Two of the elements of the tarsus are illustrated in plate 1, figures 3 to 4*b*. The astragalus and calcaneum resemble the corresponding bones in *Leptoreodon gracilis* Scott.

Concluding Remarks.—*Hesperomeryx edwardsi* is more closely related to *Leptoreodon* than to *Leptotragulus*. It differs from *Leptoreodon marshi* and from *L. gracilis* in certain features of the dentition regarded as of subgeneric rank. *Hesperomeryx* appears to be in slight measure at least, more advanced than the species from the Uinta. Among the later Eocene Artiodactyla, *Leptoreodon* is unique in the advanced character of the upper molars. This genus is obviously a leptomerycid, but I am not aware of any lower Oligocene genus sufficiently close to it to be regarded as a direct descendant. The oreodonts of the Sespe Eocene show a development quite distinct from that of *Hesperomeryx*. The cleft between the latter form and the oreodonts unquestionably extends farther back in the Eocene.

ABSORPTION OF COSMIC RAYS IN THE MILKY WAY

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A. Introduction.—If cosmic rays are of *extragalactic origin*, they must be partially absorbed by the gas and dust clouds which populate the interstellar spaces. This absorption will produce directional asymmetries in the intensity of the cosmic rays because of our eccentric location relative to the Milky Way. In addition to the straight absorption of energy a part of the cosmic rays will be scattered by interstellar matter without appreciable loss in total energy. Such scattering includes the formation of energetic secondaries and therefore tends to produce a change in the numbers and physical characteristics of the various constituents of the cosmic rays. Again, because of the segregating action of the earth's magnetic field, directional asymmetries will result. Although the effects to be expected are in all probability small it seems that modern instruments are sufficiently sensitive to make possible the detection of the before-mentioned asymmetries. Positive results of a search for absorption effects might furnish new information on

(1) Whether or not cosmic rays are of extragalactic origin.
(2) The problem of the total amount of interstellar matter.
(3) The analysis of the composition of cosmic rays.

B. Amount of Absorption—Most of the cosmic rays are absorbed in their passage through a layer whose thickness corresponds to one kilogram of matter per column of one square centimeter cross-section. A given amount of matter is therefore most effective in absorbing cosmic rays if in interstellar space it is distributed in the form of particles whose linear dimensions are less than about ten centimeters. Interstellar gases and dust clouds, as well as not too large meteorites, will therefore be most effective.

The distribution of interstellar gases and dust runs more or less parallel to the distribution of stars. In fact, observations of both the selective and non-selective absorption and the scattering of star light seem to indicate that the total mass of interstellar matter in the known regions of our galaxy is of the same order of magnitude as the total mass condensed in stars. In our neighborhood the average density of matter corresponding to the presence of stars is of the order $\rho_s = 4 \times 10^{-24}$ g./cm.^{3}. Toward the center of the galaxy the average number of stars per equal volume is much larger than in our local system. Gases and dust clouds are also highly concentrated in the plane of the Milky Way and particularly in the direction of its center. For the average density ρ of interstellar matter, including gases, dust and meteoric material between the sun and the center of the Milky Way in Saggittarius we may therefore put tentatively in order of magnitude

$$\rho = 10\,\rho_s = 4 \times 10^{-23}\text{ g./cm.}^3 \qquad (1)$$

The distance L from the sun to the center of the galaxy seems to be of the order $L = 10^4$ parsecs $= 3 \times 10^{22}$ cm. We may assume that beyond the center conditions similar to those on our side prevail, so that a cylinder of 1 cm.^{2} cross-section extending from the earth through the whole galaxy in the direction of its center will contain an amount of matter of the order

$$\Delta m = 2\,L\,\rho = 2.4\text{ g./cm.}^2 \qquad (2)$$

The number of ion pairs which are produced by the cosmic rays per second in one gram of matter at high altitudes is of the order 4×10^5. The formation of one ion pair requires about 30 electron-volts. The energy absorbed by one gram therefore is

$$\epsilon = 1.5 \times 10^{-5}\text{ ergs/g. sec.} \qquad (3)$$

Cosmic rays passing through Δm g./cm.^{2} will suffer a loss Δi in specific intensity equal to

$$\Delta i = \epsilon \times \Delta m = 3.6 \times 10^{-5}\text{ ergs/cm.}^2\text{ sec.} \qquad (4)$$

The *specific* intensity i is defined to be the flow of energy per second through one square centimeter of surface in a unit solid angle normal to this surface. The *total* intensity I is the total flow of energy per second through 1 cm.^{2} from one side of a surface to the other. If i is the same in all directions, then $I = \pi i$.

The value of i, taking in all cosmic rays with energies over 10^9 e.-v., is estimated[1] to be of the order

$$i = 10^{-3} \text{ ergs/cm.}^2 \text{ sec.} \tag{5}$$

Therefore approximately

$$\Delta i/i = 0.03. \tag{6}$$

It must be emphasized that this change of 3% is only a rough estimate because our knowledge of the actual amount of interstellar matter and its distribution over the galaxy still is very incomplete.

The value of $L\rho$ in the direction of the pole of the Milky Way is probably not more than one thousandth of $L\rho$ in the direction of Sagittarius. The absorption of cosmic rays in the direction of the pole will therefore be relatively small.

C. Suggestions for the Observational Program.—For practical purposes the question now arises, over how big a solid angle around the direction of the center of the Milky Way may we expect values for $\Delta i/i$ which are of the order of 3%? From direct observations of gas and dust clouds it seems safe to assume that an average density ρ of the order used in equation (1) prevails in all directions between about $-5°$ and $+5°$ in galactic latitude and $\lambda_c + 20°$ to $\lambda_c - 20°$ in galactic longitude, where $\lambda_c = 324°$ is the longitude of the center.

With directed sets of Geiger counters mounted on astronomical drives it should be quite possible to detect the absorption of cosmic rays through the Milky Way by exploring fields of $10° \times 20°$ or even $5° \times 10°$.

Since the declination of the center of the Milky Way is about $\delta = -30.5°$ preliminary experiments should preferably be carried out in the southern hemisphere in those regions of the earth where Sagittarius passes near the zenith.

For the interpretation of any prospective findings it must be kept in mind that the presence of the earth's magnetic field considerably complicates matters. Only the intensity of those components of the cosmic rays which are undeflected by a magnetic field, such as neutrons and photons, would have a minimum of intensity in the direction of Sagittarius. The minima corresponding to charged particles would show displacements depending on their velocity and their mass.

In order to get rid as far as possible of disturbing effects of the magnetic field, observations near the southern magnetic pole (latitude $= -72° 25'$) where some very dense regions of the Milky Way still pass near the zenith would be most desirable. For a preliminary observational analysis of the problem here proposed all regions between latitudes $-30°$ (Sagittarius passes zenith) and the south magnetic pole provide ideal locations. Both New Zealand and eastern Australia are in this respect well located.

In addition to directed sets of Geiger counters, ionization chambers in conjunction with proper screening of solid angles of the order of $10° \times 40° = 400$ square degrees might be used. If no screens are introduced one observes $\Delta I/I$ which is much smaller than $\Delta i/i$. The solid angle including all directions which contribute to I on top of the atmosphere would be a half sphere 2π or ca. 20,626 square degrees. Because of the passage through the atmosphere the actual solid angle which includes all the directions contributing to I on the *earth's surface* is considerably smaller. At sea level it is perhaps of the order of 4000 square degrees. Our expectation for $\Delta I/I$ at sea level, with Sagittarius in the zenith would therefore be

$$\Delta I/I = 0.1 \times \Delta i/i = 0.3\%. \tag{7}$$

I do not know whether any observations made from the southern hemisphere are available to check this conclusion. The best modern recording apparatus with automatic elimination of barometric effects are supposed to have an accuracy of 0.1% for single readings. It seems, therefore, quite possible to observe in small southern latitudes the absorption of cosmic rays on their passage through the Milky Way even without the use of screening devices.

It should perhaps be mentioned that beams of cosmic rays passing through the dense regions of the Milky Way lose intensity because of absorption; however, cosmic rays from neighboring directions will be scattered into the weakened beams and partly replenish their intensity. This will tend to make the value of $\Delta i/i$ smaller than that expected for straight absorption. As we do not know enough about the scattering processes involved it is impossible to estimate the magnitude of the resulting change in $\Delta i/i$.

Summary.—In this paper an estimate has been given of the change in intensity of cosmic rays due to absorption in interstellar matter in the direction of the center of the Milky Way. Successful observations of this absorption would be important for the following reasons:

(1) Data on the absorption in the Milky Way are valuable in order to decide whether or not cosmic rays are of extragalactic origin.

(2) If cosmic rays are of extragalactic origin, observations of their absorption will enable us to determine the total amount of matter which is present in the Milky Way in form of particles whose linear dimensions are less than 10 to 100 cm. This method of weighing would be very simple, since the total absorption of cosmic rays, in contradistinction to the absorption of ordinary light, does not depend on the degree of dispersion of the absorbing matter. The importance of this method for many astrophysical problems has been especially emphasized by Dr. W. Baade of the Mt. Wilson Observatory in private conversations.

(3) The existence of directional effects in combination with the deflections caused by the earth's magnetic field may provide a method to analyse cosmic rays with respect to their various constituents.

The considerations given here form a part of a more general program[2] whose aim it is to investigate possible "extraterrestrial effects of cosmic rays."

[1] E. Regener, *Zeits. Physik*, **80**, 666 (1933); and R. A. Millikan, I. S. Bowen and H. V. Neher, *Phys. Rev.*, **44**, 246 (1933).

[2] F. Zwicky, *Helv. Phys. Acta*, **8**, 515 (1935); and *Ibid.*, **6**, 127 (1933).

OBSERVATIONS ON THE RELATION BETWEEN SALIVARY GLAND CHROMOSOMES AND MULTIPLE CHROMOSOME COMPLEXES

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In 1917 Holt[1] described multiple chromosome complexes found in the pupal intestine of the mosquito *Culex pipiens* during metamorphosis. The diploid chromosome number is 6; the numbers most frequently found in multiple complexes were 12, 24 and 48.

Bogojawlensky[2] in a study of cell size in *Anopheles maculipennis* found that the large cells of the larval mid-gut had nuclei and chromosomes of the salivary gland type "Balbianischer spiremähnlicher Typus," differing however from the classical type discovered by Balbiani in *Chironomus* in the following points: 1. The chromosomes consist of granules of chromatin attached in a linear series without achromatic connecting threads. 2. There is only one nucleolar body present.

Bauer[3] cites the findings of the above two investigators as furnishing a visible demonstration of the compound nature of the salivary gland chromosomes. His argument supposes that the cells giving rise to multiple complexes are of the same type as those described by Bogojawlensky and that in mitosis the huge "compound" chromosomes separate into their component units resulting in multiple complexes.

The observations of Holt and Bogojawlensky have been repeated on *Culex pipiens* with the following results:

1. The large cells of the larval mid-gut have chromosomes which are similar to salivary gland chromosomes in that they consist of a thick chromatic cord, visible in the resting nucleus. They are made up of serially attached chromatin granules varying in diameter.[4]