Table 1. Calcium and strontium concentrations in bovine bone ash. Figures in the same column with different superscripts (a, b, c) differ significantly at $p < .05$.

Bone	Ca (%)	Sr (μg/g)	Sr^{90} (pc/g)	Sr^{90} (pc per gram of Ca)
Rib	34.8[a]	238[a]	23.1	66.3[ab]
Femur	35.1[a]	287[c]	24.4	69.5[b]
Humerus	35.6[a]	265[ac]	22.9	64.2[ab]
Frontal	35.4[a]	305[c]	25.7	72.7[b]
Incisors	40.1[b]	255[a]	20.2	50.2[a]
Thoracic vertebra	34.9[a]	265[ac]	23.3	66.8[ab]
Caudal vertebra	34.5[a]	272[ac]	24.1	69.7[b]
Average	35.8	270	23.4	65.6

Table 2. Concentrations of calcium, strontium, and strontium-90 in bone ash of cattle of different ages. Figures in the same column with different superscripts (a, b, c, d) differ significantly at $p < .05$.

Animal	Ca (%)	Sr (μg/g)	Sr^{90} (pc/g)	Sr^{90} (pc per gram of Ca)
Calf	34.6[a]	214[a]	19.4[a]	55.9[a]
Yearling	36.0[b]	243[ab]	20.2[ab]	55.7[a]
2-yr-old	36.5[b]	266[bc]	25.9[bc]	72.5[ab]
3-yr-old	36.2[b]	300[cd]	26.9[c]	74.7[b]
Cow	35.5[b]	327[d]	24.6[abc]	69.4[ab]
Average	35.8	270	23.4	65.6

others (*4*) have reported no differences in total strontium content in different human bones. It appears either that there is a species difference or that uncontrolled environmental factors mask this effect in man.

The concentration of strontium-90 apparently reached a maximum in the 2-year-old animal and remained about the same thereafter, although it was somewhat lower in the older animals. The 2- and 3-year-old animals were born immediately before the initiation of the test ban in 1958. The maximum level of strontium-90 in their bones by birth date precedes by 1 year the maximum level found in U.S. milk and the maximum deposition rate (*5*).

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References and Notes

1. This study was supported in part by Atomic Energy Commission contract No. AT (04-3)-34.
2. M. A. Wade and H. J. Seim, *Anal. Chem.* **33**, 793 (1961).
3. R. Pieruccini and R. Zotti, *Atti soc. toscana sci. nat. Pisa* **A56**, 119 (1949) (reported in *Chem. Abstr.* **45**, 2087).
4. R. M. Hodges *et. al., J. Biol. Chem.* **185**, 519 (1950); E. M. Sowden and S. R. Stitch, *Biochem. J.* **67**, 104 (1957); K. Turekian and J. L. Kulp, *Science* **124**, 405 (1956).
5. H. A. Knapp, *U.S. Atomic Energy Comm. Biol. Med. Rept. No. TID-19345* (1961).

16 January 1962

Proposed Explanation of Luminous Particles Observed in Glenn Orbital Flight

Abstract. It is proposed that the luminous particles observed by John Glenn in his orbital flight are condensed nitrogen and possibly oxygen. Irradiation by the sun would produce excited trapped radicals, which would radiate in ways consistent with the observed behavior of the particles.

One of the most surprising new phenomena observed by Glenn in his orbital flight on 20 February 1962 was the swarm of luminous particles near the space capsule. These particles have been described by him recently (*1*). Several critical facts observed by him should be summarized here. (i) The particles were luminous after "sunrise"—that is, after they were exposed to radiation from the sun; (ii) they were light yellow-green in color; (iii) their luminosity was observable for approximately 4 minutes after sunrise.

Two questions are of main concern: What are these particles, and where do they come from? I propose that the particles are solid nitrogen, possibly with some oxygen admixed; that they become luminous when radiation from the sun produces free radicals in the particles; and that the luminosity ceases when the particles are warmed up sufficiently by the radiation.

Solid nitrogen which is bombarded by x-rays and ionizing particles becomes luminous (*2*). The luminosity is related to forbidden transitions of nitrogen atoms (^2D to ^4S), and of oxygen atoms (^1S to ^1D) if any are present (*3*). In addition, molecular transitions from nitrogen and oxygen molecules are observed. The luminosity is light yellow-green; the exact hue depends on the chemical composition of the solid, on its temperature, and so on. The luminosity continues as long as the radiation continues, because a steady state is quickly reached. If the temperature rises above approximately 35°K, the luminosity disappears. It should be noted that pure solid oxygen does not become luminous if it is bombarded, but that oxygen species radiate if they are trapped together with nitrogen.

It seems most likely that the luminous particles observed by Glenn are indeed systems containing trapped nitrogen (and possibly oxygen) atoms. No other systems seem to have all the requisite properties. The present hypothesis is easy to check. Small, pocket spectroscopes carried along on the flight would suffice to show whether the luminosity lies in the regions of the spectrum appropriate for trapped nitrogen and oxygen atoms.

The second major question—Where do the particles come from?—is much more difficult to answer. They may exist independently at the altitudes involved. Indeed, Vegard proposed many years ago that such was the case (*4*). Or they might be produced from leaks of gas from the capsule, from gas trapped in various portions of the vehicle, and so on. This question will, however, be much easier to answer once the proposal made here has been verified or proved false.

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References and Notes

1. *Aviation Week* **76**, 63 (23 Apr. 1962); *Science*, this issue, p. 1093.
2. This is a well-known fact. For details see *Formation and Trapping of Free Radicals*, A. M. Bass and H. P. Broida, Eds. (Academic Press, New York, 1960).
3. The details of the transition are far from clear, but there is little doubt that atoms in these states play a prominent role in the emissions. For a recent discussion see C. M. Herzfeld, "A survey of theoretical work on trapped radicals at the National Bureau of Standards," in "Stabilization of Free Radicals at Low Temperatures," *Natl. Bur. Std. (U.S.) Monograph No. 12* (1960).
4. L. Vegard, *Nature* **114**, 357 (1924); *Ann. Phys. (Paris)* **79**, 377 (1926).

4 May 1962

Aragonite in the Resilium of Oysters

Abstract. Aragonite (orthorhombic $CaCO_3$) composes some of the fibers of the resilium of *Crassostrea virginica* (Gmelin).

The ligament of oysters consists of two kinds of conchiolin, but is divided into three portions, adjoining lengthwise. The outer layer [outer layer of Trueman (*1*) = lamellar ligament of Newell (2)] is nonfibrous, more translucent than the other layer, and dark brown; it makes up the two flanking portions of the adult ligament, anterior and posterior to the resilium, and is strong under tension and bending stresses. The inner layer [inner layer of Trueman = fibrous ligament of Newell] is fibrous, semitranslucent, and whitish-gray, and has light brown growth layers; its very fine fibers are nearly normal to its ventral or growing border. It makes up the resilium, which is the median one of the three portions; it is strong under compression, but weak to tension. The resilium is calcified, as a simple test with hydrochloric acid will show. In view of the composition of the shell of oysters, composed mainly of calcite (rhombohedral $CaCO^3$) and minor amounts of aragonite (orthorhombic $CaCO_3$), it is an interesting question which mineral is in the resilium.

To test its composition, a very small hammer and punch were used to break off small pieces of the resilium of *Crassostrea virginica* (Gmelin) until they made up several cubic centimeters. These pieces were checked under the binocular microscope for adhering fragments of the shell. All such contaminated material was discarded. The pure resilium material was ground to a powder. The x-ray powder diagram made by Dr. J. F. Burst of Shell Development Company shows the curve of the mineral aragonite.

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References

1. E. R. Trueman, *Quart. J. Microscop. Sci.* **92**, 129 (1951).
2. N. D. Newell, "Late Paleozoic Pelecypods: Pectinacea," *Univ. Kansas Publ. State Geol. Surv. Kansas Bull.* **10** (1937).

22 January 1962

Sleep Deprivation, Age, and Exhaustion Time in the Rat

Abstract. Male rats were maintained on a constantly moving wheel in a study of prolonged sleep deprivation. The results obtained revealed a striking negative relationship between age and resistance to exhaustion.

In an earlier study of the effects of prolonged sleep deprivation, six young male hooded rats, 60 days old, were placed on a constantly moving wheel for 27 days. One animal was lost after 17 days. When older animals were tested in a similar manner, it was noted that exhaustion occurred much earlier. This study reports on the relationship of this age variable to exhaustion time.

Six male animals from the following six age groups were obtained from the University of Florida colony: group I, 63 days old; group II, 89 days old; group III, 147 days old; group IV, 170 days old; and group V, 220 days old. At least two litters were represented in each group. The rats were placed, in individual 4½- by 7½-inch cubicles, on wheels, two-thirds submerged in water, which rotated at a constant speed of approximately 2 rev/min. Food trays were placed in each cubicle so that the animals could feed at any time. The rats remained on these wheels continuously except when they were removed for weighing at 24-hour intervals. The total distance covered by an animal during a day was 0.7 mile. The rats, when exhausted, fell from the wheel into the water and were unable to remount the wheel. Animals were removed from the experiment when they fell into the water after being replaced on the wheel three times during a 15-minute period.

Figure 1 shows for each age group the time at which the criterion of exhaustion was reached. The group I (63 day) animals were removed after 9 days although none had reached the exhaustion criterion. It may be recalled, at this point, that 60-day-old rats were run 27 days with the loss of one animal after 17 days. The only difference in the treatment of the 60-day-old rats was that they were kept off the wheel for a longer time (approximately 20 minutes) because several additional measures were taken.

The rats' weight loss and their intake of food while on the wheel were measured. The average percentages of weight retention for each of the five groups after 48 hours were as follows: group I, 95.8; group II, 86.2; group III, 89.2; group IV, 90.6; and group V, 93.3. These averages do not include values for one animal from group V and one from group III that did not last 48 hours. These weight losses, however, give a distorted picture in the case of group I, and to some extent in the case of group II, as these animals are still in a growth gain period; thus these figures map represent a considerable suppression of weight gain. There is a .20 correlation (rank order) between amount of weight lost in 48 hours and terminal exhaustion time in groups II through V. Finally, the overall weight loss for all animals at the weighing before exhaustion was 15.81 percent.

The average change in food intake from the first day on the wheel to the second day on the wheel was as follows for the five groups (in percent): group I, 248.7; group II, 53.4; group III, 99.1; group IV, 88.8; and group V, 45.3. These figures represent the total food intake during the second day divided by the total food intake during the first day in percentage terms. The correlation between the change in food intake and the change in exhaustion time was not significant.

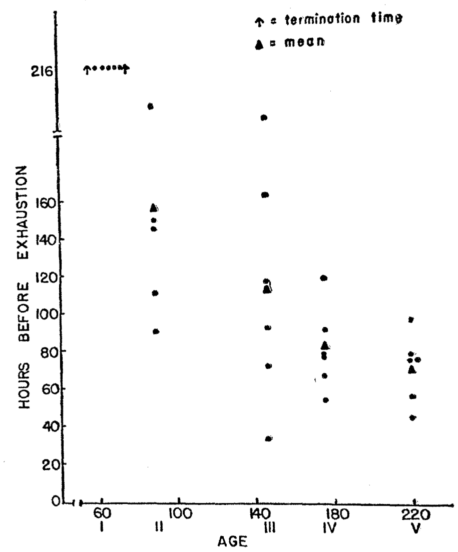

Fig. 1. Exhaustion times of each rat and group means as a function of age. Note that, in group I (age 63 days), runs were terminated after 216 hours.

In conclusion, the data show a clear-cut relationship between exhaustion time and age. Because the amount of activity involved is far below the normal free-run activity of a rat and because the weight loss before exhaustion is certainly within survival limits, it is at least plausible to hypothesize that this exhaustion is related to sleep deprivation (*1*).

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Arrangement of DNA in Living Sperm: A Biophysical Analysis

Abstract. The submicroscopic arrangement of DNA molecules in living sperm is analyzed by new, highly sensitive polarization optical techniques. It is concluded that the molecules are arranged as a coil of a coil in sperm chromosomes, which in turn appear to be arranged in single file with a definite sequence.

Despite major advances in our knowledge of the molecular structure of DNA (deoxyribonucleic acid) (*1, 2*) and its genetic significance, little is yet known of the exact arrangement of this molecule in chromosomes of living cells. We have inquired into this problem by developing a new method of fine structure analysis which takes advantage of