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**THE MENACE OF
UNDER-POPULATION**

THE MENACE OF UNDER-POPULATION

A BIOLOGICAL STUDY OF THE DECLINE
OF POPULATION GROWTH

*(Originally issued under the title of
"The Twilight of Parenthood")*

BY
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INTRODUCTION

SINCE the World War an awakening interest in population problems has borne fruit in such works as those of Carr-Saunders, Pearl, and East. More recently new factors have emerged which make it necessary to revise earlier forecasts. In the first place, developments in the scientific technique of food production have significantly changed the relation of man to the material resources of his environment. Secondly, the statistical studies of Kuczynski have led to new methods which, for the first time, make it possible for the lay reader to obtain a vivid picture of the way in which the growth-capacity of civilized communities is changing. Finally, as set forth in Chapter V, a decade of rapid progress of research into the physiology of reproduction in mammals has made us more aware of the dangers of rash speculation concerning the factors affecting fertility in man. The object of this book is to bring together these three aspects of the population problem.

The subject of population growth is one of vital interest to every intelligent citizen. This is so for two reasons. One is that in place of the Malthusian menace of over-population there is now a real danger of under-population. The other is that population changes are themselves symptoms of changes affecting the whole fabric of social life. It has, therefore, been the aim of the author to be as intelligible as possible to the general reader.

To grasp the full significance of the fallacies which have beset the study of population in the past, it is necessary to appreciate the erroneous nature of deductions drawn from crude birth-rates or crude death-rates, and the confusion arising from the imperfect statistical devices formerly used. Available books on population frequently omit to explain the statistical methods used or confine themselves to some particular method. To meet the needs of the student who is beginning a special study of the subject, Chapter II on statistical methods has been made as complete as possible. It gives an exposition of Kuczynski's methods by which most of the data presented in Chapter III were obtained. The general reader who only wishes to follow the main argument of the book can well omit in Chapter II pp. 46-50 and pp. 55-65. Similarly, in Chapter V, the discussion of the logistic curve is mainly of interest to the specialist student, and pp. 151-161 can also be omitted by the general reader.

The writer wishes to express her gratitude to Professor Lancelot Hogben, Dr. Kuczynski, Professor H. Levy, and Mr. J. L. Gray for invaluable assistance and criticism.

ENID CHARLES.

*Middle Howton,
Moretonhampstead,
February 20, 1934.*

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CHAPTER I

WHERE MOTH AND RUST NEED NOT CORRUPT

For Long the Growth of Human Populations has been Appropriated by Deductive Economics—It Belongs Rightly to the Inductive Science of Ecology—The Optimum Size of the World's Human Population can be Determined only by an Analysis of all the Ecological Relationships into which Man enters and all the Ways in which Man is Changing and can Change such Relationships—Analysis of Man's Ecological Relationships shows that no Menace of Over-population Exists or is likely to Exist in the near Future.

§ I

FOR a century the study of human population growth has been coloured by the conception of man as a conservative animal in a static environment. The *Essay on Population*, which in no small measure contributed to this attitude, was a rejoinder to a vision of human perfectibility. By attributing unchangeable attributes to man, who owes his dominance over other species to his far greater capacity for change, Malthus provided an attractive rationalization for the imperfections of a *laissez-faire* economy. Its popularity is not difficult to understand. A false antithesis between sex and food flattered the vanity of the undersexed and the overfed. The essence of the doctrine was the claim that human beings *tend* to reproduce to the limits of the available means of subsistence. Its author failed to envisage man's capacity to control and to modify either his own reproductive habits or the

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evolution of the animal and plant economy of which he forms a part. The theoretical implications of his views are therefore of interest only to the historian of human error. The practical consequences of the popular doctrines which Malthus bequeathed cannot be so lightly dismissed. They have been such as he himself would have been the last to foresee or to condone. In effect, his teaching enthroned sterility as one of the cardinal virtues. For the practice of this cardinal virtue Malthus advocated a method too unpopular to be practical. Contrary to his intentions, the changed attitude to reproduction which his writings helped to bring about has broken down the traditional prejudices which have prevented man from bringing his reproductive powers fully within the domain of rational control. The result is that the process of rationalizing reproduction has now produced a social problem of the first magnitude. The prosperous classes of industrial nations, like other ruling castes in the past, have become the victims of their own ideology. In seeking to mitigate poverty by preventing the poor from reproducing they have moulded the destiny of a civilization which has lost the power to reproduce itself.

In a sentence, this is the view which will be set forth in subsequent chapters of this book. At the outset another aspect of population growth in civilized communities is forced on our attention by current events. Side by side with a profound modification in the reproductive tradition of civilized mankind since the time of Malthus, equally fundamental changes have taken place in the rôle of man as a selective and directing agent in the universe which he inhabits. A true picture of the growth of human populations, from the

biological standpoint, can no longer be gained by concentrating attention on those features in which human activities are supposed to resemble the activities of other animals. It involves the recognition that human life functions within a system of relationships with other organisms, constantly changing as the result of human effort, and constantly reacting upon the direction of human effort.

The distribution of organic life upon this planet has been studied from two points of view. The pioneer work of Latreille, Schmarda, and Sclater, together with the experiences of their own travels, prompted Wallace and Darwin to offer an explanation of how the populations of the major geographical areas have been limited by climate and natural barriers to migration. Within such areas we encounter well-defined associations of organisms. Similar associations exist in widely separated regions. One may turn over the stones of a garden rockery in Camberwell or Cape Town, Manchester or Montreal, and find much the same familiar assemblage—woodlice, millipedes and centipedes, Collembola, beetle mites, red mite, snails and ground beetles. Only the experienced systematist will be able to detect that the several local species are not actually identical. These assemblages of organisms, plant and animal, endow a landscape with its characteristic variety. Of late years they have received an increasing measure of attention both from botanists and zoologists. Each is a group of creatures multiplying and dying, and the rates at which they die and multiply are interdependent. The fundamental limiting factors of population growth within a life community such as the underworld of the garden rockery

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constitutes the subject matter of *ecology*, now an expanding branch of biological study.

A terrestrial life community consists of green plants and nitrogen-fixing soil bacteria converting the inorganic constituents of the soil and atmosphere into organic matter, herbivorous animals and fungi living at the expense of the plants, carnivorous or parasitic animals living at the expense of the herbivorous animals, carrion-feeding animals living on the remains of both larger carnivora and herbivora, putrefying bacteria and saprophytic fungi living on the dead bodies of all these, and nitrifying bacteria converting simple organic nitrogen compounds liberated by putrefaction into nitrates for the use of the green plants. In any community many species are competing with one another at each level of the closed cycle of chemical synthesis and disintegration involved in the building up and breaking down of new organic matter. To establish itself within a life community an animal must be able to compete successfully for food suitable to its requirements and to survive within the limits of temperature and humidity to which it is exposed. If man's survival were determined by the first alone, the biological optimum of a human population would have two aspects: one involves the elimination of all species which compete at any level with the chain of living creatures which link man to the atmosphere and the soil; the other is concerned with how soon human ingenuity will exhaust itself in devising the basic chemical conditions which permit the survival of green plants suitable for man's own consumption and that of the animals which he eats.

The extent of man's power to interfere with the

chemical conditions of the soil is a peculiar feature of the ecology of the human species, arising from the circumstance that man is a tool-bearing animal, endowed with speech. In the exercise of his tool-bearing pursuits man has also acquired the means of extending the range of other physical conditions compatible with his survival. He can shelter himself from sun, rain and snow by constructing dwellings; he can enclose himself in a protective carapace of clothes. For all these devices he has been mainly dependent on other species, forest trees, the fibres of herbaceous plants, and the pelts or secretions of animals. Hence there is a third aspect of the biological optimum of a human population. The human life community includes all those organisms which man has used in making himself the dominant species of an ecological association which exists within world-wide climatic conditions.

For the human population of the planet on which man has established himself as the most numerous species of the same dimensions, the biological optimum is constantly changing with the further evolution of man's tool-bearing habit. He is constantly shifting his dependence on other organisms to a lower level in the chain of energetic processes which link him to the soil and atmosphere. Each shift makes room for newcomers which minister to human survival. In the world at the present moment there are about eleven times as many men as horses, and about nine times as many men as pigs. The steam-engine and the internal combustion engine have largely substituted the use of stored organic matter in the earth's surface for the horse as an apparatus for converting the potential

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energy of organic compounds into mechanical power. Within a century the horse will probably become a curiosity if not an extinct species. If mankind still eats bacon and wears leather shoes its disappearance will have made room for a pig population several times the size of the world population of pigs to-day. In this instance man has acted as a scavenger organism in the ecological cycle and has thus eliminated his dependence upon both living plants and animals. Till 1906 man's ability to replenish the nitrate supply of the earth was dependent upon the domestication of nitrogen-fixing bacteria, or, as we more usually say, the rotation of the crops. Man has now emerged completely from the once closed cycle of organic matter, in so far as nitrates can now be synthesized from atmospheric nitrogen.

Examples of how man shifts the level of his dependence on the succession of organic species with which he is associated or even escapes from dependence upon organic matter as a source of potential energy have multiplied during the past few decades. A century ago animal fats supplied the chief means of illumination which mankind possessed. Malthusian pessimism could have pointed, with as much justification as there ever is for setting a limit to man's inventive capacity, to the impending reduction of whales. To-day the gravitational energy of Niagara Falls sheds light over a large part of the continent where *Moby Dick* has become an old-world classic. Artificial silk has displaced man's dependence on organic matter from the animal level to that of the green plant. The use of synthetic rubber and indigo is likely to increase the available space for essential green foods in the next few decades. As Professor Haldane has pointed out,

the domestication of the cellulose-splitting bacteria could make available vast quantities of sugar from vegetable refuse. Eventually enzyme chemistry may make photo-synthesis *in vitro* more economical than growing green plants.

Among writers on social affairs Mr. Wells has been alone in recognizing that the human population problem is first and foremost a department of ecology. The implications of this view are novel and carry us into many fields. The specifically human aspect of the world's population of living units is the analysis of all the conditions affecting both the frequency with which the human species reproduces and the length of survival of individual human beings in a planetary life community. More often the problem of population growth in human communities has been stated in a somewhat different form, concentrating attention on the search for human agencies which prevent human beings from reproducing up to the limit of their capacity, and on social processes which regulate the occurrence of premature death. So stated, the problem is transferred from the science of ecology to the study of economics. Among those who have pursued no special studies in the physiology of reproduction there seems to be complete unanimity that the upper limit of man's reproductive capabilities which belong to the realm of physiology are vastly in excess of his achievements which belong to the province of political economy. The individual is arbitrarily isolated from a complex environment of physical and social processes which are intimately interwoven. One aspect of the population problem is prejudged and dismissed. We are left free to dwell upon how human reproduction is limited by

what Dr. Johnson calls man's "moral and prudential nature." The other aspect of the problem is expropriated from the domain of biology by an intellectual habit which persists from the time when starvation was an everyday occurrence in human societies. The influence of Malthus hypnotized a century of discussion, which segregated the dependence of human beings on the organic world from the complex of energy exchanges which make up the human ecological system. When his practical conclusions were completely invalidated by the progress of mechanical invention, Ricardo restored the prevailing gloom by elevating the impossibility of biological inventions to the status of an economic law.

Standing on the threshold of what Professor Haldane calls the era of biological invention, it is easier to see the peril of leaving the firm earth of inductive reasoning from patient observation for the stratosphere of deduction from "self-evident" principles. Although the so-called law of diminishing returns has fallen upon evil days, deductive logic has inexhaustible resources for rehabilitating the belief that in one way or another Nature exacts her own punishment for the sacrilege of interfering with organic processes. In the *Economic Consequences of the Peace*, Mr. Keynes could still write: "Malthus disclosed a Devil. For half a century he was chained up and out of sight. Now perhaps we have loosed him again." When this called forth a vigorous rejoinder from Sir William Beveridge, whose experience in the administration of food supplies during the European war had brought him into practical contact with the rationalization of man's ecological relationships, Mr. Keynes reiterated his original state-

ment (based on the statistics of 1912) with the additional comment: "We could maintain a higher standard of life if we had fewer to employ and *to feed*." ¹

Ten years after Mr. Keynes wrote these words, Sir John Russell summed up the food situation in an address to Section M of the British Association. The burden of this address was that "modern science, in short, has been so successful in increasing man's power over Nature that it has brought us harvests far more bountiful than we know what to do with." A wholesale destruction of wheat, coffee, and cotton crops produced in excess of the quantities which economic inventiveness can distribute in the leading industrial communities of the world had become a commonplace. "One could dilate," said Sir John, "on the achievement of the Dutch in Java, in producing their new sugar-cane which quadrupled the output and so lowered the price of sugar that the West Indies are in terrible distress, the sugar-beet industry of Great Britain is threatened, and all Europe would be in trouble but that they artificially keep out the new sugar." ² In the same strain speaks Lord Bledisloe in his recent Cawthron lecture, surveying the technical revolution in agriculture during the past three decades. "The destruction by fire of excessive wheat supplies in some of the world's chief areas of production has indicated the desirability of restricting output in order to avoid the bankruptcy of thousands of wheat cultivators now in a state bordering upon destitution." ³ As we shall now see, there is no mystery in this *dénouement*. Twenty

¹ *Econ. Journ.*, December 1923. ² *Nature*, December 19, 1931.

³ Bledisloe, *Science and the Farmer*.

years ago the necessary data for a reliable forecast were accessible to those endowed with two wholesome attributes, which are in fact the alpha and omega of the scientific outlook, humility to submit to the discipline of fact and distrust of mere logic. The present crisis of underconsumption is the nemesis of imposing a planned ecology on a planless economy.¹

§ 2

The Jeremiahs of the over-population menace have not been slow to remind us of the influence which the writings of Malthus exerted on Wallace and Darwin. If there were not a simple explanation of why people want to believe in the danger that the number of human beings will exceed or has reached the biological optimum, it would be surprising that an obvious implication of the selection theory has received so little attention. The appearance of a tool-bearing mammal as a dominant species on this planet changed the character of the selective process to a far greater extent than the climatic and seismic changes which have

¹ In his recent Alexander Pedler lecture to the British Science Guild, Sir Daniel Hall remarks: "It used to be said that the greatest public benefactor was the man who could make two blades of grass grow where one grew before. Not so to-day, when nations are considering agreements to restrict output, and even destroying the products of the soil. . . . As an American Professor of Agriculture writes to me: 'ten million acres of cotton and some thousands of tobacco have been ploughed under. The latest move is the killing of some five million pigs weighing under 100 lbs. and the slaughter of some 200,000 prospective mother sows. If this will bring national prosperity I have wasted my life.' The man of science may be forgiven if he concludes that he is no longer wanted and may retire to his ivory tower, but whatever food for irony the world spectacle presents he will not be allowed to enjoy it in detachment, for if the deluge comes, he will be swept down with the rest."

occurred during the period of recorded history. The changes which are brought about by man may be planless, haphazard, and uncongenial to human needs. They may be rationally controlled by experience in the interests of individual groups of producers. They may be rationally controlled by the collective application of scientific knowledge in the interests of a whole community. The one thing man cannot avoid doing is interfering with the selective processes of Nature on a scale which no other animal has the power to do.

The fruits of this interference meet us in every walk of daily life. One reason why it is more trouble to grow apples in a London garden than in a Devonshire village is the abundance of woolly aphis. There are less birds to check the reproduction of this organism, which if unchecked could cover the whole surface of the earth in less than a generation. One reason why there are fewer birds is that there are more cats. Man is hampered by his own commensal. A striking example of the *laissez-faire* ecology is given by Elton. Originally introduced by patriots to brighten the countryside with memories of the Mother of Parliaments, the starling has sponsored the spread of the bramble, now veritably the "blackberry plague" of New Zealand.

According to Malthus food supply is the imperative limiting factor to population growth in human society. This assertion describes a *laissez-faire* ecology which has probably never existed in the period of historic man. Even at the hunting and food-gathering stage of social evolution the limitations of food-supply do not necessarily press so hardly upon human increase as many people imagine. For some years the great bearded seal has been intensively hunted by Nor-

wegians on the outer fringes of the ice-pack round about Spitzbergen. In spite of this steady drain, the number of seals in this region is increasing because the sealers also kill large numbers of polar bears, whose principal diet is the bearded seal. When man passed beyond the food-gathering and hunting stage he became the focus and directing force of a new ecological association which had never existed before. The history of agriculture is the record of a selective elimination of species which are not congenial to human needs to make room for species which are. Till the time of Liebig and Pasteur, noteworthy improvements in food production from the milking of the cow and the sowing of grain to the use of roots for winter stock and crop rotation were purely empirical. A precarious, but on the whole satisfactory, balance between individual producers of foodstuffs and the needs of the towns was maintained without much prospect of excess. Within less than a generation this situation has entirely changed. A new conception of planned ecology has taken shape and the *laissez-faire* economy is feeling the strain. Economists are talking of surfeit when large sections of the population have no access to a biologically adequate minimum of food. One aspect of what Lord Bledisloe refers to as "this lop-sided development of human science" is the growth of large-scale state-aided projects of scientific investigation into agricultural and fisheries problems, now a world-wide movement which has received a new impetus from the lavish encouragement to fisheries research in Scandinavian countries and to research into the culture of crops and stock in the U.S.A. and more recently in the U.S.S.R. Simultaneously, a network of public technical education,

which has grown up throughout the civilized world, has become a medium for the rapid diffusion of empirical knowledge and the enrichment of theoretical science with new problems for solution.

A rationally planned ecology of mankind involves three kinds of interference with the selective processes which existed before man became a directing force in the further evolution of living matter. First, man can control the physical agencies which limit the survival and quality of species which subserve his needs. Secondly, he can eliminate the species which compete with him for the means of subsistence by preying upon the species which he uses directly or indirectly. Thirdly, he can undertake the selective improvement of the species which at one level or another play an essential rôle in the human life community. In all of these man's efforts can profit by the facilities which mechanical invention, involving an increasing control over inorganic nature, places at his disposal. Aside from these considerations a fourth factor in human survival is of great importance in the scientific development of agriculture. Like the squirrel, man stores food for himself. Unlike any other animals, except some social Hymenoptera, he stores food for the other organisms in his own life community. Whether he does so more or less efficiently depends largely on his success in eliminating smaller species which act as scavengers in pre-human associations.

The physical limitations of the environment, in so far as it is subject to human control, may be classified under three headings: the chemical constituents of the soil, the external temperature, and illumination. Under the first, which has been studied most extensively

we may distinguish three categories: water, inorganic salts, and hydrogen-ion concentration. Of these three the significance of the first was grasped when man sowed crops beside the Nile. The significance of the second did not begin to receive recognition until the middle of the nineteenth century. The third has only been recognized as a factor of outstanding importance during the last ten years.

There is little need to dwell upon the achievements of irrigation in making the desert to blossom, or on the considerable facilities which engineering science can now bring to bear on this aspect of man's ecology either by reclaiming deserts or by draining water-logged areas. The problem of water supply has other aspects which have lately received attention. It is well known that some plants resist drought more readily than others, and some animals require less water than others. Empirically man made use of this fact when he domesticated the camel. Of late years attention has been paid to the conquest of drought by using deep-rooted crops, such as lucerne and maize. Lord Bledisloe remarks that scientific investigations in Utah "in conserving soil moisture by the systematic cultivation of alternating crops of wheat and lucerne, in arid areas with an annual rainfall not exceeding six inches, and in dealkalinizing salt-poisoned land, rendering it available for market-garden crops and fruit, has received all too small public recognition, but it has, nevertheless, taken in conjunction with wheat research in Canada, contributed materially to the growing consciousness that the world can continue to increase its population at the present rate for at least another century without any risk of food shortage." ¹

¹ *Op. cit.*

A highly important development in connection with drought is the discovery of ensilage, *i.e.* the technique of storing green fodder in a moist condition without putrefaction. For land reclamation the natural hybrid grass *Spartesia Townsendii* provides an example of biological control. It grows rapidly even when deeply submerged, collecting tidal silt and thus promoting land accretion. The indirect consequences of excess or deficiency of water may be no less important than the more obvious consequences with which everyone is familiar. A single example will suffice to illustrate this. Professor Munro has recently investigated the destruction of forest trees in New Zealand by wood wasps (Siricidæ). Like other insects which appear to live on wood, the real diet of *Sirex* is the fungi which infest the wood. These fungi flourish in wood if the trees grow in water-logged soil. Draining the soil deprives the wood wasp of its means of existence.

The study of the rôle of inorganic salts as limiting factors was begun by Saussure and Liebig in the middle of the nineteenth century. Striking progress has occurred during the present century. Even so elementary a principle of soil chemistry as the part played by bacteria in the nitrogen cycle was not recognized until the late 'eighties. Present-day soil chemistry is undertaking a systematic exploration of the available supplies of all the essential constituents of living matter. Of these the most important is nitrogen, since all proteins contain it. Green plants use nitrogen in the form of nitrates. Between 1903 and 1928 the amount of nitrates used in agriculture was trebled. In 1903 the only source of pure nitrates was mineral deposits. Half the nitrates consumed in 1928 were prepared synthetically from the practically

inexhaustible supplies of atmospheric nitrogen. Perhaps the most important economic result of this lies in the possibility of renewing the qualitative value of pasturage repeatedly in a single season by the alternation of nitrogenous dressings with rotational grazing. This is now revolutionizing grass husbandry throughout the world. In addition to nitrogen, carbon, hydrogen and oxygen most proteins contain phosphorus or sulphur or both. Another illustration of the technical revolution now in progress is that the world export trade in phosphates increased by 50 per cent. during the decade ending in 1926. Phosphates, like nitrogenous fertilizers, are of great importance in the intra-ecological relationships of pasture, since they encourage clover at the expense of grass, thus raising the protein content of the hay.

Of the metallic constituents of living matter iron is essential to all oxidative processes. Iron deficiency sometimes occurs in plants, but more commonly in animals. It has been cured in apples by the homely device of driving nails into the trunk. Magnesium is an essential constituent of the chlorophyll molecule, and together with potassium and calcium occurs in all cell, sap and tissue fluids. The proportions of the last three elements determine the colloidal properties of cell substance. There is a fundamental antagonism between the rôle of calcium on the one hand and that of magnesium and potassium on the other. This antagonism is encountered in the most diverse living processes, including, for instance, the development of a sea urchin's egg or the rhythm of the isolated heart. A correct balance between the proportions of these elements is a necessary condition of a

satisfactory soil. An important consequence of this antagonism is that excess of one metallic element can be remedied by the addition of another whose physiological action is antagonistic. The addition of potash fertilizers has increased the monetary gain on citrus trees by £30 an acre. The use of lime and phosphatic fertilizers has opened up a large area of 200,000 acres of almost desert land in south New Zealand at the cost of £7 per acre. Tracts of heathland in Cornwall, where the low moor vegetation is due to lack of lime alone, have been made to yield magnificent crops of corn, seeds and roots by the addition of sea-sand, which is rich in calcium on account of shell fragments. Phosphate excess, which has led to failure of fruit and root crops in Devon, can be completely remedied by the application of potash. The correct balance of potassium and calcium salts in the soil depends on the concentration of hydrogen ions. The development of the technique of hydrogen-ion determination has taken place entirely within the last two decades. Already it has extended our knowledge of the rôle of alkalinity and acidity in a natural ecology, especially in connection with the activity of the essential soil bacteria. It is showing us how excess of either can be counter-balanced as limiting factors in the human life community, as in the reclamation of acid moorland.

A mineral content adequate to ensure the survival of the green plant is not necessarily sufficient for the needs of the animal which lives upon it. Phosphate and calcium deficiency and a poor supply of iron are sources of animal diseases which diminish human food production. Mammals need much greater quantities of iron than green plants because the red respiratory

blood pigment, hæmoglobin, is an iron compound. Bush sickness in New Zealand stock, a form of anæmia prevalent in volcanic areas, is due to iron shortage, and can be simply combated by the addition of iron to the diet. Likewise, the mammal needs more calcium and phosphates than the green plant because calcium phosphate is the main constituent of bone ash. Rapidly growing animals like the pig especially need calcium; and calcium shortage is a great source of loss in pig culture. The utilization of calcium in the animal body depends on an adequate supply of the anti-rachitic vitamin, the production or activity of which is in some way dependent on ultra-violet light. Roofs of vitaglass, which is transparent to ultra-violet light, are now being used for pig-styes with some success in combating rickets. Dopiness in sheep is a calcium deficiency disease. Another important aspect of animal nutrition directly related to soil chemistry is the necessity of iodine. The secretion of the vertebrate thyroid gland is a compound of iodine, an element which does not seem to be necessary for the existence of plants and invertebrates. Without the thyroid hormone growth is arrested. Again, the pig, a rapidly growing animal, is especially susceptible to iodine deficiency. A low iodine content of the soil was responsible for loss of stock of the value of £1,000,000 in the state of Montana in 1916. The losses are now comparatively negligible, and successful pig-farming has been made possible by supplementary iodine feeding. The depletion of minerals of one kind or another in certain Scottish grazings during the last fifty years has resulted in a 25 per cent. decrease of cattle.

The two physical limiting factors which remain are

temperature and illumination. The importance of the former has long been realized by man empirically. The latter is only now receiving systematic attention. As the efficiency of man's mechanical instruments grows the possibility of controlling these two agencies will be very much greater than it has been in the past. Glass-house protection of food plants has played an increasingly important part in food production during the last half century, and with the cheapening of manufactured commodities the cloche system has extended the growing season for vegetables, now cultivated by allotment holders for individual use. In Scandinavian countries it pays the farmer to instal central-heating for pigs, thereby reducing the requisite food ration by 20 per cent. Even in the time of Ricardo it should have been possible to see how mechanical invention would increase the return on food production by increasing the available sources of heat and light. A very recent empirical discovery concerning the influence of the latter may turn out to have very much wider application now that a scientific explanation is available. Winter egg production in fowls can be stimulated by exposure of the birds to electric light sufficiently to make it a commercially paying proposition. This appears to be because the pituitary gland, which secretes a hormone regulating the ovary, is reflexly activated by light at the red end of the spectrum.

The second aspect of the planning of a human ecology is systematic elimination of organisms which compete with man. This is a direct outcome of the impetus which Darwin gave to systematic biology. Till then man's efforts to get rid of species which

compete with him had been confined to a few elementary operations, such as weeding the ground, dipping sheep, and trapping rodents. We are only beginning to realize the magnitude of wasted effort which arises from witless competition between man and those organisms which are described as weeds, pests, or parasites. Tentative estimates of the total losses which agriculture sustains from the last two have yielded a figure of the order of 25 per cent. Such a figure based on destruction of crops and stock by known pests and parasites probably represents a small fraction of the total loss incurred, partly because it is based upon the damage done by specific agencies such as potato virus or wheat rust rather than non-specific agencies such as wireworms or slugs, and also because the loss through destruction of crop and stock may be small compared with the reduction of quality in what is not destroyed, a fact which has been brought out especially in connection with apple diseases. Although the effect of the common plant bug, known as the leaf-hopper, on pasture quality cannot be detected by the naked eye, Professor Osborn has shown that when leaf-hoppers are excluded two cows can be kept where there was barely enough for one.

A few illustrative data concerning losses may be cited. The destruction of wheat by rusts and of potatoes by virus amounts to between 10 per cent. and 20 per cent. of world production. These two diseases constitute a small part of the losses which wheat and potatoes suffer on account of parasites and pests. In addition to rusts wheat is attacked by a number of specific organisms such as the Hessian fly, a gall midge, another Dipteran *Oscinus frit*, and the gall thread-

worm, *Tylenchus*. It is attacked by several non-specific organisms such as the corn-borer, and large losses to the stored grain are sustained through the ravages of weevils. The potato is attacked by two fatal fungus diseases, potato blight and wart disease, the former of which was the source of the Irish potato famine of 1843-47. Several insects specifically attack the potato, the Colorado beetle in America and the tuber-moth in this country being the most important. In some years a third of the beet crop of France has been destroyed by the gall thread-worm *Heterodera* alone. Beet again has several specific diseases. The Economic Advisory Council estimates that during the last five years locusts have deprived mankind of the fruits of five and a half million working days per annum. The known yearly losses due to insects in the British Empire would feed the entire population of England and Wales. In 1916 the known loss of crops due to insect ravages in the United States represented a total equivalent to a contribution of one dollar per head of the world's entire population.

An even more impressive picture of the forfeit man pays in unscientific competition with other species may be obtained by considering the gains resulting when he applies science to their mastery. There are five fairly common fungus parasites of the apple: canker (*Nectria galligena*), scab (*Venturia inequalis*), mildew (*Podiosphæra leucotricha*), brown rot (*Sclerotinia fructigena*), and blossom wilt (*Sclerotinia cinerea*). Of the common insect parasites may be mentioned: Blue bug (*Anuraphis*), woolly aphis (*Eriosoma*), apple sucker (*Psylla*), Capsid bug (*Plesiocoris*), appleblossom weevil (*Anthrenoma*), codling moth (*Cydia*), and apple

sawfly (*Hoplocarpha*). Considering two of these alone, three years' trials at Wisbech with spraying against Capsid bug and scab consistently in each case increased the yield over 100 per cent. The new method of growing apples as cordons or espaliers in low hedge formation has the double advantage of increasing fruitage at the expense of vegetative growth and facilitating monthly spraying which guarantees immunity against all the parasites mentioned above.

The elimination of competitive species may be treated under two headings: species which compete with crops for space, and species which prey on crops or stock. Concerning the first an interesting development in weed control has taken place during the last few years in the Southern Hemisphere. In New Zealand, where Imperial sentiment produced a blackberry plague by introducing the starling, scientific knowledge has now introduced the cinnabar moth to stamp out the ubiquitous ragwort. This weed, which has been rapidly invading greater areas of the dairy lands of the Dominions, is doubly disastrous because it leads to hepatic cirrhosis of cattle and horses. Two other exotic insects, *Abion ulicis* and *Antholcus vari-nervis*, have also been introduced to stamp out gorse and piri-piri, the bane of the New Zealand farmer. At the Imperial Entomological Conference in 1930, Dr. Nicholson reported that an area as large as Great Britain now infested with prickly pear is being cleared in Australia by the introduction of the Pyralid moth, *Cactoblastis cactorum*.

Three principal methods for the elimination of pests and parasites have now been introduced into agricultural practice, mainly during the last three

decades. The first is chemical, *i.e.*, spraying or dusting with a fungicide or insecticide. The second is the method of hyper-parasitization. The third is genetic selection for immunity. Apart from these the mere knowledge of the life-cycle of a parasite or pest often suggests simple means for getting rid of it. For instance, one of the wheat rusts is heteroecious. It spends part of its life-cycle as a parasite on wheat and part of its life-cycle as a parasite on the barberry. By removing the intermediate host from wheat-growing areas, as is being done extensively in America, the danger of infection is practically stamped out in the same way as malaria or yellow fever can be controlled by preventing the mosquito from breeding. In North Dakota this has resulted in the saving of eighteen million bushels in ten years. A fatal disease of poultry known as gapes is due to a nematode which normally infests turkeys and does not seem to do them much harm. By keeping poultry away from turkeys the danger of contracting the disease is enormously reduced. The menace of the clover seed midge has been eliminated by cutting the first hay crop ten days earlier, thereby preventing the insect from completing its growth. The corn borer and the cotton boll-weevil, which was responsible for a loss of 500,000,000 dollars in the United States during 1921, could be stamped out if the dead stems were not allowed to stand during winter. In Texas, with the co-operation of a population of 160,000 persons and the destruction of 40,000 summer-fruited trees with the consent of their owners, who were in many cases not personally affected, the Mexican fruit-fly pest of citrus has been eradicated. This was achieved by doing away with all other fruit

growing in citrus areas and restricting the fruit-bearing period of the citrus trees, so that the insect cannot survive the period between successive fruiting seasons.

Chemical control is of special importance in connection with fruit growing and stock. Two illustrations have already been taken from the apple industry. The use of insecticides and fungicides is not the hit-and-miss method which some people imagine it to be. Intensive researches in applied toxicology have been directed to the discovery of highly specific poisons, which kill injurious organisms in quantities that do not harm non-injurious ones. The fungus diseases of potato (blight and wart) can both be controlled by spraying with a toxic preparation. Two insect parasites, the bean beetle and black fly, and an acarine which attack beans, the insect parasites of cabbages, carrots, onions, turnips, beet, peas and potatoes, can now be controlled by spraying of the shoot or soil fumigation. Longley in 1930 collected data from ninety-six apple-growers in Nova Scotia to determine the influence of spraying and dusting on yield. The results demonstrate a clear increase in yield corresponding to an increased amount of spray. This holds good with slight fluctuations from an expenditure of two dollars per acre with an average production of 16.2 barrels to an expenditure of 24 dollars per acre yielding an average production of 85 barrels.

The method of hyper-parasitization is of very recent origin. Experts differ concerning its possibilities. Its importance lies in the fact that when it is successful the cost is utterly negligible compared with the results achieved. Just as the farmer keeps the ferret to check the growth of rodents, the State can breed specific

parasites to destroy animals which attack crops or pests. Among notable successes which have been claimed for this method is the destruction of woolly aphis by the insect parasite *Aphelinus mali*. The earliest successful experiment in biological control was the introduction of the predatory ladybird, *Vedalia cardinalis*, to keep down the scale insect, *Icerya purchasi*, which attacks orange and lemon groves. The citrus mealybug has also been brought under control by the introduction of the coccinellid *Cryptolæmus*, for the breeding of which there are thirteen insectaries in the infested districts of California. An attempt is now being made to control the pink bollworm in Egypt by the introduction of a Hymenopteran parasite, *Microbracon kirkpatricki*, at an expense of £1000. If it succeeds the estimated saving will be £5,000,000.

For some twenty-five years past the commercial growing of cocoanut on one of the two large islands of the Fiji group has been made impossible by the ravages of a small Zygaenid moth. About seven years ago this moth threatened to invade the adjoining islands. Such an extension would have completely ruined the staple industry of the group, if unchecked. This would have entailed a loss of £400,000 per annum. By the introduction of a Tachinid fly which parasitizes the cocoanut Zygaenid in Malaya the Fiji pest was so completely controlled that in three years' time the moth had become quite a rarity. The cost of this work was approximately £12,000. The late Mr. Frederick Muir estimated that his introduction of the Tachinid parasite of the weevil borer of sugar-cane into the Hawaiian Islands saved the cane-growers about a million pounds a year. He spent three years in searching for the

parasite, eventually got from New Guinea. The total cost of the work was about £10,000.

The method of parasite control which probably has the greatest possibilities lies in the genetic attack on the problem. Just as turkeys are immune to the effects of the threadworm which produces the fatal disease called gapes in fowls, immune varieties to the attack of specific pathogenic organisms can be found within one and the same species. In the human species itself the negroid peoples seem to be immune to malaria. The first important step in this field of research was the breeding of a rustless wheat by Biffen in 1903. Systematic research of the same type is now going on all over the world. Varieties immune to potato wart disease are now advertised widely, and in England in areas where wart disease has been common the growing of non-immune varieties is now prohibited. Recently Dr. Salaman has isolated a variety immune to the potato virus. A strain of black currant, immune to the gall-mite which produces big bud and carries reversion disease, is now advertised, and may rehabilitate a branch of the fruit industry previously threatened with extinction in Britain. Varieties of raspberries immune to mosaic disease are also available. The John Innes Institution lately announced the discovery of a strain of apples resistant to woolly aphis. Such research necessarily goes hand in hand with selection for yield. It is often found that wild varieties are immune to diseases which ravage highly cultivated crops or stock. The application of Mendel's principle makes it possible to obtain pure stocks of high resistance and high yield by crossing susceptible high-yielding varieties with the wild type.

This brings us to the third problem of a planned ecology, the selection of high-yielding varieties of species which man uses directly or indirectly for his consumption. Reference has already been made to the new Javanese sugar-cane which has quadrupled output. It was produced by crossing a high-yielding variety with the more resistant wild type. In Sweden by crossing high-yielding English wheats with winter-resisting Swedish wheats Nilsson Ehle has established a hardy winter wheat with an increased yield of 30 per cent. By crossing Red Fife with early maturing hard-red Calcutta, Saunders produced the celebrated Marquis wheat, which can be harvested in 103 days after sowing. This has made it possible, remarks Lord Bledisloe, "to push northwards the great American wheat belt of the Middle West far across the Prairie Provinces of Canada, adding several thousand square miles to the area under the world's greatest cereal in that once frost-ridden territory, with the result that Britain's premier Dominion became the largest exporter of the modern British Loaf."¹ In animal breeding an important new line of work is the genetic study of early maturing varieties of sheep, pigs, and cattle. The significance of this lies especially in the fact that owing to the change of shape which accompanies growth the amount of edible matter per unit weight is much greater in an adult than in a young animal. In poultry sex-linked crosses are now widely used to facilitate early segregation of cockerels for fattening. Recent work on sex-linked genes is likely to revolutionize the traditional method of selection for high milk-yield. During the past decade a technical amenity of con-

¹ *Op. cit.*

siderable importance has been perfected by Ivanoff. Seminal fluid of mammals can now be made to retain its fertilizing power so that it can be transported over long distances. By artificial insemination only the best sires need be used for breeding. What this signifies may be inferred from the fact that one ejaculation of human seminal fluid contains more than sufficient spermatozoa to father the population of the United States. Ivanoff's method is being applied to live-stock breeding in the U.S.S.R. and the United States.

No less important than selection for crude yield is selection co-ordinated with the scientific study of nutrition. This is a very recent development which is already producing highly important results. Baur has produced a stock of lupins free from the alkaloids which make this plant unsuitable for fodder. Crosses of grasses for pasturage yielding a higher nitrogenous content have also been carried out. It has been found that the Vitamin C content is greater in triploid apples and tetraploid tomatoes than in diploid stocks. The content of both Vitamins A and C has been shown to differ considerably in different genetic varieties of maize and *Vaccinium*. Genetic research has also been directed to selection of varieties with better culinary properties. Biffen's "Yeoman" wheat combines the milling and baking qualities of the best wheats with greater cropping capacity and rust immunity. The "Archer" barley of Beaven combines a 10 per cent. increased yield with 30 per cent. improvement in malting value. Sir Arthur Hill remarks that this discovery alone has increased the value of the English barley crop by an amount greater than the total ex-

penditure on all kinds of agricultural research since the European War.

Little need be said concerning the storage of food for human consumption or that of the animals which man uses as food, because many of the lines of research and technical advances in this field are parallel to those already discussed. For instance, the storage properties of apples have been found to be related to manurial treatment of the trees. A major problem in the storage of grain, leguminous crops, and tobacco is the control of insect pests. Some genetic varieties of crops have better storage value than others. A conspicuous technical advance in storage problems has been mentioned incidentally in connection with water shortage. The nutritive value of ensilage prepared by the Finnish method has reduced the cost of production of butter-fat by 30 per cent. in that country. An important recent development in the storage of animal food is a technique for artificially drying young grass, which retains its nutritive and vitamin content and has three times as much protein as good average meadow-hay.

§ 3

In the preceding survey we have confined ourselves almost exclusively to practical issues bearing upon a technical revolution that has taken place in less than a generation; that has produced results which can be felt throughout the entire civilized world, and that might have been foreseen by the logicians of political economy if they did not feel "a sense almost of shame at . . . tedious discussions of . . . technical education" or did not recoil from "spineless platitudes about

manures.”¹ In practically all the examples given the application of the new technique is at present localized. It would hardly be an exaggeration to say that the world’s food production could be increased many times without increasing the area of cultivation, if mankind exploited to the fullest extent all the scientific knowledge already available. Lest this statement should appear to be exaggeration or mere surmise it is sufficient to remark that the Cambridge School of Agriculture, under normal working conditions, consistently obtains a yield of 60 bushels per acre of wheat as compared with an average of 32 for the whole country. The low average of English wheat as compared with Danish is attributed by the 1921 Commission on Land Drainage to water-logged soil, a handicap which could be remedied by collective action. Even so, the average yield for English wheat is high compared with that of Oriental and Mediterranean countries.

Not less significant than the inability of political economists to foresee a situation which the statistics of 1912 did not disclose, is their reaction now that we are witnessing its firstfruits. Three centuries ago Bacon defined the social function of science in the *Novum Organum*: “the true and lawful goal of the sciences is none other than this, that human life be endowed with new discoveries and inventions.” The grain of truth contained in the Ricardian law was the historic fact that biological observations had not advanced in the time of Ricardo to the dignity of a science which could regulate man’s organic environment by new discoveries and inventions. Might we not say much the same of Mr. Keynes’ pronouncement that we could maintain

¹ Robbins, *Nature and Significance of Economic Science*.

a higher standard of living if we had fewer to employ and fewer to feed in the midst of the abundance which applied biological science can now guarantee? Is it more than an admission that deductive political economy is unable to regulate man's social environment by new discoveries and inventions? Faced with the crisis which Sir John Russell and Lord Bledisloe have described with commendable candour, Sir Josiah Stamp blames the inventions of the scientist. May not the scientist blame the economist for his lack of inventiveness? Verily the logician is hard to please. Political economy began by telling us that poverty could not be abolished by science. It now demands the arrest of scientific progress at a moment in the world's history when science has abolished the necessity of poverty. It can only proceed to its "true and lawful goal" as a *science of wealth* by relinquishing the pre-Baconian *dialectic of scarcity*.¹

¹ The concept of scarcity in economics may be appropriate to a discussion of the state of affairs when human means are limited relatively to the inordinate desires of consumers in a competitive society. It is manifestly impossible that all should have as much as they want of objects of satisfaction of the highest order of desirability. Hence, there may be at any given moment a relative scarcity of the things most urgently desired and conversely a relative superfluity of the things not so urgently desired by those whose incomes determine the direction of production, *e.g.*, wheat and coffee to-day. This general proposition is of purely verbal significance. It will be true only if people are free to choose what they will consume and are not restrained by an equalitarian social tradition from demanding what is most difficult to obtain. It does not by itself enable us to say what things are more or less urgently desired and what things are easy or difficult to produce. It is an entirely different matter to assert, as did Malthus and J. S. Mill, or as Mr. Keynes appears to do, that there is any necessary restriction on the possible supply of any single commodity. Such a statement involves a prophecy concerning the limits of biological invention which deductive economics is wholly incompetent to justify.

Aside from the more remote possibilities of mass production of synthetic food ingredients such as sugar and some of the accessory food substances, or the sure if unobtrusive revolution in traditional agricultural methods now taking place over the whole world, all the potentialities of exhausting the food supply of our planet are not fully explored until we have recognized the distinction between man's unalterable physiological requirements and changeable preferences which are moulded by social tradition. Mankind has learned to direct the selective multiplication of species which he cherishes by custom and superstition. Biologists are only beginning to think about directing the ecological evolution of the vast reservoirs of potential food supply in rivers and oceans. The Jewish food ritual illustrates the way in which mankind imposes what Anatole France calls the "arbitrary limitations of religion" upon the selective processes of Nature. The ox may have engaging attributes which commend it to the Psalmist, but the rabbit, the oyster, and the pig—none of which is Kosher—have vastly greater thermodynamic potentialities. Mankind has not yet commissioned the biologist to draw up a new Mosaic schedule of organisms which have the threefold advantage of high nutritive content, high fertility, and rapid growth. Nor does this exhaust the possibilities of a planned ecology. In the wild state the forbears of the domestic hen did not ovulate with the frequency of a white leghorn. There may be other species of birds more suitable for the production of lecithin and albumen on a large scale at the minimum waste of the world's resources. Penguin eggs are already an article of diet. Human effort

which has guided the evolution of the Wyandotte can control the evolution of the cormorant.

The spacious prospect unfolded by controlled selection of new species, and the utilization of existing ones which are more economical than those which man now consumes, seems at first fantastic, because man is extremely conservative about his food habits. The basis of this conservatism does not lie in an innate inability of the human species to consume certain substances as food. Though it is deeply rooted in human institutions, there are no reasons to believe that it is deeply rooted in man's inborn nature. White South Africans almost universally believe that there is an innate repugnance which prevents the Caucasian and Bantu from living side by side in congenial social relations. Many people in Germany passionately contend that the same is true of Jews and Gentiles. It is only necessary to visit Jamaica to see that the first is false or to turn the pages of English history to discredit the second. It may astonish us that the Scotch like haggis or that the Japanese live largely on polished rice. It is none the less a fact. Our curious and tenacious preferences for one or another sort of food have been acquired without understanding or intelligent consideration of the facts. In times of great crisis they can be changed, as happened in the European War, when margarine came into more general use than before. If, from its present entanglements with metaphysics, social psychology emerges to the status of a science which can show us how to regulate human nature by new discoveries and inventions, it may be possible to make such changes deliberately and swiftly by common consent through the machinery

34 WHERE MOTH AND RUST NEED NOT CORRUPT

of education and government propaganda. Mankind would be capable of changing its food habits very drastically, if faced with the danger of exhausting the available supply of those foods which are now consumed.

Although selection has so arranged the food habits of animals that they are repelled by the smell, taste, or sight of objects which are harmful, and attracted by those which are adequate to ensure their survival, their reactions depend in most cases upon chemical or physical properties which are quite adventitiously associated with the nutritive value of the foods they consume. The idea that animals are endowed with pharmaceutical second sight or a dietetic conscience has been experimentally disproved by recent work. Harris has observed the behaviour of rats when offered food prepared with or without essential vitamins. The absence of Vitamin B produces immediately harmful results. Rats learn quickly to avoid such a diet even when it is disguised so as to be attractive. Absence of Vitamin A only produces harmful consequences when continued for a long time. If such a diet is made attractive to them rats never learn to reject it. That man has chosen from the infinite variety in the animal and plant world the foods most suited to his physiological needs, in the absence of any scientific knowledge to guide him, is one of the naïvely teleological beliefs which the instinct psychology of the nineteenth century fostered. It has no foundation in experiment.

Likewise, the belief that man is endowed with an instinct which forces him to reproduce when he is equipped with the means of erotic response without fertile issue has no experimental foundation, and is

certainly refuted by the statistical data which will emerge at a later stage. The Malthusian thesis had two aspects. One was concerned with how men produce the food they must eat to survive as individuals. The other was concerned with how mankind reproduces, as it must, to survive as a group. Both Malthus and his followers discussed the first on the assumption that the *laissez-faire* economy is an unchangeable property of human communities, believing at the same time that their conclusions were sanctioned by biological necessity. In this chapter we have examined how far the economy of the Acquisitive Society can utilize the fruits of applied biology. Our conclusions deprive the Malthusian thesis of any inherent biological necessity in so far as it has practical and immediate significance. Unlike the communities of termites or hymenoptera, the social pattern of human communities changes to meet the exigencies of survival. To a biologist it may seem more likely that biological necessity will set a limit to the duration of the *laissez-faire* economy than that the *laissez-faire* economy will permanently succeed in imposing its limitations upon the continued progress of biological knowledge.

That the *laissez-faire* economy can only survive if it can preserve the biological machinery by which any society perpetuates itself, is at least as self-evident as any of the assumptions upon which deductive economics is based. When we turn to the second aspect of the Malthusian doctrine, the discrepancy between the biological data and the picture which Malthus painted is even more arresting. We have seen that the food situation discloses no menace of over-population. As Lord Bledisloe remarks, mankind could continue to

grow in numbers at the present rate for more than a century without reaching the limits of ecological necessity. In fact, there is no reason to believe that the present rate of increase of world population will continue. What follows will expose to view a situation which may truly be called the *menace of under-population*. It unfolds the spectacle of a society which has lost the power to reproduce itself, is losing that power more and more, and must continue to dwindle unless a fundamental readjustment occurs within the human ecological unit. It is a situation so serious as to provoke from one of the leading authorities on population problems the pronouncement that "it would require nothing short of a religious revolution to bring about a change in attitude, to undo what has already happened." The recognition of this state of affairs has been delayed through lack of a simple statistical technique for the measurement of population growth. The reader who wishes to understand it must now be prepared for a somewhat technical and perhaps tedious digression which will be the subject matter of the next chapter. Fortunately the essential issue can be grasped without recourse to higher mathematics.

CHAPTER II

THE NEW STATISTICAL APPROACH

§ 1. Common Fallacies arising in the Use of Crude Birth Rates and Death Rates—The Vital Importance of Age Composition—Distinction between Net Increase and Capacity for Continued Growth. § 2. Measurement of Mortality and Fertility—The Standardized Mortality Rate—The Life Table—Standardized Fertility Rates—The Gross Reproduction Rate. § 3. An Index of Population Growth—The Net Reproduction Rate and its Significance.

§ 1

IN the language of mechanical science the capacity of a population for further growth may be regarded as the resultant of two opposing forces. One force, fertility, will be defined more precisely at a later stage. It stands for all those agencies which encourage reproduction, whether biological fitness, personal inclination, economic inducements, or social pressure. The other, mortality, includes all those agencies—diseases, accidents and the like—which increase the risk of death. The most common source of popular error in the discussion of population problems arises from the confusion of these two concepts with two classes of familiar statistics, the crude birth rate and the crude death rate, *i.e.*, the number of births or deaths in a given period (usually a year) expressed as a fraction of the total population. The birth rate is not a function of reproductive capacity alone. Neither does the death rate depend upon liability to death alone. Each is a

resultant of the forces of fertility and mortality, and the task of disentangling their relationship to them is one which calls for considerable statistical ingenuity.

The problems which arise in the study of population may be divided into two classes, logical and statistical. The logical problem is to decide what use can be made of the kind of data which are, or can be, easily recorded. The purely statistical problems, which do not here concern us, arise from the need for interpolation when simultaneously using population statistics which have not been recorded at identical times or have not been recorded at suitable intervals. The student who is interested in the biological and sociological aspects of population growth can take for granted the technical refinements which are necessary in the preparation of convenient indices. Without a clear understanding of what the latter mean and the general principles used in deriving them from extant data, no intelligent discussion of population problems is possible.

That the spectre of over-population still continues to haunt the imagination of educated people is partly due to a widely prevalent fallacy. Official statistics record the number of births and deaths during a given interval of time, or the net size of the population; and in practically all civilized countries we have long been accustomed to witness an excess of births over deaths and an increase in the total population. It is commonly assumed that this state of affairs must continue indefinitely unless mortality increases or fertility diminishes. Very few people realize that a population can continue to increase for some time while its fertility and mortality are such that ultimate extinction would be inevitable, if they remained unchanged. Even

fewer realize that this is the state of affairs in many civilized countries to-day, including the United States and Great Britain.

The reason for this apparent paradox is more readily grasped by considering the converse proposition that fertility and mortality rates, consistent with a large capacity for increase in the long run, are compatible with steady diminution over a protracted period. Unless replenished by immigration, an emigrant and highly fertile population with a large preponderance of males and women over child-bearing age might continue to diminish for many years on account of its abnormal sex and age composition. By the end of a generation the population would have assumed a new sex and age composition. The proportions of males and of women over child-bearing age would have diminished. Their places would have been taken by individuals who would, before their death, leave offspring to swell the population. So long as they themselves were alive, however, their deaths would not be compensated by births for which they were directly responsible. Hence, such a population would at first decline, reach a turning point, and subsequently increase steadily. Meanwhile its capacity for growth need not have changed.

In the same way we may imagine a population with an enormous preponderance of women of child-bearing age recently settled in a new country. Suppose that the number of births and the number of deaths are initially 35 and 30 respectively for every 1000 individuals per annum. If such a state of affairs could last, the population would go on increasing. Actually, it could not last for two reasons. One is that the proportion

of women of child-bearing age would diminish for at least fifteen years. During this period the proportion of males and of females below and above child-bearing age would be increasing. So the number of births per 1000 members of such a population would go down. Likewise the number of deaths would at first increase, owing to the increasing proportion of young children and older women, because the risk of death is greatest in the first few years and at the latter end of the normal span. Although fertility and the agencies affecting the risk of death remained absolutely constant, such a community, initially increasing, would soon begin to diminish and continue to do so steadily.

These situations, though extreme cases, rarely, if ever, encountered in practice, illustrate the truth that the balance of births over deaths gives us no indication of the capacity of a population for further growth unless its age and sex composition is also known. The age and sex composition of a population are not determined by the fertility and mortality prevailing at a given moment. They depend upon conditions which have prevailed during the whole previous generation, or more strictly during the whole period covered by the lifetime of its oldest member. The scientific analysis of population growth is very largely concerned with devising statistical indices which take into account the significance of age and sex composition in comparing fertility and mortality in different communities or in estimating the tempo of population growth.

The fact that a population may be increasing while it is replenishing its numbers and dying at rates which would ultimately extinguish it, if they persisted, becomes clearer when we examine the effect of changes

in fertility and mortality upon the size of the age groups. Let us suppose that there is a sudden fall in fertility, that is to say, the capacity of women to bear children. Other things being equal, the consequence will be a fall in the birth rate during the ensuing period. Now the birth rate itself depends on what proportion of the population are engaged in child-bearing. The immediate result of the birth of less children is that the proportion of women of child-bearing age in the total population increases. Since, if other factors do not vary, an increasing proportion of women of child-bearing age leads to a higher birth rate, the initial tendency of a fall in fertility to produce a fall in the birth rate is opposed by a reverse tendency towards an increased birth rate. This opposing tendency is transitory. When the fall in fertility had persisted so long that the first girls born at the new level had passed puberty, women would be entering the child-bearing period, at a rate relative to passing out of it, less rapidly than in previous years. The proportion of women of child-bearing age in the general population would begin to diminish, and this of itself would be reflected in a falling birth rate. Hence it is clear that a sudden change in fertility to a new level immediately affects the age composition of a population in a way which is the opposite to its effect a generation later. On this account there is a considerable inertia in the birth rate as an index of changes in fertility. The effect of a slow and continuous fall in fertility is not one which can be predicted with the aid of common sense because two components are acting concurrently. In this connection important mathematical researches have been made on the problem by Dublin and Lotka.

The magnitude of the inertia of a falling birth rate may be illustrated from their researches on the United States census figures. Writing in 1926 Dublin states :—

“ As the result of the higher birth rate of past generations there is at the present time an abnormally large number of persons at the reproductive ages of life, and this tends to increase the current birth rate. We have calculated what the present birth rate would be if the age distribution at the reproductive ages were the result of a prolonged continuation of our present rate of procreation (that is, births per annum per potential mother of a given age). The effect would be to reduce the figure from 23·4 per thousand to 20·9. In other words what for the time being maintains our birth rate is not our inherent high reproductive vitality but rather the fact that the surviving descendants of a more highly reproductive generation are to-day swelling the ranks of middle life and participating in parenthood.” ¹

In a sudden fall of the birth rate we thus encounter a phenomenon which is analogous to Le Chatelier's principle in physical science. The analysis of the effect of changes in mortality upon the rate at which deaths occur in a population is even more complex than that of a sudden fall in fertility. The immediate effect of raising the infantile death rate is to increase the proportion of individuals of reproductive age in a population. This begets an opposing tendency towards a higher birth rate. It is ephemeral because the proportion of women of child-bearing age will tend to diminish when the first batch of girl survivors of the increased infant mortality have reached sexual maturity. Contrariwise, the immediate effect of a fall in senile mortality would be to lower the proportion of women

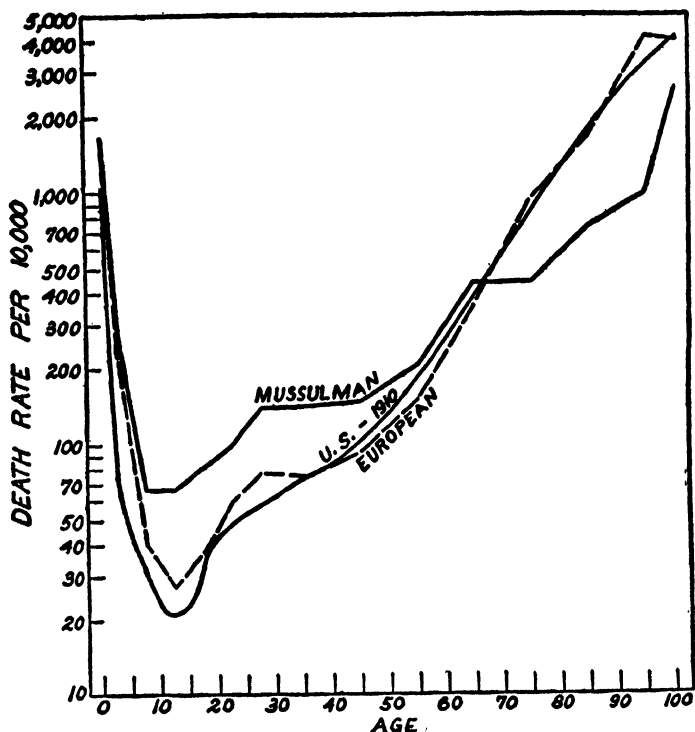
¹ Dublin, *Population Problems*.

in the child-bearing period. This would tend to lower the birth rate and expedite the attainment of a new age composition, with a preponderance of old people.

The main point to grasp is that by itself the number of births in a year is not an index of the reproductive capacity of a population, because human beings are only capable of becoming parents during a part of their lives. Hence the number of births in a year depends on the proportions of persons of different ages in the population. This in its turn depends on the rates at which people die at different ages, as well as upon fertility in the sense defined. Likewise the number of deaths in a year is not by itself an index of the liability to extinction, because human beings are more likely to die at certain ages than at others, mortality being at a minimum in recorded data from all countries during the two or three years which precede puberty (see Fig. 1). For this reason the number of deaths in a year, like the number of births, depends upon the age composition of the population, and this in its turn depends on the fertility which has prevailed in the past. It follows that the excess of births over deaths in a year of itself provides no guarantee that prevailing fertility and mortality are so adjusted as to maintain further increase or even to safeguard a population from gradually dwindling away.

The indices of population growth which will now be dealt with have one of two objects in view. One is to use the observed births or deaths so as to be able to compare the reproductive capacity or the liability to death in different communities which have not the same age composition. The other is to combine the

relevant data concerning births and deaths, so as to summarize the prospect of further increase or decrease. In many extant discussions of population growth,



From Dr. Raymond Pearl's "Biology of Population Growth" (Alfred A. Knopf, Inc.).

FIG. 1.—Mortality of Females at different ages among the European and Moslem inhabitants of Algeria and in the U.S.A. (after Pearl).

contemporary changes in fertility and mortality are indicated by exhibiting in parallel columns two indices, respectively known as standardized mortality and fertility rates. While these indices, more especially

the former, have their uses in connection with public health, and other problems which lie outside the scope of our present discussion, they are not suited to display the salient features of population growth or to indicate very clearly the prospects of a continued increase or decline in the population. Mortality rates, such as have been used by English writers on population, contain a great deal of information which is, strictly speaking, irrelevant to a study of population growth because a large proportion of deaths occur when people have passed the age of parenthood. A change in the death rate of the post-parental age groups may make a temporary difference to the growth-rate of a population but does not affect its inherent growth capacity in the long run. The fertility rates used by English writers on population are derived by methods based on analogy with the method of preparing mortality rates for medical purposes, and are not the most convenient instrument for measuring the reproductive capacity of a community.

Of late years the treatment of population growth has been revolutionized by the introduction of a very simple and direct index of population growth in a series of important memoirs by R. Kuczynski. This is called the net reproduction rate. It combines all the relevant information concerning mortality in the life table and all the relevant facts concerning fertility which are summarized in what Kuczynski calls the gross reproduction rate. It is unfortunate that the improved statistical technique of Kuczynski has not yet been applied to some important aspects of population growth. Partly for this reason and partly because the older methods are still widely used in current discussions on

population, a brief outline of the way in which they are derived will be given in what follows.

§ 2

(a) *The Standardized Mortality Rate.*

All civilized communities are to some extent concerned with the prevention of disease and the reduction of premature deaths. This prompts enquiry into whether people have better prospects of health and long life now than in past times or in one community rather than another. Medical Officers of Health point to the mortality statistics of their districts as evidence of the success of their efforts or the social policies which they are called upon to administer. Death rates have thus been largely collected and analyzed from a medical point of view. The *crude death rate* is defined as the number of deaths in a year per 1000 of the population from all causes, irrespective of age and sex. That this rate tells us very little about mortality in a population can be seen from Fig. 1. Females have a lower mortality than males at most ages, so that other things being equal a community with a preponderance of females would have a lower death rate than one with a preponderance of males. Age composition is a much more disturbing factor than sex. Since the curve of annual death rates rises steeply at the beginning and latter end of life, a community over-weighted with very young or very old people might have a much higher crude death rate than another community composed of equally healthy people with the same average expectation of life.

The following table shows the annual number of deaths per thousand individuals at three specified ages

in two European countries during the first decade of this century.

TABLE I¹

Age.	Germany.	Norway.
0-1	202·34	81·45
10	2·44	2·98
75	106·4	66·91

At the time when these figures were recorded Germany had an excess of 150 per cent. infantile mortality as compared with 70 per cent. senile mortality over the figures for Norway. Here is a very serious discrepancy, which does not appear if we compare the crude death rates for the two countries. This consideration must always be borne in mind when we quote death rates as evidence for the success of a policy of public health or the effects of prosperity. Many English seaside resorts exist largely as an antechamber to the cemetery. People who have enjoyed good health and have passed the age of useful activity retire to them in the hope of prolonging their remaining years. Hence we may have the apparent paradox that the health-giving properties of a district may result in a relatively high crude death rate. An example of a different kind of fallacy to which the use of crude death rates is liable is given by Newsholme in *Vital Statistics*. He refers to a city which showed a striking decrease in its tuberculosis death rate by the care of its tuberculous patients in an institution outside the city boundaries. Possibly this would promote a lowered

¹ Newsholme, *Vital Statistics*.

death rate; but the effect would not be shown accurately by the city death rate unless account were taken of the patients moved elsewhere.

The death rate changes very rapidly during the first year of life. At birth the probability of dying within a month according to the American figures for 1910 was 43·8 per 1000. At eleven months it had dropped to 4·4 per 1000. It is, accordingly, useful to have the death rates for the first year tabulated for each month of age. When we have the number of individuals living in each month of the first year of age and in each year of age following, and also the numbers dying in these periods, we have all the essential facts for a study of mortality. The death rates for each year of life are called "specific mortality rates." For comparison of different communities they have to be combined into some convenient index.

If we know the death rates per thousand for each year of life, it is easy to reduce two total death rates to a comparable basis for medical use. We calculate what is called a *standardized* death rate by taking the sum of the products obtained by multiplying the specific mortality rate for each age group by the proportion of people in each age group in some common standard population. This is equivalent to stating what the death rate of a given population would be if it had the same age composition as the standard population. In some British statistics, the age composition of England and Wales in the year 1901 is the standard used. The International Statistical Institute recommend an aggregate figure for several European countries about the same time. This gives an age composition of :—

TABLE II ¹

Age Group.	Per Cent.
0-5	12
5-15	21
15-25	18
etc.	etc.

It must not be forgotten that death rates for males and females are not always the same. For instance, the death rates per thousand males and females in the United States in 1920 at the two ages specified below are :—

TABLE III

Age.	Males.	Females.
0-5	32.0	26.0
65-70	58.6	55.0

This merely means that we have to keep our balance sheet for males and females as separate items. Where the numbers in a community in each sex and age group are known but only the crude death rate for the whole population is available, it is possible to obtain an approximate standardized death rate by a method given by Newsholme. An *index death rate* is obtained for the community by multiplying the sex and age groups by the appropriate death rates of the standard population, and dividing by the total population. The index death rate tells us nothing about the actual death rate of the community. It is a measure of the degree to which its sex and age composition favour a high or a low mortality. The ratio of the standard

¹ Newsholme, *op. cit.*

index death rate to the index death rate of the community then gives a standardizing factor. The crude death rate of the community multiplied by its standardizing factor gives an approximate standardized death rate.

The case of cancer may be used to show how easily mortality figures can be interpreted falsely, if no correction is made for the age and sex composition of a population. Cancer chiefly attacks people who have passed middle age. If one country has a larger proportion of elderly people than another that fact in itself will tend to raise the crude incidence of deaths from cancer. Clearly, such crude death rates could not be used to elucidate the effect of climate or polygamy upon the incidence or deadliness of the disease. Standardized death rates for cancer can be prepared by the same method of weighting which is applied to the entire death rate of a community. For the quinquennial period 1869-73 the crude and standardized death rates for cancer in England and Ireland were as follows :—

TABLE IV

	England.	Ireland.
Crude . . .	597	627
Standardized . . .	747	661

In this case standardization for age composition shows that conditions for a high mortality were more propitious in England than in Ireland, during the period stated. The crude figures would lead to the opposite conclusion.

(b) *The Life Table.*

Mortality rates such as those which have been dealt with in the preceding remarks are not suitable for the measurement of what capacity for further growth a population has at any given moment. For this latter purpose the Life Table upon which insurance and

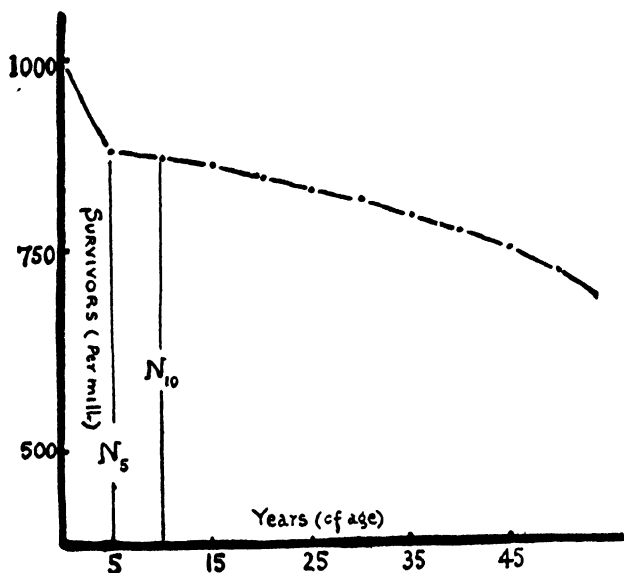


FIG. 2.—Graph based on German Life Table for 1925.

annuity risks are based is a more instructive though less compact¹ summary of the relevant data. On the assumption that the death rate at any given age prevailing at the time the life table is constructed remains unchanged, the figures in a life table represent for each year of age specified the number of people who survive

¹ The Life Table data can themselves be summarized in a single index, as the mean expectation of life at birth.

out of a given number (*e.g.*, 100,000) born. The figures in a quinquennial life table correspond with the ordinates of a curve such as that given in Fig. 2, where N_0 is the number of individuals born, *e.g.*, 100,000, N_5 the number who survive to 5 years, N_{10} the number who survive to 10 years, etc.

If the rate at which human beings die were constant and the composition of human populations were unaffected by immigration and emigration, we could construct a quinquennial life table for the present year by counting the number of children who attain their fifth year in 1933 and the number of children born during the year 1928, the number of children who attain their tenth year in 1933 and the number of children born in 1923, and so on. Actually we have to deal with a population of which the age composition is affected by the ebb and flow of migration over a long period and mortality rates which prevailed a long time ago. We can build up a curve such as Fig. 2, if we know the risk of death at each year of age. Let us denote by q_x the probability that an individual exactly x years of age will die before attaining exactly $x + 1$ years of age. Then if p_x is the probability that a person of the age x will survive to reach the age of $x + 1$,

$$p_x = 1 - q_x.$$

So $N_1 = p_0 N_0$, $N_2 = p_1 N_1 = p_1 p_0 N_0$, and generally using the customary symbol for a continued product

$$N_x = N_0 \prod_{r=0}^{x-1} p_r \quad . \quad . \quad . \quad (1)$$

The construction of a life table from population statistics raises a variety of difficulties, chiefly on account of the fact that net population figures for

different ages and death rates are not officially recorded over the same intervals of time, and because in the first two years of life the death rate changes rapidly during a short period of time. The fundamental principles involved can readily be grasped without paying attention to the refinements which are essential for accurate interpolation. To simplify the issue, let us suppose that human birthdays, like those of the pololo worm, all occur on the same day of the year. If l_x were the number of persons who reached x years on the annual birthday and l_{x+1} those who survived to the following birthday, the risk of death at x years of age would be given by

$$q_x = \frac{l_x - l_{x+1}}{l_x} \quad . \quad . \quad . \quad . \quad (2)$$

In an actual human community two such quantities as l_x and l_{x+1} cannot be determined. What we can actually enumerate in a population is the number of people (y) alive at a given moment between the ages x and $x + 1$. We also know the number of deaths which occur between these ages during some particular year for which the life table is being constructed.

For instance, in a village community on June 30th, 1932, there may be seventy-four people alive between the ages 24 and 25. Now let us suppose that in the community during the year 1932 eight people between the ages 24 and 25 die, and that these deaths are evenly distributed throughout the year. Our group between 24 and 25 will have a mean age of $24\frac{1}{2}$ at the moment of enumeration. It represents the survivors of a group of people of average age 24, who have lost four of their number before the census date and will lose another

four by the end of the year. Therefore we may say that the risk of death at age 24 is $\frac{8}{74+4}$ or $\frac{8}{78}$.

We may now generalize the argument as follows. Put d_x for $l_{x+1} - l_x$ representing in the preceding formula the number of people who die between the ages of x and $x + 1$ years during the year for which the life table is to be constructed. Then, if y is the number of persons between x and $x + 1$ in the mid years,

$$l_x = y + \frac{1}{2}d_x.$$

Hence we may write

$$q_x = \frac{d_x}{y + \frac{1}{2}d_x} \quad . \quad . \quad . \quad . \quad (3)$$

and

$$p_x = \frac{y - \frac{1}{2}d_x}{y + \frac{1}{2}d_x}.$$

The quantity p_x , which represents the probability that an individual alive at x years will still be alive at $x + 1$ years, therefore involves a knowledge of only two statistics. One is the number of persons between x and $x + 1$ years at the middle of the year for which the life table is constructed. The other is the number of deaths of persons between x and $x + 1$ years occurring during the same year. Once p_x is determined for each year of life (or other suitable age interval), the life table can be built up by the relation given in (1).

Kuczynski (*Fertility and Reproduction*) gives a worked-out example of an abridged life table for Germany for 1924-26, using a formula similar to the one given above, with a modification for the first year of life. His calculations result in the following table :—

TABLE V
ABRIDGED LIFE TABLE

Years of Age.	Female Survivors.
0	1000
1	906.23
5	882.19
10	874.50
15	868.87
20	858.24
25	842.92
30	826.14
35	808.61
40	789.34
45	767.06
50	739.70

The table stops at 50 years of age because, as will appear later, we only need to know the number of survivors up to the end of the reproductive period in order to calculate the growth capacity of a population.

(c) *The Standardized Fertility Rate.*

Let us now turn to the comparative measurement of fertility in different communities. We have seen that the crude birth rate, *i.e.*, the number of live births in a year per 1000 of the population, is an inadequate measure of the growth capacity of a population. Nevertheless, it is useful for some purposes. If the total numbers of births, deaths, and migrants since the last census are known, an estimate can be made of the inter-censal population. This will be nearer the truth than estimates involving assumptions about the *rate* of increase of the population in the inter-censal period.

The first step in the analysis of crude birth rates is to eliminate the effect of an undue preponderance of males or females in a population by relating the number of births to the total number of women in the popula-

tion, instead of to the total population. In discussions on population growth, the male section can generally be neglected. What matters is the rate at which the female population is reproducing itself. The effect of age composition on the crude birth rate is even more conspicuous than its effect on the death-rate. Within the group of women between 15 and 50 years of age, the average number of children born to women at each year of age varies considerably. The decrease is rapid during the latter years of the reproductive period. For statistical purposes, the limits of reproductive life are usually taken as 15 to 45 or 50. While reproduction can occur outside these limits, the numbers of children born when their mothers are under 15 or over 50 are so small compared with the total number of births that they can be neglected. A simple illustration of the effect of age and sex composition on the birth rate is given by Kuczynski. "If in the State of Colorado, in the year 1860, every second female between 15 and 50 years had borne a child (which would have implied a fertility such as has never been observed in the world) the birth rate of that year would still have been only 16 per 1000¹ because the females between 15 and 50 years constituted only 3.2 per cent. of the total population."²

In most countries the illegitimate birth rate is small compared with the legitimate birth rate. So for most purposes it can be neglected, and we need only consider the number of legitimate births in relation to the number of married women. We can distinguish between three factors affecting the birth rate, the

¹ Roughly that of England and Wales at the present time.

² Kuczynski, *Fertility and Reproduction*.

proportion of women in a community, their ages, and the average number of children born to each married woman. The significance of the first and last of these is illustrated by figures from two London Boroughs for the year 1921, as given by Newsholme.

TABLE VI ¹

Borough.	Crude Birth Rate.	Legitimate Birth Rates	
		Birth Rate per 1000 Women, 15-45.	Birth Rate per 1000 Married Women.
Kensington .	21.8	61.6	215.4
Whitechapel .	39.9	172.1	328.3
Per cent. excess	83	179	53

The birth rate per 1000 married women was greater in Whitechapel than in Kensington, but there was a much larger excess in the birth rate per 1000 females of child-bearing age. The reason for this discrepancy is not far to seek. Whitechapel contains a larger proportion of Jewish women who marry young, and few of whom remain spinsters. Kensington contains a high proportion of domestic servants who do not usually marry in that condition, and their mistresses for whom the prospects of early marriage are probably less than in Whitechapel. Thus the greater size of family in Whitechapel is reinforced by the greater frequency of marriage, and both together produce a greater crude birth rate.

The other consideration to be faced is the influence of age on the fertility of wives. The birth rates per 1000 wives at different ages in the Swedish population

¹ *Journ. of Hygiene*, Vol. V, 1905.

of 1891 have been widely used as a standard by English writers, and are given in the following table :—

TABLE VII¹

15-19	518
20-24	451
25-29	375
30-34	312
35-39	250
40-44	142
45-49	20

It will be seen that the fertility of married women is greatest in the group aged 15-19, and falls steadily throughout the period. These two statements are true of all populations for which statistics are available, although the rate of decrease is not always the same. Groups containing mostly wives between 15 and 25 would have a much higher total fertility than groups predominantly older. Hence, for comparative purposes, it has been customary to standardize the birth-rate per 1000 married women for age composition.

A direct way of doing so would be to weight the birth rates per 1000 married women for each year of the child-bearing period by the proportion of women of corresponding age in standard population. Since the requisite facts are not always accessible, a method analogous to the approximate procedure for obtaining a standardized mortality rate referred to on p. 49 has been advocated by Newsholme and Stevenson. As an illustration of their method, Newsholme and Stevenson compare the fertility of Berkshire in the year 1901 with that of England and Wales as a whole. The age composition of the married female population of Berkshire

¹ Newsholme, *op. cit.*

in 1901 is given in the first two columns of the following table :—

TABLE VIII
BERKSHIRE 1901

Wives, aged	No. of Wives.	Fertility Rate per 100 Wives at each Age Period, Sweden.	Calculated No. of Births which would occur if Swedish Fertility Rates Prevailed.
15-20	139	51·8	72·002
20-25	2,671	45·1	1,204·621
25-30	6,074	37·5	2,277·750
30-35	7,305	31·2	2,279·160
35-40	7,003	25·0	1,765·750
40-45	6,407	14·2	909·794
	29,659		8,509·077

The first step in Newsholme and Stevenson's method is to obtain an index "fertility" rate analogous to the index death rate mentioned earlier. This measures how far the age composition of the Berkshire wives is favourable to reproduction. In the preceding table, the number of wives is multiplied by the fertility of each age group according to the Swedish standard. This estimate is shown in the last column, which gives the number of births which would have occurred if Berkshire wives had had the same fertility in 1901 as Swedish wives in 1891.

The index fertility rate of Berkshire is thus :—

$$\frac{\text{Calculated Births} \times 1000}{\text{No. of wives aged 15-45}} = 286·9.$$

When comparisons have to be made between different communities, index fertility rates are compiled for all of them in this way. For 1901 the index fertility rate for England and Wales as a whole computed as for

the Berkshire population was 298·6. These indices expressed as births are really a convenient way of summarizing how the different proportions of wives at different ages in the communities compared, tend to swell or curtail the total number of births. In the example taken the age composition of England and Wales was more favourable to reproduction than that of Berkshire in the ratio 298·6 : 286·9, or 1·04 : 1. If provided with these index fertility rates and the actual fertility rates for the same communities, we can compare the actual fertility rate of either of them with what another would be if it had the same age composition.

For 1901 the actual fertility rate (births per 1000 wives of child-bearing age) of England and Wales was 234. The actual fertility rate of Berkshire was :—

$$\frac{\text{Births} \times 1000}{\text{No. of wives aged 15-45}} = 219·7.$$

If Berkshire had had the same age composition as England and Wales, its actual fertility would be increased in the ratio 1·04 : 1, *i.e.*, it would be 228·6. This number is called the *standardized fertility rate*. Its value depends upon the standard population with which its fertility is compared, in this case England and Wales in the same year. The index fertility rate of Sweden in 1891 is the actual number of births per 1000 wives in that year. Hence, it would greatly simplify matters if the actual fertility of Sweden were taken as a standard with which to compare other fertility rates. The correction factor in any community would then be the ratio of the index fertility rate to the actual fertility rate of Sweden. In practice, as in the example given, it is more usual to take the

fertility of the Swedish population as the basis for determining the index fertility rate, and to select some particular index fertility rate as the standard for determining appropriate correction factors.

The same process can be applied to the number of births per 1000 of the total population, and a *standardized birth rate* obtained.

Once more comparing Berkshire in 1901 with England and Wales as a whole as before, the process is as follows :—

Calculated No. of births in Berkshire = 8509.077

Total population at Census = 283.531

Index birth rate = $\frac{8509.077 \times 1000}{283.531}$

= 30.01

Index birth rate for England and

Wales obtained in the same way

(standard) = 34.91

Correction factor = $\frac{34.91}{30.01}$

Recorded legitimate birth rate of Berkshire

i.e., $\frac{\text{Births} \times 1000}{\text{Total population}} = 22.78$

Standardized birth rate

i.e., Recorded birth rate $\times$ correction factor = 26.50

The standardized birth rate resembles the standardized fertility rate in eliminating age composition. It neglects the influence of frequency of marriage. When we compare several populations by means of their standardized birth rates we are studying the combined effects upon fertility of differences in the percentage of married women in the population, and of differences in the

average size of family. Thus, simultaneous comparison of the standardized fertility rate and the standardized birth rate of two communities makes it possible to discriminate between the contribution which marriage and the mean size of the family make to their reproductive capacities. This is not without importance in the absence of a suitable index combining the relevant data concerning both the frequency and duration of marriages.

Such methods for eliminating the effect of age composition of the female population on the birth rate are open to several criticisms. Newsholme himself points out that the fertility of newly-married women of a given age is greater than that of women of the same age who have been married longer, as will be seen from the following table due to a study of 46,391 births in Budapest by Körosi.

TABLE IX

Age in years.	The Number of Children Born within a Year to every 1000.	
	Of Women Newly-Married.	Of all Married Women.
30-34	329	206
35-39	327	147
40-44	214	59

Curiously, Newsholme does not consider that this factor introduces a serious error. A second criticism concerns the validity of the use of a fixed set of fertility rates for each age group as a standard. Newsholme justifies this in the following words.

“As the standard fertility-rate is merely used as a

measure of favourable or unfavourable age distribution, and as the same measure is applied to all the populations compared, any convenient fertility rates may be employed so long as they *correctly represent the difference* in fertility between the various age-periods."

The graphs in Figs. 3 and 4 show changes in fertility with age for different communities at different times. Though all exhibit a fall of fertility with advancing age, there are noticeable differences in the gradient. Whether these considerations are sufficiently unimportant to neglect is a matter which is open to discussion. It is fairly clear that the relation between fertility and age is not so simple as the relation between mortality and age. We have less biological knowledge of the forces influencing change in fertility with age. It is true that fertility falls from the beginning of the child-bearing period, both in contemporary population statistics and in population statistics which antedate the decline of the European birth rate and the prevalence of present methods of birth control. Of itself, this does not justify us in attributing the effect of age to physiological changes in contradistinction to psychological factors which can be more directly affected by social tradition and organization. At least, it can be said that there is not sufficient direct evidence to justify the view that women tend progressively to ovulate with less frequency or become progressively more liable to abortion from the beginning to the end of the child-bearing period. The high fertility of Swedish wives between the age of 15-19 years is that of a small and probably highly selected sample of the female population, and not improbably one with abnormally high sexual vitality. Social agencies such as the widespread

knowledge of simple and congenial methods of family

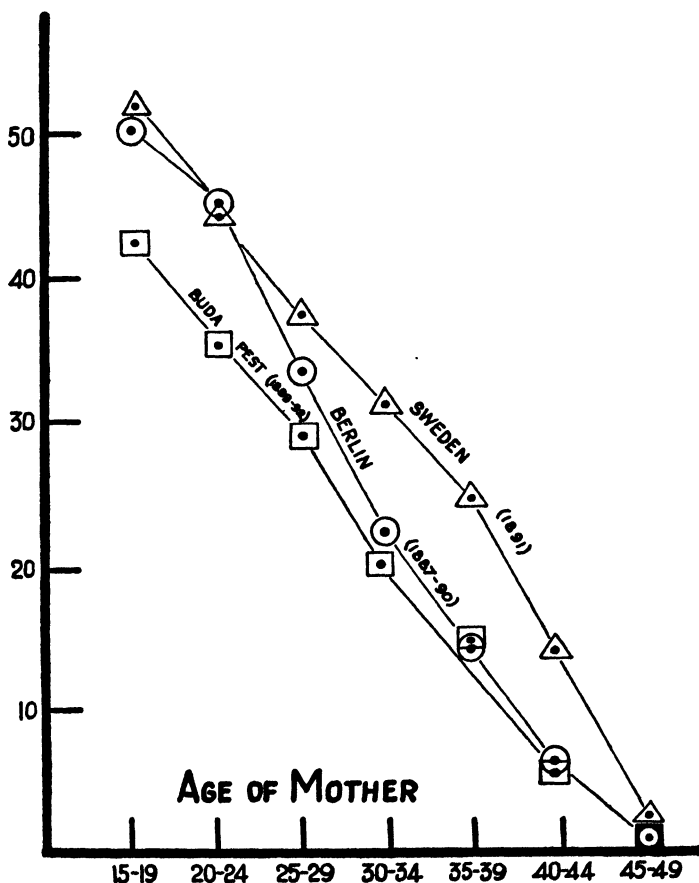


FIG. 3.—Change of Fertility with Maternal Age in Three European Communities about 1890.

(Ordinates represent number of births per hundred married women per annum.)

limitation may eventually tend to diminish the relative frequency of births in the earlier years of married life.

More crude and less widely known methods of contra-

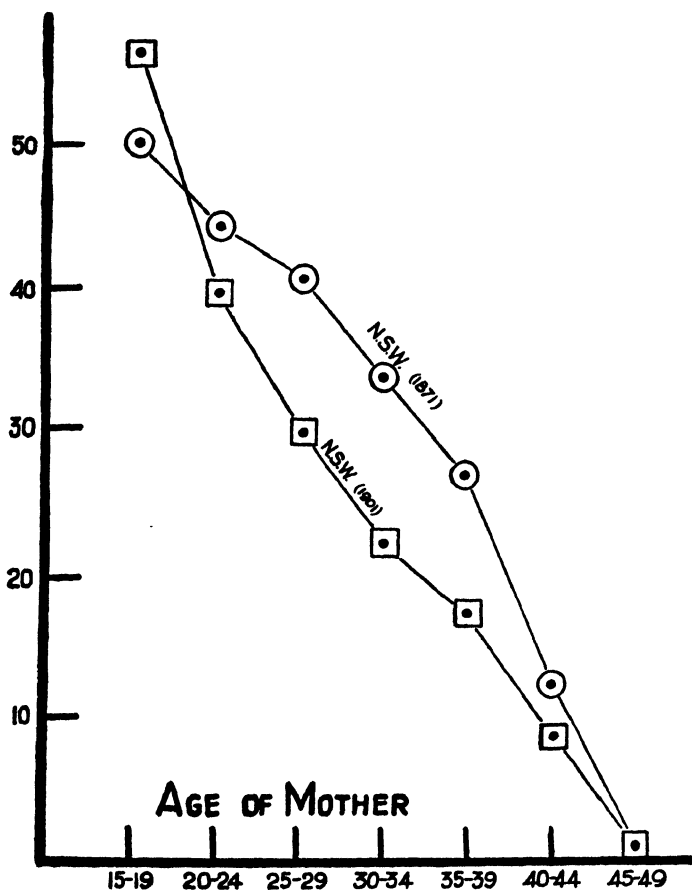


FIG. 4.—Change of Fertility with Maternal Age in the same Community (New South Wales) at Two Different Periods.

(Ordinates as in Fig. 3.)

ception have existed throughout historic times. There can be little doubt that the disposition to obtain the

requisite information and to make use of it has been greater among older women, who have already borne as many children as their means or inclination would encourage them to bear.

(d) *The Gross Reproduction Rate.*

From the intricate difficulties of the older methods of measuring fertility it will be a relief to the reader, as to the writer, to turn to the beautiful simplicity of the new methods used by Kuczynski. We can ignore for the present the various factors which affect fertility, and consider only the rate at which a given group of women are reproducing themselves. The necessary data are the annual fertility rates for women in each year of age in a population. The gross reproduction rate combines these annual fertility rates into an index, which gives the average number of children born to a woman passing through the whole reproductive period.

Taking the Ukraine in 1926-27 as an example, there were in the population 375,054 females of 15 years of age. The number of births reported to mothers of this age was 77. Thus the birth rate per 1000 women of 15 was 0.205. Put in other words, 1000 women of 15 would have between them 0.205 children, without taking into account how many were married and how many were not. We can tabulate a series of such annual fertility rates for each year of age from the beginning to the end of the reproductive period. In the case quoted, of the Ukraine, these reached a maximum of 263.494 children per thousand women at age 25, and then declined again to 8.943 at 49 years of age. If we now add together all these annual fertility rates, the total is found to be 5134.628 births. This means

that if fertility rates in the Ukraine remained at the same level as when they are measured, 1000 women all living from 15 to 50 would produce 5134.628 children. In each year, commencing at 15, our group of 1000 women would produce the number of children shown in the annual fertility rates, and if they all lived to 50, they would have produced altogether the total number of 5134.628. If any one woman out of the group is considered, she produces on an average 5.13 children. When we are mainly concerned with the growth capacity of a population it is more convenient to eliminate the males born, and to consider only the production of female children. As the sex ratio of the offspring of mothers at different ages does not differ materially, this can easily be done. It is only necessary to multiply the total fertility rate by the proportion of girls in all births (0.484). This would reduce the total fertility rate of the Ukraine to 2485.2; that is to say, 1000 Ukrainian women passing through the child-bearing period would produce 2485.2 girls if the fertility rates of 1926 persisted throughout the whole of their period of child-bearing. One woman passing through the child-bearing period would have on the average 2.49 girl children.¹

The latter figure, 2.49, is the gross reproduction rate. The Gross Reproduction Rate is defined as the number of girl children likely to be born to a woman passing through the whole child-bearing period, on the basis of the fertility rates prevailing in a given place at a given time. Statistical difficulties sometimes arise in the construction of the gross reproduction rate owing to the fact that fertility rates are often available for

¹ Kuczynski, *Fertility and Reproduction*.

quinquennial or decennial age periods only. A full discussion of this difficulty is given by Kuczynski. It will suffice to say that quinquennial fertility rates can be used to compute the gross reproduction rate without serious error. When decennial rates only are available, certain adjustments have to be made. The gross reproduction rate is a very simple and convenient method of describing the fertility of a population. It is clear that if the gross reproduction rate is less than unity, the population is bound to diminish, however much the risk of death is reduced. Gross reproduction rates of less than unity have been found to occur. In 1926, the gross reproduction rates of Washington and Montana were 0.96 and 0.91, respectively. Kuczynski estimates that in 1927 it had dropped to 0.98 in England and Wales. Even if no women died before reaching 50 years of age, such populations would diminish until an increase in fertility sufficient to raise the gross reproduction rate to unity or above occurred.

The gross reproduction rate conveys as much about the fertility of a population as the standardized birth rate. The latter was devised partly in order to analyze data referring to sections of a population, when the numbers of births classified according to the age of the mother are not available. If the necessary data can be ascertained, the gross reproduction rate is easier to compute. It has a significance which can be much more readily grasped. An index computed on the basis of the number of births per 1000 wives, but in other respects comparable with the gross reproduction rate as defined above, would serve the same use as the standardized fertility rate.

An outline of statistical methods employed to measure

fertility would be incomplete without a passing reference to estimates of the mean size of completed families. Computations of this kind were carried out on the England and Wales Census of 1911. The object of the work was to elucidate the changes that had taken place in differential fertility between various social groups. While the figures obtained are suggestive, they are open to two objections. Completed marriages cover a long period during which fertility and mortality rates have been continually changing. It is also a matter of doubt whether married survivors at ages over 50 are a truly random sample of a population dying at all ages. There may well be a correlation between high fertility and longevity.

§ 3

So long as writers on the population problem were content to record changes in the standardized fertility and mortality rates dealt with in the preceding section, it was difficult to envisage the full significance of the declining birth rate of civilized countries during the last century. During the last half century mortality and fertility have declined simultaneously in civilized countries. It has not been obvious whether the decline in the latter has been less than sufficiently compensated by that of the former. If the falling fertility rates led some to disregard the prospect of over-population as a serious menace, others could point to the diminishing risk of death as an undisputed fact to set against the significance of a falling birth rate. If two populations have equivalent fertility and mortality rates standardized by the method commonly used by English writers on population statistics, one may be capable of further

growth and the other may be on the way to extinction. Standardized for equivalent age compositions, death rates of two populations do not necessarily provide equivalent measures of mortality as it affects population growth. The specific death rate for the early years of life may be low and the specific death rate for the later years may be high in one population, and *vice versa* in another which has the same standardized mortality rate. The standardization of the birth rate by reference to a standardized population with an arbitrarily chosen age composition may be useful for comparative purposes. To envisage the inherent capacity for growth of a population we have to bring together the data concerning the frequency of births at different ages in the child-bearing period of life and the chances of survival to each age.

(e) *The Net Reproduction Rate.*

In order to estimate the growth capacity of a population it is not sufficient to know the number of children being born. Account must also be taken of the probability of survival. Is it possible to devise an index which combines the effects of both fertility and mortality? The gross reproduction rate gives the number of children born on the average to one woman. It does not include any information about the number of those children who will survive to be future mothers. Subject to the fertility and mortality rates prevailing at any given time, the average number of female children who will be born to every newly born girl is the clearest indication of the capacity for further growth in a population. Such an average which is called the *Net Reproduction Rate* can be determined in a com-

paratively simple way. We have only to weight the annual fertility rates by the proportion of female survivors in the life table, the procedure in other respects being the same as for computing a gross reproduction rate.

The necessary data for the determination of the net reproduction rate are the annual fertility rates composing the gross reproduction rate and a life table for the female population based on the current mortality rates. The method can be followed most clearly by giving part of the table for the Ukraine for 1926. The population is the same as that used to explain the gross reproduction rate. (See Table X.)

Columns (1), (2), (3), and (4) are the data used for determining the gross reproduction rate, column (4) giving the annual fertility rates for different ages. The total of column (4), when the births of boys are deducted, gives the gross reproduction rate, as was explained in the previous section. If they survived till the end of the sixteenth year from birth 1000 newly-born girls would have 0.2 offspring. Column (5), which is simply the female life table, shows that only 733 out of every 1000 girls born do survive to this age. When depleted by the risks of death between birth and 15 years of age, 1000 newly-born girls will therefore have 0.2×0.733 , *i.e.*, 0.15 offspring before attaining the age of sixteen. During the ensuing year of their lives 1000 girls would have 1.6 offspring, and since only 730 out of every thousand born survive another year, 1000 newly-born girls during their seventeenth year will produce 1.6×0.730 , or 1.18 more offspring. The mean number of offspring who will be born to a thousand newly-born girls during the first two years

TABLE X¹

COMBINED FERTILITY AND LIFE TABLE, UKRAINE, 1926-27

(1) Years of Age.	(2) No. of Females.	(3) Births per annum.	(4) Births per 1000 Females.	(5) ² Survivors per 1000 Females Born.	(6) Offspring of Survivors of 1000 Newly- born Girls.
15	375,045	77	0.2	733	0.15
16	364,914	590	1.6	730	1.18
17	354,791	5,198	14.7	727	10.65
18	344,633	21,306	61.8	723	44.70
19	333,437	45,934	137.3	719	98.81
20	324,231	62,954	194.2	716	138.93
21	314,060	72,374	230.4	711	163.95
22	303,968	74,852	246.3	707	174.16
23	293,970	75,261	256.0	703	179.99
24	284,044	74,253	261.4	699	182.67
25	274,135	72,233	263.5	695	183.00
26	264,185	69,485	263.0	690	181.56
27	254,157	66,195	250.4	686	178.69
28	244,058	62,525	256.2	682	174.70
29	233,953	58,588	250.4	678	169.73
30	223,958	54,484	243.3	674	163.88
31	241,221	50,288	234.7	669	157.13
32	204,884	46,067	224.8	665	149.55
33	196,065	41,878	213.6	661	141.14
34	187,829	37,762	201.0	656	131.97
35	180,184	33,764	187.4	652	122.18
36	173,080	29,914	172.8	648	111.93
37	166,434	26,242	157.7	643	101.41
38	160,149	22,638	141.4	639	90.28
39	154,142	19,517	126.6	634	80.29
40	148,355	16,500	111.2	630	70.02
41	142,764	13,730	96.2	625	60.10
42	137,380	11,219	81.7	620	50.65
43	132,235	8,969	67.8	615	41.74
44	127,369	6,987	54.9	611	33.49
45	122,816	5,271	42.9	606	25.99
46	118,597	3,818	32.2	601	19.33
47	114,708	2,624	22.9	596	13.62
48	111,121	1,676	15.1	590	8.91
49	107,798	964	8.9	585	5.23
Total	7,688,670	1,196,137	5,134.6		3,461.73

¹ Adapted from Kuczynski, *Fertility and Reproduction*.² Actually, the figures in column (5) give the number of females living between 15 and 16, etc., according to the life table, i.e., the number of survivors at 15½. A more accurate designation would

of the child-bearing period of those who will survive for one or both of them, is $1.15 + 1.18$. Column (6) thus gives the number of births in each year of the survivors of 1000 newly-born girls, and is obtained by weighting the annual fertility rates with the proportion of survivors in the life table for each year of the reproduction period. The total of these figures in the example given is 3461.734, and this is the total number of children who will be born to 1000 newly-born girls at current fertility and mortality rates. As before, the male births need not be considered. When these are eliminated the total number of girl births is found to be 1675.5. Dividing this figure by 1000 we obtain the net reproduction rate, which represents the rate at which the female population is replacing itself. Its significance can be put in other words by saying that if the fertility and mortality rates of the Ukraine in the year 1926 remained unchanged every mother then born would be replaced in a generation by 1.68 mothers. A net reproduction rate of unity means that every mother will be replaced by another mother and no more. A population with a net reproduction rate of unity would become stationary in the long run, if the current fertility or mortality rates did not change. Subject to the same qualification, a rate of more than unity signifies that the population must eventually increase, and a rate lower than unity means that a population is doomed to extinction.

It is important to realize that the figure given by the net reproduction rate does not represent the ratio of the total population a generation hence to the contemporary population. Only the change in the relative proportions of the female reproductive group is known. If a

population is subject to constant fertility and mortality rates it will reach a stable age composition. If the net reproduction rate is unity, it is easy to see that the number of births will eventually equal the number of deaths, and that the age composition will correspond to the life table. That *constant* fertility and mortality rates giving a net reproduction rate greater or less than unity also result in a stable age composition has been deduced by Lotka. Naturally, when the population has dwindled to a very small number of individuals, the life table ceases to be an adequate description of the biological data, since fractions of individuals do not exist in real life. This is merely an example of the universal truth that any mathematical symbolism is at best an approximate description of the changing world as we observe it. Any statistical index of population must be interpreted as an operator rather than as a number. The accuracy of the result to which the use of such an operator leads depends upon the largeness of the population to which it is applied. The important point to note is that the net reproduction rate represents to a high degree of approximation a rate of growth to which the present population is tending. The length of time before a population begins to behave in the way indicated by the net reproduction rate depends on the extent to which its age composition differs from that of a stable population compatible with the net reproduction rate.

Kuczynski has discussed in detail the length of time taken to reach a stable age composition. He takes as an example a case in which a population has been constantly stationary for a long time with a net reproduction rate of 1. There is a sudden drop in fertility

reducing the net reproduction rate to 0.9, fertility and mortality remaining constant thereafter. The approach to a constant age composition is gradual. Kuczynski states that "... slight oscillations are still noticeable after two centuries."¹ However, such a population would already approximate fairly closely to a stable age composition and a stable rate of decrease when all the children born at the old level of fertility had died, *i.e.*, within a century. The effects of the old reproduction rate might be statistically negligible before the end of that period.

The net reproduction rate in England and Wales at the present time (1933) is not much higher than 0.75, and the population has practically ceased to increase. If no further change in fertility and mortality rates takes place, a stable age composition will eventually be reached. When this point has been reached the population will be reduced in the proportion $\frac{3}{4}$ in each subsequent generation. The determination of the exact length of time implied by the term generation involves a calculation based upon data used in determining the net reproduction rate. In practice it has never been found to diverge very much from 30 years. Let us suppose that the present fertility and mortality of England and Wales remain as they are. Once a stable age composition has been reached a population, equivalent to that of England and Wales (about 45 millions) at the present time, would be reduced to less than 6 millions, *i.e.*, about half the size of greater London, in about 200 years. The possibilities of rapid decrease are not completely exhausted unless we take into account the fact that the present net reproduction

¹ *Op. cit.*

rate of about 0.75 has been reached by a process of continuous decline over a number of years. There seems to be no particular reason for assuming that the decline must stop at the point now reached. If the net reproduction rate were to fall further, say to 0.5, the population would be halving itself every 30 years, when a stable age composition had been reached. In the space of 300 years a population of 45,000,000 would be reduced to 45,000, which is the size of a small English town. Such forecasts of the future, however speculative, indicate the change in perspective which has taken place since the time of Malthus. The population of Great Britain may or may not at any future time be halving itself in a generation. Our present knowledge makes such a possibility less incredible than any of the "nightmares of population" which Malthus depicted.

CHAPTER III

THE RETREAT FROM PARENTHOOD

Comparison of Birth Rates in Nineteenth- and Twentieth-Century Europe and America—The First Fruits of the New Statistical Technique—Fertility Levels and the Receding Margin for Further Reduction of Mortality—The Prospects of a Vanishing Population—The Special Conditions of Population Growth in Japan and the U.S.S.R.

§ I

IN an article contributed to an English newspaper on January 15, 1933, M. de Jouvenel, recently appointed as French Ambassador to Italy, made the following pronouncements :—

“ . . . And, doubtlessly, it is also by international methods that the problem of Italy's over-population will have to be solved. The attribution of a mandate of such and such a country in Africa or Asia, which would have been a simple matter in 1919, is to-day very complicated, owing to the revindications of Germany and Poland, whose births are increasing in the same rate as those of Italy.”

It would not be fair to attribute such ignorance of the present condition of population growth in European countries to the majority of statesmen. At the same time it is certainly representative of a widespread attitude which is common to many educated people and others who sway popular opinion. Popular views on population usually have a factual basis, but the facts are facts of 50 or 100 years ago, and, as we have

seen in the preceding chapter, the facts about population growth require very careful interpretation.

In Western and Northern Europe the birth rate from 1871 to 1885 averaged about 32 per thousand. If the fertility and mortality rates prevailing at this period had persisted, the population would be increasing by about a half in every generation in all countries of Western and Northern Europe except France and Ireland. Actually the population in this region increased from 113 millions in 1850 to 192 millions in 1930. During the same period the growth of population in North America was still phenomenal, as it was when Malthus concocted his so-called law. A considerable part of the increase was due to immigration; it has been estimated that apart from this factor the population of the U.S.A. doubled itself every 25 years from 1790 to 1860. Such rates of increase would provide a real basis for alarmist views of the prospects of over-population if they had persisted. The changes in fertility and mortality during the last 150 years compel us to undertake a re-examination of doctrines which seemed to be justified by the facts available when Malthus wrote, and Mill vindicated, the *Essay on Population*.

With how these changes have come about we shall not concern ourselves in the present chapter. Our first business will be to take cognizance of the changes which have taken place, restricting, for the present, our survey of the data to the growth of population in communities which constitute separate political units.

Table XI shows how the crude birth rate changed in certain countries during the period for which statistics are available. All the countries, with the notable

TABLE XI¹

CRUDE YEARLY BIRTH RATES BY PERIODS

Years.	Eng- land and Wales.	Ger- many (present terri- tory).	France.	Sweden.	Italy.	Russia (Eur.).	Japan.	U.S.A. (White).	Aus- tralia
1746-50				35.1					
1751-55				37.1					
1756-60				34.3					
1761-65				34.6					
1766-70				33.8					
1771-75				31.3					
1776-80				34.7					
1781-85				31.8					
1786-90				32.1					
1791-95				33.9					
1796-1800				32.8				55.0	
1801-05				31.4					
1806-10			31.7	30.4				54.3	
1811-15			31.7	32.9					
1816-20			32.0	33.7				52.8	
1821-25			31.4	35.8					
1826-30			30.5	33.5				51.4	
1831-35			29.6	32.4					
1836-40	31.3		28.4	30.6				48.3	
1841-45	32.3	36.3	28.1	31.3					
1846-50	32.8	35.3	26.7	30.9				43.3	
1851-55	33.9	34.3	26.1	31.8					
1856-60	34.4	35.7	26.6	33.7				41.4	
1861-65	35.1	36.5	26.7	33.2	38.7				41.9
1866-70	35.3	37.2	26.1	29.7	37.1			38.3	39.8
1871-75	35.5	38.7	25.5	30.7	36.8				37.3
1876-80	35.3	39.0	25.3	30.3	36.9			35.2	36.8
1881-85	33.5	36.8	24.7	29.4	38.0	50.7			35.2
1886-90	31.4	36.4	23.0	28.8	37.5	50.2	28.8	31.5	34.4
1891-95	30.5	36.1	22.3	27.4	36.0	48.9	28.5		31.5
1896-1900	29.3	35.7	21.9	26.9	34.0	49.5	33.0	30.1	27.3
1901-05	28.2	34.0	21.2	26.1	32.6	47.7	34.8		
1906-10	26.3	31.3	19.9	25.4	32.7	45.8			
1911-14	24.1	27.4	18.6	23.5	31.7	44.8			
1915-19	19.4	16.5	11.3	20.8	22.7				
1920-21	24.0	25.4	21.0	22.6	31.1	30.9	36.2	26.1	
1922-23	20.1	22.0	19.2	19.2	29.8	33.4	34.2		
1924-25	18.6	20.6	18.8	17.8	28.1	42.4	33.8		22.9
1926	17.8	19.5	18.8	16.9	27.8	43.7	34.8	21.4	22.0
1927	16.6	18.3	18.1	16.1	26.9	43.2	33.6	20.6	21.7
1928	16.7	18.6	18.3	16.1	26.6	42.7	34.1	19.8	21.3
1929	16.3	17.9	17.7	15.2	25.6		32.7	18.9	20.3
1930	16.3	17.5	18.0	15.4	26.7		32.4	18.9	19.9
1931	15.8	16.0	17.4	14.8	24.9		32.2	17.8	18.2

¹ For all countries except Germany the territory is that of the period in question.

exception of Japan, show a continuous fall in the birth rate over a number of years. Leaving aside Russia for a moment, let us consider the other five European countries in more detail. In every case we see in the

'seventies or 'eighties a turning point, after which the steady fall in the birth rate displays no other noteworthy feature except during the War period. In nearly all the countries of Western and Northern Europe this process is remarkably uniform. There is a particularly large drop during the European War. It rises again during the five-year period following the War, but in very few countries does it reach the pre-War level. The fall then continues to the present time.

In France the decline began much earlier. The turning point, after which the decline was continuous, occurs in 1861-65, when the birth rate was 26.7, but previous to these years there had been a decline from a birth rate of 32.0 in 1816-20, followed by a period during which the birth rate remained stationary about the 1860 level. This early decline of the French birth rate probably gave rise to a widespread and apparently ineradicable belief that France has a low birth rate compared with other European countries. In 1927 the French birth rate was practically the same as that of Germany and Norway. It was lower than that of Denmark and Holland and higher than that of Sweden and of England and Wales. The crude death rate (17.5) of France in the same year was conspicuously higher than that of England and Wales (11.7), a fact which also contributes to the prevailing illusion. In Italy the decline began somewhat later, and has been less continuous, so that Italy now has a considerably higher birth rate than the countries previously mentioned. The fertility of Russian women at the beginning of the statistical period was remarkable. Statistics from such a large area over a very stormy period naturally need not be expected to have great accuracy.

ALL that can be said is that at present the birth rate is not as high as it was in the 'eighties, but appears to be still higher than anything that is found in the rest of Europe.

The effect of the War upon the number of births was qualitatively the same in all European countries, though the sudden drop during the War years was more pronounced in the more belligerent countries. It seems that there was a postponement of marriages and births during the War years. This had the effect of swelling the birth rate during the next few years. There was no alteration in the general course of the decline in the number of births. It has been pointed out in the last chapter that crude birth rates can be very materially affected by sex and age composition. In the pre-War period the proportion of women of child-bearing age in Western and Northern Europe did not alter materially. It was 25.89 both in 1860 and in 1910. After that date the effects of the previous fall in the birth rate and the loss of male lives in the World War were seen in the increasing proportion of women of child-bearing age. Thus the crude birth rates convey a fairly satisfactory picture of changes in fertility up to 1910. In order to appreciate the course of events in later years, it is necessary to make use of the devices discussed in the last chapter.

§ 2

Confining ourselves in the first place to the trend of fertility alone, the relevant data for the countries of Western and Northern Europe are given in the next table (Table XII). This exhibits the change of the gross reproduction rate as given by Kuczynski.¹ Till

¹ *The Balance of Births and Deaths.*

TABLE XII

GROSS REPRODUCTION RATES, 1866-1927

(Western and Northern Europe.)

Years.	Finland.	Norway.	Denmark.	Sweden.	France.	Germany.	England & Wales.
1866-70	2.084			2.018			
1871-75	2.388	} 2.275	}	2.147	}	} 2.459	
1876-80	2.420			2.163			
1881-85	2.363	}	} 2.220	2.081	}	}	
1886-90	2.400			2.049			
1891-95	} 2.278	} 2.144	2.140	1.968	} 1.447	}	
1896-97			2.042	1.944			
1898-1900	}	}	}	1.954	} 1.310	} 2.366	
1901-03				2.064			
1904-05	} 2.140	}	}	1.799	} 1.232	}	
1906-07							
1908-10	}	}	}	1.594	}	}	
1911-13				1.853			
1914-15	}	}	}	1.414	}	}	
1916-18				1.523			
1920	1.716	1.661		1.346			1.312
1921	}	}	}	}	}	}	
1922							
1923							
1924							
1925						1.132	1.079
1926	(1.43)	(1.33)	(1.270)	(1.11)	(1.15)	(1.07)	(1.05)
1927		(1.27)	(1.22)		(1.10)	(1.00)	(0.98)

the last decade of the nineteenth century the average number of girls born to a woman during the whole of her child-bearing period was between 2.0 and 2.5 in most of these communities. By 1926, the average number of girls born to each woman in North-Western Europe as a whole was 1.12, and the average number of children born to each woman was 2.3. In 1927 the gross reproduction rate of England and Wales had fallen below unity. In the absence of immigration or a rise of fertility the population of England must therefore dwindle away, in spite of all improvements which tend to reduce mortality. All the other countries shown in Table XII were rapidly approaching the same level of fertility. By now they have almost certainly reached it.

TABLE XIII

GROSS REPRODUCTION RATES IN SOUTHERN AND CENTRAL EUROPE

Years.	Bulgaria.	Austria.	Poland.	Italy.	Spain and Portugal.
1895-1900		2.485			
1901-05	3.176	2.393			
1906-10	3.155	2.266			
1913		1.999			
1921	} 2.502		2.241	} 2.00	} 1.9
1922			2.206		
1923			2.121		
1924			1.959		
1925	} 2.217		1.983		
1926			1.853		
1927					
1928					
1929	1.90	0.969		1.65	

Table XIII exhibits the gross reproduction rates for some of the principal countries in Southern and Central Europe. Generally speaking, a higher fertility prevailed in this part of Europe in the nineteenth century, and the figures given point to the beginnings of a process which has gone much further in Western and Northern Europe. Austria is remarkable in that its gross reproduction rate was above the North-Western European average in 1895, and has declined so rapidly that it is now below it.¹

The gross reproduction rate does not distinguish between the two main factors which may affect fertility—namely, the proportion of women who get married and the average number of children born to married women. The marriage rate fluctuates much more than the birth rate, because it responds more readily to the effect of

¹ The change is partly accounted for by the fact that Austria has lost her more fertile regions.

short-period changes in economic conditions. In England and Wales only the initial phase of the declining birth rate was accompanied by a corresponding decline in the marriage rate. Later on, the marriage rate fluctuated round a constant level, while the birth rate per 1000 married women continued to decline. The analysis of the effect of marriage on fertility is complex. Two components have to be considered, the proportion of women of child-bearing age who get married and the age at which they get married. In England and Wales in 1920 the mean age at marriage was 0.4 years later than in 1896, a difference which has clearly no practical significance. It may become a matter of some practical urgency to decide how much the gross reproduction rate could be raised by either increasing the proportion of married women or by making early marriage easier. At present all we can say is that the principal component in falling fertility appears to be the fall in the average number of children born to each married woman.

Among those countries which are now highly industrialized and play a prominent rôle in international affairs to-day, the growth of population in Russia and Japan presents features which are somewhat unique. These will be reserved for subsequent treatment. The fact that in many highly industrialized countries the average woman already has, or soon will be having, less than one female offspring throughout her reproductive life cannot be too strongly emphasized. A declining birth rate has not passed unnoticed. The Cassandra of the over-population menace have replied that death rates were falling even faster. The fact is that no change in the death rate can save a population

from extinction if its gross reproduction remains below the figure 1.0.

To be complete, our account of the decline in the birth rate must take into consideration concurrent changes in mortality, and how far the gross reproduction rate falls short of a true estimate of the prospects of a decline in the European population. Table XIV shows the

TABLE XIV
CRUDE DEATH RATES, ENGLAND AND WALES
(E. Wright.)

Period	Deaths per 1000 Population.	Infant Mortality (1 year) per 1000 Births.
1851-55	22.7	156
1856-60	21.8	152
1861-65	22.6	151
1866-70	22.4	157
1871-75	22.0	153
1876-80	20.8	145
1881-85	19.9	139
1886-90	18.9	145
1891-95	18.7	151
1896-1900	17.7	156
1901-1905	16.0	138
1906-1910	14.7	117
1911-1915	14.3	110

changes that have taken place in England and Wales in the crude death rate and in the infant death rate. While the death rates for all age groups over one year began to fall continuously after 1871-75, the death rate for infants under 1 year rose again in the period 1881-1900. Since 1900 the fall in the infant death rate has been very rapid. The years between 1881 and 1900 were thus a time of falling birth rate and rising infant death rate. This very materially affected the age composition of the population, so that the birth rate

in later years under-estimated the true decrease in fertility. A similar reduction in mortality has taken place in all European countries, though not at the same rate.

For the present discussion the most important fact about mortality is the average number of years lived by a newly-born girl between the ages of 15 and 50.

TABLE XV¹

AVERAGE NUMBER OF YEARS LIVED BETWEEN 15 AND 50 YEARS
BY A NEWLY-BORN GIRL

	<i>Circa 1896.</i>	1925-29.
Denmark . . .	25·6	29·8
England and Wales .	—	28·6 (1920-22)
Finland . . .	21·7	26·4
France . . .	24·0	27·6
Germany . . .	20·2	28·4
Sweden . . .	25·6	29·3
Ukraine . . .	18·5	23·2
Bulgaria . . .	20·0 (1901-05)	22·4
Austria . . .	19·6	27·8
Poland . . .	—	24·9

Table XV shows the present conditions affecting mortality during the period of reproduction, in the principal European countries. The maximum number of years which could be lived in the reproductive period if there were no deaths before the age of 50 is 35. Out of these, in 1926 the number of years which the average woman survives in Western and Northern Europe was probably 29. Though we have no justification for imposing arbitrary limits upon what advancing science and social organization can contribute to the extension of life beyond the reproductive period, these figures do not leave a large margin for further reduction of

¹ Kuczynski, *op. cit.*

mortality within the reproductive period. This conclusion is worthy of attention. The net reproduction rate is already lower than 1.0 in some countries which have a gross reproduction rate higher than 1.0. Where this is so, prospects of raising the net reproduction rate by further reduction in mortality are much less than is commonly realized. In Eastern Europe the position is different. In the Ukraine, for example, the reduction in mortality has been rapid, although the standard reached is still well below that of Western Europe. At the same time, the gross reproduction rate remains at a high level. It is possible that a high level of effective fertility will be maintained in the Ukraine for some time.

§ 3

When the net reproduction rate is available we can carry our enquiry a stage further, and arrive at a composite picture of the combined effects of mortality and fertility rates prevailing at the present time. Unfortunately, this convenient index has only been computed for European countries and the separate States of the U.S.A. It is highly desirable that studies, similar to those which Kuczynski has already published, should be made on the population statistics of other countries. The net reproduction rates for Western and Northern Europe are given in Table XVI. In 1926 the average net reproduction rate in this part of Europe was probably 0.93. Taking into consideration these data and those already given in the preceding paragraphs, it is most unlikely that there is any large country of Western and Northern Europe with a net reproduction rate of 1.0 or over at the present time.

TABLE XVI¹

NET REPRODUCTION RATE IN WESTERN AND NORTHERN EUROPE

Country.	1925.	1926.	1927.
Denmark . . .	1.19	1.10	1.03
England and Wales . .	1.05	0.88	0.82
Finland . . .	1.15	1.09	—
France. . . .	0.94	0.94	0.91
Germany	0.94	0.89	0.83
Sweden	—	0.95	—

Excluding migration, the population of these countries must eventually die out unless considerable changes in fertility and mortality take place. While Western and Northern Europe present a picture of uniformly low and declining fertility, conditions in the rest of Europe are much more diverse. Net reproduction rates in 1928 ranged from about 0.8 in Esthonia to about 1.7 in European Russia. Generally speaking, statistics are not so complete as in the countries previously discussed, so that some of the rates to be discussed can only be regarded as estimates. In a group comprising Austria, Latvia, Esthonia, and the Western provinces of Czecho-Slovakia, the net reproduction rate was probably below unity in 1929. Hungary illustrates the erratic course of population growth in some parts of Eastern Europe. In 1922-23 its net reproduction rate was 1.13. It might have been supposed that this rate would have decreased to about 1.0 or less by 1929. Actually, mortality in the early age groups decreased more rapidly than fertility, so that the net reproduction rate was about 1.2 in 1929.

Among the countries of this group we find some of which the populations are reproducing at a positive

¹ Kuczynski, *op. cit.*

rate of increase. In addition to Hungary these include Spain, Portugal, Italy, Bulgaria, Poland, Lithuania, and the Eastern Provinces of Czecho-Slovakia. In the last three countries the net reproduction rate was about 1.3 in 1929. In all of them there has been a decrease in the last generation. In Italy the net reproduction rate was about 1.4 in 1921-22. This figure no longer holds: according to Kuczynski, "if fertility and mortality continue to develop for another decade as they have in the last decade, the population will no longer hold its own."¹ The efforts of Mussolini to re-introduce large families do not appear to have been conspicuously successful. The birth rate in Italy followed the general European trend up to 1930. There was, it is true, a slight rise in 1930 but not to the 1926-28 level. The comment of Crocker is worthy of quotation in this context. "The French League of the Fathers of Large Families are left to sustain themselves on what hardihood we may draw from the sight of Signor Mussolini's fiery strivings to salvage some part at least of the Latin heritage by compensating every Italian parent of a sixth child with a portrait of himself."² Bulgaria has shown a more rapid decrease than any of the other countries mentioned. The net reproduction rate has fallen from about 1.88 in 1901-05 to about 1.29 in 1929. In Spain and Portugal fertility and mortality rates have been fairly stable for some time, and available statistics do not as yet disclose any striking change since the pre-War period.

Russia presents a fascinating and difficult problem for the demographer. The great extent of the country

¹ Kuczynski, *op. cit.*

² *The Japanese Population Problem.*

and variety of peoples, together with the changes in government and territory which have taken place, make it difficult to estimate the present position or to draw comparisons with previous periods. In 1896-97 the average number of children born to each Russian woman was 7. This represents a higher level of fertility than is recorded for any other European country. At the same time mortality was very high, so that the net reproduction rate was 1.65, which is not remarkably high for that period. In the Ukraine, which included about a quarter of the population of European Russia, fertility was even higher than in European Russia as a whole and mortality was lower than in the rest of the country. The net reproduction rate of the Ukraine at that time was 1.96, the highest figure ever recorded for Europe. A population of stable age composition with such conditions of mortality and fertility would double itself in every generation. During the years preceding the World War the fall in the Russian birth rate was not great, particularly when the Baltic provinces are left out of account. Such decrease as occurred was balanced by a fall in mortality. Probably the net reproduction rate in European Russia, including the Ukraine, was still the same at the beginning of the War. Practically no statistics are available between 1914 and 1922, but what there are appear to show that the birth rate moved in the same way as in all other European countries. It fell considerably, and then partially recovered. The recovery continued in Russia until 1925, which appears to have been the peak year. Since then the birth rate has fallen sharply in the Leningrad and Moscow areas, the Ukraine and White Russia, and in the Western area adjoining the Ukraine.

In the rest of the European R.F.S.S.R. the birth rate has not fallen at all since 1925.

The precedence of the Ukraine over the rest of Russia has thus been reversed. In the Ukraine the gross reproduction rate has been falling steadily to 1.98 in 1929. In the rest of European Russia it has shown no tendency to fall below about 2.7. At the same time, mortality has fallen faster in the Ukraine than in the European R.F.S.S.R. In 1926-27, both the Ukraine and European R.F.S.S.R. had a net reproduction rate of about 1.7. The growth capacity of the Russian population was as high as in the pre-War period, but this result was achieved by fewer deaths in spite of fewer births. Since 1927 the gross reproduction rate has continued to fall in the Ukraine, while mortality rose in 1929, so the net reproduction rate of the Ukraine had fallen to 1.39. The present position in Russia seems to be approximately as follows. If we consider European Russia apart from the Ukraine, Moscow, and Leningrad areas, there is at present no clear indication that the net reproduction rate is likely to fall in the immediate future. As mortality in the early age group may well diminish still further, it is quite possible that the net reproduction rate may rise. In the Ukraine by itself, there are clear indications of falling fertility and a dwindling net reproduction rate.

Reproduction rates have been compiled by Kuczynski for the white population of the U.S.A. in 1919-20, and are shown in Table XVII. Although no net reproduction rates have been calculated for negroes, most authorities appear to agree that their effective fertility has always been less than that of the white population. The negro birth rate, although it has declined in the

same way, is higher than that of whites, but this is balanced by considerably higher mortality at all ages up to 60. The average net reproduction rate in that year for the U.S.A. as a whole was 1.13. It was the same as the net reproduction rate of Sweden at that time. In passing, it is worthy of comment that the highest net reproduction rate was found in N. Carolina, which is the only state having no law against contraception. Table XVII also shows the change in the gross reproduction rate between 1920 and 1926. In his article contributed to the *Encyclopædia of Social Sciences*, Kuczynski states that during these years "fertility has decreased much more than mortality, and the net reproduction rate probably no longer exceeds unity." Thus the United States have practically the same growth capacity as Western and Northern Europe. Even as early as 1920 the population of the U.S.A. was clearly tending towards a net reproduction rate of less than 1, a figure which it reached in 1926, when Professor Wolfe of Ohio stated that "Biologists and statisticians are vying with one another to show us with what astounding speed the present rate of increase, if continued, would carry us to the physical limit of subsistence." In 1920 Ohio had a net reproduction rate of 1.03. Professor Wolfe does not speak for all his compatriots. Other economists in the U.S.A. are well aware of the implications of recent population statistics. Dr. O. E. Baker, the economist of the U.S. Department of Agriculture, has stated that his Department, after having learned Kuczynski's results for Western and Northern Europe (1928), stopped promoting the extension of the agricultural area in the United States and propagated its restriction. Estimates

TABLE XVII
U.S. STATISTICS (WHITE POPULATION)
Kuczynski, *Encyclopædia of Social Sciences*

State.	Gross Reproduction Rates, 1919-26.			Net Re- production Rates, 1919-20.
	1919-20.	1926.	Per cent. Decrease.	
N. Carolina .	2.01	1.82	9	1.65
Utah .	2.01	1.71	15	1.66
S. Carolina .	1.77	—	—	1.46
Virginia .	1.73	1.44	17	1.43
Kentucky .	1.65	1.49	10	1.34
Pennsylvania .	1.53	1.33	13	1.23
Michigan .	1.50	1.38	8	1.20
Connecticut .	1.45	1.08	26	1.19
Maryland .	1.41	1.22	13	1.14
Minnesota .	1.39	1.22	12	1.17
Wisconsin .	1.41	1.22	13	1.14
Kansas .	1.35	1.22	10	1.15
Massachusetts .	1.34	1.15	14	1.09
Indiana .	1.32	1.23	7	1.08
Ohio .	1.24	1.13	9	1.03
New York .	1.23	1.09	11	1.00
Washington .	1.15	0.96	17	0.97
Oregon .	1.10	1.03	6	0.94
California .	1.02	1.16	+ 14	0.85
Montana .	—	0.91	—	—
All States .	1.38	—	—	1.13

made by Thompson and Whelpton, based on present trends of birth and death rates and allowing for immigration, gave the U.S.A. a maximum population of 155 millions in 1980 as compared with the present population of about 125 millions. According to this estimate the population may be expected to decline after 1980. Side by side with these figures and the lugubrious prognostications of Professor Wolfe, it is interesting to note that the U.S. Bureau of Agriculture estimates that the United States can provide within

its own boundaries sufficient food for a population of 300 million people without any further improvement in the technical processes of food production.¹

Precise knowledge of the growth capacity of populations as it can be measured by net reproduction rates is at present confined to the United States and Europe. Unfortunately, the application of this method is limited because, over a large part of the earth's surface, the necessary data are either completely lacking or so inadequate that calculations based upon them can only be regarded as plausible estimates. The population of China is believed to have been practically stationary for a long time. That of India is probably slowly increasing. Interest in the growth of Oriental populations is specially aroused by one country, Japan. "The Japanese Menace" or "Danger-spots in the Pacific" are all too familiar journalistic gambits. It is therefore important to examine the situation in Japan in some detail. In doing so, one must always bear in mind that the available statistics are not of the same order of accuracy as those of Europe. Most of the statements made in the following paragraph are taken from *The Japanese Population Problem*, by W. R. Crocker, who gives references to the original sources.

The first adequate census in Japan was taken in 1925. The population of Japan in 1928 was 62 millions, having doubled itself since 1878. The crude birth rate in 1928 was 34.4 per 1000, more than twice that of England and Wales in 1927. The crude death rate was 19.8. Clearly these rates gave Japan a very con-

¹ In *Problems of Population* (1932), Dublin gives an estimate of 76 millions for the population of the U.S.A. in A.D. 2100.

siderable rate of net increase. Government experts estimate an increase of 30 millions by 1957 and of 48 millions by 1965. Such estimates have no pretensions to accuracy. They do signify the undoubted fact that under present conditions of fertility and mortality the population of Japan is increasing rapidly. The age composition of Japan differs very materially from that of the U.S.A. and Europe. The percentage of females aged 15-49 is 47 as compared with 54 in England. The fertility of the Japanese is thus relatively larger than the crude birth rate might suggest. The smallness of the reproductive group is associated with a large group of individuals under 15, among whom mortality is not only as in other countries relatively great but conspicuously greater in comparison with the reproductive period. Other things being equal, any change in the age composition of the population towards the proportions prevailing in Europe would tend to raise the birth rate and lower the death rate. Table XVIII summarizes the available information about changes in mortality and fertility. Columns (4), (5), and (6) are taken from Crocker. There appears to have been a fall in the marriage rate since 1908. Between 1898 and 1908 the average number of children born to each married woman seems to have increased. Since 1908 it appears to have fallen. The fall in fertility is most conspicuous in the group of younger mothers, whom we should expect to be most influenced by social changes such as the spread of birth control. Thus Japan is possibly on the threshold of a period of declining fertility similar to the decline which has taken place in Europe. The full effects of any fall in fertility will be masked for some time by changes in the

peculiar age composition and by a falling death rate.¹

While the Japanese population is certain to increase rapidly for some time, analysis of changes in fertility and mortality suggest the possibility that Japan is destined eventually to travel the same road as North-Western Europe or the United States of America.

TABLE XVIII

CHANGES IN FERTILITY AND MORTALITY IN JAPAN

Year.	(1) Crude Birth Rate.	(2) Crude Death Rate.	(3) Infant Mor- tality.	(4) Average Births per Married Woman, 15-44.	(5) Average Births per Married Woman, 15-29.	(6) Marriage Rate. No. of new Marriages: Woman, 15-29.
1898	34.2	23.3	—	0.27	0.62	—
1908	—	—	—	0.31	0.76	7.4
1918	—	—	—	0.29	0.73	7.1
1920	36.2	25.4	168	—	—	—
1925 } 1926 }	34.8	19.2	138	0.26	0.56	6.9

The length of time which will have elapsed between the beginning of a decline of the birth rate and the beginning of a decline in the population of England, may be taken

¹ Certain inconsistencies are apparent in the complete data given by Crocker, probably owing to the unsatisfactory nature of the official statistics before 1925. Analysis of more recent data will be necessary before any definite conclusion can be arrived at about the state of fertility in Japan. The writer has had the opportunity of seeing the calculations of Dr. Kuczynski of the fertility rate, *i.e.*, the number of births related to the number of women of child-bearing age from 1908 to 1930. This rate was at a maximum during these years of 148 in 1925, and then dropped to 141 in 1930. These figures do not confirm the view of Crocker that a fall in fertility occurred between 1908 and 1925.

as about two generations. While it would be rash to assume that this fact gives any clue to the length of time such a process might take in Japan, it does give some indication of the order of magnitude of the time period during which spectacular changes in population can take place. Probably the prospects of a declining population would not have seemed any less remote to the Englishman of 1880 than they do to the Japanese of to-day.

The Japanese themselves are naturally less concerned with the state of the population 50 or a 100 years hence than with the problems raised by the addition of many millions during the next few years. A factor which is believed to exacerbate the situation is the relative density of the population in Japan. When the number of inhabitants is compared with the total size of the country, England, Belgium, and the Netherlands are seen to be more densely populated than Japan; but there is in Japan less cultivated land per person than elsewhere. Crocker estimates that the cultivated areas correspond to between a quarter and a third of an acre per head of the total population. He considers that the amount of food which can be produced in Japan with existing methods has nearly reached a limit.

It must not be forgotten that the undoubted industry and ability of the Japanese have been exercised on a very different plane in industry on the one hand and agriculture on the other. The flow of capital and the application of scientific technique have been directed towards industry. Agriculture remains in an extremely primitive state. Apart from an intelligent and extensive use of fertilizers, there do not appear to have

been any noteworthy scientific improvements in food production such as have occurred in Europe, America, and the European colonies. If the energy which Japan devotes to industry, and more especially to armaments, were in part diverted to the co-operative development of the food resources of the community, the present relation between the density of the population and the available food supply could be greatly changed. This being so, the onus of proof lies on those who assert that an aggressive military policy is a necessary consequence of the growth of the Japanese population.

The available population statistics of South America are unsatisfactory for our present purpose. Brazil with a population of nearly 43 millions was unable to furnish any figures of birth and death rates for the *League of Nations' Statistical Year Book* for 1932-33. The same is true of Peru. The three largest countries for which current birth and death rates are available are Argentine, Colombia, and Chile. Birth rates in all three countries appear to be very high. Chile has a high death rate, but mortality is reported to be low in Argentine and Colombia. All three countries thus show a large excess of births over deaths. While they have participated in the almost universal decline in mortality, the crude birth rate has not yet begun to decline steadily, except in the Argentine. In the latter country there has been a steady though very gradual decline in the crude birth rate figures during the last two decades.

Statistics for the British Dominions are sufficiently accurate to make it possible to determine gross and net reproduction rates. This task is now being carried out by Dr. Kuczynski, whose results are not yet published.

Until such data are available, the main point of interest which arises in connection with these countries is the extent to which the fall in mortality has proceeded. Australia and New Zealand have the lowest published death rates in the world. In 1931 they were 8·7 and 8·3 per thousand respectively. At the same time, the birth rates have followed a course of rapid decline similar to that which has taken place in Western Europe. In 1931 the crude birth rate for these two countries was about the same as that of Belgium and Denmark. It has not yet fallen as low as in Great Britain and some other European countries. Australia and New Zealand may thus be still in a position to maintain a stationary population. It is clear that if the fall in the birth rate continues on its present course they will soon be unable to do so, in spite of the very low death rate. In Canada the birth rate has not fallen so steadily. It is still comparatively high, while the death rate is very little higher than in the other dominions. There is at present a large excess of births over deaths. The Catholic province of Quebec contributes to the relatively high birth rate of Canada. It may also be partly due to the existence of a considerable immigrant population from Eastern Europe retaining for a time their high fertility habits and at the same time subjected to the low mortality of Canada.¹

¹ According to Kuczynski (*Birth Registration and Birth Statistics in Canada*) the gross reproduction rate in Quebec in 1926-27 was 2·25. In 1928 it was 2·21. In English-speaking Canada as a whole it was 1·56 in 1926-27. In Ontario and the Maritime Provinces fertility "approaches the present low level of Western and Northern Europe."

§ 4

In reviewing the facts set forth in this chapter we can divide the world roughly into industrialized and non-industrialized portions. The two principal non-industrialized countries, India and China, between them account for about two-fifths of the world's population. Their populations are probably more or less stationary. In the more industrialized part of the world we have discussed the state of affairs in the United States, Europe, and Japan. These countries account for nearly another two-fifths of the world's population. In the United States and most of Europe a developed industrial civilization is found, in conjunction with a net reproduction rate of less than unity. Russia, Italy, and Japan have begun the process of industrialization much later than Western Europe, and are proceeding to carry it through with great rapidity. Italy and Japan are peculiar in that they are endeavouring to build up a manufacturing and food-importing economy at a time when the old machinery of exchange between specialized manufacturing and food-producing countries appears to be breaking down.

An increasing population has always accompanied industrial development. Industrial development has led to the result that the number of new and profitable markets has become limited. Industrialists who secure those that are available profit accordingly. The situations to which a rapidly increasing population in one country gives rise, concern the distribution of profits between rival groups of industrialists. We may doubt whether they are less acute in England, where the population is about to decline, than in any other

country. Such questions only affect the even distribution of available food throughout the world indirectly. One of the most cherished social dogmas of our generation is that over-population is a "cause" of war. Even so discriminating and critical a student of population problems as Dublin asserts, as if no proof were necessary, that "the World War was essentially an outgrowth of a pressing population problem. . . . In Japan the intense pressure of population in the Island Kingdom accounts for its desire to spread out to unsettled areas near at hand. . . . The mistrust thus aroused is responsible for the rapid growth of the war spirit." ¹

By over-population is meant a population that is rapidly increasing under certain economic conditions. An increasing population of this kind is a cause of war, just as much as, and no more than hydraulic sanitation or sewing machines. Italy and Japan are trying to develop rapidly a type of civilization that in other parts of the world has begun to fall to pieces. They focus conflicts which arise not from any inherent disharmony between the number of people alive in the world and the available food, but from the absence of a planned ecological relationship between man and the planet on which he lives. The most novel and significant fact which has emerged from a survey of world population conditions is the very low growth capacity of the more highly industrialized nations. Since 1928 Germany, Austria, England and Wales, and some states in the U.S.A. have had a gross reproduction rate of less than unity. We have also seen that in the remainder of the U.S.A. and North-Western Europe, the fertility was

¹ *Population Problems.*

declining rapidly. It had already reached a level so low as to suggest that in the last six or seven years conditions similar to those in England and Germany have been reached over the whole of this region. The significance of a fractional gross reproduction rate has already been emphasized. In the periods of rapidly increasing population of which we have most accurate knowledge the main factor was the sharp decline in mortality. The new situation which has been disclosed dispenses altogether with the need for discussing the effects of further reduction in mortality. No change in the risk of death short of a recipe for immortality can avert ultimate extinction if fertility remains at its present level.

Whether it is desirable or not that populations should die out is not a matter for the social biologist to decide. Our concern is to analyze the factors involved in the present decline. An understanding of these is the necessary foundation for any programme which may be formulated in the future, if there emerges a determination to arrest the process of diminution. Many people believe that it would be desirable to reduce the population of this country to below its present level, and then to keep it stationary. Such a view merely postpones for a few years the time when the problem of declining fertility will have to be faced. We have no reason to believe that the decline will stop at any fixed point unless we also have reason to believe that factors responsible for the decline are going to change or that they can be changed at that point. The practical conclusion which emerges from the application of the new statistical methods introduced by Kuczynski is that the populations of the U.S.A. and North-Western

Europe can only be maintained in existence by increasing the average number of girls born to each woman. They can be maintained in no other way. The future of population in the United States and North-Western Europe thus depends on either removing obstacles to parenthood or finding new incentives to the production of more children. Light can be thrown on the problem by examining the different reproduction rates of people living under different social conditions. The varying fertility of urban and rural populations, of different occupational classes, and of groups with different standards of life and modes of living will form the subject of the next chapter. We shall then be equipped to decide upon the nature of some of the relevant factors affecting declining fertility.

The conditions of population growth in contemporary Russia vividly recall other aspects of the question which will have to be faced. The net reproduction rate in Russia is very much higher than anywhere in Europe. In 1927 the Russian rate was more than twice the net reproduction rate of England and Wales. In spite of a high rate of reproduction there is no over-population problem in the U.S.S.R., nor is there any obvious reason to think that its numbers constitute in any sense a menace to the peace of the world. Russia is in some ways in the same position as the United States after its revolution. It is building up a new type of economy in a country with vast undeveloped internal resources. Any increase in population in the near future will be advantageous to the U.S.S.R. It remains to be seen whether the process of industrialization has been too recent to affect fertility or whether fertility is being maintained by the still very large preponderance of

people living under rural conditions. In all other countries the introduction of industrialism has involved fundamentally similar arrangements for the control of production and distribution of commodities. The social arrangements which these involve also have many common features which do not exist in Russia. It is possible that conditions of life in any mechanized civilization may tend to lower fertility. On the other hand, concomitant social factors which are not found in Russia may be the principal agencies responsible. Some of the factors limiting fertility in Europe are being put into operation in Russia with great thoroughness. Abortion is legalized, and at present it is the policy of the state to make contraceptive information available to all. At the same time, the U.S.S.R. is attacking the problem of food supply by systematic research and utilization of all possible means of improving and extending food production. A notable example of the beginning of a planned ecology within the planned economy is shown by the projected search for unfamiliar plants which might be extensively and profitably cultivated for food. In this respect Russia displays, as other countries do not, the beginning of an attack on the fundamental population problem, the future of man in a biologically planned universe.

The most important conclusion which has emerged in this chapter is that in parts of Europe and America the population has already ceased to be capable of maintaining its numbers. It cannot be too clearly emphasized that this statement is not a prediction of future events based upon extrapolation from a series of statistics but a description of what is actually happening at the moment. In the cities of England,

the United States, Germany, and Scandinavia there are not enough babies being born to replace the present generation. In other parts of Europe the same process appears to be at work, though an equally advanced stage has not yet been reached. Everywhere, except possibly in Russia, industrialism is accompanied by declining fertility, which has dropped to a level corresponding to the stage of economic development. In Japan, the most recently industrialized nation, Crocker discerns the beginnings of a declining birth rate. When placed against the biological background outlined in the first chapter, the Japanese situation is seen to be a symptom of strains in the social machinery rather than scarcity in the means of subsistence.

The facts which we have studied supply the raw materials for a biological assay of the civilization in which we live. Although industrialism has reduced mortality very considerably, it is a biological failure because it has lost the capacity to reproduce itself. The devastating significance of this fact is difficult to grasp in a society which has built up a pattern of social behaviour on the assumption that too many people are being born. Some writers on population problems have consoled themselves with the reflection that civilizations pass through cyclical phases of rising and falling fertility. It is hard to understand the mental processes of those who consider that such a generalization is a contribution to the population problem. It amounts to saying that fertility has differed in different times and places. It gives no clue to the nature of the phenomena occurring at the moment and no indication of the future course of events. The interpretation of

the significance of current population statistics involves three main considerations. First, we must ask whether the phenomena we are witnessing represent a new phase in world history due to the increasing ease with which man can control his reproductive activities. We must next enquire how far the conditions which have brought about these phenomena are cumulative in nature, and whether or not they are likely to be intensified in the near future. Finally, we must ask whether contemporary conditions are producing a social tradition which tends to perpetuate itself. Later chapters will attempt to answer these questions.

To confront the facts of population decline with the assertion that there are too many people in the world or that it does not matter if the human race dies out is merely flippant and generally insincere. It is perhaps natural that people who are addicted to privacy and rural surroundings should deplore the present density of population in Great Britain or Japan, though it is arguable that the density of the population in these two countries would not be excessive if its distribution were rationally planned. Those who put forward this plea do not stop to examine the process by which their objective could be obtained or to consider whether a decline in population with a rising proportion of the aged provides the economic conditions for rehousing the people in country cottages. Whatever may be the desirable density of population in any country, the first requirement for attaining it is the social, as opposed to the individual, capacity to control the course of fertility in the desired direction. When a sports car is rushing downhill without brakes, it is no comfort to be told that the scenery may be more

delightful a few yards further on. The crash at the bottom is our first concern.

In later chapters analysis of the factors underlying low fertility will indicate that unless a social change of considerable magnitude takes place it is likely to be intensified. To say this is not to adopt a fatalistic attitude. The business of science is not to predict but to prescribe. Analysis of the population situation would be so much waste of paper if it did not provide the necessary materials for a reorientation of human activity. When we have completed our task we may hope to arrive at a clearer understanding of the kind of social machinery which will enable civilized man to maintain a fertility consistent with the survival of the individual and of the species.

CHAPTER IV

THE COMMUNITY WITHIN THE COMMUNITY

Significance of Differences within National Units—The Quantitative Aspects of Differential Fertility—The Progressive Diminution of Differential Fertility—The Selective Significance of Fertility and Death Rates—Bearing on the Course of a Declining Birth Rate.

§ I

THE previous chapter unfolded a picture of declining fertility and loss of growth capacity in the United States and a large part of Western Europe. This naturally leads us to ask what agencies have brought about such a situation and to what outcome they are likely to lead. Before attempting to answer these questions we may carry our analysis of population growth a stage further. Hitherto we have considered the trend of fertility and mortality in national populations regarded as homogeneous units. We have paid no attention to the fact that there are big differences in fertility between groups of people belonging to the same nation. The difference between the fertility of rural and urban communities in the United States or in Germany is far more striking than the difference between the fertility of these two nations as a whole. Likewise, the net reproduction rates of New York and Moscow are not far apart, although Russia as a whole has a much larger total net reproduction rate than the United States.

Analysis of the fertility of groups within a nation

presents considerable difficulties. Figures are usually extracted from the national census, although occasionally special studies have been made of a district or occupational group. Census questions cannot be framed so as to throw light on all the issues which the student of population would like to raise. We can seldom obtain gross reproduction rates of separate groups within a nation. Still less often are net reproduction rates available. Of necessity, a variety of statistical indices will be introduced in the course of the ensuing discussion. Some of the figures are corrected for age composition and others cannot be. All figures referring to differential fertility must be perused with judgment and a recognition of the many limitations to which they are subject.

Differential fertility rates are of interest from several points of view. Observation of the different rates of reproduction of people living under different social conditions may provide information about social agencies associated with the low fertility which is now so widely prevalent. Where different fertility rates prevail we are led to ask whether the recorded differences are likely to persist and, if not, what effect their disappearance will have on the growth capacity of the community as a whole. In all that has been said so far we have considered quantity of population alone, irrespective of the kind of people who make up a population. The existence of differential birth rates has led to many discussions about possible changes now taking place in the quality of populations. A phenomenon which has especially alarmed writers of the eugenic movement has been the relatively higher fertility of the less prosperous classes.

Accurate analysis of net fertility in different social groups is difficult. In this chapter very little reference will be made to differential mortality. Referring to a study of differential fertility among the social classes of England and Wales, Newsholme comes to the conclusion that "greater survivorship does not go far to compensate for lower fertility."¹ This appears to be increasingly true as the general death rate falls. The order of social classes in respect to fertility was affected less by taking into consideration mortality in the marriages of 1896-1901 than in those of 1861-71. Although high fertility usually goes hand in hand with high mortality, the latter is not usually high enough to compensate for the former.

In discussing the possible effects on future generations it is difficult to hold the balance evenly between pseudo-scientific rationalizations of personal preferences and the over-cautious reticence which undisciplined speculations encourage the scientist to adopt. In any ecological unit the struggle between the different members tends to preserve or eliminate individual variations within a species. When investigating the human species the scientist does not have the opportunity to make his observations with a standardized environment, such as the agar culture bottle in the incubator which the animal geneticist employs for the study of selection among fruit flies. Advances in the study of animal heredity have been facilitated by the provision of a uniform environment for different genetical types. The differences between human groups living in widely different social environments are not comparable to the differences shown by

¹ *Vital Statistics.*

genetically unlike groups of animals living in the same environment. The ideal requisite for the study of inherited human differences is the removal of inequalities of environment. Failing this, we need more refined methods of analysis than are often regarded as adequate before we can draw any justifiable conclusions about the distribution of genetic types in a population.

§ 2

Within all communities we generally find a different level of fertility in rural and urban areas. The distinction between rural and urban areas involves an occupational difference as well as a different mode of life, since most, though not all, adult male inhabitants of rural communities are engaged in agriculture. Usually, rural communities have a higher fertility than contiguous urban populations. This is apparently, but not conspicuously, true of England and Wales for which the relevant data are summarized in the table on p. 112. The figures given are not corrected for differences of age composition.

An examination of the English data reveals that the differences between rural and urban areas are not so striking as the consistent difference between the northern and southern districts of either type. The high fertility of the London area also calls for comment. A possible explanation lies in the relatively large proportion of comparatively recent immigrants from other countries with higher fertility. The difference between rural and urban areas in the United States is more striking. In this case we are on surer ground. From data given by Whelpton and Thompson it is possible

TABLE XIX

THE RATIOS OF THE NUMBER OF CHILDREN BORN AND OF CHILDREN SURVIVING PER 100 COUPLES (WIFE UNDER 45 YEARS OF AGE AT CENSUS) FOR CERTAIN CLASSES OF AREA AND SECTIONS OF ENGLAND AND WALES TO THE CORRESPONDING FIGURES FOR THE WHOLE POPULATION TAKEN AS 100

	England.						Wales.		England and Wales.	
	North		Midland		South		Born.	Sur-viving.	Born.	Sur-viving.
	Born.	Sur-viving.	Born.	Sur-viving.	Born.	Sur-viving.				
London . . .	—	—	—	—	99	98	—	—	—	—
County Boroughs . .	102	97	102	100	88	90	107	105	101	98
Other Urban Districts . .	99	97	97	100	89	93	112	109	98	98
Rural Districts . . .	107	109	103	109	96	103	110	112	103	108
All Areas . . .	101	98	100	102	95	97	110	109	100	100

to compute gross reproduction rates which are exhibited in the next table.

TABLE XX¹

GROSS REPRODUCTION RATES IN URBAN AND RURAL AREAS AND
SELECTED STATES IN THE U.S.A.

	Native-born White Women.	
	1920.	1929.
U.S. Urban	0.98	0.83
U.S. Rural	1.83	1.47
Mass., Conn., and N.Y.	1.02	0.89
Southern States	1.77	1.36
	Foreign-born White Women.	
	1920.	1929.
U.S. Urban	1.80	1.22
U.S. Rural	2.54	1.79

Both in 1920 and in 1929 there is a very pronounced disparity. Possibly the greater proportionate decrease in fertility in the rural areas may be an indication of a levelling-down tendency. It remains a fact that the difference in fertility was still very great in 1929. In the Ukraine in 1926-27 the gross reproduction rates for the urban and rural districts were 1.53 and 2.77 respectively. Apparently the discrepancy between urban and rural fertility is greater in sparsely populated countries like the U.S.A. and Russia than in a densely

¹ The figures given by Whelpton and Thompson are partly estimates. They probably exaggerate the difference between urban and rural fertility. The rural rates given may be characteristic of rural areas in remote parts of the country, but it is unlikely that they correctly represent the fertility of people living under rural conditions near large towns.

populated country like Great Britain, where no part of the population is far removed from a large urban centre.

A bird's-eye view of fertility in America and Europe presents an appearance of something analogous to what Professor Elliot Smith calls the diffusion of culture. The forces producing low fertility appear to fade away as we recede from the congested centres of population. France presents the only striking exception known to the rule of higher rural fertility. The decline in the European birth rate began in Normandy in the early years of the nineteenth century and spread slowly to other parts. Although areas of high fertility remain in Brittany, French Flanders, and Auvergne, the birth rate is, generally speaking, somewhat higher in the towns than in the rural districts of France. If Paris is excluded from the former there is no consistent difference between the crude birth rates of town and country during the last decade.¹

Attempts to compare the fertility of different occupational and social classes have now been made in several countries. Bertillon, in 1901, appears to have been foremost in directing attention to the disparity between the more and less prosperous classes. His figures are given in Table XXI. In the Registrar-General's report on the 1911 Census in England and Wales, marriages of different durations were tabulated for the different social classes. The population was classified in eight social groups. Classes I, II, III, IV, and V corresponded more or less to the upper and middle classes, skilled, semi-skilled and unskilled workers,

¹ League of Nations, *C.E.L.*, 4 (1). *Revue d'Econ. Politique*, Mars-Avril, 1929.

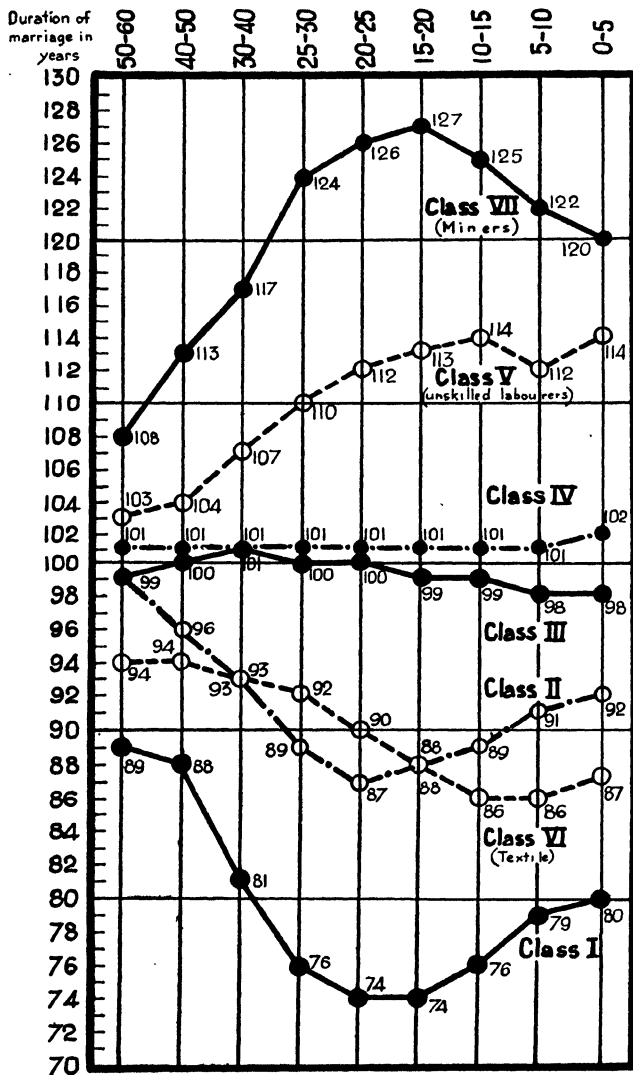
respectively. Classes VI, VII, and VIII were composed of textile workers, miners and agricultural labourers respectively. These three classes were strictly occupational categories. In Classes I to V, occupations were grouped together in a series of diminishing prosperity and social prestige. The standardized total fertility of marriages in the various groups is shown in Fig. 5 as a percentage of the corresponding rates for occupied persons of all classes.

TABLE XXI

BIRTHS PER 1000 WOMEN, AGED 15 TO 50 PER ANNUM, IN DIFFERENT QUARTERS OF LONDON, PARIS, BERLIN, AND VIENNA (Bertillon.)

Classes of Population.	London.	Paris.	Berlin.	Vienna.
Very Poor	147	108	157	200
Poor	140	95	129	164
Comfortable	107	72	114	155
Very Comfortable . .	107	65	96	153
Rich	87	53	63	107
Very Rich	63	34	47	71
Average per 1000 women.	109	80	102	153

The disparity in fertility between the classes appears to have been at a maximum about 1891 and since then to have decreased somewhat. The low fertility of textile workers is usually attributed to a very high proportion of employed married women. The high fertility of miners may be partly accounted for by the fact that in the prosperous period of the mining industry, employment was assured and a miner reached his maximum earnings at a very early age. The significance of the figures given for marriages of long duration has been rightly criticized by R. A. Fisher. The chief objection is that census returns only give informa-



From Sir Arthur Newsholme's "Elements of Vital Statistics" (Allen & Unwin).

FIG. 5.—Standardized total Fertility of Marriages of Various Dates in Different Social Classes, each stated as a percentage of the corresponding rates for occupied persons of all classes jointly, for the same duration of marriage.

tion about survivors who may not be a representative sample of persons born at the same time. If people who live long are on the whole more fertile, census returns will tend to give a higher estimate of fertility as we go backwards in time. Fisher comments: "While the period of class equality is thus quite hypothetical, the increase in the disparity, since the middle of the nineteenth century cannot reasonably be denied."

TABLE XXII ¹

ENGLAND AND WALES: LEGITIMATE BIRTH RATES IN CERTAIN SOCIAL CLASSES, 1911 AND 1921

	1911. Births per 1000 Married Men under 55 Years of Age.	1921. Births per 1000 Married Men under 55 Years of Age.
1. Upper and middle class	119	98
2. Intermediate	132	105
3. Skilled workmen	153	134
4. Intermediate	158	153
5. Unskilled workmen	213	178
6. Textile workers (not included above)	125	110
7. Miners (do.)	230	202
8. Agricultural labourers (do.)	161	155
9. Working classes	175	152
All classes	162	141

Table XXII shows the changes in the legitimate birth rate per 1000 married men in the different social classes between 1911 and 1921. In these years the figures cited do not appear to indicate any noteworthy change in the respective contributions of different groups to the total birth rate.

¹ Figures for 1911 from the *Annual Report of the Registrar-General*, 1912, p. xxiii. Figures for 1921 were supplied by the courtesy of the Registrar-General and are as yet unpublished.

A study made by Sydenstricker and Notestein (*Am. Stat. Ass.*, 1930) on a random sample of the population of the U.S.A. in the Census Year 1910 yielded results similar to those obtained in England.

TABLE XXIII

STANDARDIZED CUMULATIVE BIRTH RATE FOR EACH URBAN AND RURAL SOCIAL CLASS (U.S.A. CENSUS, 1910)

Urban Sample :

Professional	129
Business	140
Skilled Workers	179
Unskilled Workers	223

Rural Sample :

Farm Owners	247
Farm Renters	275
Farm Labourers	299

To Fisher's remarks cited in a previous paragraph, we may add that a decrease in the disparity since the date at which Stevenson's enquiries terminated is not less striking than the undeniable increase to which he directed attention. Latterly, a number of studies have shown that, at least in certain parts of Europe, the differential birth rate between classes has either mainly or wholly disappeared. Table XXIV gives the results of one of the best and most recent occupational and social censuses which was taken in Bremen.

In 1901 the birth rate in the labouring population was more than three and a half times that in the wealthy classes. In 1925 it was less than a third larger.

The same thing has happened in Stockholm, where in 1927 Eder's enquiry into birth rates showed that complete parity had been reached between the birth rates of the wealthier and poorer districts. Table XXV gives the figures for the birth rate in the two districts of Stockholm from 1911 to 1927.

TABLE XXIV
BIRTH RATES IN BREMEN

	1901.		1925.	
	No. of Inhabitants.	Births per 100 Inhabitants.	No. of Inhabitants.	Births per 100 Inhabitants.
Wealthy Districts	8,952	1.27	17,584	1.47
Middle Class Districts . .	24,303	2.89	36,526	1.42
Artisan Zone . .	12,386	4.37	23,507	1.95
Mainly Labouring Population .	11,636	4.62	9,779	1.89

TABLE XXV
BIRTH RATES IN STOCKHOLM

Year.	Wealthier District.	Poorer District.	Per cent. of Wealthier.
1911 . . .	66	92	139
1916 . . .	48	58	121
1921 . . .	47	50	106
1927 . . .	36	36	100

TABLE XXVI
(a) *Bavarian Family Statistics for Officials :*

	Higher.	Lower.	Middle.
1916 . . .	1.5	1.7	2.5
1926 . . .	1.02	1.15	1.2

Average No. of children per official.

(b) *Bremen Occupational Census (Roument) :*

	Professional.	Labourers.
1901 . . .	2.59	3.96
1925 . . .	1.58	1.61

Births per 100 individuals.

Table XXVI gives data presented by Grotjahn to the World Population Congress in 1927. This concerns Bavarian civil servants and two selected occupational classes in Bremen.

Both sets of figures in Table XXVI illustrate the tendency towards the equalization of birth rates which were formerly at different levels.

More recent figures relating to the fall in differential fertility were published by Dr. Tietze in the *Eugenics Review*, April 1932. They refer to Prussia in the quinquennium 1925-29, and were obtained by dividing the number of legitimate live births by the number of marriages. The results obtained are shown in Table XXVII. The differential birth rates shown in this table appear to distinguish groups of people having different modes of life rather than different economic status. The rural population has a higher fertility than the average. The professional class as a whole has a lower fertility. Within the "Industry" and "Trade" groups, the wage-earners have an invariably lower fertility than the owners. This is a complete reversal of the picture presented by differential fertility rates in the earlier part of this century.

Such information leaves little doubt that the decline in the birth rate began among the more prosperous classes, and that the pronounced differential fertility, which existed in the early years of the twentieth century and provoked so much eugenic speculation and propaganda was a temporary and exceptional phenomenon. It would be going too far to assert that there was no differential fertility before the decline of the birth rate or that there is likely to be none in the near future. We have some reasons for presuming that differential

fertility of the social classes is tending to disappear, because the most recently compiled statistics indicate that it has actually disappeared in some large cities and also because a general levelling-down tendency is recognizable in many communities where a difference still persists.¹

TABLE XXVII
FERTILITY RATES IN PRUSSIA, 1925-29
(Tietze.)

Liberal Professions :

Artists and Writers	1.0
Engineers	1.1
Doctors	1.6
Lawyers	1.7
Clergymen	2.4

Industry and Trade (A) Owners :

Merchants	2.1
Butchers and Bakers	2.3
Tailors and Shoemakers	2.6
Smiths and Locksmiths	3.0
Innkeepers	3.1
Masons and Carpenters	3.8

Industry and Trade (B) Wage-earners :

Butchers and Bakers	1.0
Waiters	1.1
Tailors and Shoemakers	1.2
Clerks and Foremen	1.3
Metal Workers	1.5
Textile Workers	1.8
Masons and Carpenters	2.1
Miners	2.7

Agriculture :

Farm Labourers	2.3
Peasants	3.9
Total Population	2.0

¹ A more recent study of fertility in Stockholm presented by Edin to the 2nd Assembly of the International Union for the study of population problems confirms that already quoted. Only marriages of 1919 were studied. Their fertility in the ensuing ten years was followed. The most wealthy class had a fertility rate of 163 as compared with 117 in the least wealthy. The percentage of sterile marriages was 36.3 in the latter class as compared with 19.6 in the former class.

Within a single country a different level of fertility may distinguish groups of people with recognizably different social mores. Noteworthy examples of the *community within the community* are provided by Catholics and Jews. The division may not be without occupational significance, since Catholic communities are often predominantly rural; while Jews much less frequently choose agricultural pursuits. The movement of the Catholic birth rate is particularly interesting, because Catholic doctrine is officially hostile to birth control. The significance of the Catholic birth rate in connection with the contraceptive hypothesis will be dealt with later. For the present we are only concerned with examining the facts. Generally speaking, Catholic countries have a higher birth rate than non-Catholic countries. On the other hand, the birth rate declined first in two predominantly Catholic countries, France and Ireland, and is now conspicuously low in Austria which is predominantly Catholic. Fertility in Ireland has since been relatively high, but that of France has continued to decline and now occupies an intermediate position among the neighbouring Protestant countries. Catholics have a higher birth rate than Protestants living in the same country. Table XXVIII gives Catholic births and all births in England from 1922 to 1925. The figures are taken respectively from the *Catholic Directory* and from the Registrar-General's Returns. The Catholic birth rate was decidedly higher than the birth rate for the whole country. The fall in the Catholic birth rate between 1922 and 1925 was, however, proportionately greater than the fall in the birth rate of the whole country.

The Jewish birth rate is usually slightly lower than

that of the rest of the community. Data have been collected for Bavaria showing the different fertility of Catholic, Protestant and Jewish marriages.

TABLE XXVIII
CATHOLIC BIRTHS IN ENGLAND (Heron)

	From the <i>Catholic Directory</i> .			From the Registrar-General's Returns.		
	Bap- tisms.	Mar- riages.	Ratio of Baptisms to Mar- riages.	Births.	Mar- riages.	Ratio of Births to Mar- riages.
1922	70,349	20,159	3.49	780,124	299,524	2.60
1923	68,445	20,210	3.39	758,131	292,408	2.59
1924	67,565	20,394	3.31	729,933	296,416	2.46
1925	65,411	20,635	3.17	710,979	295,166	2.41

TABLE XXIX
BAVARIAN BIRTHS

(a) *Legitimate Births* (Krose) :

	1891-95.	1913.
Wholly Catholic Marriages . . .	5.2	4.7
„ Protestant „ . . .	4.2	2.9
„ Jewish „ . . .	3.3	2.2

(b) *Ratio of Yearly Births to Marriages of Previous Years* (Lenz) :

	1913.	1920.
Wholly Catholic Marriages . . .	4.0	2.0
„ Protestant „ . . .	3.0	1.6
„ Jewish „ . . .	1.8	1.0

Throughout the period covered by Table XXIX Catholic fertility was uniformly higher. Between 1895 and 1913 all three fertility rates fell, but the fall was greater in the Jewish and Protestant rates. Between 1913 and 1920 the Catholic rate fell proportionately

more, so that the disparity was greatest in the 1913 figures. In 1920 the disparity was about the same as in 1891-95 but on a very much lower level.

Ethnic differences in fertility have already been apparent in comparing fertility levels in different countries. In the United States we have the opportunity of observing the fertility of two well-defined races within the same nation. The figures already given in Table XX have shown the higher fertility of white women from foreign countries as compared with white women born in America, and also the very steep fall in the fertility of the former during recent years. After the first generation the descendants of immigrants become native-born and presumably approximate to the general level of low fertility. The rate of increase or decrease of the negro population is not complicated by this fact. Racial continuity is not lost after one generation. Accurate estimates are very difficult since so many negroes live in parts of the States where registration is imperfect. It is believed by some that the number of negroes recorded in the 1920 Census was far below the true figure. The present negro and coloured population of the States is about 10 millions. East gives statistics for the growth of the white and dark populations from 1790 to 1920. These show a consistently lower figure for the percentage rate of increase of the latter. At the time of writing (ten years ago) the negro population was decreasing slightly in proportion to the whites. Since then there is some evidence that the negro rate of decrease has suffered a check. In the North Central States the gross reproduction rates of negroes rose very slightly between 1920 and 1929 from just under to just over unity, as

TABLE XXX
TREND OF BIRTH AND DEATH RATES AND TRUE NATURAL INCREASE, 1920-1928. U.S.A.

	Crude Birth Rate.			Infant Mortality.			Crude Death Rate.			True Rate of Natural Increase.		
	1920.		Change.	1928.		Change.	1920.		Change.	1920.		Change.
<i>Whites:</i>												
Va., N.C., S.C., Ky.	28.7	23.9	-4.8	72.9	72.0	-0.9	11.1	10.8	-0.3	19.7	12.8	-6.9
<i>Negroes:</i>												
Southern States	28.3	25.2	-3.1	128.2	111.9	-16.3	17.3	17.0	-0.3	13.0	8.9	-4.1
Northern States	21.6	23.0	1.4	162.0	117.0	-45.0	21.0	20.1	-0.9	-4.8	-1.1	3.7
Large Cities	23.3	24.1	0.8	156.2	114.6	-41.6	21.2	20.3	-0.9	-12.7	-9.9	2.8

shown in the preceding table. The calculations in Table XXX are by Whelpton, and the table is taken from Woofter's *Races and Ethnic Groups in American Life*. The determination of the "true natural increase" is based on the same principle as the net reproduction rate. It indicates the *annual* rate of increase or decrease which would be seen in a population of which the prevailing fertility and mortality rates had remained constant long enough to achieve a stable age composition. The net reproduction rate represents the rate of increase or decrease in a generation on the same assumption. Whelpton concludes that "taking all areas as a whole the decline in true rates from 1920 to 1928 amounted to about 60 to 65 per cent. for whites and 30 to 45 per cent. for negroes."

§ 3

If the differential fertility of the social classes is an ephemeral phenomenon, it is hardly necessary to discuss at length its bearing on the quality of a population. However, it undoubtedly existed at the beginning of the century, and we are not in a position to state definitely that it will disappear altogether within the coming generation. The urban-rural differential birth rate still persists. In many parts of the world it seems almost certain that there is still some measure of differential fertility between different social classes. All that we can say with confidence is that recent tendencies do not confirm the alarmist assertions which eugenists made about the qualitative effects of differential fertility ten or twenty years ago.

Profitable discussion concerning the qualitative significance of differential fertility depends upon

whether, by any agreed standard, groups in the community which have recognizably different survival rates are superior or inferior in hereditary equipment. Encouragement or discouragement of individual stocks which are by general agreement socially valuable or retrograde is an essential feature of any project for a planned ecology with man as its pivotal species. A project of this kind must be based upon convincing scientific evidence for the genetic differentiae of such stocks. This task need not be compromised by the prevailing disposition of eugenists to identify the perpetuation of individual stocks with the rate of reproduction of social groups whose distinguishing characteristics may be of purely environmental origin. Differences between social groups might conceivably involve genetic differences, such as we encounter in a polymorphic species like the primrose with its thrum-eyed and pin-eyed varieties. On the other hand, differences between social groups may be mainly determined by environment, as appears to be true of the caste system in social hymenoptera. The woolly, wavy, and straight hair of Negro, Caucasian, and Chinese types in America provide an example of how a difference between social groups may be determined by heredity. The different languages spoken by French and German communities in Switzerland is equally certainly due to environment. *A priori* it is not easy to be sure when we are dealing with one or the other. A permanent wave can do as much for a Mongolian as Nature can confer on a Caucasian.

Studies on group differences with respect to social behaviour are necessarily limited by the paucity of strictly objective and quantitative methods for de-

scribing it. Of such methods as are available at present the intelligence tests devised by Binet, and subsequently refined by Terman, Burt, Spearman, and others, are the only ones which can easily be adapted to the measurement of group differences. They have been used in several investigations in America. The largest scale investigation of this type in Britain was carried out by Duff and Thomson in 1923. On the whole, the children of the more prosperous classes secured higher ratings than those from poorer homes. The mean I.Q. of children from the professional class was 112. It was 96 for children of parents belonging to the unskilled or labourers' class.

These results have been repeatedly quoted in eugenic propaganda, usually without any regard for the genetic status of the tests employed. The fact that intelligence tests undoubtedly measure a characteristic which is influenced very little by school environment led to the impression that observed differences of I.Q. are almost entirely determined by differences of genetic equipment. By itself the fact stated has no bearing on the conclusion drawn from it. There is no direct evidence showing that the indices obtained by such tests are independent of social environment during the early formative years which intervene between birth and the age when children can be tested or by physical variations in the uterine environment during the period which elapses between conception and birth. Studies on birth rank in relation to observed intelligence quotients favour the view that early environmental factors are by no means negligible. The most direct evidence bearing on the point is derived from the measurement of twin resemblance. The mean

difference in the I.Q. of identical twins has been found by three groups of workers to be at least half as great as the mean difference between the intelligence quotients of fraternal twins, and fraternal twins are themselves more alike than ordinary brothers and sisters. There is little doubt that considerable differences with respect to intelligence can be produced by such differences of environment as exist within the same family unit. Since this is so, there is very little justification for regarding comparatively small differences in the mean ratings of children belonging to different families at different social levels as conclusive evidence in favour of a significant difference in genetic equipment.

The difference between the mean intelligence quotients of children brought up in the homes of professional parents and in the homes of parents of the unskilled labourer class was found by Duff and Thomson to be 16 points. The mean difference of the intelligence quotients of pairs of identical twins brought up together in the same home is given by Herrman and Hogben as about 10. Thus the difference between children brought up in homes at widely different levels is not very much larger than differences which may arise from relatively small differences within the environment of a single home. Aside from this consideration there are some curious anomalies in the data of Duff and Thomson when they are subjected to closer scrutiny. One of their critics has commented : " Detailed examination of the results does not increase confidence in their reliability as indices of genetic differences. For instance, the children of clergymen were found to do much better than the children of teachers. On the other hand, the children of dock

labourers obtained higher scores than a group of children whose fathers were doctors, dentists, and veterinary surgeons." ¹

Some leaders of the eugenic movement have been content to state the danger of dysgenic selection in more general terms. It is pointed out that the recruitment into the professions from the less prosperous strata by means of scholarships entails the transference of individuals of exceptional intelligence into a class with a social tradition which discourages them from reproducing as fast as they would do if they were not promoted, or as fast as those who are left behind. It cannot be denied that there is some plausibility and, not improbably, a grain of truth in this argument. At the same time, the situation involves a complex group of correlations; and it is quite possible that those who look at the process in this way are inclined to put the cart before the horse. From many points of view, high fertility is undoubtedly a handicap to vocational advancement in adult life. The sterile person can devote himself to his life work with fewer pre-occupations. He has fewer financial embarrassments. He has less temptation to engage in subsidiary ways of earning money. He enjoys opportunities of travel which enlarge the scope of his social influence and his linguistic resources. To some extent it may be true that people are encouraged to become less fertile, if they are intelligent. It is equally plausible to argue that intelligence receives recognition, when it is accompanied by sterility. If all scientists were equally intelligent, it is highly probable that the least fertile ones would achieve the greatest distinction in their

¹ Hogben, *Genetic Principles*.

profession. The sterility of the more distinguished could not then be used to show that superior ability encourages sterility or that any selective process affecting the survival of intelligence is at work. The sterile persons would be subject to negative selection, as they would be in any case. If we regard social promotion as a process which sifts out the relatively sterile, the apparently dysgenic effects of recruitment into occupational levels which demand a minimum standard of intellectual ability may be more apparent than real.

To this the obvious reply is that infertility is not a predisposing factor to success in the earlier stages of social advancement. In a literal sense this is true. Even at this level we may discern some possible and not perhaps improbable correlations in the light of recent psychiatric studies. In any case, certain additional considerations have to be borne in mind. Though there is a fairly high correlation between educational attainment at school, the results of intelligence tests and personal estimates, it would be a gross exaggeration to imagine that such correlation is by any means perfect. Other things being equal, we might say that the child who rates higher in the intelligence quotient scale will have a better chance of passing an examination or winning a scholarship. In everyday life, other things never are equal. As Burt has not been slow to point out, apart from health, we have to take into account a whole complex of temperamental idiosyncrasies. For want of a better name, this might be called educability, that is to say, the response of individuals of the same intelligence to the particular type of education they receive. Our present educational system en-

courages the advancement of the bookish type, and discourages the type of child who is disinclined to use its intelligence unless it recognizes some practical or human significance in the studies prescribed for it. There is no difficulty in imagining a system of education designed to exclude the bookish type from the professional vocations and to give preference to practical intelligence.

Founded on an idealistic philosophy of education, the educational systems of Protestant democracy have prescribed a type of studies and technique of instruction, both of which are probably more suited to the introverted than to the extroverted temperament. An educational system with a more materialistic bias would reverse this. The American system of education probably favours the advancement of a temperamental type which receives less encouragement from the Scottish system. It may be that the most conspicuous effect of promotion by the scholarship system is to sift out the introverts, and we cannot dismiss the possibility that the introverted type is on the whole less fertile than the extrovert. If such considerations are admittedly speculative, they are at least no more speculative than the assertions which have prompted them. There is as much reason to believe that genetic differences play a significant rôle in affecting differences of fertility as to suppose that genetic differences play a significant rôle in determining differences of intelligence. There is every reason to believe that many factors besides intelligence, as defined by the results of Terman tests, influence the selective ascent of the educational ladder. Some of these are social and as such purely environmental. Some are individual and

as such partly environmental in origin and partly genetic.

The fact is that sociologists have paid far too little attention to the natural history of social promotion. The belief that social promotion actually sifts out the characteristics which are commonly assumed to be selected by it may be an example of the gratuitous teleology which led an earlier generation of naturalists to speculate upon the utility of the peacock's plumage as an amenity of sexual exhibitionism. On a small scale, a recent investigation by Miss Bourgeaud into the employment careers of a group of Hoxton boys has provided us with some definite information. Miss Bourgeaud found that the record of school work or general health taken as rough measures of individual capability had little, if any, connection with whether the boys she investigated drifted into more or less skilled occupations. The decisive factors were home conditions and financial circumstances. The explanation of this is not far to seek. The skilled worker attains a higher wage in the long run but has a period of apprenticeship during which earnings are small. The unskilled worker more generally reaches at an early age a maximum which is higher than the wage of the apprentice. Hence the boy leaving school from a poorer home with a large family is more likely to drift into the class of casuals. It follows that in times of unemployment especially there is a necessary correlation between high fertility and unskilled work irrespective of innate aptitude or lack of it.

This feature of the selective process involved in social promotion is true to some extent of all levels in a society with large inequalities of wealth. In the

professions and in business it is generally true that the highest emoluments reward those means of livelihood which offer a small initial return. Thus infertility is doubly affiliated to low earning power. More pressure is brought to bear upon an individual with a large number of brothers and sisters to select an occupation in which he will achieve his economic independence early. Likewise there is more pressure on the individual who marries and undertakes the responsibilities of parenthood early to select a calling which enables him to reach his maximum earning power quickly. It is curious that a prominent eugenicist, Professor R. A. Fisher, does not realize that he has emptied out the baby with the bath water when he admits :—

“The reformer must expect to encounter deep-seated opposition in the classes on which he would naturally rely for an intelligent anxiety for the future of their country, owing to the fact that many in these classes owe the social promotion of their forbears, and their present prosperity, less to the value of their services to society than to a congenital deficiency in their reproductive instincts.”¹

The peril of the low fertility of the professional class as a purely qualitative aspect of the population problem has been chiefly proclaimed by persons who themselves belong to the professional class, often by those who are themselves conspicuously infertile. In the course of human history we may doubt whether any privileged class in process of extinction has refrained from lamenting its disappearance as an irreparable loss to civilization. Posterity has generally decided that what was lost on the roundabouts has been gained on the swings.

¹ *The Genetical Theory of Natural Selection.*

A plea for a more balanced view of the problem is made in the following passage, in which Hogben refers to group studies on intelligence: "The difficulty of treating group differences in a genuinely scientific temper will be less when psychology can equip biological research with a sufficient variety of similar methods for the precise description of other aspects of social behaviour. One can assert that deaf-mutism is commoner among Jews than among Gentiles, without incurring the charge of anti-Semitism. With so many diagnosable physical ailments to choose from, it is possible for normal people to discuss the occupational or racial distribution of any single disease of the body without assuming a tone of impudent superiority. No single group has the monopoly of all the virtues. It is quite possible that the distribution of genes among the Scotch tends to favour a rather higher general level of intelligence than would be found among negroes educated in the same way. One can be open to be convinced that this is so, and retain a personal preference for generosity, cheerfulness, a sense of humour, vocal music without the accompaniment of bagpipes, and the restraint which permits a man to listen to a joke without explaining the point of it to its inventor. Time may show that there are genes which have something to do with all these estimable attributes. We shall then see the superior intelligence of the Scotch in a proper social perspective."¹

Confusion between the results arising from the perpetuation of certain stocks and from the rate of reproduction of social groups has been introduced in a particularly subtle and prevalent form in discussions

¹ *Nature and Nurture.*

upon mental defect. There is no doubt that genetic differences play some part, and as regards certain categories of mental defect a vital part, in deciding whether an individual brought up in a particular environment will, or will not, be recognizably defective. Hence, it is natural to ask whether mentally defective stocks, which in fact exist in all social classes, are reproducing more rapidly than others. *Certified* defectives are most common in the more impoverished social classes. The habit of arguing from the high fertility of the pauper class to the high fertility of the defective group within the community is open to two criticisms. The first is, that a biologically inadequate environment, including poor nutrition, especially uterine nutrition which is known to be a condition propitious to the manifestation of certain kinds of mental defect, may favour the exhibition of a particular kind of genetic constitution. The second is that the occurrence of mental defect is most likely to be recorded in a social group which is brought into close contact with public assistance authorities.

Dr. Lionel Penrose in the only English work which presents the fruits of recent research on mental defect states this issue very clearly in the following passage. Referring to individuals who are certifiably mentally defective within the meaning of the Acts, he states :

“Strictly speaking, an environmental element enters into the description of every case actually certified, since the necessity for certification depends upon social conditions. In homes where there is no economic necessity, low grade cases can be cared for and trained without recourse to institutional facilities: quiet medium grade cases live comfortably, and often usefully, with their rela-

tives. Persons who have private means committing minor offences against the law are able to get good legal advice and to pay fines instead of going to prison. They are much less likely to be certified as moral defectives than are their counterparts without private means at their disposal. Subcultural mental deficiency is not confined to any social class. Each class contains all grades of mental ability, although there is doubtless a general tendency for the more intelligent to improve their social status. We see here that there is a considerable difference between subcultural mental deficiency and the class of persons defined as the social problem group in the Wood Report. The latter term carries with it implications of low social and economic status. It may be true that most of the cases of the subcultural type requiring certification merit such a description, but it should always be remembered that environmental factors have usually been instrumental in bringing such people to the notice of the authorities. These social factors may be quite arbitrary, and, from the point of view of human biology, largely irrelevant." ¹

By many writers of the eugenic school great stress has been laid on the following considerations. It is argued that in former times the fertility of intelligent persons was maintained by the absence of effective methods for preventing conception and that a certain minimum of intelligence is a prerequisite of those methods which have come into general use since the decline of the birth rate began. Hence the fertility of mentally defective stocks as compared with the rest of the community is becoming relatively greater. At first sight this view appears to be above criticism. If it were wholly true, the situation might well give rise to grave concern and demand immediate precautionary

¹ Penrose, *Mental Defect*.

measures pending more accurate knowledge of the genetics of mental defect. On probing a little more deeply we discover a serious fallacy arising from a confusion between the multiplication of defective persons and the multiplication of defective stocks. The truth is that a very small proportion of defective individuals have one or both parents defective. According to Penrose: "Something like 5 per cent. of all defectives have one or other parent mentally defective." This means that only 5 per cent. of the next generation would be eliminated if no mentally defective people became parents. We may agree that such a result would be desirable. At the same time any increase in the proportion of mental defectives produced in the next generation as a result of differential fertility is much less alarming than the arguments commonly put forward by eugenic writers would suggest. We may hope to have much more scientific knowledge on which to base a preventive policy before the problem becomes a serious menace to the further advancement of human civilization.

In what has been said so far we have been primarily concerned with the eugenic or dysgenic effects of changes in the birth rate. A diminishing death rate at all ages of life is also a characteristic of population growth in modern communities. This has been held by some authorities to be dysgenic. Pearl and his co-workers have established the existence of genetically determined strains of *Drosophila*, distinguished by the mean duration of life. The life line ¹ of a short-lived strain is steeper than that of a long-lived strain from

¹ *I.e.*, a graph of which the ordinates correspond to the figures in a life table.

the beginning of its existence. Hence Pearl argues that by increasing the number of short-lived types a low infant mortality would in the long run decrease the expectation of life in human populations. While there is no conclusive evidence pointing to the existence of genes determining human longevity it is highly probable that such genes do exist. This does not commit us to the conclusion that any dysgenic effects arise from lowering the risk of death in the early years. That the expectation of life at birth is far greater now than in previous epochs is beyond dispute. On the other hand, Pearl and Karl Pearson have asserted that the expectation of life at 70 or over has diminished. This appears to be true to a slight extent in the U.S.A. but not in any other country. The data of Methorst show that in Holland the expectation of life increased throughout the latter half of the nineteenth century in all age groups up to eighty-five years. Whether it is desirable to extend the expectation of life beyond this limit under existing conditions is a debatable proposition.

Writers in the *Eugenics Review*, the official organ of eugenic propaganda in Great Britain, have repeatedly defended retrenchment in the social services by an argument which is hardly less foolish than insincere. It is said, in effect, that if more babies of the poorer classes die there will be fewer physically unfit people to be a burden to the community in subsequent generations. English and Australian statistics of infant mortality show that there has been comparatively little decline in mortality in the first month, when many of the deaths are due to general debility and malformations which are not preventable in the present state of medical knowledge. The main reduction has

occurred among deaths after one month from controllable agencies such as infectious diseases, diarrhoea, etc. There is no evidence whatever for the view that a reduction in the incidence of, and fatality from, measles and whooping cough must result in the general enfeeblement of the population. If the current eugenic view is correct it is difficult to see why the benefits of natural selection should not be extended from Poplar to Mayfair. We have yet to hear of the practising eugenicist who conscientiously refuses medical attention to his own children from considerations of race fitness. If like the Christian Scientist and the Peculiar People, eugenists practised what they preach, they would advocate a campaign for conferring the advantages of undernutrition and tuberculous milk upon social classes which are at present deprived of these wholesome remedies.

A remarkable prejudice which obtrudes into many discussions of differential fertility is the assumption that people who bring up large families with limited means, when knowledge of family limitation is available, are necessarily less intelligent than those who refrain from doing so. The use of contraception implies an individual response to certain stimuli. It is generally agreed that the principal stimuli or causes are economic. In other words, people tend nowadays to have no more children than they can afford. What people can afford is generally interpreted in terms of a standard of life relative to their social upbringing or social aspirations. It is less clearly recognized that the number of children which a group of people can afford to have is also relative to their inclination to undertake parenthood. There is little general agreement about the correct

number of children for a given size of income. While the birth rate has fallen, standards of life for all classes have risen. The decrease in fertility has been most marked in the more well-to-do classes. If the economic stimuli exist and contraceptive knowledge is available, any failure on the part of the individual to respond by limiting the family to a size regarded as suitable by some other person is often dismissed as lack of intelligence. When such statements are committed to print, the person who passes judgment is usually a member of the professional class. Undoubtedly there exist great individual variations in the biological factors affecting fertility. We may refer to this complex of factors, of which little is known except its great individual variability, as reproductive intensity. Clearly the response to any given set of economic stimuli will be different according as the reproductive intensity of the individual varies. Observers drawn from a professional class in which success is partly dependent on sterility will tend to undervalue the importance of individual variations in reproductive intensity. It may be that a woman who produces a large family in conditions which a richer person would describe as squalor, is not very different from the artist or poet doing "creative" work in a garret. She may not necessarily be of inferior intelligence to her neighbour who prefers the aspidistras and lace curtains of respectability. It is not proved that everything embodied in what is commonly regarded as a high standard of life for children is necessary to produce the best kind of people. Some of it, such as certain of the more expensive kinds of education, may be definitely harmful. Disease and lack of vigour are not unknown in

the spotless and safeguarded nurseries of the well-to-do. The fact is that much which has been said and written about the qualitative results of differential fertility is a psychological compensation for the biological inadequacies of the professional type.

Even a journal of so high an academic standing as *Nature* (Vol. 132, p. 540, 1933) in a discussion of high-grade mental defect makes the following assertions :—

“ Our social legislation has raised their survival rate and thrown the cost of their maintenance on the really fit members of the community who have *in consequence* restricted the numbers of their own offspring. . . . A remedy for this state of affairs would be to adopt sterilization as a *penalty* for bringing into the world children whom the parents are unable to support. . . . Public opinion in England will not easily be reconciled to this course, but if our *over-population and unemployment* continue we may ultimately be drawn to it. . . .” [Italics inserted.]

The plain truth is that the infertility of the prosperous classes in general and the professional section in particular diminished while real income was still rising. It is, therefore, difficult to see what the upkeep of the mentally unfit, however regrettable that may be, has to do with it. Nor is the juxtaposition of unemployment and population more felicitous as the facts discussed in the first chapter have sufficiently shown. Traditionally and objectively over-population signifies pressure of a population on the available means of subsistence. The existing situation at a time when large crops are being destroyed for lack of markets is that the system of production has outrun its capacity for distribution. Far from there being any obvious connection between unemployment and an excess of

human beings, it would be more true to say that we are witnessing the pressure of our supplies of the means of subsistence upon the population. As regards the prospects of further population growth, the facts which have been set forth in this chapter and the previous one show that the situation is by no means propitious to eugenic proposals which aim at restricting births. The infertility of civilized communities is now so low that any policies tending to lower fertility still further will be prejudiced by the fear of racial extinction, when the facts become widely known. Even if this were not so, it may be doubted whether the claims of a rational eugenic policy will be advanced by associating the use of sterilization with the stigma of a "penalty" and a Mosaic conception of retributive justice.

§ 4

Somewhat diverse issues have emerged during the discussion of differential fertility in this chapter. It is now necessary to emphasize the more important conclusions to which the discussion has led us. Concern about degeneration in the quality of the population is without sufficient basis, for two reasons. One is that there is insufficient evidence of significant differences distinguishing social classes with different fertility rates. The other is that such differences between fertility rates seem likely to become less pronounced. A more pressing danger has been overlooked. If we need no longer take an alarmist view of changes in the quality of population, a study of differential fertility rates makes the prospect of further decline in reproductive capacity greater than we have found reason to suppose. In the previous chapter we were able to

forecast the course of population growth on the basis of fertility and mortality rates prevailing at the present time. We saw that in many parts of the world these rates are inadequate to maintain a stationary population. We have no reason to believe that net reproduction rates, which have been falling steadily to their present level, will be stabilized at that level. Changes of differential fertility rates which have been taking place of late years make it well-nigh certain that fertility is likely to decrease.

Among the features of social life which are found to be associated with high or low fertility, we have seen that rural life and a preponderance of Catholics in a community are both associated with the former. Thirty years ago fertility was very much lower among the more prosperous classes than among the poor. Evidence which has become available during the past few years points to the conclusion that the less-prosperous sections of the community are moving towards the low level of fertility attained at an earlier date by the more prosperous groups. Whenever we have been able to trace the history of differential fertility rates up to the present day, we can generally detect a tendency for the higher rate characteristic of the larger section of the population to fall to the lower level characteristic of the smaller. Certain population groups have reached a rate of decline which is far below that shown by the population as a whole. The more fertile groups, for instance, rural as compared with urban, or working class as compared with the well-to-do, are often the larger. If these are approaching the level of the less fertile sections of the community there seems little hope that the populations of industrialized countries

will sustain their existing growth capacity, which is already very low. Unless some very striking change in social conditions takes place, our study of differential birth rates within industrialized communities points to the likelihood that the gross reproduction rate will continue to fall steeply for some time to come.

There are further considerations which intensify the gravity of the present situation. Until comparatively recently birth-control propaganda in most countries was largely furtive and frowned upon by the ruling powers. The public encouragement of birth-control clinics is of extremely recent date in English-speaking countries, where the prevailing reaction of philanthropic organizations in face of the unemployment crisis and the rise in infantile mortality in the areas where there is great unemployment is to advocate sterility as a cheaper alternative than the maintenance of efficient social services. Applied biological research directed to the improvement of the technique of contraception has only been pursued during the last few years. Baker's investigations into chemical spermaticidal agents are an example of the kind of work which is now being undertaken. They have already led to the discovery of a new and possibly more efficient chemical contraceptive. Improvements in the technique of rubber manufacture are making already known methods of contraception cheaper and far more reliable. In the field of reproductive physiology a new era of rapid progress initiated by the work of Allen, Lipschutz, and others on sex hormones has had as yet little practical application. We may anticipate that it will lead in the near future to novel and highly effective improvements in contraceptive technique. The widespread

use of contraception in industrialized communities is universally recognized. Few people realize the unreliability of most contraceptive methods in general use at present. Other things being equal, the substitution of more efficient for less efficient methods can only have the effect of reducing the number of births. The significance of progress in contraceptive technique must be borne in mind, when we proceed to discuss the influence of birth-control propaganda among other agencies affecting the declining fertility of civilized communities. This will form the subject matter of the chapter which follows.

CHAPTER V

THE INVENTION OF STERILITY

Theories of Population Growth—The Logistic Hypothesis and the Limiting Size of a Population—The Influence of Contraceptive Practice and Technique—Physiological Effects of Civilized Living—The Prospects of Extinction.

§ I

WE have now surveyed the relevant statistics of various aspects of population growth in contemporary civilization. Aside from any considerations concerning the world's potential food resources, population statistics fail to provide a shred of evidence to support the belief that the peoples of the world are going to increase so rapidly as to raise an acute world over-population problem. In the countries observed, with the possible exception of Russia and Japan, a real pressure of numbers on the means of subsistence could only occur if a sudden and spectacular change in fertility took place. In spite of this the prospect of over-population is still re-echoed in the pronouncements of statesmen, and still influences public opinion. One reason for this has already been emphasized. This is the fact that crude birth rates do not adequately represent the fall in fertility which has taken place. There is yet another reason for the survival of the Malthusian mythos. As yet we cannot point to a steadily decreasing population in any industrial country. With two exceptions the *League of Nations*

Year Book for 1932-33 gives an excess of births over deaths in all the countries of the world for which statistics could be obtained in the years 1928 to 1932. The exceptions are France and Esthonia, both of which showed a very slight excess of deaths over births in 1929. Naturally, it is difficult for most people to accept the conclusion that populations are likely to decline so long as they are actually increasing. We have not disposed of the possibility that the fall in fertility in civilized communities other than Russia may be a temporary phenomenon related in some way to the fall in mortality. That such a relation exists was inherent in the Malthusian doctrine. In another form it has been asserted to exist by a contemporary school of writers who, unlike Malthus, do not base their conviction upon any considerations concerning the available supply of the means of subsistence. No doubt the belief has been fostered by the older statistical practice of tabulating fertility and mortality rates as separate items. The calculation of the net reproduction rate, or what Dublin and Lotka call the "true rate of natural increase," at least shows that no simple compensatory relation between the forces of fertility and mortality is evident in recent statistics. Still it must be admitted that such a relation might be found, if sufficient trouble were taken. This leads us to ask whether there is any general law of population growth or whether the growth of human populations is subject to particular laws appropriate to different historical epochs. To put the issue in another way, is the general movement in favour of sterility a passing phase in the growth of civilized communities or is it a new product of human invention?

The search for a general law of population growth raises issues of profound interest in the domain of scientific method. In the history of science two different avenues of approach have both led to progress. One is to use the known properties of the constituent elements of a system to throw light on the characteristics of the whole system. The other is to study the behaviour of the whole system in different contexts. The first method of approach gives rise to hypotheses which are variously described as atomistic or mechanistic. The latter term has to-day lost the rigidity of meaning inherent in its Newtonian usage, and has degenerated into a weapon of abuse in current philosophical disputes. The second method of approach leads to hypotheses of the statistical or, in its strictly objective sense, "holistic" type. The respective merits of the two types of hypotheses have often prompted unprofitable discussions. Both are essential to the progress of science. At one stage, emphasis on the qualitative features of a system as a whole is necessary. At another, it is necessary to stress the quantitative relations between the parts of a system. During the first half of the nineteenth century chemistry progressed under the influence of the atomic speculations of Dalton and Avogadro. During the second half of the same century the thermodynamic treatment of Nernst and van't Hoff became the growing point. It reached the peak of its usefulness at the beginning of the present century in Ostwald's plea for relinquishing the atomic concept. Meanwhile, new information about the electrical properties of matter was accumulating. Chemistry reverted to atomistic modes of thought. Already theories about the electron are assuming a

more statistical character. Before long the pendulum may swing in the opposite direction. In biology the biometrical approach to the evolutionary problem by the Neo-darwinian school gave place to the atomistic approach of the Mendelian renaissance. Recent statistical developments which embody the results of Mendelian analysis in human genetics may lead to a reaction against the atomistic preoccupations of experimental genetics at an earlier stage.

Analogous to these two tendencies in the natural sciences are two different schools among students of population growth. Malthus himself must be placed among the hierarchy to which belong Lamarck in biology and in chemistry the founders of the phlogiston theory. For the tendency of population to outgrow the means of subsistence as an inherent feature of human ecology, there is to-day no more convincing evidence than there ever was for the existence of phlogiston. The atomistic approach to the population problem takes into account the behaviour of individual human beings. The most generally accepted conclusions which emerge from this treatment of population growth are embodied in the contraceptive hypothesis. The work of Verhulst, Pearl and Reed is the most notable example of an attempt to formulate a general law of the statistical type.

§ 2

The nineteenth century witnessed the gradual accumulation of a large body of data relevant to the growth of populations. It became apparent that civilized communities were adding to their numbers in

a fairly regular manner. In these circumstances it was natural to seek for a general law of population growth. Of such attempts the most noteworthy is that of Verhulst, revived in our own time by Raymond Pearl. According to this view, the decline of the birth rate which began in the latter half of the nineteenth century is a particular case of a law which applies to all ecological systems. The existence of such a law implies that the development of populations depends upon their size. In other words, fertility and mortality are both functionally related to the size of the population. Their relationship to it is such that all populations tend to a stationary limit at which further growth ceases. In the belief that such a limit exists, we may perhaps discern the optimism engendered by expanding industrialism. The iron hand of necessity is less apparent than when Malthus wrote. We are permitted to hope that a population may cease to grow before available food supplies are exhausted.

In the *Physique Sociale*, Quetelet (1835) pointed out that Malthus and his followers had not given any description of the way in which populations actually increase. Quetelet compared the growth of a population to the motion of a body in a resisting medium, a physical analogy which is embodied in Newton's law of viscosity. Quetelet never published the evidential basis for his mathematical postulates. However, his work stimulated his pupil Verhulst to a more ambitious treatment of the problem. Verhulst assumed that an increment of growth of a population at any time is a simple function of the size of the population at that time. The form of the function which he chose is embodied in the differential equation :—

$$\frac{1}{p} \cdot \frac{dp}{dt} = m - np.$$

In this equation p is the size of the population at a time t , and m and n are arbitrary constants for any given community. The equation can be solved in the form :

$$p = \frac{L}{1 + e^{\frac{\beta - t}{\alpha}}}$$

L , β , α , are again constants and L , involving m and n , is clearly the limiting value of the population. The curve obtained by plotting the values of p and t given by this equation has been called the "logistic" curve. Its form is shown in Fig. 6. Verhulst's equation involves no statement of the reasons why populations grow in a particular way. It is simply an attempt to devise a shorthand method of describing the size of a population at different times. Having made an entirely arbitrary assumption about the form such a law might have, he applied it to the statistics at his disposal, and satisfied himself that it described them adequately.

A mathematical statement does not assume the dignity of a law in natural science unless it serves as a guide to conduct. The mere fact that Verhulst's logistic equation can describe the growth of the populations to which he applied it does not entitle us to regard it as a law in this sense. It is true that if we already know the size of the population at certain intervals in countries in which censuses have been taken, we may sometimes wish to estimate the population at intervening times. For this purpose the logistic curve is

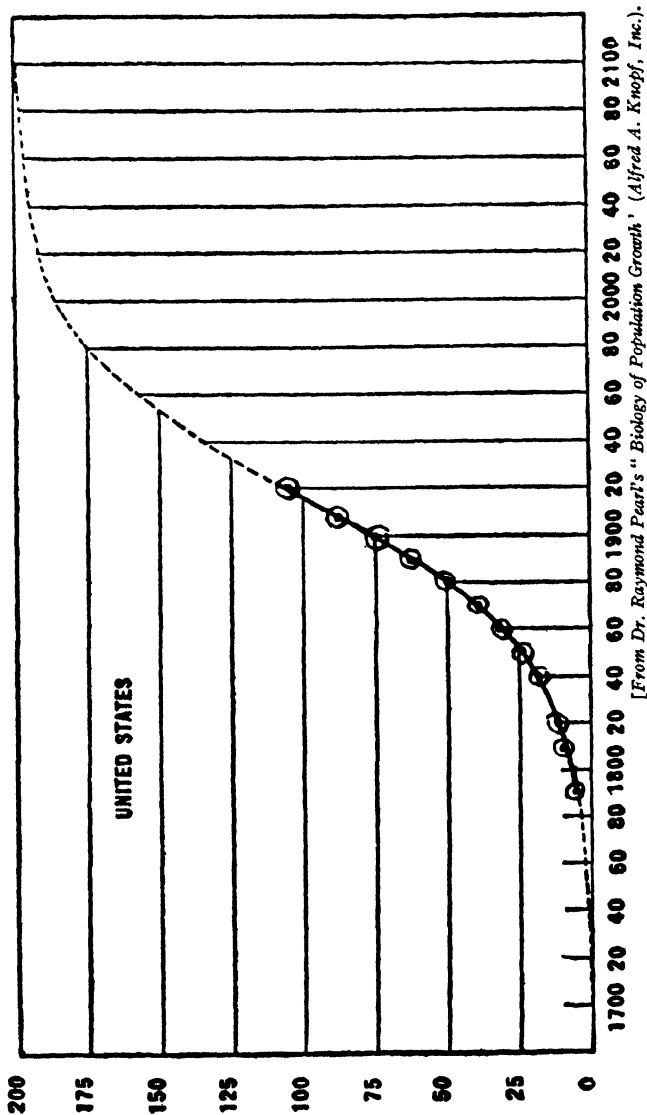


FIG. 6.—Population of the United States fitted to a Logistic Curve.

only one of a number of efficient methods of interpolation. As such it has no advantages over other methods, such as the method of finite differences which is frequently used for the same purpose. We know already what changes in population have taken place. The logistic hypothesis can only rank among the laws of natural science if it helps us to adapt our economic arrangements to the probable future size of the population or to alter them so as to change the course of population growth.

In natural science we may distinguish three methods which have been used to seek out laws. The first method is to examine a body of data and select one of the many types of general expressions consistent with them by means of graphical representation, finite differences, etc. Newton's Law of Cooling is an example. A second method is not always easy to distinguish from the first. The investigator selects a relationship which seems likely, because it has some implicit basis in experience, because it is suggested by entirely fantastic considerations like Maupertuys' Principle of Least Action, because it is easy to handle, or for all these three reasons. He then explores the data to find out whether his hypothesis correctly describes them. The third method starts from simple and established relations between the parts of a system, and builds up a more complex description of the whole. In genetics the modern theory of inbreeding provides an illustration. The second method can be quite useful in natural science because no generalization ranks as a law of natural science until the limits of its usefulness have been explored. In social science it is a very dangerous instrument. The Principle of Least

Action was suggested by the belief that the deity is economical. Experiment has justified the principle as a symbolical device in physics. The biological study of vestigial structures warns us against the danger of relying on the belief which suggested it.

In his search for a law of population Verhulst adopted the second method. It might be argued that Newton had done the same when he assumed that the resistance of a medium to a moving particle is directly proportional to the speed of the particle. It seemed to him a likely relationship, and it led to an easily soluble differential equation. There was no difficulty in putting it to the test of experiment and finding where it broke down. We know that it is a good guide to conduct when we are dealing with the damped oscillation of a slowly vibrating steel bar and a bad guide to conduct when we are dealing with the path of a rapidly moving projectile in a highly resistant medium. It is a useful guide to conduct just in so far as we know when it does cease to be true. To proceed in the same way in the social sciences is always fraught with greater danger, because we are so seldom in a position to provide a control for testing when the result ceases to be true. In the region where the logistic curve becomes most interesting as a guide to conduct, Verhulst had no data with which it could be checked. It is not surprising that his work did not attract notice until attention was drawn to it by the independent studies of Pearl and Reed.

Before turning his attention to the growth of human populations Pearl had studied exhaustively the isolated ecology of fruit flies in an artificial universe. The universe of his fruit flies was a half-pint or pint milk

bottle. They were provided with a fixed and regular food supply and kept under standard conditions of temperature, moisture and illumination. In these conditions Pearl found that the fertility and mortality of his flies were related in a simple way to the density of the fly population, that is to say, to the number of flies per cu. cm. of space available. To use his own words, "birth rates are markedly affected adversely by small increases in density at relatively low densities, while after a certain density is passed further increases produce only slight decreases in birth rates down to an asymptotic limit." "Death rates are insignificantly affected by increasing density at relatively low densities, while after a certain limit is passed death rates markedly increase with increasing density up to an asymptotic limit."¹ Using the third method to which we have referred, Pearl deduced a general law from the two empirical laws obtained by means of the first method. He successfully verified the applicability of his general law as a correct description of his experiments. The form of the equation obtained proved to be identical with that which Verhulst applied to human populations.

Impressed by this coincidence, Pearl applied the logistic curve to a larger body of statistical data which had accumulated since the time of Verhulst. He found that the data for any single country could be fitted to some part of a logistic curve with considerable precision. "The logistic curve," as Hogben observes, "is characterized by an initial phase of slow growth, a succeeding stage of rapid increase, and a final phase of declining increase tending towards a stable limit. It is, therefore, suited to describe populations displaying

¹ *The Biology of Population Growth.*

slow, rapid, increasing, or diminishing growth rates; and it is not surprising that census statistics can generally be fitted on to some portion of a curve which possesses such catholic characteristics." ¹ Pearl himself rightly concedes that "what is really wanted is the census history of the same human population throughout a growth cycle." ² He believed that Algeria provides an example of such a population. The Algerian data will be discussed later. We may first inquire whether there is any reason to believe that the resemblance between Pearl's curve for the growth of populations of *Drosophila*, and Verhulst's curve for the growth of human populations is more than a mathematical coincidence. This is only so if it can be shown that Pearl's two empirical laws of fertility and mortality are universal laws of ecology which apply to all populations of organisms, including man himself.

An initial difficulty which presents itself in the interpretation of Pearl's laws of fertility and mortality arises from the obscurity of the density concept. Defined as the number of organisms in a given amount of space, density has no biological significance. It must first be interpreted in terms of the interaction of the organisms concerned and the materials of the space in which they live. In a typical experiment different numbers of flies ranging from 1 pair to 50 pairs were placed in a series of bottles of uniform size, and the average number of adult offspring per mated female per day recorded. The mean number of offspring was always less if the initial population was larger; but the biggest recorded difference was between the offspring in a bottle containing one pair of flies and a bottle

¹ Hogben, *op. cit.*

² *Op. cit.*

containing two pairs of flies. Since Pearl himself was unable to offer any explanation of the fall in fertility observed in *Drosophila*, the relation between density and fertility cannot be said to have been established as a universal law for all animal populations. In relation to mortality, density clearly involves greater chances of parasitization, disturbance of the optimum ratio of respiratory gases, and mutual interference in obtaining access to the available food supply. That mortality increases with density is probably true of all organisms except man. It is demonstrably false of man. Increasing populations in the nineteenth century were universally associated with a falling death rate in civilized communities. The inventive capacity of man has enabled him to control the factors which make high density propitious to mortality in an unplanned animal ecology.

There is thus little reason to believe that the observed relations between fertility and density in populations of *Drosophila* give further support to the Verhulst hypothesis. As already stated, Pearl believed that he had found a human population which had traversed nearly the whole of a growth cycle represented by the complete logistic curve. The census data of Algiers from 1886 to 1921 fit a logistic curve with some precision. The figure for 1921 was very near the upper horizontal limit of the curve. From this Pearl concluded that the native population of Algiers would not grow beyond 5·379 millions. The 1931 population as given by the curve would be about 5·2 millions. Fortunately we are now in a position to put Pearl's crucial illustration of the validity of the logistic curve to the test of observation. The native population of

Algiers in 1931 was 5,632,663 millions. Fig. 7 is a reproduction of Pearl's curve for the growth of the Algerian population, and the actual population in 1931 is shown on it.

It may be admitted that Pearl has safeguarded himself against such criticism. He himself pointed out that the population of Germany, disregarding the logistic curve after following it for a time, began to increase too rapidly. To meet this difficulty he introduces a subsidiary hypothesis of separate growth cycles. When a new invention becomes available or an improvement in agricultural technique is introduced a population can proceed to grow in accordance with a fresh logistic curve. With reference to Algiers, Pearl states, "The population may be stimulated to start upon a new cycle of growth, or slighter, but still in kind, new factors may alter somewhat the upper limiting value of the present cycle. Such a factor which might conceivably have stimulated population growth was the law of February 7, 1919, which gave political rights to certain portions of the native population."¹ Since factors of much greater significance are of frequent occurrence in civilized communities this refinement of the logistic hypothesis deprives it of much use in forming judgments about the future course of population growth.

The only practical conclusion which remains is that the logistic curve does not admit the possibility of a decreasing population. However, we do know that populations have died out in the past and that some oceanic populations are rapidly diminishing in numbers to-day. The whole history of evolution is a story of

¹ *The Biology of Population Growth.*

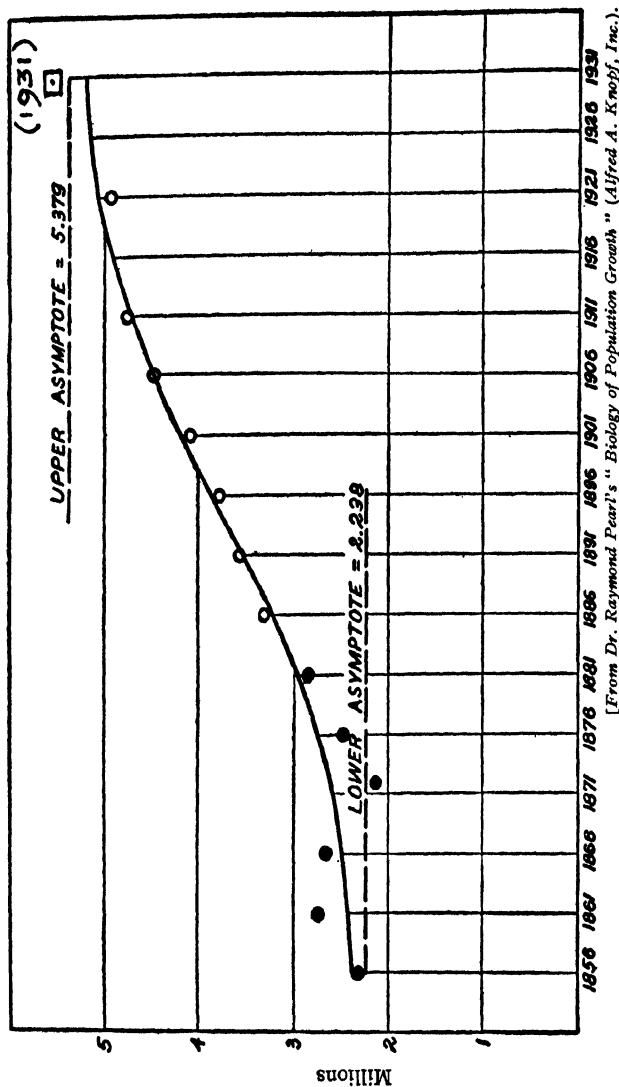


FIG. 7.—The Growth of the Indigenous Native Population of Algeria. The observations from Column A of Appendix Table 12 are plotted as circles, solid before 1886 and open thereafter. The smooth curve is the graph of equation (xix).

[From Dr. Raymond Pearl's "Biology of Population Growth" (Alfred A. Knopf, Inc.).]

the replacement of one type of ecological association by another. Admittedly, it is difficult to envisage the extinction of a species through sterility, because sterility must always have a negative selection value. The more sterile members of a species will always tend to be eliminated in favour of the more fertile members. In this respect man is different from other animals. Because of his ability to regulate his own reproductive activities, the process of selection assumes a new aspect. As a socially organized whole, the human species has the power to seal its own doom in a way that has probably never happened in the history of any extinct species.

§ 3

In the absence of conclusive evidence for believing that there is a universal law of ecology applicable to human population, it is natural to ask whether man's power to control his own reproductive process confers any special characteristics on human population growth. The extent of artificial interference with reproduction is extremely difficult to assess. A veil of mystery and taboo envelopes the sexual behaviour of the human species. Its influence is so powerful that the most honest realize how little objective value can be attached to statements they make about their own sexual behaviour. In spite of the impossibility of accurate estimation it would be absurd to ignore the prevalence and importance of birth control. Though evidence concerning its effects is mainly indirect, the dubiety of the evidence should not prevent us from recognizing the importance of the phenomenon. Before attempting to estimate how much the growth of population in

recent times has been affected by contraception it is essential to examine the magnitude of human fertility in the absence of deliberate interference. Ignorance of the physiology of reproduction is an inherent weakness of much speculation in this field. Sociologists are too prone to endow human beings with a riotous fecundity, which is not very convincing to anyone who has kept rabbits in the laboratory. Having started with what may be an entirely fictitious model of human capabilities it is easy to infer the exercise of artificial interference when populations do not fulfil such expectations. The logic may be flawless. The conclusions may be unsound because the initial assumptions are not founded on fact. Though the rabbit has bred prodigiously on the Australian continent, the breeder in the laboratory is apt to encounter an obstinacy which need not be attributed to "prudence" or "vice" in the Malthusian sense.

Of the factors involved in the production of living children, the first requirement is the formation of functional gametes in both sexes. The male gamete must then be deposited in the body of the female at a time when it can meet with a fertilizable ovum, and no mechanical barrier or toxic agent must be present to prevent the sperm fertilizing the ovum. This involves two issues. One is the frequency with which male gametes are deposited in the body of the female, the other is the accessibility of the ovum to them. Finally, the fertilized ovum must survive through the nine months of pregnancy. Each of these factors is subject to individual variation arising partly from the genetic constitution of the individual and partly from the fact that sexual behaviour is highly conditioned by external

agencies. All such individual differences contribute to observed differences in fertility. Sterile individuals of both sexes are known to occur. The term sterility as applied to males implies that the first requirement is not realized, that is to say, that functional gametes or spermatozoa are not produced in sufficient numbers. In females sterility is used to imply at least three possible contingencies. One is that the secretions of the generative tract are unfavourable to the activity of the sperm. One is that ovulation fails to occur regularly. A third is the early resorption of the embryo—*i.e.*, a failure to meet the third requirement in the production of living children.

Generally speaking, contraceptive technique involves interference with the second requirement enumerated above. The sperm is prevented from fertilizing the ovum after coitus has taken place. Recent physiological research does not permit us to neglect the frequency of coitus as a factor materially affecting the probability of conception. This consideration is almost universally neglected by writers on contraception. In addition to this, anatomical displacements of the internal organs of the female may facilitate or otherwise the entrance of the seminal fluid into the uterus. Finally, postural differences in executing the sexual act and the relative size of the sexual organs of the two partners involve differences in the degree of penetration effected and the likelihood that ejaculation will or will not occur in close propinquity to the cervical orifice.

The high foetal mortality known to exist in the later stages of pregnancy is one presumption in favour of the view that there is considerable mortality in the earlier

stages. This presumption is abundantly supported by experimental evidence, which shows that very early resorption of the embryo can be produced by dietetic deficiency in animals. Early resorption of embryos due to lethal genes is also known to occur in mammals. Very early resorption of the embryo would frequently be dismissed as an irregularity of menstruation and would not be classified as a pregnancy. Differences in fertility of this kind arising from genetic constitution or environment may be associated with the use of a particular contraceptive technique.

Since all that can be accurately observed at present as a result of contraceptive technique is the end-product of a complicated biological process, more knowledge of the individual factors involved is evidently essential to a complete study of contraception. Every known feature of the reproductive process is subject to individual variability. In many animals differences in fertility have been shown to be genetically determined. In animals capable of forming conditioned reflexes the sexual impulse can be conditioned. This has even been shown to be true of the rat. Much more so is it true of primates, as Dr. Zuckerman has shown. In baboons the sex act, so far from being a simple reflex, cannot be satisfactorily carried out unless an educational period has been passed through at the right age. Such conditioning of the sex impulse with its great capacity for variability in behaviour might seem too obvious to need statement. It is frequently overlooked. The divorce laws of this country are still founded on the assumption that sex is a simple reflex. Since sexual behaviour is a conditioned pattern, differences in the freedom from supervision which children enjoy may

well contribute to the differences in fertility which are found in different social classes.

The need for a clear understanding of the reproductive physiology of human beings, as a basis for any conclusions concerning the rôle of contraceptive practice in population growth, emerged in the evidence given by the heads of religious bodies to the Commission on the Declining Birth Rate. Both Catholic and Jewish authorities agree in condemning unreservedly all contraceptive methods involving any mechanical or chemical device or any departure from what is popularly regarded as the normal method of performing the sexual act. However, both Catholics and Jews sanction the practice of confining intercourse to a part of the menstrual cycle commonly called "the safe period" when it is believed that conception is unlikely to occur.

The existence of a safe period is of profound sociological importance. Its significance has not been fully recognized by statisticians who are disposed to interpret the recent decline of the birth rate in European countries as exclusively due to the spread of contraceptive methods. If there actually exists a period in which conception cannot take place, changes in frequency of sexual intercourse involving no deliberate limitation of the family must be regarded as possible contributory factors to a declining birth rate. From the biological standpoint, the existence of a safe period involves three suppositions. Each of these can be tested by experimental methods in the case of other mammals. None of them has been established by direct observation in the human species. The first supposition is that the duration of life of the sperm within the female body is short compared with the length of the menstrual cycle.

The second is that the period of survival of the unfertilized ovum is short in comparison with the length of the menstrual cycle. The third is that the time at which ovulation occurs in the menstrual cycle varies within narrowly prescribed limits. Strictly speaking, only the first two suppositions are relevant to the possibility that small changes in the frequency of sexual intercourse might statistically affect the birth rate. The third is only of importance in so far as reliance upon the existence of a safe period is individually employed as a contraceptive practice.

With regard to the duration of the period over which seminal fluid retains its fertilizing power within the body of the female, it has been frequently stated in the past that human spermatozoa may survive for several weeks. This statement has, till recently, been current in many medical text-books. It rests solely upon anecdotal evidence of highly debateable value. It passed without criticism so long as there was no experimental evidence concerning the duration of life of the sperm in related mammals. During the past five years very careful studies have been made by Hammond, Walton and Moore to determine the length of survival of spermatozoa in domestic mammals. The maximum period of survival within the body of the female of the same species in the rabbit, the guinea-pig and the horse lies between twelve and twenty-four hours. It would not be legitimate to assume that these figures are representative of the survival of human spermatozoa within the human body. On the other hand, until there is direct experimental evidence bearing on the point, the earlier estimate varying from three to six weeks must be regarded as most improbable, or at

least treated with the gravest suspicion. There is no direct evidence concerning the duration of life of the unfertilized human ovum. In mammalian species which have been studied from this point of view, a period of two to ten hours may be taken as representing the limit commonly found. Although it has been asserted that the spermatozoa of the bat survive for some months, there are no observations pointing to the conclusion that the duration of life of the mammalian ovum is of an order of magnitude comparable with the length of the menstrual cycle. As far as human beings are concerned, there is no positive evidence pointing to the existence of a safe period. On the other hand the most recent and critical work on the survival of spermatozoa and ova in other mammals provides strong presumptive evidence in favour of the affirmative view, until such time as evidence from other sources than anecdote has been brought forward to prove the contrary.

As a reliable method of deliberate contraception, the existence of a safe period not only implies that the duration of life of the sperm and the unfertilized egg is comparatively short, but also presupposes that the time of ovulation can be ascertained. In the past, partly owing to a false analogy between the menstrual cycle of primates (men and monkeys) and the œstrous ("heat") cycle of the lower mammals, it has been very commonly believed that ovulation occurs in the human species about the time of menstruation. If the first and second assumptions already discussed were established this would imply that the middle of the month is the period in which conception is least likely to occur as the result of intercourse. The disposition to believe

this may be reinforced by a teleological supposition based on the evidence pointing to the conclusion that the middle of the month is the period of minimum excitability. The only thing that is reasonably certain about the problem we are now discussing is that the prevailing belief in the efficacy of restricting intercourse to the middle week or middle fortnight of the month as a means of avoiding conception is undoubtedly wrong.

The results of recent study point to two conclusions. One is that the time of ovulation varies within wide limits in the human species. The other is that the time at which ovulation is most likely to occur is from the seventh to the thirteenth day. The only point upon which profound disagreement exists concerns whether ovulation occurs before the seventh or after the thirteenth day sufficiently often to preclude the use of the safe period as a contraceptive practice of great reliability. In any case, it is generally agreed that the seven days immediately preceding menstruation constitute a period during which the probability of conception is at a minimum.

The second conclusion stated in the last paragraph, receives powerful confirmation from the recent work of Corner, Zuckerman and others on monkeys. Zuckerman states the salient facts in the following terms :

" All female Old World primates experience approximately four-weekly menstrual cycles. Many of them manifest cyclical changes, varying in degree, in the colour and form of the external pudendal organs and the skin adjacent to them, an area known as the 'sexual skin.' These changes are shown, for instance, by the Chimpanzee, Orang, *Cercopithecus talapoin*, *Macaca*, and all the species of the

genera *Papio* and *Mandrillus*. The sexual skin becomes active immediately after the middle of the cycle. Shortly after the middle of the cycle the sexual skin suddenly resumes its quiescent appearance, in which condition it remains until the onset of the next catamenia, when it again becomes active. . . . Ovulation in the monkey occurs midway between the two menstrual periods. Monkeys, however, do not ovulate every cycle."¹

Three methods have been chiefly employed to ascertain the time of ovulation in human beings. The first relies on correlating microscopic changes in the uterus and the vaginal secretions, or observations on the contractions of the uterus in human beings with characteristic histological or physiological events in the menstrual cycle of monkeys. In the latter, the time of ovulation can be determined directly, and is known to vary within very narrow limits. Evidence from this source has led to conflicting conclusions concerning the extent of variation in human beings, and its value is somewhat dubious for a reason disclosed in the last sentence cited from Dr. Zuckerman's paper. A second method is based upon personal enquiries into alleged cases of conception following isolated coitus. These are very carefully surveyed in a recent paper (1927) by Dr. Dickinson of New York. Dr. Dickinson concludes his survey of evidence from this source in the following terms :

" There is general agreement on five matters : (1) Conception can occur at any part of the month. (2) There is very marked difference between favourable and unfavourable periods. (3) The week or ten days following men-

¹ " The Menstrual Cycle of the Primates," Part I, *Proc. Zoo. Soc.*, 1930.

struation is the time of greatest likelihood of conception. (4) The week preceding menstruation presents the least likely chance of conception, averaging about 7 per cent., or in various lists, 3, 6, 9, 9, 3, 10 per cent. (5) Conception during menstruation is relatively frequent, about 13 per cent." ¹

Being based on personal testimony, the second method cannot be taken as a trustworthy indication of the absolute frequency of conception at different stages of the menstrual cycle. At best it can only be regarded as an indication of relative frequency. As far as it goes, it supports the conclusion that ovulation is most likely to take place towards the middle of the intermenstrual period, when it occurs in monkeys. The range of variation and frequency of exceptions to such a rule must remain an open question in the absence of evidence from other sources.

A third method available for ascertaining the time of ovulation in the human species depends upon the fact that the liberation of an ovum in the mammal is followed by the development of the glandular structure known as the *corpus luteum* which is formed from the follicle of the ovum. Evans and Swezy ² (1931) in a recent paper discuss the observations which have been made on ovaries removed or examined during operative procedure. The evidence from this source does not permit us to draw any certain conclusions. As an illustration of the neglect of research in the physiology of human reproduction, it may be pointed out in this connection that there exist both direct means and a variety of indirect methods for settling the limits of

¹ The "Safe Period" as a Birth Control Measure.

² "Ovulation in Primates," *Am. Journ. Phys.*, Vol. XCVI, 1931.

variation of the time of ovulation in the human subject. An enormous mass of data for applying the third method could be collected in a very short time if a concerted effort were made to ascertain, where possible, the date of the last menstrual period in all cases of autopsies on the female subject. By pooling information from all the hospitals of this country sufficient material could be obtained in a few months. An indirect approach to the problem which demands more extensive application is a correlation of the biochemical changes of the menstrual cycle with changes in the composition of the blood at the time of ovulation in other animals.

If we accept the present presumptive evidence from the study of other animals to support the conclusion that the possibility of conception in any given individual is limited to a small fraction of the menstrual cycle, it is evident that changes in the frequency of sexual intercourse may exert a very appreciable statistical effect upon the birth rate. It has been pointed out by Hogben that there are reasons for believing that changes in social hygiene, such as have been introduced during the period of the declining birth rate, may have tended to diminish the frequency of sexual intercourse. The recognition that ovulation occurs most frequently in the post-menstrual fortnight increases the cogency of this contention. A statistical study by Katherine Bemont Davies¹ shows a very striking minimum of sexual desire during the intermenstrual period. Maximum excitability occurs immediately before and after menstruation. Two new factors which would tend to promote greater frequency of

¹ "Periodicity of Sex Desire," *Am. Journ. Obst. & Gynec.*, Vol. XII, 1920.

sexual intercourse in what we may now assume to be the "safe" period, if indeed a safe period exists, have both come into operation during the period of the decline of the European birth rate. One of these is the increasing disposition among married couples to adopt separate sleeping arrangements. The other is the birth of the feminist movement. In its initial stages feminism was identified with a revolt against the sexual demands of the male partner and a puritanical exaltation of abstinence. With the growth of a more enlightened attitude to sex, this has given place to a recognition of the sexual needs of both partners and the attempt to adjust them in such a way as to secure maximum satisfaction to both. It can hardly be doubted that this attitude, reinforced by the factor of additional privacy which operates to-day in so many marriages, must reduce the frequency of sexual intercourse at the time when conception is most likely to occur, even if the net frequency of sexual intercourse remains unchanged.

That the spread of contraceptive practice has been mainly responsible for the decline in the European birth rate is a view which has been advocated by Carr Saunders, Beveridge, and Sargent Florence. Before examining the evidence it is important to remove any ambiguity about what is meant by the practice of contraception, and how far it is a new phenomenon in human history. Contraception may be defined as any method which enables sexual intercourse to take place without resulting in conception. Excluding the use of a safe period, which has been discussed already, contraceptive methods fall into two main categories. The first includes a variety of mechanical or chemical

devices designed to destroy spermatozoa or to prevent them from reaching the uterus. The second consists of various modifications of the sexual act. Of these the most important in this context is *coitus interruptus*. The importance of making this distinction is that it directs attention to the existence of a method which is seldom emphasized in current discussion, although it is known to have been used in biblical times and is undoubtedly used very widely at the present time. Recently, the present writer studied a number of questionnaires on the practice of birth control issued by the Birth Control Investigation Committee. According to the depositions the rubber sheath and *coitus interruptus* were the two methods most frequently used. *Coitus interruptus* was almost as widely used as the sheath. It was much more common than the much-advertised rubber cap. If any credibility can be attributed to the answers given it has a higher reliability than the chemical method (quinine) most commonly used.¹

In his book on population, Carr Saunders has collected a large body of evidence bearing on the fertility of pre-literate peoples.² Although accurate estimates of the mean size of family are obviously impossible, there is a general consensus of opinion that such peoples do not as a rule have large families. The estimates of most observers suggest that the mean size of the family in pre-literate peoples is between two and five. Three main reasons are given to explain the small number of living children. The first is that among many tribes prohibitions are enforced upon sexual intercourse at certain times, more especially during the period of

¹ *The Practice of Birth Control.*

² *The Population Problem.*

lactation which may be very prolonged. The other two reasons are abortion and infanticide. Taboos restricting sexual intercourse also exist among literate peoples. The Jews prohibit intercourse during twelve days of the menstrual cycle starting from the first day of the menstrual period. Infanticide, in the sense that unwanted children are deliberately killed, hardly exists in civilized communities but abortion continues to be very frequent.

It is difficult to say when the history of mechanical and chemical contraception begins. Obscure references to practices of a more or less magical character are known in the oldest civilizations. In the Middle Ages an Arabic manual of the sixteenth century described chemical methods. At the same period Gabriello Fallopius, an Italian anatomist, whose name is associated with the fallopian tubes, gave an account of various types of sheaths made from fine linen, lamb's gut, etc.¹ Such literature as can be traced does not, however, throw much light on the nature and extent of contraception. In the seventeenth century the subject began to achieve publicity in England and America. The earliest documents of importance in English appear to be the *Diabolical Handbills* (1823), usually attributed to Francis Place. Only one contraceptive device, the sponge, is mentioned in the handbills. They were followed in 1825 by Carlile's *Every Woman's Book; or What is Love?* This is cited as the first book in the English language to treat extensively of contraceptive theory and practice. We have no knowledge of the extent to which these early works were widely circulated. Organized publicity for contraception began

¹ The sheath was advertised in England in 1783.

with the publication of Knowlton's *Fruits of Philosophy* in America. This was later to achieve fame as the *corpus delicti* in the Bradlaugh-Besant trial. Forty thousand copies of Knowlton's book were circulated in England before 1877. In 1857 Drysdale published his *Elements of Social Science*, which has since run through thirty-five English editions.

In English-speaking countries the most important landmark in this period is the well-known Bradlaugh-Besant trial in 1877. Charles Bradlaugh and Annie Besant were prosecuted for participating in the circulation of the Knowlton pamphlet. A fierce storm of controversy was roused by the trial. One result was that 185,000 copies of the pamphlet were circulated in the three and a half years following. Contraceptive propaganda by means of the dissemination of literature has continued in ever-increasing volume up to the present time. With the World War a new phase of contraceptive history began. The first birth-control clinic in England was opened in 1921 by Dr. Marie Stopes. Numerous others have now been opened throughout the country. They are widely spread on the Continent and in America. The legal position varies considerably in different countries, but governmental edicts appear to have a very dubious effect upon the spread of contraceptive knowledge. In practice, birth-control propaganda is unrestricted in Great Britain. In most states in America it is technically illegal. France in 1920 and Italy in 1925 have made attempts to stem the spread of contraception. Japan until recently had a social tradition strongly opposed to family limitation. Recently there are signs that this attitude is changing, and contraceptive advertise-

ments occupy a prominent position in Japanese magazines.

The history of birth control can thus be divided into three periods. The first period covers the whole of human history until the end of the eighteenth century. We can say very little about it except that *coitus interruptus* was certainly known and practised, and some of the artifices widely used to-day were already known. The second period begins about 1830 in English-speaking countries and lasts till the World War. Contraceptive propaganda increased rapidly against strong religious and social opposition, but with an increasing amount of reputable support. The predominant artificial device used throughout this period was the sheath. It is highly probable that a significant feature of the period is the substitution of the sheath for *coitus interruptus*, through dissemination of knowledge concerning the latter method. The end of the War saw the beginning of a third phase. Social prohibitions against the discussion of contraception practically disappeared. Religious opposition among the Protestant Churches weakened. Birth control clinics were started. The rubber cap became a fashionable method in this period. In the last few years a change in social tradition has been reflected in the systematic exploration of the use of the older, and the possibility of devising new, methods. One result of this has been pointed out by the writer elsewhere (*op. cit.*). It is now clear that many of the contraceptive devices which are most widely used have a low reliability, and some are utterly useless.

Writers who have emphasized the important rôle of contraceptive practice in connection with the decline

of the birth rate have not always clearly distinguished between two totally different issues. One is whether contraceptive appliances constitute the chief means of maintaining a low level of fertility during the period of a declining birth rate. The other is whether contraceptive practice has anything to do with the fact that the decline began when it did. The history of birth control shows that the technical amenities existed two centuries earlier. So if contraceptive practice was the principal means of maintaining a declining fertility, the explanation of how the decline began must be sought in the social conditions which prompted people to seek and use devices long since available. Contraceptive practice may provide a true explanation of how a low level of fertility was maintained. It cannot be a correct explanation of why fertility started to decline at a particular period of modern history.

Four features of the decline in fertility of civilized communities since the middle of the nineteenth century have been emphasized by those who regard the spread of contraceptive knowledge as the principal explanation of it. The first is the differential fertility of the social classes. The second is the high Catholic birth rate. The third is the high fertility of rural populations. The fourth is concerned with contemporaneous economic changes. The evidence derived from any single source is inconclusive. The appeal of the argument is not free from the legal plausibility which arises from the cumulative weight of circumstantial evidence.

Perhaps consideration of the differential fertility of the social classes raises the most debatable issues. In his book on population,¹ Sargent Florence gives a

¹ *Population*, Psyche Miniature Series.

table, in which he correlates the birth rate of different occupational groups with the opportunities of individuals belonging to such groups for obtaining access to information concerning birth control, to support the view that the recent decline in the European birth rate is mainly, if not exclusively, determined by contraceptive practice. The system of arbitrary marks, which he assigns to assess facilities for obtaining access to information concerning contraceptive methods, is largely conjectural, and is not supported by data obtained by the present writer. Those of the latter may not have been a random sample of the population. Hence, conclusions drawn from them are not necessarily contradictory to those which Sargent Florence has advanced. It is perhaps worth emphasizing in this connection a fact, of which the significance has not been brought into clear perspective by writers on the history of birth control. Sargent Florence, like other sociological writers who emphasize the spread of contraceptive practice as the all-important factor in the decline of the birth rate, tacitly assumes that opportunities for obtaining information concerning birth control go hand in hand with educational amenities in general. The fact is that birth-control propaganda from its earliest beginnings in Britain and Germany has been closely associated with radical and socialist propaganda among the skilled workers. It is, therefore, difficult to see why there is any *prima facie* plausibility for the view that the middle classes as a whole, possibly excluding doctors and nurses, have had greater access to knowledge concerning the technique of contraception than the better-paid sections of the working class during the period in which the decline

of the birth rate has occurred, and more especially during the period when differential fertility was most pronounced.

In this connection it is necessary to distinguish between two separate issues. One is whether the fact of differential fertility offers any presumption in favour of the contraceptive hypothesis. The other is whether the spread of contraceptive practice offers an explanation of the fact that the differential fertility of the social classes is apparently disappearing and certainly diminishing at the present time. The two propositions are logically and chronologically distinct. It is possible to maintain the second and deny the first. It is also possible to assert the first for reasons which are entirely different from those usually given by advocates of the contraceptive hypothesis, while repudiating the reasons that they themselves give. A clue to the significance of the differential fertility of the social classes has already been given in the preceding chapter. In a society with large inequalities of wealth and expanding opportunities of advancement, the process of social promotion may be regarded as a means of sorting out the more sterile members for social promotion. Since man's reproductive behaviour is highly conditioned, infertility may result from idiosyncrasies of the reproductive apparatus or of the central nervous system. We may if we like distinguish between physiological sterility, which is unaffected by social environment so long as no cure for it is available, and psychological sterility, which includes all those temperamental peculiarities prompting the individual to avail himself or herself of opportunities for family limitation provided by human society. There is not the slightest doubt

that some occupations tend to sift out the more sterile types. The evidence for the absence of differential fertility before the decline of the birth rate began is unsatisfactory. Indeed, there is good reason to believe that infertility played a part in social promotion before the decline of the birth rate started.

Evidence for the rôle of sterility in social promotion is very decisively presented by Dr. Wagner Manslau, who has made a study of the German nobility and finds that marriages contracted with wealthy persons of a lower social status are relatively infertile. The figures he gives are arresting. He states his conclusions in the following words :

“ It is only in a negligible minority of cases that a commoner is elevated to the peerage for sheer merit, since the overwhelming majority owe their elevation to the great wealth that makes it possible for them suitably to support a title. And we know that great wealth regularly accumulates in families with the fewest children. Thus the conditions of civilized life operate automatically to select the wealthiest commoner families who at the same time are those with the weakest desire for offspring. These families pour upwards into the ranks of the nobility in a mighty stream, the men by acquiring a peerage and the women by marriage. And since the elevation does not alter the Reproductive Intensity of either sex they both help to destroy the fertility of the Old Nobility.”¹

In the early part of the twentieth century we have seen that the fertility of Catholics was higher than that of members of other religions in the same community. Those who advocate the contraceptive hypothesis attribute this to the condemnation of contraception by

¹ *Eugenics Review*, 1932.

the Catholic Church. Such a causal relationship cannot be maintained without examining the attitude of other religious bodies to birth control. The irreligious intellectual of the English professional classes is apt to argue as if the Roman Catholic Church were the only religious body with an effective ethical tradition. Although the Jewish faith has always been as intransigent to contraception as the Catholic faith, Jewish fertility is particularly low. It is more difficult to determine the attitude of Protestant Churches. Before the World War the sexual tradition of Protestantism was undoubtedly as rigid as that of Catholicism. By the time the Commission on the Declining Birth Rate in England was held, the Bishops had begun to waver and the Nonconformists had practically abandoned any attempt to stem the tide of changing social tradition. Several facts cast doubt on the view that the rigid attitude of the Catholic Church towards contraception is wholly responsible for the high fertility among Catholics. The decline in the birth rate began in France and Ireland, both predominantly Catholic countries. At the present time Austria, a Catholic country, has almost the lowest gross reproduction rate in Europe. In the U.S.A. the states with the highest gross reproduction rates have practically no Catholics. Their citizens are mainly Negro Baptist or Mormon (Utah). The two states with the greatest proportion of Catholics are Massachusetts and Connecticut. Both have fairly low gross reproduction rates. Connecticut showed a greater fall in fertility between 1920 and 1926 than any other state. If Catholic authority encourages high fertility by prohibiting contraceptive practice other than *coitus reservatus* (i.e., *karezza*), we should

expect the difference which existed in 1911 to hold good at the present time, and even be more pronounced. The attitude of the Church has remained unaltered, while Protestant teaching has relaxed. Clearly other factors besides the influence of Catholic doctrine have maintained the relatively high fertility of Catholics where it has been found to exist.

Somewhat similar difficulties arise when we examine the fertility of urban and rural communities. France again provides a stumbling block. The decline in the French birth rate began in the rural areas. Generally speaking, the differences in fertility between different regions are consistent with the view that there has been a diffusion of contraceptive knowledge outwards from more highly industrialized and progressive regions. On the other hand, wide differences in personal habits and manner of life distinguish rural and urban populations. The nineteenth century witnessed a considerable revolution in personal and domestic hygiene. This revolution in personal cleanliness, which was catalyzed to some extent by the discoveries of Jenner, Pasteur, Lister, and others began in the more highly industrialized countries and in the towns. It spread from the more prosperous to the poor. By current standards of Protestant countries, Roman Catholic countries are generally backward in domestic hygiene. Frequent washing of the body is one aspect of the cultural change which has taken place. Fifty years ago very few houses had hot-water installation for baths. In the prosperous classes it is now common to take daily prolonged baths. Baker (1931)¹ has shown that common soap is a very efficient spermicide.

¹ *Journ. of Hygiene*, Vol. XXXI, 1931.

It is more than 20 times as toxic to human spermatozoa as quinine, until recently the most widely sold chemical contraceptive. The widespread habit of excessive washing,¹ most common among the prosperous and educated, less common in Catholic countries, in rural communities and among the poorer classes, is a habit which began to spread about the same time as Malthusian propaganda, and is in itself a form of contraceptive practice—possibly a very powerful, but not a deliberate one.

As a further consideration which favours the contraceptive hypothesis, Beveridge has drawn attention to the lack of any apparent correlation between the declining birth rate and contemporaneous changes in material prosperity. "Equally impossible is it," he states, "to connect the fall of fertility with any economic movement. In 1881 Britain, Germany, Australia, and France were all at totally different stages of economic development, yet all experienced a heavy fall of fertility. Moreover, if the vital revolution were in any sense occasioned by an economic revolution, we should have to find the latter in our economic records. Nothing of the sort can be found." The final conclusion which the same writer draws is that "the practice of birth control, that is to say the deliberate prevention of fertilization, suddenly increased about 1880, not because there was any change of economic conditions making restriction of families more desirable than before, but because the means of birth control were perfected and the knowledge of them was spread."²

There is little doubt that contraceptive practice

¹ Accompanied by irrigation of the vagina.

² *Economica*, March 1925.

has enabled people to have less children than they would otherwise have had. Difference of opinion in this connection only arises concerning the relative importance of the biological consequences of changing social conditions. It is quite another thing to argue that people have less children merely because they are, for the first time, enabled to do so, or, in the words quoted above, that fertility began to decline because the means of birth control were perfected. Likewise, it is one thing to assert that Britain, Germany, Australia and France were all at totally different stages of economic development in 1881, and another thing to deny that economic agencies played any part in encouraging people to use contraceptive devices perfected at a much earlier date. Studies by Stopes and others, who have traced the history of contraceptive practice, show that no striking improvement in the technique of contraception immediately antedated the decline of the birth rate. It is beyond dispute that the fall in European fertility was accompanied by a greatly increased dissemination of contraceptive information and by a more widespread and rigorous use of all available methods. The spread has gone on with ever-increasing rapidity, particularly since the World War. It is reflected in the rapidly changing attitude of public opinion to birth control. When this has been admitted, two reservations should be borne in mind. The first is that the spread of contraceptive propaganda in the 'eighties is itself a fact which needs explaining, as Beveridge and Yule have pointed out. It was made possible by the growth of a social tradition in favour of sterility. This tradition did not become apparent until long after the devices which were the actual

means of implementing it were first manufactured. An explanation which is fully compatible with the economic data is that it was probably strengthened by the social promotion of sterile individuals, illustrated by Dr. Wagner Manslau's data. The second reservation is that the contraceptive hypothesis fails to account for as many facts as it explains. Those who advocate it have paid too little attention to changes in social habits which do not come within the field of deliberate limitation and may have a considerable influence on fertility. We know far too little of the physiology and psychology of reproduction to dogmatize about their relative importance.

In the passage cited above, Sir William Beveridge is evidently thinking of economic changes in a very restricted sense. The decade which preceded the decline of the birth rate in England was signalized by two important series of events. Each of these prepared the poorer classes to respond to the social tradition promoted by the more prosperous. The Royal Commission which investigated the conditions of children's employment in 1861-63 initiated fresh restrictions to child labour in a succession of measures culminating in the Consolidating Act of 1878. School Boards were set up in 1870, and the Compulsory Bye-Laws Act of 1880 recognized a *fait accompli* by making school attendance obligatory. The child had ceased to be an asset, and was becoming more and more a liability. Contemporaneously, an efflorescence of popular culture had spread the gospel of the Wages-Fund, the merits of Self-Help and the duty of thrift among the artisan class. Expanding opportunities for social promotion, colonial appointments, and new professions, the emergence of a

tradition of ritual hygiene, these and doubtless many other innovations more important in other countries are characteristic of the decades which antedate a decline in fertility. In this situation of supersaturated equilibrium, the catalyst of an economic catastrophe may well have sufficed to seal the fate of the patriarchal family. Such a catastrophe was the world-wide depression of 1879. Thereafter we witness a consistent decline in fertility in countries so far apart as Canada and Sweden.

If it would be rash to deny any connection between economic changes and the decline of the English urban birth rate, it would be even more rash to say the same about the earlier decline of the French rural birth rate. Individual property in land was a cardinal doctrine of the Revolution which abolished feudal rights and hastened the replacement of seignorial and communal holdings by small individual proprietors. This class maintained its hold on the soil through all the subsequent political events. The effect of the provisions for the subdivision of the family inheritance in the Code Napoleon are thus described by Clapham: "The slow growth of population, and its actual decline on the land, have prevented any conspicuous increase in the subdivision of the holdings. It could in fact be said with almost absolute truth that population has not grown in order that holdings might not be sub-divided; some of the districts where the fairly prosperous peasant owner or the comfortable farmer predominates being those in which the birth rate is lowest. Such are the Garonne valley, Burgundy and Normandy." ¹

¹ Clapham, *Economic Development of France and Germany*.

§ 4

In the present chapter we have surveyed two principal hypotheses concerning population growth. One is general. The other, that is to say, the contraceptive hypothesis, does not specifically involve any predictions. Its chief value lies in directing attention to the fact that in the period in which we live a new factor has emerged. Man's increasing disposition and ability to regulate his own reproduction makes it impossible to compare population growth in the twentieth century with anything that has taken place previously. The evidence bearing upon deliberate contraception leaves open the possibility that unintentional agencies may contribute to the decline of fertility in recent years. It emphasizes the fact that the field of diminishing fertility is continually extending. The logistic hypothesis did not admit the possibility of a declining population. It led us to envisage a stationary population in a future which is not remote. From either point of view the menace of over-population is entirely imaginary.

After Pearl's prediction of a saturation point for the population of the U.S.A. somewhat below the 200 million mark, Professor East was inspired to follow in the footsteps of Sir William Crookes, who in 1898 predicted an approaching world famine of fixed nitrogen. Ten years after this prediction the air was already being used as a source of nitrogen. The thesis of Professor East's reflections bearing the arresting title, *Mankind at the Crossroads*, was that current standards of farming in the United States could support only 166 millions of people. "The world" proclaimed Professor East in a passionate pulpit appeal for contraceptive practice,

“confronts the fulfilment of the Malthusian prediction here and now.” Here and now ten years after Professor East’s intrepid expedition into the upper ether of agricultural prophecy, the *U.S. Department of Agriculture Year Book* informs us that “technical progress has increased farm productivity tremendously in the last fifteen years, but the benefit has gone largely to the consumers. Farming has been industrialized and mechanized. It has used science, decreased its production costs, and increased its output, without finding either profit or security in the process. It has made two blades of grass grow where one grew before, only to find the second blade depressing the price of both. Continuing in the path in the hope that still greater efficiency will eventually force our competitors out of the market, seems likely to work no better in the future than it has done in the past. Farming is becoming more efficient all over the world, and crop acreage and livestock breeding are increasing. The competing groups know that a halt in production will have to be called, but no group wishes to be the first to slow down. In the last seven years it ” (the wheat producing world) “has produced an annual average of forty-three million bushels of wheat more than has been consumed and the United States carry-over has piled up to the record total of 275,000,000 bushels.”

Pearl’s figure for the saturation limit of the world population lies about 30 per cent. above its present level. Probably the bulk of the increased food requirements demanded by such an increase could be met by parasite control alone. Concerning Professor East’s conviction that the Malthusian ratios have at last come into their own, it is sufficient to remark that according to the

source quoted above " with a population only 20 per cent. greater than that of 1900, the world's wheat and rye production is now something like 30 per cent. greater, and its production of corn, oats, and barley taken together, about a third greater."

Writers on birth control have pointed out that of late years there has been no Malthusian correlation between the standard of living and the birth rate. The birth rate has fallen while real income per head has gone up, and it has fallen most in the more prosperous classes. It does not follow from this that there are no economic agencies affecting declining fertility. In a society stratified in different levels of consumption national indices cannot adequately represent the condition of a large portion of the peoples. This is borne out by the fact that a world wheat surplus exists side by side with a vast amount of undernutrition at the time of writing. One element in the economic situation associated with the decline of the birth rate was the intensification of social promotion when markets were expanding. It is becoming clear that such social selection has played a part in the low fertility of the more prosperous classes who have imposed or are imposing their mores on the rest of the community. The response of the less-prosperous classes has been favoured by a new economic pattern of family life resulting from the restriction of child labour, the introduction of universal education, and new conditions of land tenure. Hence arises the paradox that people limit their families for one of two reasons, because they are prosperous or because they are not. The social tradition which has been generated by individual competition in economic life is now proving to be self-

destructive in its biological repercussions. Present economic arrangements discourage reproduction. If the human race is to continue as a dominant species, man must now devise new economic arrangements more adapted to the requirements of his own ecology.

CHAPTER VI

THE REINSTATEMENT OF THE CHILD IN A PLANNED ECOLOGY

Task of Science to Prescribe Rather than Predict—The Arithmetic of Birth Control Propaganda—The Necessity for some Large Families—Industrialism and Acquisitiveness as Agents of Sterility—The Situation in Soviet Russia—The Place of the Child in the *Public* Society.

§ 1

It is not the aim of this book to perpetuate the blunders of those who have made prophecies about the future of human population growth. We cannot tell how far the progress of scientific invention may aggravate the prospect of decline or furnish remedies which now seem as fantastic as the discovery of television to our grandfathers. Even the substitution of ectogenesis for our present methods of rearing a family is less fanciful than it may have seemed to readers of *Daedalus* when Professor Haldane first published his diverting speculation on the future of biological invention. Within the last two years the rabbit embryo has been cultured *in vitro* up to and beyond implantation. So far the expectations raised by Professor Haldane's programme have been fulfilled. Contemporary biological knowledge discloses the germs of many alternatives. Recently, a Russian scientist has succeeded in effecting the separation of male and female determining spermatozoa in the seminal fluid of the rabbit.

There is no reason why a similar method should not be applied to man. Indeed, sex-determination by artificial insemination may very well be achieved before many years have passed.

The effect of this upon the sex-composition of a population would raise unforeseen and formidable difficulties. Artificial parthenogenesis by physico-chemical agencies, first carried out with sea urchin eggs in the 'nineties, has now been extended to the rabbit. Though no mammal has yet been reared to maturity from an unfertilized egg in the laboratory it is eminently possible that this will be done. If it ever is accomplished, human beings will be able to produce families by a method which has always proved singularly attractive to devout persons. On cytological grounds it is probable that mammals produced parthenogenetically would prove to be females. If so, the male sex would become unnecessary. Another possibility in the field of biological invention lies in further research into the environmental and hereditary factors which affect multiparous births. If twin births were the rule rather than the exception a new class of problems would arise.

In bringing together the principal conclusions which have emerged from the preceding pages, the reader may be reminded of Bacon's words. Our aim has been to study the growth of the human ecological unit as a branch of "such philosophy as shall not vanish in the fume of subtile, sublime, or delectable speculation, but such as shall be operative to the endowment and benefit of man's life." We have directed attention to a state of population growth which seems likely to lead to a rapidly diminishing population, and possibly

to extinction in some of the leading civilized communities of the modern world. Since biologists no less than politicians carry on their work on the assumption that it will interest future generations, it would be an affectation to deny any concern for the continuance of the human experiment. We cannot, therefore, relinquish our task without exploring the possibilities of social conduct which could alter the present trend of population growth.

Before embarking upon a discussion of this nature, two points need emphasizing at the outset to avoid misunderstanding and misinterpretation. The first is that the magnitude of the problem raised by the declining birth rate of industrialized communities is compatible with the fact that the increase of man's rational control over his reproductive powers, through the improvement of contraceptive technique and the diffusion of knowledge concerning it, is of itself an advance in the amenities of civilized life. Every advance in social tradition entails the need for new adjustments of one kind or another. The dissociation of parenthood (which is still to many people a gratifying experience) from sexual companionship (which in one form or another is essential to the happiness of most human beings) undoubtedly heightens the enjoyment derived from either.

A second point which calls for emphasis is that opposition to birth control offers no solution of the problems raised in the preceding chapters. So long as no simple devices of a harmless nature were widely available it was easy to make a virtue of the necessary connection between sexual companionship and reproduction. Possibly the cultivation of lettuces would

have been associated with the loftiest moral sentiments if the connection between Vitamin E and human fertility had been elucidated at an earlier date. In agrarian communities the moral sentiment which accepts reproduction as a natural consequence of sexual gratification, harmonizes with a prevailing disposition to endow high fertility with social prestige. Social conditions, especially those associated with large urban communities, have brought about a different attitude to parenthood. Children are felt to be a burden. Contraceptive practices which existed long before the advent of industrialism have become popularized. The moral sentiment towards sex and parenthood has changed, and in this generation a new ethos has been accepted as a *fait accompli* even by the Protestant churches. Where an earlier moral tradition has been revived to check the spread of contraceptive information, no effective increase in the birth rate can be claimed, and one is left to conclude that abortion, infertile variants of sexual behaviour, or illicit traffic in Malthusian appliances take the place of contraceptive practice sanctioned by public opinion. To abandon family limitation is not practicable. Even if it were it would involve a sacrifice of human health and happiness and of one of the instruments of a rationally planned ecology of mankind.

These advantages must not blind us to a significant, and from the present standpoint, highly dangerous current in the diffusion of contraceptive knowledge. Birth-control propaganda has been associated with the acceptance of a new norm for the size of the family. Among the prosperous classes the family of two is almost universally regarded as a sufficient ideal. The

woman with four or more children is a subject for comment, condolence, if not opprobrium. A growing social pressure is being brought to bear on the classes which do not conform to this standard with results which have been discussed in Chapter IV. The protagonists of the birth-control movement have not faced, and some obstinately refuse to face, the arithmetical results of a tradition which they themselves have helped to universalize.

Indeed, very few people nowadays pause to consider what will happen if the view that condemns families of more than three children is universally adopted. The prevalence of this sentiment does not mean that every married woman will have two or three children. Many will have one or none. The fashionable family means an average family of little more than one at the best, more probably less than one. On the basis of the marriage and mortality conditions which existed in the United States in 1920, Dublin has given us an estimate of the average family necessary to safeguard a population against extinction.

“ Out of every thousand females born, 788 will eventually marry. In other words, we must count on 788 married women to give birth to one thousand daughters to replace the thousand from whom they sprang. To put it another way, each thousand married women must have 1268 daughters to replace themselves under present mortality conditions. Likewise, each thousand married men must be the fathers of 1350 sons in order to replace themselves. Combining our figures, we find that 1000 families must, on the average, have 2618 children, or each family must, on the average, produce 2.6 children, to replace the original quota from which the parents sprang. Not all families,

however, have children; at the present time one marriage in six is either sterile or does not lead to living issue. The burden of child-bearing falls, consequently, on the remaining families, who must bring into the world an average of not 2.6, but 3.1 children." ^{1, 2}

This estimate sheds a formidable light upon the attitude which many birth-control propagandists adopt towards the ideal size of the family. Under all conditions of fertility which have been observed many families of only one or two children occur. In order to maintain an average family of more than three there must thus be an appreciable proportion of families of four or five children. Although it is true that the average given by Dublin could be reduced if there were less infant mortality and a higher marriage rate, the effect of such changes can only be slight. It still remains true that *a population can only maintain itself at a stationary level, if every woman bears on the average about three children, and this is only likely to happen when many women bear four or five children.* Hence the pressure of public opinion among the urban Protestant population of English-speaking countries is being exerted to depress fertility below the necessary level. The problem before us can be put briefly by asking how we are to obtain a sufficient number of four- or five-child families.

¹ *Population Problems.*

² On comparison with the number of survivors in the life table it is clear that Dublin's estimate of 788 for the number of women who live to get married is decidedly too high. The mean size of family should, therefore, be higher than that given. This consideration strengthens the argument put forward in succeeding paragraphs.

§ 2

We cannot hope to formulate any practical proposal to safeguard against a continuous decline of population unless we clearly envisage the agencies responsible for the present state of affairs. Some of these have already appeared in the course of previous discussion. We have seen that the rate at which new human beings are being produced bears no relation to the capacity of society to provide for them. When we ask how the attitude of the individual parent is affected by economic circumstances an apparent paradox arises. Where real incomes have risen fertility has declined. The more prosperous classes have the fewer children. At the same time inadequate means is universally given as the most potent motive for limiting the family. The paradox can be easily resolved when we reflect that children have almost ceased to become an asset. They are an expense. As such industrialism proffers a number of alternative and often more attractive ways of spending money. Statistics clearly show that the choice between a Ford and a baby is usually made in favour of the Ford. Nor is a higher standard of life demanded by parents for themselves alone. Their demands for their children have perhaps increased even more. Increased attention to child welfare has raised the standard of life for children. A single man with no dependents is not a little better off than a man with a wife and four children. He is about six times better off. Children are a competing element in a rising, because more variegated, standard of life.

Children have ceased to be a form of old-age insurance. Urbanization and increased mobility have

helped to break up the family as an economic unit. Old-age pensions and social provisions for the physically unfit have decreased the interdependence of the members of a family upon one another. Housing is possibly the most striking example of the difficulty which children place in the way of attaining an acceptable standard of life. Landlords play no small part in promoting family limitation. The evidence given before the Commission on the Declining Birth Rate brought out clearly that necessitous parents of large families find suitable accommodation almost impossible to obtain. A vicious cycle results. Owing to the scarcity of large families fewer and fewer new houses or flats are erected to accommodate them. So the tradition which favours the family of two is built into the structure of contemporary civilization.

Another circumstance which contributes to family limitation is the increased employment of women outside the home, and their desire to compete on equal terms with men in similar occupations. That the birth rate of the textile workers is considerably lower than that of other sections of the working class can be partly attributed to the avenues of employment open to women in that industry. Conversely, the new status of the family under industrialism is itself a factor in the exodus of women from the home. Motherhood no longer offers a satisfying career for the majority of women from the cradle to the grave. The adolescent girl has to face this difficulty at an early stage in her education. The precarious possibility of finding a congenial male willing to undertake the responsibilities of a family at an early age compels her to train for some other occupation. Once again we can detect the

accumulative effect of the agencies associated with a declining birth rate. The exodus of women from the home encourages family limitation, and family limitation encourages women to seek occupation outside the home.

An increased standard of life for children involves more than the material and educational amenities which parents demand for them. Among the prosperous classes eugenic sentiment emphasizes the peril of transmitting undesirable hereditary qualities. Since eugenic teaching is apt to attribute most human irregularities to the effect of a bad hereditary equipment, few families are without a genetic skeleton in the cupboard, a conclusion which is conspicuously true of some pedigrees which have been cited to illustrate the transmission of inherited ability. While nothing could be more desirable than the growth of a eugenic conscience, such fears are more often a rationalization which reinforces a disinclination to reproduce than a socially adequate reason for refraining from doing so in our present state of knowledge. At the opposite extreme of crude environmentalism psycho-analysis has assisted in transferring the burden of original sin from the child to the parent. Fortified with beard and bible, the Victorian father shouldered his responsibility for the misdeeds of his offspring light-heartedly. Deprived of their protection, the modern mother approaches her task with the misgiving that the most trivial ineptitude may lay the foundations of a psychoneurosis.

It has been pointed out in an earlier chapter that frequency and proficiency of sexual intercourse may appreciably affect the possibility of conception. In what direction if any this consideration is relevant to

the possibilities of further decline we have no means of knowing. One thing is certain. The psychological characteristics of sex and parenthood are changing both for men and women. A characteristic and not necessarily regrettable narcissism of women is perhaps one of the most striking features of contemporary civilization. Intensive culture of personal appearance and bodily fastidiousness is not readily reconciled with the corporal realities of reproduction. The difficulty of reconciling narcissism with the pursuit of motherhood may be largely due to the backwardness of obstetrics and gynæcology, especially in their preventive aspects.¹ Although modern women, particularly the more prosperous, often embark on a series of major surgical operations with the advent of a first child, the repetition of pregnancy and parturition can even now be a congenial and rejuvenating experience for a small minority. We have no reason to suppose that the advance of biological knowledge will prove unable to increase their number. Further research in the physiology of reproduction is one of the first desiderata for the solution of the population problem. Equally great is the need for extending the scope of anthropological studies, such as those of Havelock Ellis or Malinowski. The sexual behaviour of Manchester or Montana is of more moment than that of Melanesia. At present we know rather less about it.

¹ That the leader-writer of the *Lancet* is right in asserting (Nov. 3, 1928) that "the science of Gynæcology and Obstetrics is generally admitted to be the Cinderella of the medical curriculum" may be illustrated from the fact that the maternal death rate per 1000 confinements increased from 3.87 in 1912 to 4.42 in 1928 while the death rate from respiratory tuberculosis fell by 29 per cent. in the same period in England and Wales.

It would be a grave error to assume that the main drive to family limitation comes from women. A series of data recently studied by the writer showed that in the small sample available by far the larger part of the contraception practised was due to methods used by the male. There cannot be any doubt that men are at least as determined as women to limit their families and are showing an increasing disposition to avoid the economic burdens involved. The contrary impression is sometimes given by neo-Malthusian propagandists who carry on their work through the medium of clinics. Clinic reports might lead one to imagine that the main incentive to the extended use of contraception is the determination of women to rid themselves of a burden imposed on them by men. Conflicting views about the respective rôles of men and women in family limitation can be reconciled by distinguishing between two stages in the evolution of contraceptive practice. In classes or districts where there is no tradition of family limitation the burden of excessive child-bearing probably falls most heavily on the mother. When a fixed weekly wage only provides for the bare necessities of life, the mother has to stretch the family income to meet the needs of many children at a great cost to herself. It is natural to suppose that the first impulse to break through the inertia of custom and tradition comes from those most affected by it. Of such women the *clientèle* of birth-control clinics in their early years was largely composed. Conversely, it would seem that men are even more ready than women to perceive its advantages when a tradition of family limitation has been firmly established. Many, if not most, women still find in motherhood compensa-

tions which to some extent counterbalance the disabilities entailed. For many men there are no such compensations. Perhaps it would be correct to say that we are approaching a state of affairs when all children will be born either as the result of an accident or through the initiative of the mother with the more or less reluctant consent of the father. Evidence in support of the view that men are more antagonistic to reproduction than women was brought forward in an earlier book by the writer. Analysis of questionnaires showed that the correlation between the number of children born and the duration of reproductive life was nearly unity when female methods of contraception were employed, and nearly zero for male methods. The difference is too great to be accounted for by differences in the reliability of the methods used. Although the numbers studied were small, the result is striking, and it reasonably suggests a difference in the attitude of men and women to contraception. The main concern of women would appear to be spacing out their pregnancies so as to safeguard their health and that of their children, or so as to avert the risk of an excessively large family. Men, it would seem, are determined to restrict their families to at most two, or more rarely three, irrespective of the rate at which the children are produced. Evidence from the same source suggested that some small part of the greater unreliability of the rubber cap as compared with the sheath arises from a conflict between the desire of women to have children and the complex of social and economic forces which inhibit it.

A consideration of present rates of fertility, and observation of the behaviour of women, indicates that

if the reproductive physiology of women involves a disposition to produce children, it is not sufficiently strong to override inhibitory forces inherent in modern civilization. In many marriages there is little difficulty in achieving a satisfactory compromise between the desires of both partners. However, it is likely that the full effect of the male attitude to reproduction resulting from the social emancipation of women has not yet been realized. The protective attitude of the patriarchal husband to the child-bearing and home-keeping wife is being replaced by a conception of marriage based upon equality of responsibilities and community of interest. The irruption of children into the modern erotic marriage involves a displacement of the emotional pattern. The woman may gain something. The man more often experiences a loss of emotional and physical intimacy. Such a situation is not infrequent at present. It is likely to become more common. It has an especial bearing upon population growth in the U.S.S.R., where all occupational fields are thrown open to women. Conceivably this might encourage the growth of a type of sexual relationship incompatible with reproduction, though it would be rash to predict that it will inevitably do so. The emotional reactions of human beings are capable of profound modification in response to extrinsic forces, and many other things are happening in the U.S.S.R. besides the opening up of careers to women.

What we can see clearly is that the rôle of men and women respectively in restricting reproduction is highly significant in relation to any possible solution of the population problem. In this context there is nothing to be gained by introducing a word which has

long been abandoned by experimental biology. Instinct may still be a convenient way of saying that people behave in a particular way in particular circumstances, or a convenient way of saying we do not know what leads them to behave in a particular way. It does not help us to decide when they will cease to behave in the way which we expect or to explain how the characteristics of behaviour arise. Taking the facts as they stand it does not seem that women betray a disposition to reproduce at a rate sufficient to maintain a population in existence. To guarantee this result incentives for both sexes are necessary. It might happen, however, that incentives which would be adequate for women would fail to overcome the opposition of men. This would lead to one of three results. The first is that industrial civilization of the type with which we are familiar would cease to exist. It is also conceivable that the determination of women to reproduce and to continue the race will lead to a sex war surpassing in bitterness the fight for professional education or the vote, and terminating in a more matriarchal type of social organization. Alternatively, if we are optimistic, we may hope that men and women may both be able to make the necessary emotional adjustments to a society in which children fulfil a social function.

§ 3

Two views concerning the economic and psychological factors which inhibit reproductive vitality in contemporary civilization must now be distinguished. One is that they depend on the productive character of industrial civilization. The other is that they arise

from the distributive arrangements which have hitherto prevailed in the industrial era. The two possibilities are not mutually exclusive. We may attribute our low fertility to the spread of large-scale industry with its resultant changes in methods of living. We may attribute it to the tradition created by an acquisitive society which appeals to the incentive of private profit coexistent with large inequalities of wealth. Industrialism has increased the number of amenities and amusements, more particularly greater ease of travel, thus providing distractions alternative to parenthood. The individual desire for a more varied life is bound to restrain the production of children. It might even do so to a greater extent, if a more equitable social distribution of amenities is attained. A wider field of occupation for women competing with men for the same distinctions and responsibilities can hardly fail to curb reproductive activity in any type of society. The existence of large cities which are definitely unpropitious to reproduction does not seem to be necessarily a concomitant of any particular method of production or distribution but of the chaotic way in which industrialism has developed. The unequal distribution of the economic burdens of parenthood and the lack of security which makes people unwilling to undertake them are consequences of our arrangements for the distribution of wealth. Most important of all is the tradition of sterility to which the industrial revolution gave birth. The conclusion which emerges most clearly from our study is that the *laissez faire* economy is a biologically self-destructive arrangement of man's social life. It puts a price upon parenthood. It confers social prestige upon sterility

by ensuring the social promotion of persons with low reproductive vitality. The less prosperous incur the stigma of thriftlessness for the discharge of their racial responsibilities. The facts conclusively show that they too have now succumbed to the suicidal prudence of their betters.

Thus the fundamental issue raised by our enquiry into the conditions of population growth in modern civilization is whether any possible modification of a society which depends on the incentive of private profit could suffice to counteract its biological incapacity for perpetuating itself. Various devices have been suggested and adopted in the hope of encouraging a higher rate of reproduction without departing from the essential pattern of the economic system which exists in Western Europe and America. Of these the system of family allowances has raised the highest hopes. Family allowances have now been tried on a large scale in France and Australia. One of their principal advocates, Professor R. A. Fisher, says of the situation in France : " Whereas, however, the economic objects of the French system, in combating unmerited poverty, in inducing industrial contentment, . . . seem to have been very satisfactorily realized, the biological object of increasing the number of births has met, so far, with no appreciable success, even in those associations in which the allowances for the later children are sufficient to give a positive economic inducement to further parentage." ¹ Still less is any visible effect apparent in Australia.

This is not a sufficient reason against extending the practice of family allowances which have much

¹ *The Genetical Theory of Natural Selection.*

to commend them on other grounds. They may promote a higher standard of life all round and enable better provision to be made for the children who are born. The same applies to such measures as increasing the income-tax allowances for children. They ease a little the burden of parenthood. There is no evidence that they increase the number of children born. Such readjustments may possibly do something to check a further fall in the birth rate. There is not the slightest reason to believe that income-tax reduction or family allowances, except possibly on a scale that would wreck the present distributive machinery, are likely to have any appreciable effect in raising fertility where it is now below the level adequate to maintain a stationary population. In prescribing any policy which could reinstate fertility in a society regulated by the profit-seeking motive, everything depends upon what we regard as "positive economic inducement." Academic discussion of family allowances is often vitiated by complete disregard for the commonplace realities of child-rearing. By understating the magnitude of the necessary inducements, the advocates of family endowments sometimes give the impression that they are more anxious to justify or perpetuate the existing economic system in its main features than to achieve their ostensible biological objective. For many reasons, the estimates of adequate family allowances usually given are grotesquely and fantastically low.

If as Dr. Fisher and the writer believe, social promotion favours the sterility of a class which has imposed its mores on the rest of the community, it is of foremost importance to consider what financial inducements would be necessary to raise the fertility of the com-

paratively well-to-do. With the advantage of being at the same time the mother of four children and a wage-earner in the academic profession, the writer can approach the discussion of a family allowance adequate to act as an incentive to parenthood in the professional class with first-hand knowledge of the difficulties. Three main points merit emphasis in this connection. The first is that a professional man not infrequently marries a woman who is actually or potentially a wage-earner. Under existing conditions the wife's capacity to earn is seriously handicapped and usually cancelled by the production of several children. In the second place, an examination of the family budget shows that taking all items together a child consumes at least as great a proportion of the family income as an adult. A rapidly growing child eats more than an abstemious adult. Its clothes cost at least as much, since they are rapidly outgrown and more rapidly outworn. It consumes an equal share of house-room, heat, light, and service. Its doctor's and dentist's bills, for preventive and specialist treatment, are often about ten times those of the adult. A man with four children and an annual income of a thousand pounds has therefore a standard of life corresponding to an income of less than £200, or roughly a fifth of that enjoyed by his bachelor colleagues or unmarried women of the same status. This estimate does not take into account the fact that the professional classes generally adopt an artificial standard of education which tends to accept high school fees as a criterion of educational merit.

One college of London University has instituted a scheme of family allowances by which £30 a year is paid for each child under 13, and £60 a year for each

child over that age if at school or college. While such provision is certainly generous compared with any scheme that has been suggested for the less-prosperous classes, it is obvious that these figures represent only a small fraction of the actual cost of a child to those who receive the allowances. Let us consider one item of expenditure, assuming that a housing standard of one room per person, whether child or adult is not unreasonable. The sum of £30 does not pay the rent of a single unfurnished room in any district of London where academic persons normally reside. It would be surprising if the fertility of the staff in the College where this system has been introduced were unusual. For any scheme of family allowances intended to be an effective inducement to reproduction, as well as a benevolent gesture, it would be necessary to obtain a grant of considerable magnitude from the State. A third issue brings us back to the existing mechanism of social promotion. The handicap of children is felt most acutely in the early stages of a professional career. To a very large extent rapid advancement depends on mobility and facilities for social intercourse. The unencumbered individual can avail himself of opportunities for work and personal contacts wherever they may be found without great cost. Directly he has a family, travel involves the upkeep of two establishments, or, when there is a change of permanent residence, formidable domestic rearrangements.

Somewhat similar considerations affect the feasibility of family allowances for industrial and agricultural workers. The practical results achieved by the French system have been severely criticized by several writers. It was operated chiefly in the heavy industries in North-

Eastern France. Owing to an increase in the cost of labour, capital has ceased to flow into them, so the State has been obliged to subsidize these industries. The working of the scheme has met with strong Trade Union opposition because of the absolute reduction in the wages of single men and the consequent lack of community of interest between single and married men. The total inadequacy of existing provision for family endowment to meet the real cost of a child emerges even more clearly in working-class schemes than in the professional illustration already cited. The *reductio ad absurdum* is reached in the allowance of 2s. per week for a child of parents who are unemployed. This sum is about sufficient for the soap and hot-water necessary to regulate the excretory activities of a newly-born human being in conformity with current hygienic conventions.¹

In a society which invokes the incentive of private profit it is difficult to devise any scheme of family endowment which completely evades the danger of defeating its own end. Married men with dependents may still suffer in competition with single men or unmarried women when the expense of adding their cost to the pay-roll assumes formidable dimensions.

¹ Family allowances are paid at the rate of 2s. per week for each child in New Zealand and 5s. per week for each child in New South Wales. In Belgium the monthly scale is 15 francs for the first child, 20 francs for the 2nd, 40 francs for the 3rd, 70 francs for the 4th, and 100 francs for the 5th and subsequent children. Two typical French scales range from 27 or 60 francs per month for the first child to 321 or 540 francs for the sixth child. In the Parisian metal industries wages are increased by 1 per cent. for 1 child, 10 per cent. for 2 children, and 40 per cent. for 5 children. Vide *Insuring the Essentials*, by B. N. Armstrong, and *Labour Movement in Post-War France*, by Sapoess.

If this difficulty could be overcome a scheme which would provide really adequate financial inducements to the bearing of more children would involve the raising of enormous sums by taxation in one form or another. The existing machinery for providing industry with capital would cease to function. That we do not provide for children a standard of life good enough to make parents feel that it is worth while bringing them into the world is not because productive resources for such a standard do not exist. It is because a change in the distributive machinery needed to make it available would undermine the *laissez faire* economy.

The advocates of family allowances, especially those who are childless, have busied themselves with devising trivial incentives for individual parents who suffer from serious handicaps arising from defective social organization. No economic rewards of practicable dimensions can meet the need for efficient ante-natal treatment or child clinics. They do not supply the need for crèches and holiday camps to enable the parent to enjoy the same amenities of travel as the bachelor or childless woman. They do not prevent parents from limiting their families to meet the demands of schools which exact exorbitant fees in return for the social prestige which they confer. Taken by itself family endowment leaves the whole competitive pattern of social relationships which are inimical to fertility exactly where it is. Possibly the doctors, dentists, children's outfitters, dairies and more expensive educational establishments might benefit from it. There is no reason to believe that national fertility would increase. The psychological background for the very strong appeal which family endowment makes

to the professional worker is easy to understand. A class of society which is accustomed to unload its domestic drudgery upon a class with a lower standard of living and, until recently, a much higher fertility tends to think in terms of what it is pleased to call the "domestic servant problem." For them a higher income means more hired labour, and hence, somewhat inconsequentially, higher fertility. Since they have now succeeded in imposing their pattern of family relations on the rest of the community, the attractive simplicity of this syllogism has ceased to have any bearing on the problem we are now discussing.

Some of the stumbling blocks which we have traced primarily to industrialism could certainly be alleviated. Decentralization of industry, by making it possible for more people to live in fairly rural surroundings, should make it easier for them to have children. Maternity for wage-earning women could be facilitated by allowing them the requisite amount of leave and by more extended provision of crèches and social and medical services. In the *laissez faire* economy the first raises administrative difficulties which feminists have been remarkably slow to face. The latter stands little chance of acceptance at a time when social services are being curtailed on every side. Many similar suggestions could be put forward with little prospect of achieving much. They would usually encounter insuperable obstacles within the prevailing economic system. Apart from that, they do not touch the underlying psychological causes of sterility. Meanwhile the problem with which family allowances and other palliatives are intended to deal is almost certain to become increasingly and accumulatively more acute.

If for no other reason, contraceptive methods are likely to become vastly more efficient.

By the time Governments are faced with rapidly declining populations the process will have gone so far that moderate and facile proposals will have ceased to have any plausibility. As the producers of an essential and scarce commodity women may then be able to enforce their own terms for its production. The victorious march of feminism during and immediately after the European War has concealed the fact that some of the ground won has been lost. Men are still the dominant sex in most fields of activity. In a population crisis such as we may now envisage, women may use their new position of power to monopolize large spheres of government and professional activity, to deprive men of property rights, and restrict their social function to routine occupations such as the care of children and the home. There is nothing biologically ridiculous in such speculations. In some primitive societies men have found their place in the home. Sooner or later we may expect that sex-determination and artificial insemination will be a commonplace of child-bearing, so that girl babies could be produced in the main with sufficient males to form a small and serf-like class. Fortunately perhaps, we are not limited to the consideration of such a *dénouement*. For our practical purpose it is more profitable to examine possible developments in the U.S.S.R., where drastic changes in the economic system have already taken place.

§ 4

The present state of population growth in the U.S.S.R. was described in an earlier chapter. Till

1929, when statistics were last published, fertility in rural Russia was still very much higher than in the rest of Europe, though there were indications of a decline in the Ukraine. Analysis of the factors affecting population growth in the U.S.S.R. is difficult in view of the rapidity with which conditions change, but the main trends are clear. Some of the sterilizing features of industrialism are being repeated and even intensified. Travel, of all the amenities which industrialism provides the least compatible with parenthood, is being greatly extended. Women are encouraged to enter all occupations, and no explicit sex barriers are put in the way of their advancement. According to Joan Beauchamp this has not involved a very radical change in the habits of the women, since the home in the English sense has hardly existed in Russia. Women of the working class and peasantry have always worked outside it either as unskilled labourers in the towns or on the fields. In the long run the tradition of "socialist emulation" in the service of the community which women share equally with men may conceivably prove as deterrent to the *large* family as the acquisitive competitiveness of Western Europe.

The U.S.S.R. could have set before itself either of two alternative programmes. It might have adopted the social-democratic plan of recognizing motherhood as a profession safeguarded by State endowment of the family. It has actually set out on a different road. To a considerable extent the care of children has been taken over by the State, and the production of children is regarded as a subsidiary interest consistent with the mother's pursuit of some other calling. Far from destroying the economic basis of the family, com-

munism has made more rigid provision than any that prevails elsewhere to ensure that every man is economically responsible for his own children. At a first glance it might seem that conditions in the U.S.S.R. are propitious to a rapidly falling birth rate. This is only one side of the picture.

A good deal can be placed on the credit side of the account. The woman factory worker has time off on full pay when she bears a child, free medical services for herself and her child, and also extra rations. In the large state factories crèches are provided. She can leave her child both in the day-time and in the evening when she wishes to go to the opera or cinema. When pregnant she has a right to a seat on trams. One might ask why any woman should have a child, if it is going to live at a crèche, but it must not be forgotten that a seven-hour working day, one day's holiday in six, and annual holidays are in force. Such complete provision for the child is not yet available for the whole Russian population; but where it is available there is no doubt that everything possible is done to make it easy for the working woman to have a child. On the farms the arrangements are somewhat different. The care of the children are the concern of the commune. The women frequently take it in turns to look after the children.

An important result of provisions already made is that it is just as easy to have a baby at 17 as at any other time. No stigma is attached to illegitimacy. Since the arrival of a baby is not attended by any particularly unfortunate consequences there is little to check common laziness and carelessness in the use of contraceptive devices. Since the abortion clinics

refuse to perform an abortion during the first pregnancy except for very strong reasons the inevitable contraceptive accident usually results in a baby. According to Miss Beauchamp many girls of 17 and 18, both factory workers and university students, have babies without hardship. The tendency to early maternity is strengthened by the declared views of leading women who hold that it is desirable for a woman to have children early so that she can concentrate on her career between 30 and 40 when she is likely to do her best work.

The effect of early motherhood on the birth rate may well be considerable. There is good reason to believe that women take more kindly to child-bearing, if they start early than if they put it off to an age when settled habits have been formed. No tradition of sterility appears to have arisen under communism as yet. It is true that the Communist Party of Russia somewhat savours of an ascetic priesthood. The Catholic Church shows that a celibate clergy is compatible with a high fertility in the rest of the population. In comparing the population situation in Russia with that which exists elsewhere it must not be forgotten that mass unemployment does not exist, and that the U.S.S.R. has a government which can offer to its citizens hope for the future.

An encouraging feature of the Russian economy, both as regards quantity and quality of population, is seen in the relative importance of rural and urban life. For several centuries in Western Europe there has been a constant drift of the most able and energetic individuals from the country to the towns where their fertility is low. That this is an essentially dysgenic feature of the *laissez*

faire economy can hardly be doubted. In the early years of the U.S.S.R. it might have seemed as though this process was going to be repeated. With the collectivization and mechanization of agriculture the tendency has been reversed. Science and culture are being concentrated in the rural areas. At the same time new industries are being started in thinly-peopled areas at some distance from the existing large towns. Whether the drift from the country to the town in Western Europe has already had serious genetic consequences is open to controversy. That it would result in deterioration in the long run seems fairly certain. Such deterioration had not occurred on a large scale in Russia, where the reports of American engineers represent the Russian peasant as remarkably apt at learning the requirements of a more complex civilization in spite of his age-long torpor. It is clearly of some eugenic importance that there is a demand for the best brains and energy of the community in surroundings which in Russia as elsewhere are propitious to high fertility.

To sum up the Russian population situation, the process of rapid industrialization carries with it social factors which are capable of depressing the birth rate very considerably. In fact, they may already have done so. On the other hand certain agencies which encourage the ideology of sterility in countries with a planless economy are lacking. The U.S.S.R. has the advantage of a very high fertility which had not depreciated as late as 1929 over the greater part of its domain. If foreseen in time it is reasonable to suppose that the task of maintaining a high fertility or of checking its fall at any desired point will be easier

than that which confronts Europe and America, where it will be necessary to raise fertility from a level already far too low for continued existence. The policy of the U.S.S.R. favours collective planning of the whole human ecology. In one important respect, an ecology suitable for reproduction is *en rapport* with developments in the U.S.S.R.

§ 5

In the light of everything which has been written in the preceding chapters it would be foolish to minimize the gravity of the prospect which lies before civilization as we know it. It would be equally foolish to overlook any new features favourable to reproduction emerging within contemporary societies. The planned economy of the U.S.S.R. is already developing a network of new social services which mitigate some of the more serious handicaps of parenthood. These include ante-natal clinics, crèches, children's camps and a unified system of education which eliminates competition for expensive and ostentatious educational amenities. Such services only touch one aspect of the problem. To the present writer a more hopeful line of development is concerned with a new attitude towards the social function of the child. Parenthood is no longer a necessity to the normal individual. If biological science continues to progress there will be no more unwanted children intruding into a world where they are increasingly regarded as a parasitic growth upon the active adult population. In more primitive civilizations the child was an asset to its parents. In the earlier and harsher stages of industrialism before the abolition of child labour this was still

true of the working classes. By all sections of the Acquisitive Society children have now come to be regarded as a form of capital expenditure which brings the parent no return commensurate with its investment value to society as a whole. The crucial problem of maintaining the reproductive vitality of civilization is how to reinstate the child as a functional unit in a planned ecology.

This is the consideration which makes the Russian experiment of such moment. "Both industrially and educationally," writes J. G. Crowther in his fascinating study, "Soviet Russia's policy is a gigantic exercise according to Samuel Butler's principle '*learn by doing.*'" ¹ The educational outlook of the new Russia is imbued with a conception derived from Marx. Of all the sayings of Karl Marx few are more shrewd and more arresting than his contention that the factory system "is the embryonic form of the educational system of days to come, when, for all children above a certain age, productive labour will be combined, not only as a means of increasing social production but also as the only method of bringing about a many-sided development." ²

By many who have been accustomed to Western ideas about the upbringing of children these words will be read with surprise and shock. The pressure of humanitarian sentiment since the industrial revolution

¹ *Technical Education in Soviet Russia.*

² Among the constructive proposals included in the historic manifesto of Marx and Engels we find "Combination of agriculture with manufacturing industries; gradual abolition of the distinction between town and country, by a more equable distribution of the population over the country," and "Combination of education with industrial production, etc."

has been directed, and rightly directed, to the elimination of child labour. The justification for this movement has arisen from the harsh conditions under which most wage labour is carried on, from the impossibility of regulating such labour in the best interests of the child, and from lack of provision for education in later life. It does not follow that the segregation of the child in nursery, school or university for its first 14 or 21 years of life is necessarily the best plan for the fullest development of human personality. Indeed, this is already recognized to an increasing extent in modern educational practice. The Montessori system includes the training of the child to look after its own person and its own meals. Observation of intelligent children who have not been unduly inhibited by an environment of adults discloses the enthusiasm with which they learn to cook dinners or make simple objects of furniture. Their enthusiasm for such pursuits is far greater than the zest they display towards scholastic subjects whose usefulness cannot be rationally grasped at an early age.

Our present educational practice consists almost exclusively of forcing mathematics on children who have nothing to measure, foreign languages on children who have no opportunities to use them for social intercourse, literary composition on children who have nothing to write about, history on children who know next to nothing about the social institutions into which they have blundered, geography on children who have never travelled beyond the confines of one country and in many cases may never travel beyond the confines of a single parish. The idiocy of this procedure is now becoming evident to educationists who are neither so

silly nor so immodest as to blame for their failures the capabilities of pupils who have no reason to co-operate with their efforts. In a rational system of education a child would begin by learning to perform all the manual operations carried out by the adults round him. As he acquires proficiency in these and his mental horizon is widened by experience of the ecological association to which he belongs his education would be continued to embrace all fields of natural knowledge within the scope of his capacity and interests. The efficiency of such a policy will be recognized by anyone with a wide experience of University education. The older student who takes up university studies after having been through a period of wage-earning or any kind of productive activity is far more educable than a student of equal intellectual ability unfortified by experience of the world.

It is self-evident that such a system of education is impracticable in the Acquisitive Society, which endows manual and intellectual pursuits with totally irrelevant caste associations. To say this does not detract from its merits. It is merely a condemnation of the Acquisitive Society as an organ of social reproduction. For biological reproduction its effect would be to make the child begin to be a useful member of the community from the age of three onwards. At first more would have to be done for the child than he or she could do for others. This would very soon cease to be true. In this way children would not be felt to be a burden either to those immediately responsible for them or to the community as a whole. They would not be an alternative form of expenditure but an integral part of the communal productive machinery.

If the child becomes a producer soon after birth it follows that education will be regarded as a process which continues throughout the whole life of the individual instead of being something to be finished with and dropped as soon as possible. Every new access of experience in the life of the individual should mean increased ability and desire for fresh knowledge and skill, and there is no reason why this process should not continue up to an advanced age. A community in which education is a life-long pursuit will not confine its interest to one generation. Each new generation will be welcomed as an opportunity for a fresh educational experiment. A new social motive for the production of children thus takes shape. Children will be regarded as an amenity in the social group. One of the depressing aspects of a falling birth rate is the over-weighting of the community with the mentally and morally tired.

We have envisaged a society in which children and adults share equally in the activities of production and education. The extra work and care necessary for babies and very young children would be compensated by a recognition of the creative possibilities presented by a new mosaic of genetic combinations. The eugenic improvement of the human race would then reinforce the reproductive impulses. Professor Haldane, one of the foremost geneticists of our time, has remarked that he prefers the eugenics of Lenin to the eugenics of Dean Inge. The justification of his preference is twofold. The first precaution of the experimental geneticist is to standardize the environment of his stocks. One may well doubt whether knowledge of human heredity can advance

far until mankind has been educated beyond what Professor Tawney calls "The Religion of Inequality." The Acquisitive Society cannot create the conditions for developing or applying knowledge of man's inborn nature. Its ultimate condemnation is that it has now ceased to be able to accommodate the biological machinery by which any form of society can be perpetuated.

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