shipments of materials are made only after allocation. Allocations can be obtained in one to three weeks after submission of properly completed request forms, the time depending on action that may be necessary by advisory allocation groups.

Although it is not possible in this limited space to give due credit to all individuals who have contributed to the success of this program, it is possible to designate certain organizations and groups which have made enormous contributions.

The Clinton Laboratories pile has been chiefly responsible for the production of radioisotopes, although piles of other areas have been used to some extent.

The preparation of chemically separated radioisotopes has been accomplished through the cooperative activities of the Chemical, Technical, and Production Divisions at Clinton Laboratories, operated for the Government by the Monsanto Chemical Company.

The Chemical Division at Clinton Laboratories and various groups at the Argonne National Laboratory and Radiation Laboratory of the University of California have made numerous contributions to basic radiochemical and physical techniques which aided the development of presently employed processes.

Matters pertaining to scheduling, shipping, and billing have been efficiently handled by the management and other groups at Clinton Laboratories. The Health-Physics Department there has given expert supervision to the safety and health protection phases of packaging and shipment.

Production of deuterium gas from deuterium oxide as well as the shipping and billing for the produced gas and deuterium oxide are being managed by Stuart Oxygen Company, San Francisco, California. The deuterium oxide was produced by facilities contracted for by the Manhattan Project.

Allocations by the Atomic Energy Commission have been made by the Isotopes Branch with the assistance of advisory committees composed of personnel outside the Commission staffs. Each request has been reviewed and rated on its individual merits by subcommittees on allocation and on human applications. These advisers are as listed in the original announcement in *Science*. Their continuing service, which is voluntary, is indeed keenly appreciated.

The success attained in the isotope distribution program has been the result of cooperation of a number of organizations and hundreds of interested persons. The Commission appreciates the fact that it can rely on the continued cooperation and efforts of these individuals, as well as on further participation by others. Increasing success of the program is therefore guaranteed.

Suggested Principles of "Social Physics"

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A NEW DEMOGRAPHIC INDEX, CALLED "potential of population," was found in 1940 (*1*). Studies have been resumed, and it is now established that, when averages are considered, principles resembling some of those of physics apply not only in demography but in related aspects of economics.

When celestial mechanics was being developed, in the 16th and 17th Centuries, the order of advance was: (1) the collection of quantitative observations (Tycho Brahe); (2) their condensation into empirical mathematical regularities (Kepler); and (3) theoretical interpretation of the latter (Newton). If there is to be a social physics, its beginnings must follow the same standard pattern. During recent years, social statisticians have published amazing amounts of numerical observations. That stage is well advanced. Several pioneers (especially G. K. Zipf and A. J. Lotka) have described significant empirical regularities. A great deal more attention must, however, be given to the third stage by numerous investigators before it is fully achieved.

Mathematical rules in demography are described in a current report (*2*) which contains numerous references to previous work. Intensive further studies have been carried on with the cooperation of the School of Economics and Politics of the Institute for Advanced Study. Only a partial and condensed description of these can be given below.

An important empirical relation is found between the population and the average area of cities in the U. S. Census of 1940, namely,

$$A = \frac{P^{\frac{3}{4}}}{350},$$

the area, A, being in square miles. This is the land area of the "political" city, within the official city limits. The rule holds statistically for cities above the rural limit of 2,500, including the largest ones. Examination of less inclusive data published by the Bureau of the Census for 1890 shows that the same formula applied, except that the numerical constant was 400 instead of 350. That is to

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say, a city of any assigned population averaged no more than 6 or 7 per cent larger in linear dimensions in 1940 than in 1890, notwithstanding the development of rapid transit.

The existence of this conspicuous regularity demands the éxistence of additional ones in the average distribution of people within each city. For each of 60 leading cities in 1940 the internal distribution of population by "census tracts" is available. There is strong evidence for the following standard internal pattern, as a first approximation: The normal city, regardless of size, has roughly the same density of population at its edges, averaging there about 3 people per acre or 2,000 per square mile. From edge to center, the density tends to increase exponentially with the distance, reaching a peak density in some inner census tract which usually is adjacent to others having densities nearly as great. The peak density tends to increase with the size of the city, reaching in 1940 more than 400 per acre in Manhattan (Avenues B to D, 3rd to 9th Streets).

The "demographic gravitation" implied by various applications of the concept of potential of population serves to account in part for these facts. But a statistical countertendency is required to explain why all the people in a city do not pile up in the most dense census tract. An adequate mathematical description of this appears to be found in the concept of the "human gas." Each individual seeks some elbowroom or living space. The idea of a two-dimensional gas is already familiar in physics (monomolecular layers). In the demographic analogue we write: $pa = NT$, where a is the area occupied by N individuals (molecules), p is the "demographic pressure," and T is the "demographic temperature." In the physical case, p is the force per unit length of boundary.

Since the well-to-do normally live in larger quarters than the poor, the use of per-capita rent suggests itself as a measure of demographic temperature. This, in turn, following obvious physical analogues, leads to the interpretation of the "demographic energy," NT, as value or wealth. The quantity T can be measured by the value per capita of the land plus improvements, while p is its value per unit area. In general, the "demographic force" is interpreted as the rate of change of a value with distance.

The high land-value per acre reached in cities is a consequence of demographic gravitation. People gather in urban concentrations because both the means of livelihood and the material services which enhance living can be more varied and abundant in such situations. The suggested combination of gravitation and the gas laws is already a familiar pattern in astrophysics, in the elementary theory of stellar constitution.

Confirming the above ideas, a relation at once follows to the previously observed average dependence of the density of rural population on the potential of population (*1*). Not only in 1930, but also in 1940, 1900, and 1840, the rural density in the United States tended to vary as the square of the potential. Cities are "anchored" in place by special considerations (often topographic), but the rural population can distribute itself with relatively little distortion by sharply local influences. In order for the density of a perfect gas to vary as the square of the gravitational potential, the temperature, as can easily be shown, must vary as the potential. Full data concerning rents are available in the Population and Housing series of the U.S. Census of 1940. It is a fact that in the 28 states east of Colorado and north of the Deep South—where the rural density rule held especially well—the rural nonfarm rent was, on the average, proportional to the first power of the potential of population.

This result leads to a dollar quotation (or conversion factor) for the demographic unit of value—the value of the propinquity of two people placed one mile apart, as evidenced in the value of land. It was of the order of half a cent in 1940, in terms of capitalized rural rent.

A rough survey of rural land values at different times and different places in the United States suggests that the dollar quotation of the unit of propinquity has been much less unstable than the cost of living. Indeed, the speculative suggestion may be made that the secular increase in the latter has not been produced by inflation in the value of the demographic unit, but by the continued growth of population. That has increased the number of units of propinquity involved in normal subsistence.

Just as the telephone subscriber on a large exchange must pay more because he can make more different calls than the subscriber on a small one, so the individual in the United States of the present is involved in many more possible relations with his fellows than when our population was smaller. The number of relations of N_1 people who are at a distance d from N_2 people is proportional to N_1N_2/d; this is the demographic energy. The introduction in this formula of the factor of inverse distance agrees with common sense; but its final justification is found in a large variety of statistical evidence in the social field.

References

1. Stewart, John Q. *Science*, 1941, 93, 89–90.
2. Stewart, John Q. *Geogr. Rev.*, July, 1947.