Table 1. Numbers of *Drosophila pseudoobscura* males [among 12 Arrowhead (AR) and 12 Chiricahua (CH) pairs] mating in the upper chamber. Early matings represent only the first half of all matings observed. Chi-square values (1 d.f.) are calculated to test for deviations from panmixia (from mating in proportion to frequency present).

Type in lower chamber		Space between chambers	Mating among males in upper chamber						
			All matings			Early matings			Replications (No.)
Female	Male		AR (No.)	CH (No.)	χ^2	AR (No.)	CH (No.)	χ^2	
CH	CH	Yes	48	52	0.16	21	30	1.59	5
CH	CH	No	63	39	5.65*	28	24	0.31	6
AR	AR	Yes	51	54	0.09	26	27	0.02	6
AR	AR	No	37	64	7.22†	20	32	2.77	6

* Significant, $P < .05$. † Significant, $P < .01$.

Table 2. Numbers of *Drosophila pseudoobscura* females [among 12 Arrowhead (AR) and 12 Chiricahua (CH) pairs] mating in the upper chamber. Early matings represent only the first half of all matings observed. Chi-square values (1 d.f.) are calculated to test for deviations from panmixia (from mating in proportion to frequency present).

Type in lower chamber		Space between chambers	Mating among males in upper chamber						
			All matings			Early matings			Replications (No.)
Female	Male		AR (No.)	CH (No.)	χ^2	AR (No.)	CH (No.)	χ^2	
CH	CH	Yes	51	49	0.04	18	33	4.41*	5
CH	CH	No	49	53	0.16	25	27	0.08	6
AR	AR	Yes	50	55	0.24	21	32	2.28	6
AR	AR	No	52	49	0.89	25	27	0.08	6

* Significant, $P < .05$.

Here the designation "space" indicates the addition of somewhat less than 1 cm of space between the upper and lower levels. This much space, between two taut layers of coarse cheesecloth, prevents physical contact between flies in the upper and lower chambers. A comparison of early and total matings may be of interest because, whereas a female can mate only once during the 3 hours of observation, a male can mate more than once. Both times that significant deviation from random mating occurred, it was in favor of the artificially rare males and there was no space separating the "contaminee" flies below from the "contaminated" flies above. Where there is space between the two sections random mating occurs (Table 1). *Drosophila* females do not exhibit frequency-dependent mating success as do males and all are eventually inseminated (Table 2).

These data are in agreement with previous observations [(*5*) and Table 1]. They indicate the importance of physical contact (touch) to discriminating *Drosophila* females when they are presented with a choice of mates. However, it should be noted that the mating advantage accruing to artificially rare males is smaller than that observed when there is a genuine minority among the courting males (*1–5*).

If two or more genotypes are each more successful in mating when they are rare than when they are frequent, the Darwinian fitness of these genotypes will grow as their frequencies diminish and vice versa (*2*), if other variables remain unchanged. The result will be a balanced polymorphism which can be maintained by sexual selection in the absence of heterosis in the heterozygotes. If this phenomenon is at all widespread in natural populations, it may play a very considerable role in evolution, bolstering genetic diversity (*6*).

LEE EHRMAN

Rockefeller University, New York City 10021

References and Notes

1. C. Petit and L. Ehrman, *Evol. Biol.* **3**, 177 (1969); L. Ehrman and E. B. Spiess, *Amer. Natur.*, in press.
2. W. W. Anderson, *Proc. Nat. Acad. Sci. U.S.*, in press.
3. L. Ehrman, *Amer. Natur.* **101**, 415 (1967).
4. ———, B. Spassky, O. Pavlovsky, Th. Dobzhansky, *Evolution* **19**, 337 (1965).
5. L. Ehrman, *ibid.* **23**, 59 (1969).
6. J. Neel and W. Schull, *Perspect. Biol. Med.* **11**, 565 (1968).
7. Supported by PHS research career award 5K3 HD-9033-05. I thank E. Spiess, University of Illinois at Chicago Circle, for advice.

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Blue Haze and Mariner 6 Pictures of Mars

The preliminary report on Mariner 6 television pictures (*1*) indicates that surface craters were recorded in blue pictures (effective wavelength, 469 nm). The authors state categorically, "the 'blue haze' hypothesis is disproved" thereby.

This is not a credible conclusion on two grounds.

1) The effective wavelength used on Mariner 6 and 7 is too long to reveal the blue haze phenomenon. Slipher (*2*) reports that little obscuration of surface features is found in the range 460 to 520 nm while notable obscuration occurs with an effective wavelength of 430 nm and still more is recorded below 400 nm. Öpik (*3*) adopts a range of 425 to 455 nm as the critical one where surface detail disappears. Thus it is clear that the effective wavelength used on the recent Mariners was definitely larger than those identified as representing the upper limit for detecting the phenomenon on earth-based telescopic photographs.

2) The features recorded telescopically are large compared with those recorded by the Mariner spacecraft. Since they represent an average over the discrete elements (such as craters) revealed by the Mariners, it is virtually inevitable that the telescopic features are inherently lower in contrast than those seen by the Mariners. Thus, a thin "blue haze" could exist that would obscure the gross telescopic features while permitting the higher-contrast small features to be recorded.

It is of some interest that earth-based blue photographs which fail to record the semipermanent dark features on Mars do characteristically show the polar caps. Thus it is clear that high-contrast features are easily recorded. This fact has led those who advance the hypothesis of a haze layer (be it scattering or absorbing) to conclude that it has a low optical thickness of perhaps 0.1 to 0.2.

A particulate haze layer would be expected to have optical thickness varying as about the inverse first power of wavelength. Thus, if the above fractional thicknesses are assigned to 400 nm, one expects about double that value at 200 nm. This would be a value below unity, and one would expect that the polar caps would still be detectable. I am informed that unpublished results obtained from the Mariner 7 ultraviolet spectrometer indicate the cap was detected at about 190 nm, a result that is still compatible with a blue haze layer.

There seems to be nothing in the preliminary results from Mariner 6 and 7 that clearly eliminates the hypothesis of an optically thin, particulate, scattering layer commonly referred to as "blue haze." More complete results will, of course, be awaited with interest.

SEYMOUR L. HESS

Department of Meteorology, Florida State University, Tallahassee 32306

References

1. R. B. Leighton, N. H. Horowitz, B. C. Murray, R. P. Sharp, A. G. Herriman, A. T. Young, B. A. Smith, M. E. Davies, C. B. Leovy, *Science* **165**, 685 (1969).
2. E. C. Slipher, *Mars* (Sky, Cambridge, Mass., 1962), p. 38.
3. E. J. Öpik, *J. Geophys. Res.* **65**, 3057 (1960).

22 August 1969

Conditions on Mars on 10 June 1969 provided a unique opportunity to examine the phenomenon of blue clearing which was very strong on that date, but only over part of the disk. By observing both the normal and the "blue cleared" part of the disk simultaneously and by constructing curves of contrast as a function of wavelength, it is possible to show that the blue clearing is due to an actual change in the contrast conditions on Mars.

I obtained photometrically accurate intensity profiles of Mars in two colors simultaneously with a newly designed dual-beam area scanning photometer. An aperture (1.2 seconds of arc in diameter) was swept across the planetary image from pole to pole. The light which passed through the aperture was split into two beams by a dichroic filter. One beam passed through an interference filter with a peak wavelength of 6000 Å. This served as a reference beam. The other beam passed through one of ten filters with peak wavelengths ranging from 3300 to 5000 Å. Photomultipliers and pulse-counting electronics recorded the intensity of both beams, yielding direct intensity scans of a strip of the planetary image 1.2 seconds of arc wide.

The photoelectric observations were obtained alternately with photographic images (*1*) at the same telescope. Dark features become less apparent in the scans (Fig. 1) at the bluer wavelengths. Blue photographs normally fail to show the dark regions with good contrast, but since part of the Mare Cimmerium is very clearly visible on the blue photograph (Fig. 2), at least part of the martian disk exhibited a high degree of blue clearing on 10 June. However, Trivium Charontis in the center of the disk is obscured in the blue image, as is normal for photographs taken at this wavelength with no blue clearing present.

Defining the contrast of the dark features as the ratio of the intensity at the center of the dark area to the intensity just outside the dark area as measured on the photoelectric scans, the contrast, at least for the dark features reported here, is a linear function of wavelength (at the wavelengths we studied) whether or not clearing is present (Fig. 3). On 4 July, when no blue clearing was evidenced on photographs, the contrast curve for Mare Cimmerium was almost identical with the 10 June (obscured) curve for Trivium Charontis, whereas on 10 June, when the photograph showed strong local blue clearing, the contrast curve for Mare Cimmerium was shifted toward the ultraviolet, not reaching unity until 3800 Å. Thus, the phenomenon of blue clearing is due to a change in the physical characteristics of the martian atmosphere or surface and is not, as has been suggested by Pollack and Sagan (*2*), due to seeing variations in the earth's atmosphere.

In addition, the contrast curves obtained for dark regions when no blue clearing was present on photographs still do not reach unity until a wavelength of about 4200 Å (Fig. 3). Hence, under normal conditions it

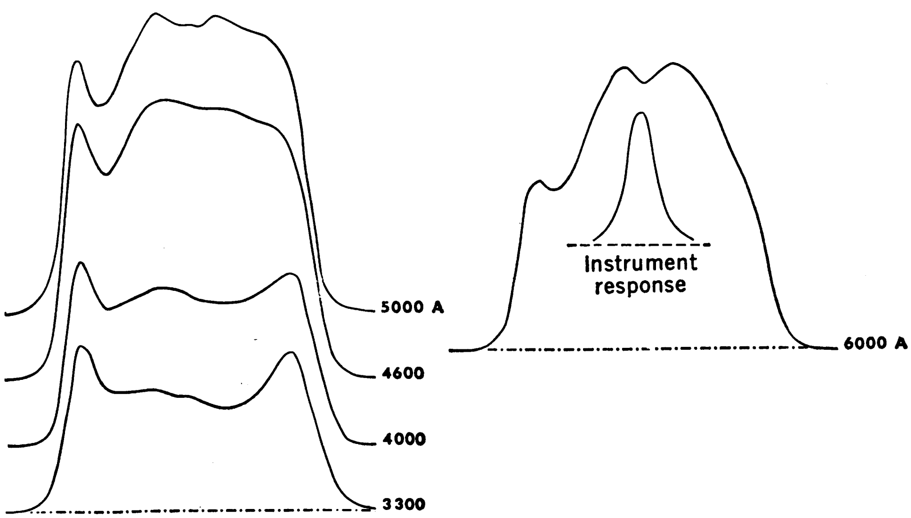

Fig. 1. Polar intensity profiles (N-S scans; 10 June 1969; 0608 to 0640 U.T.; L.C.M. = 210) of Mars at five wavelengths showing Trivium Charontis near the center and Mare Cimmerium at the left as dips in the profile. North is to the right. Mare Cimmerium is evident in the 4000-Å curve, but Trivium Charontis has vanished at that wavelength due to the effects of nonuniform blue clearing.

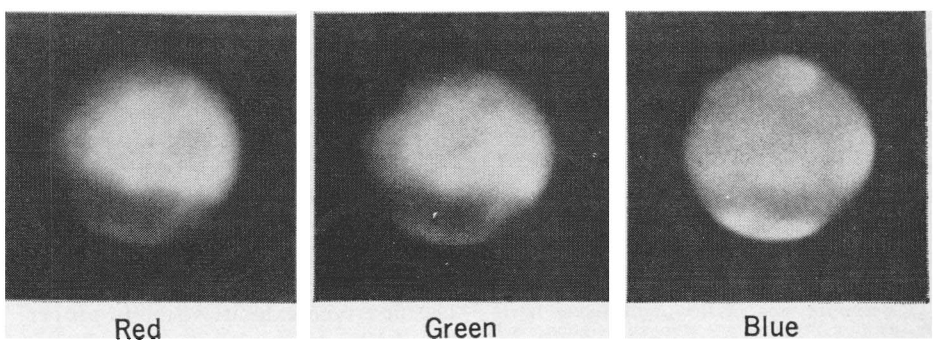

Fig. 2. Red, green, and blue photographs (at effective wavelengths of 6200, 5560, and 4340 Å, respectively) of Mars obtained at the same time as data in Fig. 1, showing a high degree of blue clearing over the lower third of the disk as indicated by the visibility of the dark Mare Cimmerium on the blue photograph. North is at the top. Trivium Charontis is the dark marking at the center of the disk in the red photograph.

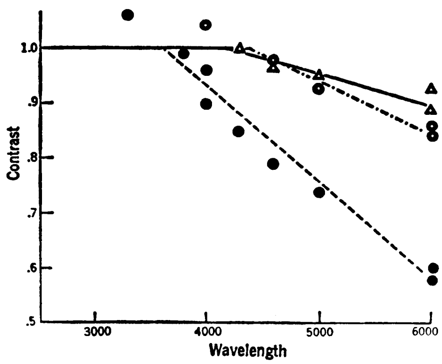

Fig. 3. Contrast of dark surface features on Mars. The curve for Mare Cimmerium on 10 June (solid circles) was taken at a time of strong blue clearing. The other two curves (Mare Cimmerium on 4 July, open circles; Trivium Charontis on 10 June, triangles) were taken when no blue clearing was present.

seems that the "blue haze" does not completely mask the surface features except at wavelengths shorter than 4300 Å. It should more properly be called a violet haze.

In view of this, the statement (*3*) that "the blue haze hypothesis has been disproved" by Mariner 6 photographs needs to be reconsidered. The Mariner 6 blue filter had an effective wavelength of 4690 Å (*3*). At this wavelength, even in the absence of blue clearing, the dark surface markings remain visible from the earth, although with low contrast (Fig. 3). Thus, the presence of craters in the blue Mariner photographs is not in itself sufficient to rule out an atmospheric origin for the "blue haze."

PETER B. BOYCE
Lowell Observatory, Flagstaff, Arizona 86001

References and Notes

1. The present observations were made as part of a program of Mars photometry undertaken during June and July 1969 at the Cerro Tololo Inter-American Observatory using the Lowell-Tololo 24-inch reflector at the *f*/75 Cassegrain focus. Cerro Tololo was one of six stations used in a worldwide survey in connection with the Lowell-NASA International Planetary Patrol Program.
2. J. B. Pollack and C. Sagan, *Smithson. Astrophys. Observ. Spec. Rep. No. 258* (1967).
3. R. B. Leighton, N. H. Horowitz, B. C. Murray, R. P. Sharp, A. G. Herriman, A. T. Young, B. A. Smith, M. E. Davis, C. B. Leovy, *Science* **165**, 684 (1969).
4. I thank the staff of the Cerro Tololo Inter-American Observatory for cooperation and assistance in setting up and maintaining the equipment and electronics. Sponsored in part by the Air Force Cambridge Research Laboratories, Office of Aerospace Research, under contract AF 19(628)4070. Contribution from Cerro Tololo Inter-American Observatory No. 100.

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Hess (*1*) and Boyce (*2*) have questioned a statement that the martian blue haze hypothesis, historically invoked to explain the invisibility of surface features in blue light, is disproved (*3*). Hess says (i) that the effective wavelength of the Mariner 6 and 7 blue filters is too long to reveal the blue haze phenomenon, and (ii) that the craters observed in the Mariner blue photographs are of higher contrast than the larger albedo features seen from the earth. Boyce reports contrast changes in his spectrophotometric measures of martian surface features and interprets these changes as the variable opacity of a "violet" haze. He also says that the effective wavelength of the Mariner blue filters is too long to test the blue haze hypothesis.

We now reassert our original conclusion, and, while acknowledging that optically thin aerosol layers do exist in the martian atmosphere, we contend that their optical thickness is not of the order of 0.1 to 0.2 as suggested by Hess (*1*). Our preliminary measures indicate that the aerosol thicknesses are in fact less by nearly a factor of 10, implying that any obscuration would be negligible and that most of the light in blue photographs of Mars comes from the surface—not from its atmosphere.

Contrary to references quoted by Hess (*1*) there is no critical wavelength at which martian surface detail disappears. Contrast between the larger bright and dark areas decreases nearly linearly throughout the range of wavelengths from 600 to 400 nm, with the average contrast becoming zero at about 400 nm (*4*). Our measured contrasts of wavelength-dependent albedo features recorded in the Mariner 6 and 7 photographs (*5*) are in very good agreement with the earth-based observations (*4*), thereby negating any suggestion of unusual conditions at the times of encounter of the two spacecraft.

The Mariner photographs show two photometrically different types of craters: those distinguished by wavelength-dependent albedo differences, and those made visible by nonwavelength-dependent surface scattering properties or photometric slope effects. The first type exhibits visibility properties similar to the larger classical dark features observed from the earth—easily seen in the red or green photographs, but nearly invisible on the overlapping blue pictures. The second type is seen equally well (or equally poorly, depending upon solar illumination angle) in the overlapping areas of red, green, and blue photographs. Although photometric decalibration of the Mariner photographs is still incomplete, we see no significant difference in the visibility of these features in green and blue light.

The contrast curve of Mare Cimmerium (10 June 1969) given by Boyce (*2*) is in general agreement with similar measures of Syrtis Major/Arabia (*4*), although he shows somewhat higher contrast in the wavelengths from 400 to 500 nm. The contrasts given for Cerberus (*6*) (10 June 1969) and Mare Cimmerium (4 July 1969), however, are abnormally low and require some comment. The case of Cerberus is easily explained—the effective width of the point spread function of the spectrophotometer given by Boyce (*2*) for 10 June 1969 is at least four times the width of Cerberus (0.65″) along the scan direction. The low contrast is simply a matter of insufficient geometric resolution. The 4 July observations of Mare Cimmerium (3″ along the scan direction) are more difficult to explain. However, examination of 160 plates of the Mare Cimmerium region taken between 27 March and 28 September 1969 at the New Mexico State University Observatory shows no anomalous appearance, and this includes the dates of 10 June and 4 July. We can only conclude that Boyce's 4 July anomaly was caused by smearing effects of the earth's atmosphere at the time of his observations.

B. A. SMITH
New Mexico State University, Las Cruces 88001
A. T. YOUNG
Jet Propulsion Laboratory, Pasadena, California 91103
C. B. LEOVY
University of Washington, Seattle

References and Notes

1. S. L. Hess, *Science*, this issue.
2. P. B. Boyce, *ibid.*, this issue.
3. R. B. Leighton, N. H. Horowitz, B. C. Murray, R. P. Sharp, A. G. Herriman, A. T. Young, B. A. Smith, M. E. Davis, C. B. Leovy, *ibid.* **165**, 684 (1969).
4. R. Younkin, *Astrophys. J.* **144**, 809 (1966); T. B. McCord and J. B. Adams, *Science* **163**, 1058 (1969); B. A. Smith, unpublished result.
5. These include near-encounter photographs by Mariners 6 and 7 and photographs taken 2 hours before encounter by the wide-angle camera of Mariner 7.
6. Boyce refers to this feature as Trivium Charontis, a common error attributable to the use of older maps of Mars. In recent years the Cerberus-Trivium Charontis region has been strongly dominated by Cerberus.

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Blue Haze and Mariner 6 Pictures of Mars

Seymour L. Hess, Peter B. Boycr, B. A. Smith, A. T. Young and C. B. Leovy

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