Among the assay microorganisms, two species of yeasts, *S. cereviseae* and *R. minuta*, were inhibited most often by 12 and 9 isolates, respectively. Against the other assay organisms the number of bacteria showing inhibition were as follows: *B. megaterium*, 2; *S. aureus*, 2; *E. coli*, 3; *P. aeruginosa*, 0; *C. albicans*, 7; and *C. neoformans*, 7. With the exception of *C. albicans*, the extent of inhibition of the assay yeasts was greater than that observed for the test bacteria, that is, <5 mm radial cleared zone for the latter organisms compared with radial zones of 5 to 10 mm, or more, for the assay yeasts. Approximately equal degrees of inhibition were observed for *S. cereviseae*, *R. minuta*, and *C. neoformans*.

It is apparent from this preliminary work that bacteria with antiyeast (competitive?) properties may be encountered frequently in the marine environment. It is not known whether the inhibition observed is a result of competition for nutrients, physicochemical factors (*p*H, redox potential, etc.), or the actual elaboration of specific antagonistic substances, as has been shown in other investigations (*3*). Nevertheless, to assess adequately the diversity of marine microbial activity, investigations of antibiosis in the sea should incorporate appropriate species of yeasts into basic screening programs (*9*).

JOHN D. BUCK
SAMUEL P. MEYERS
KATHERINE M. KAMP
Institute of Marine Science,
University of Miami, Miami, Florida

References and Notes

1. E. N. Krasilnikova, *Mikrobiologiya* **30**, 545 (1962); P. R. Burkholder, in *Symposium on Marine Microbiology*, C. H. Oppenheimer, Ed. (Thomas, Springfield, Ill., 1962), chap. 14.
2. T. W. Johnson, Jr. and F. K. Sparrow, Jr., *Fungi in Oceans and Estuaries* (Cramer, Weinheim, Germany, 1961); J. W. Fell, D. G. Ahearn, S. P. Meyers, F. J. Roth, Jr., *Limnol. Oceanogr.* **5**, 366 (1960); F. J. Roth, Jr., D. G. Ahearn, J. W. Fell, S. P. Meyers, S. A. Meyer, *ibid.* **7**, 178 (1962); J. W. Fell and N. van Uden, in *Symposium on Marine Microbiology*, C. H. Oppenheimer, Ed. (Thomas, Springfield, Ill., 1962), chap. 32.
3. J. D. Buck, D. G. Ahearn, F. J. Roth, Jr., S. P. Meyers, *Bacteriol. Proc.* **20** (1962). A description of the details of these experiments is in preparation.
4. J. D. Buck and R. C. Cleverdon, *Limnol. Oceanogr.* **4**, 78 (1960).
5. A. J. Carlucci and D. Pramer, *Proc. Soc. Exptl. Biol. Med.* **96**, 392 (1957).
6. Baltimore Biological Laboratory, Baltimore 18, Md.
7. Millipore Filter Corporation, Bedford, Mass.
8. R. C. Cleverdon, E. Leifson, R. A. Murchelano, *Proc. First Natl. Coastal Shallow Water Res. Conf.* (1961), p. 127.
9. Contribution (427) from the Institute of Marine Science, The Marine Laboratory, the University of Miami, Miami, Florida. Aided by grant G-16146 from the National Science Foundation.

9 November 1961

Moon Illusion: An Observation

Abstract. Size comparisons of the moon are made from different locations by direct viewing (as opposed to comparisons by instrumental techniques). Under the proper conditions, the illusion is seen while the moon's position remains essentially unaltered. By this means, evidence is adduced in favor of Ptolemy's apparent-distance hypothesis.

The illusion of change of lunar size yielded by direct observational comparison ordinarily requires a considerable waiting period during the moon's ascent from, or descent toward, the horizon. A simultaneous size comparison of the real or artificial horizon moon versus the elevated moon is made possible only by mirror arrangements, as in the extensive experiments of Holway and Boring (*1*) and of Kaufman and Rock (*2*).

Where the terrain is suitable, however, the observer's movement may substitute for the moon's movement. The illusion is then visible during certain months by direct observation of the moon at or near the full, at a relatively constant celestial elevation and with no significant time lapse.

A particular street in the Borough of Queens, New York City, slopes about 5°. With the slope behind him, the observer, at the summit of the slope, can view the moon before him against an expanse of open sky about 40 minutes after moonrise, at an elevation of about 10°. By this time the moon appears diminished in size compared to the horizon moon. From a point some 200 yards downslope the moon is seen with intervening landscape and with its lower rim touching the tops of trees and low buildings. By visual estimate, its diameter is now 1¼ to 1½ times as large as when seen from the summit. The observer can move back and forth along the slope several times and view these changes alternately for 10 or 15 minutes until the illusion disappears after the moon has risen too high. Since the apparent path of the moon through the sky exhibits periodic variations, the illusion is not visible every month. For example, on 21 May 1962 (moonrise 10:18 P.M., EDT; 2 days past the full) the foregoing observations were made near 11:00 P.M., EDT. The illusion was seen again in July and September; in October it was no longer visible. No observations were made in June and August.

The hypotheses concerning the moon illusion, or suggestions as to relevant factors involved, may be summarized as follows:

1) The illusion depends, in some unestablished manner, upon the position of the eyes within the head. The horizon moon is seen with eyes level and the elevated moon with eyes raised (Holway and Boring's angle of regard hypothesis; see *1–4*).

2) It depends upon the brightness of the image on the retina. The horizon moon appears fainter and, therefore, larger than the moon in elevation (Bishop Berkeley's hypothesis; see *2, 4, 5; 6*, p. 361).

3) It is due to differences in light refraction based upon differences in the angle of incidence to the earth's atmosphere (see *2; 6*, p. 360).

4) Factors such as gravity, or the redder and therefore larger appearance of the horizon moon, may be pertinent (*2*).

5) It is a consequence of the measure of great distance conveyed by the terrain in viewing the horizon moon (Ptolemy's apparent distance hypothesis; see *2; 6*, pp. 290, 360; *7*).

Under the described conditions of observation, the angle of regard, brightness, elevation, orientation with respect to gravity, and color are constant. Accordingly, this would appear to render untenable the first four considerations enumerated above, while lending support to the fifth.

In connection with Ptolemy's hypothesis, it may be of interest to note that the horizon is about 3 miles distant for a man standing on a level plain with unobstructed view; Kaufman and Rock, in one set of experiments, worked with a horizon about 700 yards distant; in the present description, the horizon is effectively only about 200 yards from the bottom of the slope. Clearly, the illusion can occur even when the intervening distance is much less than the usual horizon distance (*8*).

GILBERT GOLDSTEIN
Department of Chemistry,
Mount Sinai Hospital, New York 29

References and Notes

→ A. H. Holway and E. G. Boring, *Am. J. Psychol.* **53**, 537 (1940).
2. L. Kaufman and I. Rock, *Science* **136**, 953 (196 → I. Rock and L. Kaufman, *ibid.* **136**, 1023 (1962); L. Kaufman and I. Rock, *Sci. Am.* **207**, 120 (July 1962).
3. O. Zoth, *Arch. Ges. Physiol.* **78**, 363 (1899); → E. Schur, *Psychol. Forsch.* **7**, 44 (19 → A. H. Holway and E. G. Boring, *Am. J. Psychol.* **53**, 109 (1940); E. G. Boring and A. H. Holway, *Science* **91**, 479 (19 → D. W. Taylor and E. G. Boring, *Am. J. Psychol.* **55**, 189 (1942); E. G. Boring, *Am. J. Phys.* **11**, 55 (1943).

4. G. von Békésy, *Am. J. Pyschol.* **62**, 540 (1949).
5. G. Berkeley, *The Works of George Berkeley, Bishop of Cloyne*, A. A. Luce and T. E. Jessop, Eds. (Nelson, London, 1948), vol. 1, "An essay towards a new theory of vision," sections 67–78, and appendix; also, "The theory of vision vindicated and explained," section → A. H. Holway and E. G. Boring, *Am. J. Psychol.* **53**, 587 (1940).
6. H. L. F. von Helmholtz, *Treatise on Physiological Optics*, vol. III, translated from the 3d German edition, J. P. C. Southall, Ed. (Optical Society of America, Rochester, N.Y., 1925).
7. T. K. Abbott, *Sight and Touch: An Attempt to Disprove the Received (or Berkeleian) Theory of Vision* (Longman, Green, Longman, Roberts and Green, London, 1864), p. 137; C. J. P. Cave, *Nature* **141**, 290 (1938); H. M. Dadourian, *Am. J. Phys.* **14**, 65 (1946).
8. Approximately the same side of the moon faces the earth at all times. To a stationary observer on the moon the earth would therefore neither rise nor set, but, except for librational effects, would maintain a fixed position in the sky. If an "earth illusion" were visible to him, it would normally be due only to his movement between points where the earth is seen on the horizon and in elevation. But the moon's curvature being greater, its horizon is consequently less distant than the earth's.

15 October 1962

Recovery from Radiation-Induced Delay of Cleavage in Gametes of Arbacia punctulata

Abstract. A decrease in delay of cleavage, when irradiated sperm fom *Arbacia punctulata* were allowed to "recover" inside eggs, occurred when cell division was interrupted by the removal of oxygen soon after fertilization. The recovery mechanisms in irradiated eggs of this species before and after fertilization have been compared and appear to differ.

Exposure to ionizing radiation of either the egg or sperm of *Arbacia punctulata* quantitatively retards the time of first cleavage of the fertilized egg (*1*). Early experiments by Henshaw demonstrated that the magnitude of the cleavage delay induced by radiation decreases with the length of time that the irradiated eggs remain in sea water after irradiation but before insemination (*1*). Henshaw found that with time this decrease was exponential and termed the phenomenon "recovery." No such recovery could be demonstrated in irradiated sperm, which consist mostly of nuclear material. It has been assumed, therefore, that certain cytoplasmic components are necessary for the recovery mechanism to operate.

In a recent reinvestigation of aspects of this recovery process, the recovery rate of irradiated eggs in sea water was independent of oxygen (*2*). When irradiated eggs were kept, prior to fertilization, in deoxygenated sea water the same decrease in delay of cleavage was observed as when they were kept in fully aerated sea water for the same period. It was decided, therefore, to look for recovery in irradiated sperm by allowing the sperm to enter the egg and then blocking cell division for various lengths of time by removing oxygen. This technique demonstrated that recovery does indeed occur in irradiated sperm if the sperm is inside the egg during the recovery period.

The criterion of effect was the delay in the time of first cleavage of fertilized eggs induced by exposure of either the eggs or sperm to a dose of 10,000 r. The time of cleavage was measured, in minutes, from the time of fertilization to the time when cleavage took place in 50 percent of the eggs. The time of cleavage is considered to be good to about ± 1 minute; hence the values for cleavage delay are accurate to about ± 2 minutes. Irradiation was delivered by a 5000-curie, cesium-137 gamma-ray unit, at a rate of 5000 r/min.

For the investigation of sperm recovery, irradiated and nonirradiated sperm from the same animal were used to fertilize normal eggs in test tubes. Within a few minutes after fertilization, nitrogen was bubbled continuously through the fertilized egg suspensions to displace the oxygen. Samples were removed thereafter at intervals to finger bowls which contained fresh sea water, and the time of cleavage was measured. The time of cleavage of the unirradiated samples treated with nitrogen was compared with that of the normal controls to give values for the prolongation of the cell division cycle caused by the removal of oxygen. These prolongations are plotted as "recovery periods" in Fig. 1.

The results of two experiments shown in Fig. 1 illustrate the two types of recovery curve observed. In two out of four cases, the radiation-induced delay of cleavage decreased exponentially with recovery time (curve *A*). In the other two cases there was an initial sudden drop followed by a slower exponential decline (curve *B*). The similarity in the terminal slopes of curves *A* and *B* is coincidental; some variation in recovery rate occurs when the sperm are obtained from different animals.

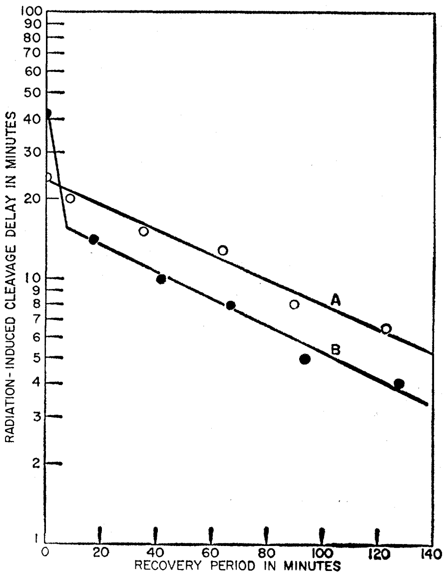

Fig. 1. Recovery of *Arbacia* sperm inside the egg after exposure to 10,000 r. Curves *A* and *B* show results of two experiments and represent the two types of response found. Abscissa, prolongations of cell division are plotted as "recovery period" intervals. Ordinate, time delays of first cleavage, logarithmic scale.

It was then decided to apply the same technique to irradiated eggs and to compare the curves for eggs allowed to "recover" before and after fertilization. The results of two such experiments are shown in Fig. 2. In the case of the unfertilized eggs the recovery period represents the time interval between irradiation and fertilization; for the fertilized eggs, inseminated immediately after irradiation, the recovery period represents the time interval that cell division was retarded when oxygen was replaced by nitrogen. The two forms of recovery curves were the same as the forms of the curves with irradi-

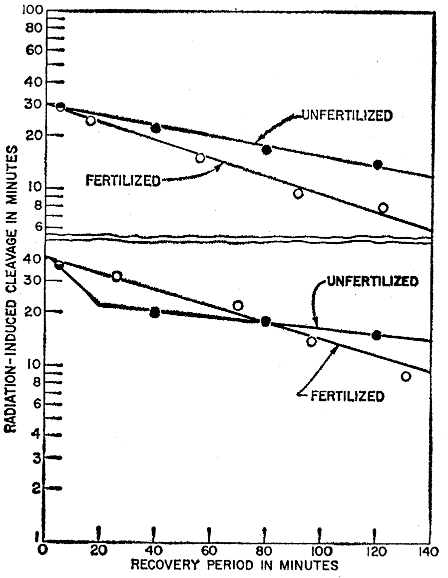

Fig. 2. Recovery of *Arbacia* eggs exposed to 10,000 r. Abscissa and ordinate as in Fig. 1. Results of two experiments indicate the types of response found.