some of the small condensations fall in toward the sun (with just a little sideways motion so that they miss hitting the sun). Lyttleton's spherical plot, restricted to new comets, would reveal from which part of Oort's spherical shell comets have come, but there is no way of assessing precisely how a passing star would deflect the material. A more decisive test comes from the statistical treatment of comets' energies and their random changes due to the gravitational jerks or perturbations caused by planets the comets happen to pass. Because the space about the sun is so nearly empty, comets move with frictionless ease, and their energy (kinetic plus potential) would be determined only by the distance they fall toward the sun, were it not for planetary perturbations. Accurate observations of some 20 comets show that the difference between energy of approach and energy of recession from the sun is a small random quantity with a mean of zero (the increases balance the decreases) and a certain "spread" or mean deviation that agrees with theoretical predictions by Kerr.

Hammersley attacked the problem of how long a comet can remain within the solar system when its orbit is perturbed in this random manner on each approach to the sun. If a comet gets several large, positive-energy perturbations, its energy exceeds that required for escape and it never returns. One method of studying this problem is by many trials, the so-called "Monte Carlo" method. Hammersley also developed two approximate analytical solutions, one based on the analysis of Brownian motion that holds for a small number of passages and low starting energy and one that is expected to hold for a very large number of passages. The Monte Carlo runs, over 1.5 million on the Ferranti machine at Harwell and 1700 on the IBM 704 at the California Institute of Technology, confirm the analytical results over long time intervals, as shown in Fig. 3. Hammersley found that, depending slightly on the starting energy (that is, the distance from which new comets start falling toward the sun), the probability of a comet's remaining in the solar system decreases to 1 percent in about 200 million years. If a 4 percent chance of break-up on each passage is assumed, the decrease is a good deal more rapid, all comets being lost or disintegrating in a few million years.

The conclusion drawn by Lyttleton and Hammersley is that comets must be replaced at a fairly continuous rate. A possible alternative conclusion is that the number of comets was 1500 to 15,000 times greater when the solar system was formed, some 5 billion years ago, than it is today. (It is estimated that there are now 40 million comets.)

Adopting the former conclusion, Kendall examines the question: What energies should comets have at present if they are being formed as rapidly as they disintegrate or are lost? Using analysis similar to Hammersley's, Kendall derives the spectrum of energies which would result if new comets were all being dropped into the sun from a distance about 3000 times the earth's distance from the sun. This spectrum is modified for the effects of observational selection, account being taken of the fact that we see comets on long orbits less frequently than comets on short orbits, and the results are compared with the energies of 23 comet orbits measured accurately in the interval 1850 to 1936.

Figure 4 (middle and right) shows that confirmation is lacking; Lyttleton's theory predicts a maximum of comet energies corresponding to the 3000-unit starting distance, while the observations show a peak at energies corresponding to much larger distances. In a second trial Kendall assumed that the new comets fall from almost infinite distance, as in Oort's theory, and this theoretical spectrum of energies agrees quite well with the observations, as shown in the left and right curves of Fig. 4.

The tentative conclusion is that new comets are being formed at very great distances—10,000 to 100,000 times the earth's distance from the sun—and added to the diminishing number that we see circulating among the planets. The data cannot prove that the total number remains constant over long periods of time; in fact, it appears that *more* new comets have been added in recent times than were needed to keep the observed population constant. If Oort's theory is correct, the sun may at present be closer than usual to stars that disturb its shell of cometary material—a subject for further statistical investigation (*2*).

References and Notes

1. This is the subject of an unfinished investigation by Neyman, Page, and Scott.
2. Proceedings of the 4th Berkeley Symposium, including a full account of each of the investigations outlined in this article, will be published by the University of California Press in 1961.
3. B. Y. Mills, O. B. Slee, E. R. Hill, *Australian J. Phys.* **11**, 360 (1958).
4. C. O. Edge *et al.*, *Mem. Roy. Astron. Soc.* **68**, 37 (1959).

Thurlow Christian Nelson, Marine Biologist

Thurlow Christian Nelson, marine biologist, was drowned on 12 September, 1960, off a storm-swept shore near his summer cottage at Green Creek, Cape May, N.J., while trying to secure his rowboat against hurricane Donna. He would have been 70 years of age on 22 September.

He was born in Highland Park, N.J., in 1890 and attended Rutgers elementary and preparatory schools in New Brunswick, just across the Raritan River from his home. He graduated from Rutgers University in 1913 with a B.S. degree in biology, and from the University of Wisconsin in 1917 with a doctorate in zoology and physiological chemistry. During World War I he served as a first lieutenant in the Army Sanitary Corps.

He was invited to join the Rutgers teaching staff in 1919 as assistant professor of zoology, becoming associate professor in 1922 and professor in

1926. From 1925 to the time of his retirement in 1956 he was chairman of the department of zoology, and he was biologist in charge of shellfish investigation at the New Jersey Agricultural Experiment Station from 1916 to 1950. In addition he served as chairman of the New Jersey State Water Policy and Supply Council from 1945 until his death. After his retirement he was named Julius Nelson Professor of Zoology in the Rutgers Graduate School, a chair founded in memory of his father, who began oyster research in New Jersey for Rutgers in 1888.

In 1934 Thurlow Nelson was honored as Rutgers' Distinguished Scholar and Gifted Teacher. Five years later the university awarded him an honorary degree of doctor of science and in 1958, the Rutgers Alumni Federation Award.

In *American Men of Science* Nelson's specialties are listed as biology of the oyster, estuarine ecology, marine biology, and limnology. His research in these areas resulted in more than 125 papers on the anatomy, physiology, and ecology of the oyster and associated organisms; on parasitology; and on water supply.

Thurlow C. Nelson

Nelson held membership in many scientific societies. He served as president of the American Society of Limnology and Oceanography in 1953, as president of the National Shellfisheries Association from 1931 to 1933, as vice president of the American Society of Zoologists in 1948, and as vice president of the American Microscopical Society in 1941.

Viewed in perspective, this long list of accomplishments is an impressive one. Equally impressive were Nelson's contributions as a teacher over a span of some 45 years. His keen mind, warm personality, sincere and forceful speech, genuine interest in people, and deep enthusiasm for biology attracted many students to him. As an active church leader with deep religious convictions, Nelson often wrote and spoke on the common ground of religion and science. He died in the midst of the elements which provided so much of the stimulus for his productive life.

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Science in the News

Castro and Kennedy

From Havana: During the past weeks the two men in this hemisphere who clearly command the attention of the world moved to consolidate their positions in preparation for the political struggles they will have to face in the year ahead. Kennedy's artful selection of his cabinet and Castro's preparation for the liquidation of remaining organized opposition to his regime offer an interesting contrast between the politics of democracy and the politics of totalitarianism. The precision with which both followed the precendents of earlier men in their respective positions suggests that there is indeed a science of politics. Kennedy moved to pacify his opponents, and even to win some of them over; Castro, since the politics of extremism, to which he seems wholly committed, allows little chance of pacifying his opposition and no chance of winning it over, moved to lay a basis for future claims that his actions are forced upon him by his utterly unreasonable foes.

Castro's situation requires that he try to destroy his present opposition now, while he still commands the strong support of the mass of the Cuban people. He began with nearly unanimous support, and as he has moved further and further left, he has so far been able to deal effectively with each wave of defections, one by one; a necessary policy since if he allowed his enemies to accumulate they would eventually overwhelm him.

Castro's position thus far has been unassailable, partly because of the genuine reforms he has brought to Cuba, partly because the austerity and restrictions that forced industrialization will require are still in the future, partly because of the force of his personality. But when the genuine reforms come to be taken for granted, when disenchantment sets in as the people realize that things are not going to be quite the way they thought Fidel was saying they would be, the regime will necessarily begin to lose some part of its mass support. Against that day, Castro moved last week to throttle the two remaining centers of organized opposition to whom defections among the masses could rally.

Last week Castro moved to destroy the last important anticommunist figure in organized labor in Cuba, Fraginals, the president of the electrical workers' union, who had recently led his men in the first open anticommunist demonstration in Cuba in a year. The union had held a demonstration in front of the presidential palace, chanting "Cuba, si! Russia, no!"

Soon afterward the newspaper began to be full of stories of the "traitors" in the electrical workers' union, of sabotage and bombings by certain members