Racemization and Epimerization

In recent reports (*1*) the term *racemization* is used inappropriately.

It is stated in both reports that L-isoleucine racemizes to D-alloisoleucine. This reaction is epimerization, not racemization. Racemization of L-isoleucine results in the formation of DL-isoleucine. As stated in Eliel (*2*): "racemization is the process of producing a racemic modification starting with one of the pure enantiomers."

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References

1. K. A. Kvenvolden, E. Peterson, F. S. Brown, *Science* **169**, 1079 (197→ J. L. Bada, B. P. Luyendyk, J. B. Maynard, *ibid.* **170**, 730 (1970).
2. E. L. Eliel, *Stereochemistry of the Carbon Compounds* (McGraw-Hill, New York, 1962), p. 33.

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In the strictest sense Smith is correct in pointing out that the reaction is epimerization, not racemization. In a practical sense, however, the use of the term racemization may be justified or at least rationalized.

In geochemical situations configuration changes of amino acids involve asymmetric centers attached to amino and carboxyl functions. Centers not attached to these functions remain fixed. Although isoleucine, for example, has two centers it is only at the carbon next to the carboxyl that the configuration changes. Therefore, so far as the molecule is concerned, isoleucine reacts with regard to changes in configuration in the same way as any amino acid with a single asymmetric center.

Most amino acids have single asymmetric centers and can undergo racemization. Exactly the same reaction can take place with isoleucine, but because of definitions, a different name is given—epimerization. Use of the term racemization does not seem to create any confusion even when applied to amino acids like isoleucine which have two centers only one of which is involved in configuration changes. Certainly when a collection of L-amino acids undergoes reactions yielding DL-amino acids the term racemization seems adequate even though a few of the amino acids in this collection may have two asymmetric centers.

In earlier geochemical literature (*1*) the term racemization has been employed in a general, practical sense and can be justified in the light of the arguments just presented. When future work is done in organic geochemistry, however, all authors probably should consider using the term epimerization where applicable.

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Reference

1. P. E. Hare and P. H. Abelson, *Carnegie Inst. Wash. Year B.* **66**, 526 (1968); P. E. Hare and R. M. Mitterer, *ibid.* **67**, 205 (1969).

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Was the Moon Originally Cold?

Recently several vigorous attacks have been made on the idea of a cold or cool origin of the moon. Since this idea was first definitely stated by me (*1*) and since there is considerable misunderstanding of what is involved, I would like to explain the origin and purpose of the suggestion and my present ideas in regard to the problem.

Brown (*2*) pointed out that the ratio of the polar flattening of Mars to the ratio of centrifugal force at its equator to its gravitational force was sufficiently large to suggest that it had no core. Reviewing the evidence led me to conclude that this was the case. The planet accumulated at low temperature, and it had not become sufficiently hot, owing to radioactive heating, to form a core. Today, it still seems that this is the case. Mars has no magnetic dipole field, and the constants still seem to be in accord with this conclusion.

This led to the question as to whether the earth was formed as a mixture of metal and silicate rocks without a metal core and had formed such a core during its history. It is generally believed that, if this is the case, the core was formed early in terrestrial history. The changing moment of inertia has provided a way of separating the moon from the earth by those who favor this origin. Also, single cell convection in the earth, which is possible only in an earth without a core, has been a favorite explanation in the theory that all the continental masses formed on one side of the earth and were subsequently scattered over the earth by several convection cells which developed later, after a core had formed. The timing of these events proved to be very difficult, and this theory is generally not thought to be true.

Was the moon also formed in a low-temperature condition? Its moments of inertia deviate markedly from those expected for a body under the forces of rotation and terrestrial tidal effects, and, if the moon is a body whose density does not vary with angular position, a stress of 19 bars should exist at the center of the moon, implying considerable strength somewhere in the body of the moon. Also, high mountains exist on the moon, and, since mountains on the earth are in fairly good isostatic adjustment, it appeared that the moon's mountains, if they had no low density roots, were now supported and had been supported throughout lunar history by more rigid rocks than now exist below the earth's surface. Thermal calculations made in the early 1950's indicated that this was difficult to explain unless the moon began its history at a fairly low temperature.

No one was very happy about this conclusion. My co-workers and I (*3*) suggested the formation of the moon from a limited number of objects of variable density, which made possible a statistical variation of density along the three axes, and thus permitted isostatic conditions in the moon as a whole but also permitted the observed variation in moments of inertia. Levin (*4*) pointed out that lower temperatures at the poles were another way of securing density variations at the polar and equatorial regions. Runcorn (*5*) has argued for deep convection currents that produce similar effects. Others (*6*) have pointed out that a cold outer shell of considerable thickness would support the variations required and yet permit a hot interior. The past history of the moon has always been a problem in some theories, for the various differences in moments of inertia that have been produced imply the ability of the surfaces to move at one time and then to freeze later.

There was no change in this situation until Muller and Sjogren (*7*) discovered positive gravitational anomalies and, thus, the mascons in the circular maria and a few other places. Although I had suggested the presence of metal masses in these maria (*8*), this discovery was a surprise to me and to every-