to ocean is 67 percent. This value is close to the median of 68 percent found by Harrison for both circles and triangles; the closeness of the match indicates that the median is not sensitive to the number of continents. Note that this island model has a degenerate distribution of antipodal land, with probability 1 of antipodal portion $1 - p$, which again suggests that Harrison's estimate of expected continent antipodal to ocean may be conservative if it is based on too few or too smooth continents, which would cause too large a standard deviation.

Altogether, it seems reasonable to conclude with Harrison that the observed portion of land antipodal to ocean is unlikely to have occurred by chance, even allowing for the a priori selection, especially if Runcorn's statement is correct.

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14 October 1966

Thompson questions the use of the figure of 17.4 percent of continental area being antipodal to continent. In the report by Harrison (*1*) the figure was derived from Vening Meinesz (*2*), and it had also been used by Evison and Whittle (*3*) in their study. As to whether the figure of 17.4 percent is more correct than Runcorn's (*4*) figure of 4 percent, we have no information. The figure of 17.4 percent is supposed to be for continents out to the edge of the continental shelf, whereas the figure of 4 percent is presumably for the continental areas above sea level. We are at the moment engaged in refining the study started by Harrison. We are now using the actual shapes of the present-day continents, rather than circular or triangular continents, another factor mentioned by Thompson. This study will incidentally give a new measurement of the percentage of continental area antipodal to continent for the present-day distribution.

Finally, the problem of how many continents one should use, while being fascinating, is much more speculative, as one has to decide (i) what were the original continents, and (ii) how much one is going to allow them to overlap. At present we feel that the study should not include such speculative decisions, but we may consider them at a later date.

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Toxicity of Antibiotics in Laboratory Rodents

The deaths of a number of experimental rodents that had been treated with antibiotics impressed upon us our ignorance of the toxicity of certain of these compounds to small animals. In an attempt to arrest a bacterial infection that appeared in a group of hamsters (100 to 150 g) we administered a preparation of procaine penicillin G in dihydrostreptomycin solution. The dosage recommended in the package insert was ¼ cc for small animals (0 to 5 lb). Each hamster was therefore injected intramuscularly with ¼ ml of the preparation. Within several minutes, all the hamsters were dead. When we injected normal mice apparently free from infection to study further this fatal reaction, similar results were obtained. Mice weighing 18 to 22 g having each received either intraperitoneally or intramuscularly ⅛ ml of a different batch of the same preparation or of a preparation containing streptomycin without penicillin died within 5 to 6 minutes.

It seemed probable that the carrier or other material included in the formulation of this antibiotic was lethal. The chemical firm of J. D. Copanos and Company, Incorporated, Baltimore, Maryland, was contacted, and it kindly provided us with the following useful information on the toxicity of streptomycin and dihydrostreptomycin compounds.

Data released by the National Academy of Sciences and the National Research Council after a search of the literature show that streptomycin and dihydrostreptomycin are extremely toxic to mice, rats, and other rodents. A mouse weighing 20 g apparently has a 50 percent chance of survival if it receives a 4-mg dose of streptomycin or dihydrostreptomycin intravenously, regardless of the volume in which this amount is contained. Also, a mouse weighing 20 g has a 50 percent chance of survival if it receives 18 mg of streptomycin or dihydrostreptomycin parenterally (other than intravenously); a similar mouse has a 50 percent chance of survival if it receives 180 mg of streptomycin or dihydrostreptomycin orally. Therefore, a single dose of penicillin-dihydrostreptomycin to be administered parenterally (other than intravenously) to a 20 g mouse should not exceed 0.08 ml of the standard product; a dose to be administered orally should not exceed 0.8 ml of the standard product.

Apparently the toxicity of certain antibiotics in rodents is generally known throughout the field of chemotherapy. There are several accounts concerning the lethality of small doses of penicillin in the guinea pig, and recently Farrar, Kent, and Elliott (*1*) described similar lethal effects of bacitracin in the same rodent.

One of the antibiotic preparations that we were using is intended mainly for use by veterinarians; this preparation was not accompanied by a warning regarding dosages for small experimental animals. Consultation with several local veterinarians indicated a lack of familiarity with the toxicity of these compounds for rodents. In view of this, and as a result of our own experience, we would suggest that other investigators use caution in treating small laboratory rodents with antibiotics.

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21 January 1967

Quasi-Stellar Objects: Possible Local Origin

Terrell (*1*) discusses the arguments favoring and contradicting the local-origin hypothesis of quasi-stellar objects and concludes that the galactic origin suggested by him (*2*) can account for all known characteristics of quasi-stellar objects.

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He stresses as an achievement that the energy requirements are reduced by a factor of 10^6 to 10^7 and can be footed therefore through nuclear processes. He fails to mention the objection raised by Setti and Woltjer (*3*), namely, that in case of galactic origin, total energy of the order of 10^{60} to 10^{62} erg is needed, thus increasing rather than reducing the energy problem.

Terrell emphasizes the difficulties in reconciling the maximum size of the sources obtained from flux variations, with their minimum size derived from interferometer measurements, if the objects are at cosmological distances. This difficulty is easily avoided if quasi-stellar objects are optical effects produced by gravitational lenses (*4*).

Terrell assumes that quasi-stellar objects with a mass of a few thousand solar masses were ejected, the catastrophic collapse of the ejected masses being prevented through their rotation, with the outermost parts moving with velocities of the order of 1000 km/sec.

Let us, for the sake of an example, consider 3C9, a quasi-stellar object with a redshift of $z = \Delta\lambda/\lambda = 2.012$, λ being wavelength. If this object originated in our galaxy, the speed of ejection would have been 240,000 km/sec; hence the kinetic energy of the ejected mass (gas, particles, stars, and others) would exceed by a factor of 30,000 the gravitational binding energy that holds together the constituents. In an explosion, whenever an aggregation of particles is expelled and the kinetic energy which the constituents gain in the explosion is much larger than the binding energy holding them together, the aggregation would disintegrate, as any nuclear physicist or demolition expert could tell.

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14 December 1966

J. M. Barnothy (*1*) has raised two objections to the local model of quasi-stellar objects (*2*). The claim (*3*) of serious mass and energy problems for the local model is based in part on a surface radius too large to be consistent with optical fluctuation data. A reasonable optical diameter, less than a light-hour, leads to a mass near 1000 $M_\odot$ (solar masses). The total mass of 10^4 such objects would then be $\sim 10^7$ $M_\odot$ and the total kinetic energy would amount to about 30 percent of this, or 10^{61} erg. This energy is about what is also required for observed radio galaxies (*4, 5*), perhaps not by coincidence, and could readily be produced by the gravitational collapse of 10^9 $M_\odot$ at our galactic center (*2*).

These energy requirements of the local model could easily be reduced by assuming that the optical line width is due to electron scattering, rather than to surface rotation. This would lower the required mass to that needed to produce the optical flux by nuclear reactions, or about 100 $M_\odot$ per object, for 10^7 years lifetime. This mass could be further reduced by making the assumption commonly made for other models, namely, that the radiation need not be maintained for so long a time. However, such assumptions have not been made, as a total mass of 10^7 $M_\odot$ and the corresponding energy seem quite feasible for the local model.

The issue should not be whether such an energy is more (or less) spectacular than required by cosmological distance, but whether there are physical mechanisms and possible models consistent with the evidence. This is a difficult requirement for cosmological distance, the most recent difficulty being the report (*6*) that quasi-stellar objects with large red shifts tend to lie near the galactic poles.

In his second objection, Barnothy points out that the kinetic energy of a relativistically moving quasar would greatly exceed its gravitational binding energy. The same argument could be applied to distant galaxies with large red shifts, which nevertheless manage to cohere. Barnothy states, in effect, that it is impossible for gravitationally bound objects to be ejected, or produced after ejection, from a relativistic explosion. His conclusion should be of interest to cosmologists, as it at once rules out the "big-bang" origin of the universe.

The ejection of coherent drops from a gravitationally collapsing galactic center has also been suggested by Hoyle and Fowler (*5*), in connection with radio galaxies. It would seem that this possibility can only be ruled out by a deeper understanding of the details of a gravitational collapse.

As to the possibility of gravitational condensation following the ejection process, a simple nonrelativistic calculation can be made. What is required for condensation in the denser regions of an ejected gas cloud is that the gravitational potential due to the mass within a small region exceed kinetic energies relative to the local center of mass. If all the gas is ejected at essentially the same time, the density ρ required for gravitational binding at a time T later is given by $\rho > 3/8\pi G T^2$, in which G is the gravitational constant. If the source of the gas is a gravitational collapse of mass 10^9 $M_\odot$, its radius will be somewhat larger than its Schwarzschild radius of 2.73 light-hours (the density in the source will then be correspondingly less than 0.0185 g/cm^3, less than the solar density of 1.41; the limiting density of a gravitational collapse of mass M varies inversely as M^2).

Condensation of ejected gas would be expected to occur only outside the Roche limit, the distance at which the disrupting effect of the larger mass balances the gravitational forces within the smaller mass. A reasonable distance for condensation might thus be of the order of a light-day, and the density required for condensation would then be $\rho \gtrsim 2.4\ \beta^2 \times 10^{-4}$ g/cm^3, in which βc is the velocity of the gas relative to the source. This required density is much less than that of the gravitational collapse (it is similar to that of quasi-stellar objects, if local). Thus condensation might be expected to occur within localized regions of an ejected gas cloud.

Barnothy's model of quasi-stellar objects as optical effects produced by gravitational lenses apparently cannot account for the number of quasi-stellar radio sources of optical magnitude 19 or brighter, much less for the numbers of blue stellar objects. Since it also seems unable to account for associated radio sources, jets, diffuse clouds, and other features of quasi-stellar objects, this model seems less attractive than the local model (*2*).

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