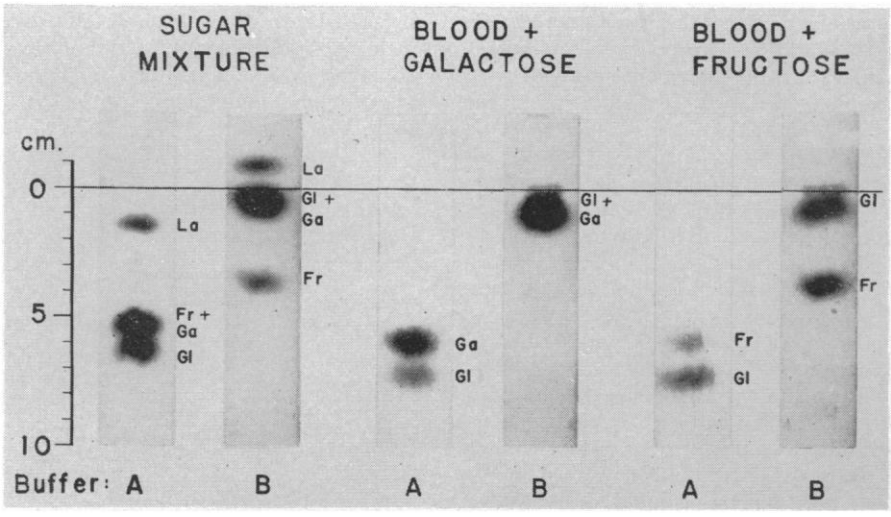

Fig. 1. Typical strips illustrating the separation of glucose (Gl), galactose (Ga), fructose (Fr), and lactose (La) in a standard sugar mixture and the separation of added galactose or fructose from the glucose of normal blood.

percent (weight by volume) aqueous solutions of reagent-grade glucose, galactose, fructose, and lactose, respectively, and of a mixture containing all four sugars, are used as controls. On the standard strips, 2 μl are used per sample. The aniline hydrogen phthalate bath used consists of 930 mg of redistilled aniline and 1.66 g of phthalic acid, dissolved in a solution of 5 ml of water in 95 ml of acetone. This solution, used as a bath, proved far superior to sprays based upon various alcohols.

Method. Heparinized blood (0.1 ml per determination) is pipetted into 2 ml of ice-cold ethanol (95 percent) and chilled in ice water for 15 minutes to precipitate the proteins. The mixture is then centrifuged (at 2000 rev/min) for 5 minutes. The supernatant liquid is decanted into a 2-in. petri dish and evaporated to dryness in a vacuum. The residue is taken up in 50 μl of water in a micropipette (*4*) and is applied to the mid-point of a paper strip (3 by 30 cm) and air-dried. The strip is mounted on the apparatus with the applied spot at the apex and is wetted carefully with buffer on each side, just below the spot, in accordance with Durrum's technique (*5*). After 1 hour is allowed for equilibration, an electromotive force of 210 v is applied for 4 hours. The strips are then dried, dipped in the aniline hydrogen phthalate bath, and suspended in an oven at 125°C for 10 minutes. Compact, stable, brown spots indicate the presence of the sugars.

Under these conditions, when buffers A and B are used in turn, the sugars migrate, as indicated in Fig. 1. Comparison with control strips indicates the presence, or absence, of glucose, galactose, fructose, or lactose in the blood sample. Heavy streaking of the spots indicates either insufficient equilibration time or too concentrated a sample.

The method has been applied to a large number of blood samples, and no interfering substances have been encountered in either normal or galactosemic blood. To date, neither fructose nor lactose has been found naturally in any sample (*6*).

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4. Although not quantitative, the recovery from 0.1 ml of blood is adequate to complete the determination of a 4-mg per 100 ml. sample; 2 μg of sugar, applied directly to the paper, gives a visible spot on development.
5. E. L. Durrum, *J. Am. Chem. Soc.* 72, 2943 (1950).
6. We are indebted to the department of biochemistry and pathological chemistry, University of Western Ontario, London, Ontario, for technical aid in this study and to the Department of National Health and Welfare, Ottawa, for financial assistance.

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On the Nature and Color of the Moon's Surface

The interstellar dust particles presumably responsible for the reddening of distant stars may consist largely of random aggregates of unsaturated and free-radical molecular species rich in carbon, nitrogen, and oxygen (*1, 2*). By theoretical and empirical analogy with similar terrestrial species it has also been shown that such particles would need to have diameters only of the order of 20 A or less in order to absorb strongly in the visible region of the spectrum (*3*), since with such dimensions the average gap for allowed transitions between randomly filled Fermi levels is of the order of 3 ev. The random geometric and magnetic anisotropy of such particles also appears adequate to account for the polarization associated with interstellar reddening.

Particles of such properties and sizes differ considerably from the chemically stable or closed-shell dielectric and ferroelectric particles about 0.5 μ in diameter which are classically postulated for the interstellar dust. To give the same optical effects, the free-radical particles can be of the order of 200 times smaller in linear dimensions and 10^7 times smaller in total bulk than the dust particles required by approaches based only on classical metallic and dielectric scattering theory. Even if chemically stable dielectric or metallic particles should be formed, laboratory experience suggests that, under high-energy collisions and ultraviolet light, the particles in interstellar space would soon come to resemble radiation-damaged material, with randomized structures highly absorbing in the visible region.

These arguments should apply not only to particles but also to large airless surfaces in space if they are poor in hydrogen—perhaps, for example, the surface of the moon or of the planet Mercury. Whatever the original composition of the underlying material or its overlying interplanetary dust-fall, the surfaces we see may be extensively damaged by radiation and highly absorbing in the visible region. Even if there is progressive healing of the damage with ionic recombination and formation of renewed stable bonds during the hot lunar day, laboratory experience suggests that it may not be complete, especially when ultraviolet radiation is also present during the heating.

This prediction of surface disorder and opacity, possibly accompanied by porosity in layers of recombined dust, would help account for two perennially striking properties of the moon's surface: (i) the generally low albedo of the moon (and Mercury), about 7 percent, which has previously been taken as evidence that the surface resembles our blackest terrestrial rocks, slates, and basalts; (ii) the low thermal conductivity even on high lunar surfaces that might be expected to be free of loose dust. [Gold (*4*) has mentioned "radiation-induced coloration" but seems to suppose that it is negligible "in the denuded (eroded) highlands."]

Surfaces of such a chemically unstable character could also be highly reactive, and extensive exothermic reactions might be easily triggered, as in the Donn-Urey explanation of cometary outbursts (*2*). The first man who plants a rubber boot on a lunar surface may be in for an unpleasant surprise. This suggests a number of possible experiments as well as a num-