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BIOSOCIAL ASPECTS OF LIFE IN BRITAIN

C. O. Carter — Director, MRC Clinical Genetics Unit, Institute of Child Health, London

Nature and distribution of genetic abnormalities p. 261

O. G. Edholm — Head of Division of Human Physiology, National Institute of Medical Research, London

Biological effects of current patterns of occupation p. 273

John B. Gibson — Lecturer, Department of Genetics, University of Cambridge and Fellow of Churchill College, Cambridge

Social mobility and the genetic structure of populations p. 251

G. Ainsworth Harrison — Reader in Physical Anthropology, Anthropology Laboratory, Department of Human Anatomy, University of Oxford

The effects of modern living p. 217

G. Melvyn Howe — Professor of Geography, University of Strathclyde, Glasgow

The geography of life and death p. 285

John Peel — Head of Department of Social Studies, Teesside Polytechnic, Middlesborough

Patterns of fertility p. 241

D. Malcolm Potts — Medical Director, International Planned Parenthood Federation, London

Reproduction and its control p. 229

E. Sunderland — Professor, Department of Anthropology, University of Durham

Discussion p. 307

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Biosocial Aspects of Life in Britain

THE EFFECTS OF MODERN LIVING

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Increasingly, attention is being given to problems of the world's environments. This is surely right; although many of the issues are highly controversial, as is shown for instance in the on-going debate which has followed the publication of *Limits to Growth*, and the prophets of doom may, hopefully, turn out to have been unduly pessimistic, no one can doubt that very serious problems exist and it is high time that they were brought into the public forum. Real attention must be devoted to their solution before extensive irremedial damage is done, if it is not already too late.

However, there are indications that other important changes are occurring, which are going relatively unrecognized because of the preoccupation with the natural environmental situation. Some of these seem to be, if more subtle, no less insidious than the environmental crisis. They concern the nature of the human biological condition itself.

Of course, it is well recognized that there is an intimate reciprocating relationship between any organism and its environment, and man is no exception. The most serious problem by far for the environment and for man himself is the continued growth of world population, and the active concern with environmental pollution is primarily anthropocentric, with the nature of environmental quality evaluated in essentially human terms. However, whilst the attention which is being devoted to the natural environment perforce raises many questions about the human biological condition, it certainly does not raise all of them. In particular, it omits those which arise from inter-human relationships and the nature of society, though it is recognized that individuals form part of each other's environments. This area is usually regarded as the preserve of the social scientist and is typically analysed in solely social terms. Clearly such an approach has been highly rewarding, but there are biological causes for, and consequences of, the ways societies are organized, and these are poorly illuminated by either natural science or social science. They demand a biosocial approach. In this address, I shall attempt to exemplify some aspects of this approach, especially as it relates to the life styles in so-called advanced societies, and some of the problems and issues which these life styles appear to be generating.

Throughout most of human evolution, man and his ancestors apparently lived

as small bands of hunters. It is dangerous to extrapolate in detail from the life styles of present-day hunter–gatherer groups to those which prevailed throughout the Palaeolithic, especially since today such groups are confined to particularly inhospitable environments, but, in general terms, one can envisage early man existing in ways not too dissimilar from Bushmen, Australian aborigines and Eskimos. A recent symposium, *Man the Hunter* (Lee & Devore, 1968), affords an excellent description of the life styles and social structure of these peoples. During the long period of evolutionary history when man was a hunter, human populations were exposed to a set of selection pressures which adapted them to their natural conditions, and to the cultural conditions produced by their life styles. It was in fact these conditions which produced most of the distinctive biological features of *Homo sapiens*. The time that has elapsed since even the earliest change in this way of life—with the onset of the Neolithic in the Middle East—is, in evolutionary terms, very short. There can be little doubt that the neolithic evolution dramatically altered some of the selective pressures—patterns of infectious disease, for instance, must have changed and many totally new diseases certainly appeared—with consequent effects on the genetic composition of populations. But even with the most intense forms of selection that can reasonably be envisaged, one would expect man still to retain many biological features of his palaeolithic existence, in view of how recent this has been. And since the Neolithic itself, conditions for human existence have been changing so rapidly, especially with the advent of industrialization only 200 years or so ago, that one would not expect any form of balance to have been established between the genetics of human populations and the totality of the environment to which most present-day groups are exposed. Of course, man is renowned for his individual adaptability, physiologically as well as behaviourally, and indeed his evolutionary success, and the very changes I have enumerated are attributable as much to this capacity to respond appropriately to change as to produce it, but it is an axiom of evolutionary theory, as S. V. Boyden (1970) has said 'when the conditions of life of an animal population deviate from those to which it has become, through natural selection, genetically adapted, some signs of biological maladjustment are almost inevitable'. However physiologically adaptable the human organism may be, and however far man has through cultural adjustment been able to preserve for himself the essential biological requirements for homoeostasis, it would be very surprising if the conditions of modern living, and especially those associated with advanced industrial societies, were not only affecting the biological condition of the human individual and the biological structure of human populations, but affecting them in some ways adversely, so different are the conditions from those which prevailed in pre-neolithic times.

Of course, one of the most striking biological characteristics of modern life in developed societies is the long life expectancy as compared not only with developing and agricultural societies, but also as compared with hunter groups, past and present. And seen in individual terms, this phenomenon, brought about by improve-

ments in public health and modern medicine, and affecting almost all age groups but especially the very young, must be judged desirable. It might reasonably be asked whether there can be cause for concern, when most of us are living for so long. Few, however, would deny that the nature of the living is as important as its length, and it is in this quality of life that perhaps the symptoms of maladjustment are appearing.

Before considering evidence for this, I think it is desirable to summarize what appear to be the main changes in living conditions between now and the palaeolithic past. The following list is heavily derived from S. V. Boyden who, more than anyone, has studied the biological nature of so-called civilized living (Boyden, 1972).

Modern nutrition is characterized by a high intake of refined carbohydrate, but less cellulose than formerly. Fats of animal origin have relatively increased, certainly by comparison with simple agriculturalists and probably by comparison with most hunters, and these differ in their levels of saturation from fats of plant origin. Intake of salt has risen and many foods now contain artificial additives as flavourings, preservatives and emulsifiers as well as herbicide, pesticide and detergent contaminants. Cow's milk has tended to supplant human milk for the nutrition of the human baby, who is generally weaned much earlier than in typical simpler societies. The chemical environment involves exposure to pollutants of air as well as food and individuals are presented with an array of pleasure-promoting and antidotal drugs as well as other chemicals in cosmetics, sun-tan lotions, etc. It is estimated that some half million different chemical substances are released daily by cities into the environment. Other changes in the physical environment involve more stable temperature conditions, diurnally and, outside the tropics, seasonally; longer exposure to visible light during the day; an increase in ionizing radiation, and, in general, a very considerable rise in noise levels. The greater population density also changes the nature of possible host–parasite relationships and therefore patterns of infectious disease. The daily time budget is very different in innumerable ways but in simple consideration one can note the greater regularity in feeding and sleeping times, and for most people a markedly lower rate of physical work and exercise. Long periods are spent in sitting and standing, and activity is not usually required to obtain food. Further, if present-day hunter groups are any true indication of palaeolithic conditions generally, man was formerly exposed to periods of fairly acute starvation, but was still called upon to be physically active. This is in marked contrast to the situation in developed societies today and even tends to differ from conditions among simple agriculturalists where chronic starvation and malnutrition usually tend to prevail rather than acute starvation. When one comes to consider social conditions comparisons are endless, but of particular biological relevance is the tendency in the modern world for high population densities and crowding. This increases dramatically the number of individuals with whom any one person has contact, including members of the opposite sex, but many of these

contacts are transitory and between people who have no close social relationship with each other. Other features of biological concern are increased spatial mobility, a matter I will return to at some length later, and the nature of occupations. Whilst in industrial societies individuals have a wider choice of jobs than in simpler societies, there is often a decreased variety of task within the chosen occupation.

The effects of some of the physical changes in the environment, such as noise and pollution, are now beginning to be actively and systematically studied, but just as the physical environment profoundly influences the health patterns of a community, so there is increasing evidence of the psychosocial environment affecting disease states also, both psychosomatic and more strictly organic (Levi, 1971). One field where this is becoming especially apparent is in diseases of the cardio-vascular system and it is of some relevance to my general thesis to review some of the data which have been obtained by recent workers.

Although life expectancy has throughout the present century tended to increase in all developed societies, there are now indications that at least a plateau has been reached and indeed that there may be even a declining expectancy. One of the major causes of death arises from cardio-vascular disorder, and there is good evidence that defects from some of these pathologies such as coronary heart disease are not only becoming more common, but are progressively affecting ever younger age groups, particularly of men (Furness, 1970). A number of factors are involved in the aetiology of coronary heart disease, genetic predisposition, nutrition, exercise and stress, and some of these, at least, are manifestly affected by conditions of modern life. A hypothesis recently advanced by Carruthers (1969) relates the physiology of stress, especially that arising from aggressive behaviour, to atheroma and cardio-vascular pathology. It has been known for some time that the secretion of catecholamine hormones is dependent upon emotional state; fear is mainly associated with the increased secretion of adrenaline, while anger causes nor-adrenaline liberation. These hormones and especially nor-adrenaline cause the mobilization of free fatty acids from the body's fat stores. These responses are part of an adaptation, the type of flight/fight response which must have been critical to survival in the conditions under which palaeolithic man lived, and were no doubt perfected by natural selection in relation to hunting and inter-individual and inter-group conflict. The free fatty acids provided a source of energy for the increased physical activity which inevitably was associated with these behaviours, and incidentally, since they increase the stickiness of the blood platelets, enhanced the blood's clotting properties, which would be advantageous in the likely event of wounding. If, however, the behaviour is not completed in this form; if instead of the aggression being followed by activity it is associated with low levels of physical work, as for instance appears to happen in driving a motor car, and is well witnessed in motor racing drivers (Taggart & Carruthers, 1971), then the free fatty acids are converted into neutral fat and cholesterol. According to Carruthers, some of this conversion may occur in the walls of the arteries themselves, while another venue is the liver, but in either

case it would be responsible for atheroma, which in the coronary arteries will predispose to coronary thrombosis, especially in association with 'sticky' blood platelets. The situation is exacerbated by obesity, which is associated with high resting levels of free fatty acid, and which itself is related to low activity levels and the high carbohydrate intake characteristic of modern diets. If this hypothesis of Carruthers is confirmed, and there is already much evidence in favour of each of the different steps, we have a prime example of a situation which, while highly adaptive under the circumstances for which it developed, is becoming maladaptive under present-day conditions which generate aggression but little opportunity to 'work it off'.

Phenomena of this kind can easily become regarded as normal and inevitable. It was long thought that a raising of blood pressure with age—partly due to atheroma—was part of the natural process of ageing in man. However, observation on populations with other types of economy and life style has shown that an elevated blood pressure is not a necessary consequence of growing old and in some groups, indeed, there would even appear to be a fall in blood pressure with age.

Many other ailments have a psychosomatic component as for instance, asthma, duodenal ulcer, rheumatoid arthritis, backache and menstrual, skin and bladder complaints. It seems quite probable that at least some of these are increasing in frequency, though it is difficult to be sure of this. In a recent study of the effects of new housing, Hooper *et al.* (1972) found that only 47% of the women interviewed reported good health over a 6-month period; of the remainder 32% reported mild illness and 21% moderate physical illness, and many of the complaints were ones with a psychosomatic component.

When one comes to consider effects of modern living which are solely measurable as yet at the behavioural level, the problems of analysis become still greater and the likelihood that systematic changes have occurred and are occurring which, while essentially adverse, are being accepted as the norm, still more probable. Apparently, after difficulties over ascertainment and diagnosis have been taken into account, there is no certain evidence of a rise in the frequency of defined psychological disorders in developed societies, nor any systematic contrast between occupational groups differing in environment, economy and life style within such societies. And phenomena, such as for instance the dramatic rise in suicides and attempted suicides which have been reported by workers in some populations, may be wholly determined by special new circumstances, as for example in increased availability of convenient drugs and changes in social attitude towards self-destruction. Nevertheless, there are many general indications of breakdown in at least some aspects of mental fitness associated with modern life styles and the type of new behavioural stresses to which man is exposed. In the study of Hooper *et al.* (1972), already mentioned, some 61% of women and 47% of men, when asked to report on their own health over a 1-month period, complained of some form of ailment. And in the case of the women it was those who expressed dissatisfaction with social life, family

life, neighbours and use of their leisure time, who were most likely to complain of illness. At the moment my colleagues and I are involved in a fairly extensive human biological study of some Oxfordshire populations. Our concern is mainly with genetic, demographic and biochemical aspects. We have made no measures of behavioural fitness, and, indeed, we do not know of any suitable way of measuring this objectively on the sort of subtle scale subjective impression provides. But if there is any value at all in the latter, there is no doubt in any of our minds of a relationship between life style, and economy on the one hand, and personal assessments of mental well-being, such as contentment and friendliness, on the other.

The nature of modern society imposes innumerable quantitatively and qualitatively new demands on human behavioural plasticity. The fact that so many different contacts are made daily between individuals who share so few close social structural relations with one another, is almost bound to elicit more aggression, and this must surely be enhanced by social values which, almost from birth, encourage and praise competitiveness. There can be few societies where less emphasis is placed on co-operative behaviour than our own. In general terms too it seems possible to indict an educational system which not only favours extreme competitiveness, but hardly prepares individuals for the sort of life most of them have to live. One has the ironic situation of children being encouraged to develop their potential abilities and individuality to the full, and then being called upon as adults to undertake the most tedious and repetitive of tasks at work. It is hardly surprising that dissatisfaction and boredom, so rarely found in simpler societies as far as one can judge, are rife in large sections of our community. As presently recognized, these are solely psychological ills, but it is more than probable that they have organic effects, like aggression, and are adversely affecting general health.

It seems to me that much more research is sorely needed in this area. Even some simple measures of malfunction, such as the need for sleeping pills, tranquillizers or stimulant drugs, would be useful, but although the total national prescriptions for these medicines are known, there is no breakdown available of the frequency of individuals' using them, or the type of community where they are considered most necessary.

So far, I have been concerned with conditions which are directly ascribable to individuals, to their health and well-being as viewed in everyday terms, or to their fitness and its components of comparative fertility and mortality when viewed in more general biological, including evolutionary, terms. I would now like to consider some of the effects of modern life on the structure of populations as a whole, where the population itself is the focus of attention, rather than the individuals who compose it at any one time. Here the issue of deciding scales of judgement seen either in terms of subjective human desires, or more objectively by biological criteria, is more difficult, and I do not wish to pursue it here, but there is no doubt that population structures have been profoundly affected by the conditions of modern life.

The biological structure of a population has many components, demographic, genetic and ecological, which interact with one another in complex ways, and are themselves profoundly influenced by social conditions, past and present. As compared with simpler societies, and particularly hunter–gatherers, the demographic characteristics of industrialized populations are ones of reduced fertility, reduced mortality, a less pyramidal age structure and much greater spatial movement. The latter, with which I shall be mainly concerned, is particularly important in determining the genetic definition of populations and their genetic structure.

The ways in which genes are distributed within and between populations are determined in the same way as the distribution of ancestry and the patterns of relatedness between individuals. This is essentially a function of what is termed 'parent–offspring distance'—the difference between where an individual receives his genes at birth and where he passes them on to the next generation through his children. Parent–offspring distances have been constantly increasing throughout historic times, but especially during the last few hundred years in industrialized societies. Unfortunately we have few accurate measures of them. In this country reasonable estimates of them are provided by the National Census but these data are not available to researchers until a hundred years have elapsed since their collection, and the Census was only started in 1801. One can, however, obtain estimates of one considerable component, marital distance—the difference in the birth places of spouses—from marriage registers which record the place of residence of groom and bride at the time of the marriage. Until recently it would seem that women tended to get married in the parish of their parental home, and where comparison with Census information is available this usually corresponded with their birth place, i.e. that there was little post-marital movement—in which case parent–offspring distance is solely a function of marital distance. My colleagues and I have been examining the components of marital movement in some local Oxfordshire village populations over time and find that, for those marrying outside their own parish, this averaged at about 6–8 miles from the middle of the 16th century, when records are first available, to around the middle of the 19th century. There then occurred a dramatic increase to 25–30 miles, corresponding with the arrival of the railway in the area. On the other hand, the total amount of parish exogamy has gradually increased over time from the 16th to the 20th century (Boyce, Küchemann & Harrison, 1971). Similar phenomena have been reported from other parts of Western Europe (Cavalli-Sforza, 1958; Alström & Lindelius, 1966).

What is the general significance of observations of this kind? There can be no doubt that increased movement has led to a considerable reduction in inbreeding, and gene pools are spatially much wider than formerly, even when they are composed of communities which are still small and discrete. It is, however, probably dangerous to extrapolate either too far backwards or forwards from these trends. Whilst high levels of inbreeding have been found in small isolated populations, and

these are invariably underestimates, it seems likely that throughout most of hominid evolution, and certainly since the advent of hunting, there has been gene exchange between neighbouring populations. It has been argued that affiliation between groups through marriage is vital to a hunting economy where the chasing of wounded game necessitates passage into a neighbour's territory. Warfare between groups also typically involved the taking of one's enemies' wives. There has thus probably always been a continuous channel for gene flow between human populations and more intermixture than in other animal groups. What has subsequently happened is that the channel has got wider, the flow larger, and the distance over which genes can travel in a single generation substantially greater, with ever increasing individual mobility. This mobility, of course, has been largely due to technological advances, but it is also dependent upon social changes, especially economic and political developments and the banding together of many populations to form nations and states within which the individuals can travel with ease and impunity.

On the other hand, despite the extensive distances over which most people now travel in the developed world, human behaviour remains in some ways very parochial. Thus Spuhler (1961) found the median marriage distance for the population of Ann Arbor in Michigan to be 160 miles, and Clarke (1952) noted that in Columbus, Ohio, 50% of married couples first met when they were resident within sixteen blocks of one another—and this in the world's most mobile society. Further, national and cultural boundaries are still acting as strong barriers to breeding, as apparently do the marked physical differences which distinguish many of the world's racial groups.

Nevertheless we can conclude that the increased mobility characteristic of modern living is reducing inbreeding and increasing outbreeding more or less over the whole world. The former may be in part responsible for some other biological changes, such as the secular changes in human growth—increased growth rate, greater adult stature and earlier maturity—which have been occurring in developed countries this century, but the evidence for this is not strong and many believe that improved conditions of nutrition and hygiene are solely responsible. The increased outbreeding must be acting to diminish the genetic differences between human populations as gene flow is the main homogenizing influence in evolution. One can perhaps look forward to the day when the large between-population genetic variety is replaced by large within-population variety, but, in view of the nature of the breeding barriers I have mentioned, this is likely to be many generations away, even though only a modest random exchange between populations is required to achieve it quite quickly (Hiorns *et al.*, 1969). I should also add that all the evidence indicates that, in man, miscegenation between even the most different racial groups carries no biological disadvantage. This in fact is one of the reasons for believing that gene exchange between populations has been a commonplace throughout human evolution and that populations have become largely adapted to the possible disadvantageous effects of intermixture.

I have so far considered mobility very much as if it were a characteristic equally shared among all members of a population. This is clearly not the case, especially in developed societies where occupation and social status profoundly influence the probability of being mobile. In some recent studies of marital movement in the City of Oxford, my colleagues and I have found a strikingly linear relationship between social class and the probability of contracting an endogamous marriage inside the city as defined by the residence of bride and groom, both in this century and the last. Further there is evidence that distributions of marital distance among the exogamous groups are affected by occupation, and for instance, that people in non-agricultural occupations tend to take partners from other urban areas rather than from the surrounding countryside. It could thus be that urban and rural groups in Britain are to an appreciable extent reproductively isolated from one another.

The existence of subgroups within populations such as social classes, castes and religious groups, between which there is a marriage barrier, introduces a third dimension into genetic structure and may profoundly influence factors of evolutionary importance, such as population breeding size. They can, indeed, be appropriately envisaged as much as separate populations as spatially distinct groups, and with gene flow occurring between them through, in social class terms, social mobility and interclass marriages. We have examined the nature of this flow in the Oxfordshire populations we have been studying and find that the amount of exchange between social classes is greater than the amount of spatial exchange. There is, however, also a temporal change with less exchange in the last century than in the present one and an urban/rural contrast with greater social mobility and less assortative marriage for class in the city than in the surrounding countryside (Harrison, Hiorns & Küchemann, 1970, 1971; Hiorns, Harrison & Küchemann, 1972).

The existence of a class-like structure in a population raises an issue in relation to population exchange, which, at least in relation to short range spatial migration, is of little significance—the effects of selective movement. If the probability of an individual moving in the social scale is a function of some attribute of his and if this attribute has a genetic basis, then the movement can, and usually will, tend to produce stratification in the population of those genetic systems which affect it. In other words, the movement is no longer homogenizing, but a cause for heterogeneity. Social mobility is affected by attributes such as IQ and personality, which have a genetic component to their variation, and positive assortative marriage also occurs for some of these characteristics. We may therefore expect that in the sort of meritocracy which societies like ours purport to be, the increased channels for gene flow between the social classes will lead, on the one hand, to a diminution of any genetic differences that might exist between classes in systems unrelated to the class structure, but, on the other hand, to an increase in the differences between classes in genetic systems determining what the society has valued as merit. Efforts to reduce environmental inequality can only act to accentuate this phenomenon by

increasing the genetic component to the variability. This seems to me to be a consequence of our present-day social organization about which sociologists, politicians and educationalists should not be unaware.

Finally, I would like to turn to the question of the nature of the main evolutionary force—natural selection—as it is now acting in developed societies. This is a particularly speculative area because we know of so few detailed cases of genetic systems in man being controlled by selection, but much of a general nature can reasonably be deduced.

It is sometimes said that, in man, natural selection has been largely replaced by cultural selection. This seems to me to be an unhelpful distinction. It is, of course, true that nowadays almost worldwide, and especially in developed countries, the natural environment has been so modified by man as to bear little resemblance to its quality in palaeolithic times, and it is also true that most of the changes have been brought about to meet man's apparent needs; old selective forces arising from climatic, nutritional and disease variations have disappeared or are disappearing and with them the causes for the geographical genetic differentiation of the world's populations. But the essence of natural selection as an evolutionary force, is genetically determined differences in mortality and fertility, i.e. in Darwinian fitness; from this point of view it is not of fundamental distinction whether the causes for these differences arise from the natural environment or the man-made environment, physical and cultural. Of course the nature of the forces affects the direction of the evolution, and man's future biological evolution may be said to be in his own hands, but the difference between natural selection and cultural selection is not, for instance, like the difference between biological evolution and what is often called 'cultural evolution', or to my mind preferably just 'cultural change' where totally different processes are involved (Harrison, 1972). And in relation to the statement that cultural selection has replaced natural selection, the nature of a society and the way individuals are called upon to interact with one another and with their technology have long been important vehicles for the operation of natural selection in human populations.

Turning specifically to the amount of 'room' for selection in developed societies, the low levels of mortality from birth to the end of the normal period of reproduction do not allow much opportunity for selective processes. There are, of course, specific abnormalities often of a genetic nature which still cause premature death and if there were, as well there might be, some genetic component to such causes of death as accident proneness, then clearly selection would be operating on it. In this connection it is also worth noting that there appears to exist a definite personality type, characterized by aggressive behaviour and particularly susceptible to social stress (Levi, 1971). If this variation has a genetic basis, what might once have been selectively favoured, in a hunter–gatherer life style, would probably now be selected against as stress diseases, such as coronary heart disease, are beginning to afflict individuals in their reproductive years. This might afford a very illuminating

example of the nature of environment/genotype interactions in the selection process. Recent evidence, incidentally, indicates a strong hereditary element in heart disease.

The converse of the situation is where genetic conditions which once were lethal are now surviving as a result of treatment with modern medicines. This is sometimes advanced as a matter of eugenic concern, it being pointed out that the relaxation of the selection will lead to an increased frequency of the deleterious genes. It is a debatable point whether these conditions can even continue to be regarded as deleterious when the remedy is always to hand—diabetics, for instance, today can surely be thought of as being no more than individuals with a specific additional nutritional requirement—but the issue is only of academic interest since some simple sums show that the effect on gene frequency of relaxing selection for rare abnormalities is very small indeed.

It is possible, however, that some of the diseases now associated with middle and old age are the products of former selection against disadvantageous genes. As Medawar (1957) pointed out some years ago, such selection may operate to remove the genes from a population or to favour modifiers which prevented their expression. In the latter instance the modifiers would only need to be effective during the normal life span of the individual which in the past rarely exceeded the reproductive period. With, however, the dramatic increase in life span brought about by the conditions of modern life, the modifying homoeostasis might well break down and allow the disadvantageous genes to express themselves again.

In considering the possibilities for selection to operate through mortality, the high levels of intra-uterine death, particularly during the early months of pregnancy, must not be forgotten. It has been estimated that a high proportion of zygotes—as much as 50%—may never even implant and gametic selection could be very strong. Nevertheless it seems likely that the most significant selection in modern populations will operate through differential fertility. Despite the tendency to reduce the number of live-born children in the family it has been shown that there is still ample room for selection to operate here (Crow, 1958). Variations in family size exist and are likely to continue to exist. In this country about 6% of individuals never marry, and of those that do, 10% remain childless. It is unlikely that there is no genetic variation to this variability, which could well increase. Reproduction in man, as well as in other animals, is probably extremely sensitive to environmental conditions and a sense of well-being. If, as seems likely from what I have already said, the stresses of modern life are affecting this sense of well-being and there are, as one would expect, genetic variations in the capacities of individuals to cope with or avoid the stresses, then fertility differentials are, if anything, likely to increase. It should never be forgotten that natural selection operates through the lives of peoples as they go about their everyday business.

As a post-script one can perhaps single out the important position of the motor car in affecting the conditions of modern life—as a major source of pollution, as the

most important single agent responsible for increased movement, as a source of stress and ill health and a cause of accidents—which could be having important effects on the genetic composition of populations through natural selection.

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Biosocial Aspects of Life in Britain

REPRODUCTION AND ITS CONTROL

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Summary. The maximum potential of the human reproductive system is very rarely fulfilled. Social factors, such as the age of marriage, and biological factors, such as the incidence of infertility, limit the number of women in the community at risk for pregnancy. Reversible methods of contraception can best be understood as a technique to extend the interval between any two conceptions. Induced abortion is an important determinant of achieved family size. As a result of certain legal and medical restraints the necessary means of fertility control are not used in the optimum way.

Introduction

Currently, there is a lively interest in Britain in problems of population and family planning, but all too frequently the control of human fertility is seen in over-simplified terms. Sometimes, provision of the contraceptives and the setting up of family planning clinics appear to be the starting and the end point of interest.

The aim of this paper is to put into perspective the several biological variables determining the birth rate and to highlight points at which social and biological factors interact. It is hoped that this perspective will give useful insights into present and future ways in which the community can assist the individual to achieve his or her family goals.

The range of human reproductive performance is wide. A Russian woman is reported to have had sixty-nine children and an English woman thirty-eight deliveries (see Parkes, 1973, for details). Conception has occurred following hysterectomy and has failed to take place in couples in whom every measurable biological parameter has been normal. This discussion is concerned with the average and for nearly every statement it will be possible to find exceptions.

Biological limits

The universality of self-imposed restraints on human fertility makes it difficult to establish the average number of term deliveries the human female may have been

evolved to carry. At the 1941 census in rural Quebec the average family had ten children. In some developing countries women are having an average of seven or more live-born children but it seems that few historic or contemporary communities breed at the biological maximum. Queen Victoria had nine children and might therefore be considered an 'average' woman.

The fertile life time

In the female, conception is possible between puberty and the menopause. There is a relatively brief interval after puberty when anovulatory menstrual cycles are more than usually common and a long period before the menopause when fertility declines. The age of puberty (Tanner, 1962) and the menopause are subject to individual variations within a population, and the means for different communities differ. The factors controlling those differences are not fully understood. In the male, spermatogenesis continues from puberty throughout life, although sperm production and the ability to ejaculate decline in old age.

The pregnancy interval

If a woman engages in regular coitus without contraceptive precautions it will take on the average several cycles for conception to occur. The distribution of the time taken to conceive is skew, with many women conceiving rapidly, but a few taking many cycles and thus drawing out the mean. Coital frequency, unless extreme, does not appear to be a major determinant of the time taken to conceive. It has been claimed (Ford & Beach, 1952; Symington, 1972) that in some African communities intercourse occurs on average more than twice a day, but even this appears to be unassociated with any unusual fertility rate among the women.

Very early embryonic mortality, before the first missed menses, occurs in some cycles. The whole problem of early embryonic wastage and of spontaneous abortion is important. Reproduction, at least in mammals, is an imperfect process and the elimination of errors of development is essential. A large number of spontaneous abortions are demonstrably abnormal on microscopy or chromosome analysis, and probably others would prove to be, if our analytical tools were more precise. Biologically, abortion is a necessary, healing process, without which society would be burdened with an intolerable load (perhaps one in five of deliveries) of grossly abnormal babies. The biological facts about abortion may be expected to have a social and ethical impact as they become more fully understood.

Once recognized, pregnancy can have one of a number of possible outcomes. It may end in a live birth to be followed by breast or artificial feeding. Amongst those who breast-feed weaning takes place at a variety of times. The number of non-ovulatory menstrual cycles following delivery will be determined by the presence and duration of breast feeding. Although women are correctly encouraged to take contraceptive precautions during lactation, it remains true that breast feeding reduces the possibility of pregnancy and, on average, extends the interval between

two pregnancies. It is true to say that today, when prolonged breast feeding is a minority activity for British women, they could bear more children in a fertile lifetime than did their ancestors. If pregnancy ends in a peri-natal death then menstruation will return particularly rapidly.

A conception may end in a term delivery, or a spontaneous or an induced abortion. The pattern of biological events in either case is similar and most spontaneous and induced abortions occur before 12 weeks of pregnancy. A few induced abortions are delayed for administrative reasons, because of certain imposed patterns of medical practice.

The interval between the time when the woman was first at risk for pregnancy and the time when she reaches that state again—the pregnancy interval—consists of the number of menstrual cycles taken to conceive, the duration of pregnancy itself, and the interval of relative infertility after delivery or abortion. In the case of an abortion the duration of pregnancy is shorter than in the case of normal delivery and the return to fertility frequently occurs with a normal ovulatory cycle taking place a month or 6 weeks after the abortion. It is easy to appreciate that more spontaneous or induced abortions can be fitted into a unit of a woman's fertile life than term deliveries. Queen Anne, in contrast to Victoria, had many spontaneous abortions and had conceived eighteen times before she came to the throne. In fact it may take two or possibly three induced abortions to avert one term delivery, especially if delivery is normally associated with a reasonable interval of breast feeding.

Primary and secondary infertility

In any population some are unable to conceive or to cause conception. There are biological causes, such as endocrinological errors or embryological abnormalities of development, which give rise to infertility. Bacterial and viral infections, such as mumps or venereal disease in men, and venereal, post-abortion or post-partum infections in women, can also give rise to infertility. In women, infertility is divided into primary infertility, which is the inability to conceive at any time, and secondary infertility, which is the inability to conceive following one or more deliveries or abortions.

Social modifiers

A number of social factors reduce human fertility to below its biological potential in nearly every society.

Abstinence is a much more important factor than contemporary observers of the so-called permissive society would have us believe. In western countries it is very rare for a girl to start regular coital activity at puberty, although in many developing countries this is what happens and is one of the several reasons for their acute demographic problems. In the past two decades it is probably true to say that pre-marital activity has become more widespread, although it is still uncommon for

it to begin in the early teens. There has also been an important decline in the age of marriage. The increase in pregnancy and pre-marital sexual activity is probably most closely correlated with the rising economic status of young people. It does not appear to be related to the availability of contraceptives or the change in abortion legislation. Economic independence makes the young less amenable to parental guidance and increases the opportunities for sexual activity.

Monogamy is an important variable in fertility because it cuts down the number of women at risk for pregnancy in a variety of ways. The selection of partners itself takes some time. When a monogamous relationship has been established it may be broken by the death of the man while the woman is still in the fertile years. Even if remarriage takes place there is likely to be an interval of time before it occurs. It is also very common for the two partners to be physically separated due to travel, to the husband establishing a new job in a new locality before being joined by his wife and to illness. The Western European pattern of nuclear families, partner choice in the selection of mate and relatively late age of marriage is to be contrasted with the extended family where the parents' choice determines the selection of bride and groom and marriage is usually early. Pre-industrial Europe had a lower birth rate than many contemporary developing countries because of this important social syndrome.

Birth control

Contraception

Contraceptive practices can best be understood as techniques which extend the interval between two pregnancies. No available method of contraception is totally effective. Clinical thinking has probably been somewhat misled by the wide application of the Pearl formula, which calculates the number of women in a hundred who will fall pregnant if they use a particular method of contraception over a year. With marriage in the early 20s and a desired family of two or three children many women will have achieved their fertility goals by the late 20s or early 30s. They will then be faced with 10–15 years of fertile life during which they must take contraceptive precautions. Hulka (1969) has made theoretical calculations which show, for various methods of contraception and on the basis of two different suppositions concerning the spacing of the initial desired family, how many women will be involuntarily pregnant throughout a fertile lifetime. An effective method, like an intrauterine device (even if it remains in place for the whole of this interval), will be associated with a quarter of the women having an unwanted pregnancy. Surveys of fertility control support the theoretical assumptions.

Therefore, with the possible exception of oral contraceptives, no available method of reversible contraception, even if well and consistently used, is sufficiently predictable to allow a community to control its family size within the goals now set in an industrialized nation such as Britain. The other side of the coin must also be noted, namely a simple method of contraception, even poorly used, makes it

relatively easy to extend the number of cycles required for a woman to fall pregnant. As already mentioned, in the absence of contraceptive practice, one induced abortion will not avert one live birth. However, when the number of cycles taken to conceive is extended, then an abortion and a live birth nearly approximate to one another.

Induced abortion

Abortion is not a new problem in the United Kingdom. It may have been widely used among some social groups before the industrial revolution, but in the 18th century infanticide appears to have been equally or even more common. The infanticide of the 18th century was not always frankly recognized, but the foundling hospitals of London, with their appalling infant mortalities, can only be regarded as a type of social institution geared to child destruction; at the Coram hospital early in the 18th century, of 14,934 babies received, 10,204 died, and between 1728 and 1757, 468,081 babies were christened but only 273,930 reached the age of 2 years.

The 19th century saw a slow change from infanticide to criminal abortion. The evidence for criminal abortion in the 19th century is mainly qualitative but it is unequivocal. A few doctors commented upon the frequency of illegal abortion. A writer for the *British Medical Journal* visited an abortion institution in the 1870s. The trial of the Crimes brothers demonstrates the extent of illegal abortion in the late part of the century. A climbing rate of abortion admissions to hospital testifies to the widespread nature of the practice. Probably the highest abortion rates in Britain were in the time of the economic depression in the 1920s and 1930s (Parish, 1935). There is evidence from maternal deaths due to abortion and also from hospital admissions which, if they do not prove this assertion, certainly make it a possible one. The latter half of the 20th century is seeing some degree of replacement of criminal abortion by legal abortion. This slow, painful process is probably the best that is likely to be achieved and it does a disservice to the community to imagine that the need for induced abortion can be eliminated in the foreseeable future.

The combination of simple ways of extending the pregnancy interval and abortion allow a society to achieve any desired level of fertility. The use of coitus interruptus, the commercial sales of condoms and spermicides, and illegal abortion brought the birth rate in England during the years of the depression below that necessary for biological replacement. Even in the 18th century, delayed marriage, coitus interruptus, and probably some resort to abortion, reduced birth rates to a much lower level than those found in most contemporary developing countries (Wrigley, 1969).

Sterilization

Sterilization after desired family size has been achieved is the alternative option to contraceptive use and induced abortion. For some it is acceptable, for others not;

for some it is advisable, for others not. Currently female sterilization is considerably more common than male, although vasectomy is becoming more widespread. Sociological observation suggests that it has been lack of availability of the operation rather than the community's unwillingness to use it which has retarded the progress of sterilization, and especially vasectomy (Deys, 1973). There seems no reason to assume that it could not have been widely used in the latter part of the 19th century had surgical attitudes been different. The rate limiting factor in its present use is almost certainly on the side of those who provide the service and not on the side of those using it.

Availability

To use a method of birth control a couple need to be motivated and require access to the method selected. It is fashionable to decry the weakness of motivation among some sections of the community, but familiarity with family planning suggests that lack of availability remains the major gap in services in Britain. There have been improvements in the past decade but there is still a long way to go. Availability of contraception is much more than the provision of clinics. Clinics are worthy, luxury services which give a high standard of care to self-selected groups in the community but only one in ten women seeks family planning advice from a specialized clinic (Cartwright, 1970). Clinics enable some members of society to achieve what they would have done anyway, but in a more pleasant and humane way.

Health consequences

Planned fertility, unrestrained fertility and the control of fertility all carry risks of death or ill health. The risks of maternity almost invariably outweigh the risks of birth control. Among the reasons that maternal mortality has fallen in Britain during the present century is that women of high parity and in the older age groups, who are at special risk during pregnancy, have come to control their fertility more successfully.

The hazards of the control of fertility are those of abortion, sterilization and the side effects of contraceptive methods. Between the two World Wars up to 500 women a year were dying from abortion, and most of those deaths were probably due to criminally induced procedures. Today the number has fallen. The advent of antibiotics and the availability of blood transfusion services has undoubtedly improved the medical profession's capacity to deal with women with serious complications of illegally induced abortion. The total abortion rate in the community has probably also fallen. Since the 1967 Abortion Act (and for a number of years before that Act made law what was an increasingly common medical practice) an increasing number of illegal abortions have been transferred from the back streets to the hospitals.

The mortality rate for illegal abortion is difficult to establish because the denominator is never accurately established. The risks of legal abortion can be very low, especially if the operation is done early and with a simple procedure. Considering registered abortion deaths only and using conservative assumptions taking into account the historic realities of surgical practise, perhaps 10,000 fewer women would have died in Britain if the 1967 Abortion Act had been written in 1867. Currently, British women are continuing to suffer a slightly higher mortality and morbidity than is necessary, because of the attitudinal and administrative difficulty of introducing outpatient local anaesthesia abortion techniques. These have been demonstrated in other countries to be preferable to the techniques still used in the United Kingdom (Nathanson, 1972; Tietze, 1972).

The hazards of the pill have had much ink spilt on them. If the unwanted pregnancies following the use of less effective reversible methods of contraception are taken into account then the known hazards of oral contraceptives are more than offset (Potts & Swyer, 1970).

It is interesting to speculate whether the use of oral contraceptives would be increased if methods of supervision were eased. It is possible that ready availability, without a doctor's prescription, would lead to more widespread use, would therefore prevent more unwanted pregnancies and would consequently lead to an overall reduction in deaths due to the consequences or prevention of reproduction. Certainly in the case of progesterone-only methods of contraception, where no contraindications to use have been established, it is difficult to argue that medical supervision has any advantage over free retail distribution.

Intrauterine devices have a low morbidity and mortality. It has not been measured as accurately as in the case of oral contraceptives and may be more dependent upon the type of medical supervision. It is of the same order of magnitude as that in the case of the pill and the same arguments apply concerning the risks of non-use. Deaths due to misuse of condoms have never been recorded. The only known death due to coitus interruptus is that of Onan, whom God struck down for his sin.

The fact that use of the rhythm method may present a hazard to the mother and also to her offspring is not widely appreciated. The subject has not been studied in depth, but a number of biological possibilities do exist. If pregnancy supervenes in a couple using the rhythm method there is a greater than usual probability that the egg or spermatozoon at the time of fertilization will be older than usual. There is unequivocal evidence from animals that fertilization with aged gametes is associated with an increased rate of embryonic abnormalities (Witschi, 1952). It has been suggested that fertilization late in the menstrual cycle in the human female may also be associated with certain abnormalities of implantation which could raise the incidence of tubal pregnancy and of cervical pregnancy (Iffy & Wingate, 1970).

It is essential to carry the analysis of health hazards beyond that presented by using a particular method for a certain time interval. As the community tends to use

a variety of contraceptive methods and supplements these with abortion the morbidity and mortality consequences of the combined use of several birth control measures must also be reviewed. Just as the combination of abortion and contraception gives great flexibility in fertility control, so a rational combination of the two procedures allows the community to plan its families with the minimum of risk. A simple method of contraception, such as use of the condom (or even coitus interruptus), combined with legal abortion when the method fails, presents less risk to life over an interval of time than either repeated legal abortions or the use of a biologically active method of contraception such as the pill or an IUD. The risks involved are small and the aesthetics of the more effective methods of contraception might well be the main factor determining choice for many couples, but the arithmetic is important as it throws a new light on the role of abortion in fertility control.

Social consequences

The control of human fertility has been one of the first, and remains one of the most important, responses of man to a changing environment. In biological and social terms it is a noble and unselfish act of individual self-restraint. Paradoxically, men and women in groups frequently place barriers between themselves and the means of fertility control, even when the majority is attempting to use the very procedures from which they isolate themselves. For example, doctors and clergymen were among the first social groups to limit their families in Britain, but were amongst those most vociferously opposed to the early family planning movement (Peel & Potts, 1969). Roman Catholic pressure groups oppose liberal abortion services but surveys demonstrate that religion is either without influence in the incidence of induced abortion or that Catholics resort to abortion more frequently than others. A higher than expected frequency of induced abortion among Catholics has been recorded where the abortions are legal, as in England (Ingham & Simms, 1972) and where they are illegal, as in Basle and Trinidad (Hoyte, 1965). The private nature of contraceptive practice, the discontinuity of the abortion problem at the individual level and the persistence of mythical beliefs in the supernatural may be partial explanations of this curious form of communal masochism, whereby those most in need of the cure can be the most opposed to therapy.

Data are available to show that teenage marriage, pre-marital pregnancy and high parity can be socially damaging, increasing the probability of marital breakdown and placing children at a number of disadvantages. However, no positive correlation between contraceptive use or abortion practice and adverse social parameters has been substantiated. Some can be hypothesized and are sufficiently important to discuss. It could be argued that ready access to the means of birth control might increase the incidence of sexual intercourse before the formation of sexual partnerships that would choose to become parents. On the one hand, such

unions might lead to the spread of venereal disease, they might be associated with birth control practices which could adversely affect future fertility, or the emotional relationships could prove premature and damaging. On the other hand, they might encourage the rational assortment of parental partners and might of themselves add to the sum total of human happiness. Assuming the ill, rather than the beneficial, hypothesis (as is characteristic of some commentators) what is the likely result of contraceptive availability?

Such availability will reduce the incidence of unwanted pregnancy. This would appear to be beneficial to all aspects of family life. Condoms, possibly some spermicides, will reduce the possibility of venereal disease. Observation shows that when contraceptives are available to the young and unmarried they seem to take up the option when they have established what appear to be meaningful relations and when they have already embarked upon sexual intercourse. It is very rare, in the experience of those providing contraception for the unmarried, to meet girls who wish to obtain contraceptives in order to begin sleeping with their boy friends (Potts, 1969). It is interesting that the illegitimacy rate is higher in New Zealand than in Britain. Contraceptive advice is less readily available and 19th century abortion laws remain. However, more young people own their own cars than in Britain and these and other factors provide greater opportunities for coital activity.

Unfortunately, society appears to be more concerned with sexual behaviour outside marriage than in it. It may condone the 18-year-old boy who marries a 17-year-old bride, although sociological data suggest that the marriage may not be as stable as that of older partners. It tends to be ambivalent towards the man of 25 and the girl of 22 who, feeling themselves in love but not necessarily wanting children, choose to establish a non-fertile sexual partnership.

Conclusion

On the one hand, it is possible to control human fertility at any desired level and communities have done it and will continue to do it. Simple methods are likely to triumph over complicated ones. Combinations of techniques will always remain more effective than single methods alone. On the other hand, there is no single answer to the problem of controlling human fertility any more than a single vehicle will meet every transport need or a single method of communication answer all requirements. Pills, condoms, IUDs, abortions and sterilizations are as rational and necessary as bicycles, lorries, taxis, barges and railway trains and interlock in the same way as telephones and radio, television, picture postcards and carrier pigeons. Political pressures, lack of vision, the medical profession's reluctance to practise preventive rather than curative medicine have all combined to make it appear as if birth control practices should be an exception to the rule that a combination of different options gives a greater degree of flexibility than the use of a single measure. In the field of fertility control there is little likelihood of finding a one-shot solution:

one of the most important new horizons in family planning may be the rational combination of established methods.

Barriers to the open sale of condoms and spermicides persist. Some doctors remain ignorant of how oral contraceptives should be prescribed (for example they force women to stop using the medication after an arbitrary interval of use—for which there is no scientific basis). Relatively few doctors can perform vasectomies. Abortion services are unbalanced and in some cases exploit women in need of sympathetic help. These things can be improved. A major attitudinal advance needs to be made so that birth control procedures become the choice of the responsible couple concerned and not an item which a doctor gives or withholds on an arbitrary series of contraindications, based, at best, on his partial knowledge of a particular situation or, at worst, on his own prejudices. The various methods of birth control must be made to interlock in an optimum way. Abortion services need to be brought into the same administrative structure as contraceptive services. Those who provide one need to be able to provide the other and to link them in the most constructive way possible. It is biologically reasonable to suppose that our search for a high degree of effectiveness has brought with it a penalty of certain side effects. For example, both steroidal contraceptives and intrauterine devices might be developed which had significantly less side effects than those at present in use, but with a higher pregnancy rate. As side effects determine continuation rates, it is possible that less effective but more widely used methods, when looked at from the point of view of the community as a whole, might result in a lower overall abortion rate than the use of current methods.

Abortion is particularly common when the birth rate begins to fall in a community and the ability to take action retrospectively appears to be learnt before that to plan ahead (Potts, 1970). The majority of women know when their period is late and have well-defined feelings of pleasure or panic. Menstrually related techniques of fertility regulation, if perfected, are likely to be widely acceptable and might provide a moment when biological trauma would be minimized. Prostaglandins offer a possible medical method of inducing menstruation; a lot of work and time will be required before a definitive judgement can be given on the likelihood of developing an acceptable technique but the further possibility of self-administration, even if remote, justifies such an expenditure of effort.

Simple surgical techniques of menstrual aspiration can be evaluated more rapidly. It is possible that menstrual aspiration is a step simpler and safer than outpatient abortion, just as outpatient abortion is a considerable improvement on the techniques which preceded it. The cervix does not need to be dilated. This removes a possible hazard to future pregnancies and removes the need for local or general anaesthesia. With a very small, preferably flexible, cannula the lining of the uterus is removed in a procedure which lasts about 30 seconds. Perforation of the uterus is improbable, although it could happen. Infection is a risk and sterile precautions must be taken. The procedure is sufficiently simple to teach to non-physicians. A

very large series will be necessary before possible side effects can be discovered and properly evaluated. If the procedure were carried out within a week of a woman's missed period then it would be done more frequently than abortions.

It is probably the first method which is potentially simple enough that some women might abandon the use of conventional methods of contraception. However, it should be emphasized that menstrual regulation gives rise to very considerable uterine cramping pains. The present needs are to study the method rationally, to discover the reaction of women to it, to try and predict its long-term effects and not to prejudge the situation.

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Biosocial Aspects of Life in Britain

PATTERNS OF FERTILITY

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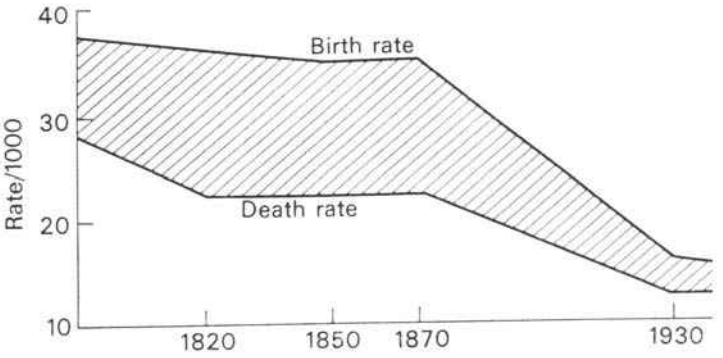
Dr Potts has pointed out that few communities have ever bred to the biological limit. One exception to this generalization is to be found in mid-Victorian England, the first and last period in the history of this country when large surviving families were the rule. The first set of data in Table 1 illustrates the pattern of family building amongst those marriages which took place in 1860. If we bear in mind that these figures represent the size of completed families and that the rate of infant mortality was high during this period (nine or ten pregnancies being required to produce seven or eight surviving children) it is clear that the reproductive function was being exploited to the full in mid-19th century marriages. As Titmuss (1958) has pointed out, the expectation of life of a woman aged 20 was 46 years, one-third of which would be devoted to childbearing.

Table 1. Changes in distribution of families by size

	No. of children in family									
	0	1	2	3	4	5	6	7	8	>8
Marriages of 1860 (%)	9	5	6	8	9	10	10	10	9	24
Marriages of 1925 (%)	17	25	25	14	8	5	3	2	1	1

The spectacular decline in the English birth rate which began in 1878 and is illustrated in Text-fig. 1 is one of the most remarkable features of world population statistics. In 50 years the birth rate fell from 35 births per 1000 of the population to a mere 15 per 1000. From the completed family of nine, ten or more children characteristic of the mid-Victorian era there was a fall to an average of 2·3 children per family in the 1930s with all the consequent discussion, in those years, of underpopulation and the threat of 'race suicide'.

This simple biological transition—from the large family system to the small family norm—has had far-reaching sociological consequences; the social impact of this resort to family limitation in Britain and in other western societies during the last 100 years could hardly be exaggerated. Whatever major theme of sociological concern one cares to single out for examination, basic to most of them is the fact of



Text-fig. 1. The decline of the English birth rate.

family limitation. The transformation of the dynamics of family life, the reduction of the wider kinship networks which the earlier system produced, the development of the so-called 'child-centred society'—these have been the subject of much sociological and anthropological study. Or, if we look at the broader structure of society—the increase in social mobility, a theme of much sociological discussion, is due at least in part to differential fertility whilst the growth of consumer affluence has been made possible by the liberation of spending power formerly absorbed in the upbringing of children and is now disposed of in a market where patterns of consumption are increasingly dictated by the childless. In all these processes family limitation has been a catalytic agent.

But if the social consequences of this revolution in family building patterns is an obvious one, the social determinants of the process are less readily understood. The personal, social and economic motives which led the English middle classes to initiate the process of family limitation have been exhaustively analysed by Banks (1954). Less has been written about the means by which this was achieved beyond the general acknowledgment that contraception became, for the first time, an acceptable feature of married life. The main evidence for this assumption has been the fact that the decline in the English birth rate coincided with the Bradlaugh Besant trial of 1878 by which the legality of propagating contraceptive information was established for the first time. This trial, involving two notable and respected public figures, was widely reported and, by focusing public attention on birth control as a feature of responsible parenthood, the controversy provided an important impetus to family limitation. As a result there grew up in England in the 1890s a flourishing trade in contraceptives; indeed, with the sole exception of the oral contraceptive, there is not a single method of birth control in use today which was not available, and available in great variety, in the 1890s.

But the contraceptive trade was a clandestine trade and birth control was not publicly discussed in the early years of this century. Differential fertility, the fact that the largest familes occurred amongst precisely those social groups who could least afford them, was acknowledged, and the English birth control clinics were

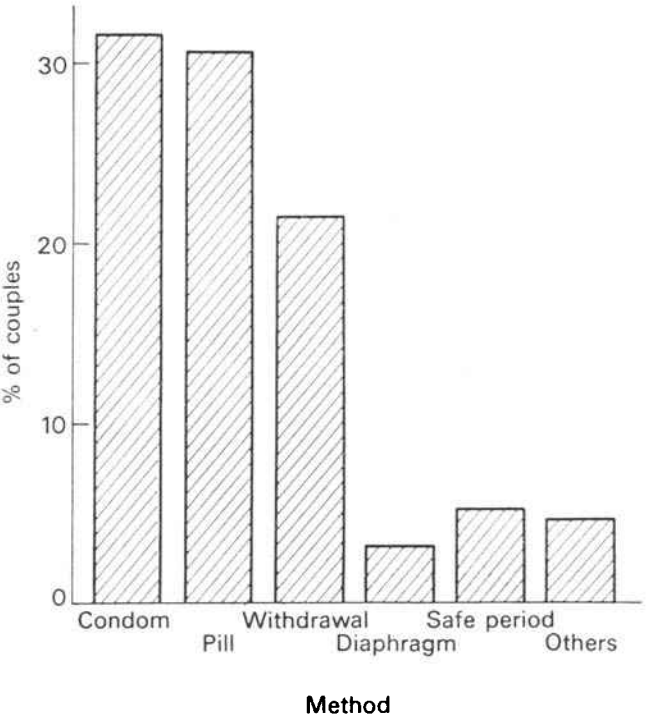
set up explicitly to deal with this problem. But the birth control clinics never served more than a small minority of the married population and little was known about the contraceptive practices of the rest of the population. Indeed, it was not until 1946 that the first survey of contraceptive usage was conducted in this country and even then it was not regarded as a subject which could be put to a sample of the general population. Instead, Lewis-Faning (1949) interviewed, in the general wards of selected hospitals, 3281 married women who represented marriages taking place at every decade during the present century. His results, published in one of the Royal Commission on Population volumes, provide an interesting illustration of the increasing resort to family limitation amongst successive marriage cohorts (Table 2).

Table 2. Increasing contraceptive usage by marriage cohort

Date of marriage	% using contraception at some time during marriage
Before 1910	15
1910–19	40
1920–24	58
1925–29	61
1930–34	63
1935–39	66

Investigations based on more recent groups of marriages have shown a continuation of the trend and an increase in the proportion of couples who adopt the practice at the outset of marriage rather than at a stage when desired family size has been attained or exceeded. Thus, the Population Investigation Committee survey (Rowntree & Pierce, 1961) showed that amongst those couples marrying in the 1950s the percentage ever using contraception had increased to 74% whilst Dr Cartwright's recent national study (1970) and my own study of Hull marriages (1972) show that about 93% of recently married couples now use some form of contraception at some time during their lives.

This trend towards greater use of contraception has been accompanied by a shift towards more reliable methods of contraception than formerly. Amongst those wives interviewed in the 1957 Population Investigation Committee survey—which included marriages taking place over the previous decades—16% had used chemicals, a further 16% the safe period, 11% had used the diaphragm, whilst other methods, such as douching and the sponge, were all represented. It is clear from the most recent survey that three major methods of contraception have come to dominate the English birth control scene—the condom, the pill and withdrawal. As Text-fig. 2 shows, the diaphragm and the safe period have been reduced to the status of minor methods whilst those more bizarre methods found in earlier surveys



Text-fig. 2. Method of contraception currently used or last used by couples in the Hull Family Survey.

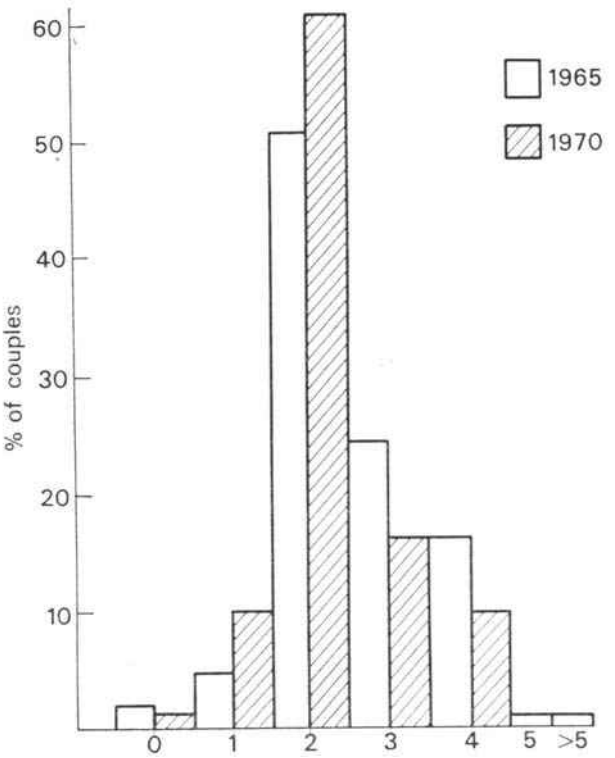
have completely disappeared. Of these three major methods now favoured, two are extremely reliable; the third is a highly controversial method. The condom is the most widely used method of contraception in Britain: it is the first choice for a good many couples and it is everybody's method of second choice. It is a very ancient method of contraception; it enjoyed an important role in 18th century England. Having said this, however, it is also necessary to point to the vast improvements in manufacturing technique and testing which have been developed in recent years and which, together, give the condom a success rate second only to the pill—and statistically only a little behind the pill—amongst careful users. The pill is a product of the 1960s and its influence on family planning goes much further than the 30% of using couples. The arrival of the pill in Britain in 1960 and the discussion which has accompanied its growing popularity have done much to educate the public in birth control matters. Moreover, it was the pill which finally provided the medical profession with a legitimate professional interest in birth control and did so much to transform medical attitudes in the whole field of family planning. Even the debate on the health hazards of the pill had its positive side in directing attention to the corresponding hazards, to the mother's life, entailed in term pregnancy. And the realization of these latter dangers became an important issue in the abortion debate which, once again, was a logical outcome of the improved methods of contraception

of the 1960s. For, once women are led to expect that they can control their fertility by contraception, they are more likely to demand the right to terminate an unwanted pregnancy if this occurs. Better contraception does not necessarily mean fewer abortions; it may well mean more.

The third method of contraception currently in use—withdrawal—arouses strong emotions amongst family planners. It used to be fashionable to condemn withdrawal as physically and psychologically injurious, and a variety of disturbances have been attributed to its use, including impotence in men and frigidity in women. More recently, and following the realization that it is a widely used method of birth control, it has attracted many advocates who will claim for it a number of very real advantages—it is cheap, it requires no preparation, the baby can't eat it and it can't be left behind when the couple go on holiday. On the other hand, our own evidence is that it is not a very reliable method of contraception and its popularity will undoubtedly decline in the face of increasing sophistication about birth control matters.

Against this background of increasing resort to contraception and the shift towards more reliable, and more uniform, techniques, it is hardly surprising that there has also been a revolution in couples' attitudes to family planning and family building. In 1965 we interviewed a random sample of newly married couples in Hull and virtually without exception they were able to tell us how many children they wanted, how they intended to space them and what sex distribution they would prefer. It was clear also that they entertained high hopes of being able to achieve these plans. In view of the fact that over half these couples wanted only two children and that the average desired family size was only 2·6 children these results would have been surprising enough. What is even more surprising is that when we revisited the couples 5 years later, to determine the extent to which their plans had been fulfilled in practice, we found that they had had fewer children than they anticipated at marriage and that many of them had downwardly revised their intentions on family size (Text-fig. 3). They now wanted families which averaged 2·2 children. This finding stands in marked contrast to previous studies in which fertility has been found to outrun expectations. We have, in other words, a new generation of married couples who are not only rational about family planning but are rational too in their contraceptive behaviour.

This revolution in attitudes to family planning and in contraceptive practice has tended to narrow those social differentials formerly associated with variations in fertility. Occupational differences in intended family size have tended to converge. The positive correlation between length of education and family size expectations had almost disappeared. Most surprisingly of all, perhaps, religious differences in family building patterns—formerly by far the most significant social correlate of fertility—were found to have diminished. Thus, whereas in 1965 Catholics had wanted familes 30% larger than those wanted by non-Catholics, in 1970 the excess amounted to only 8%.

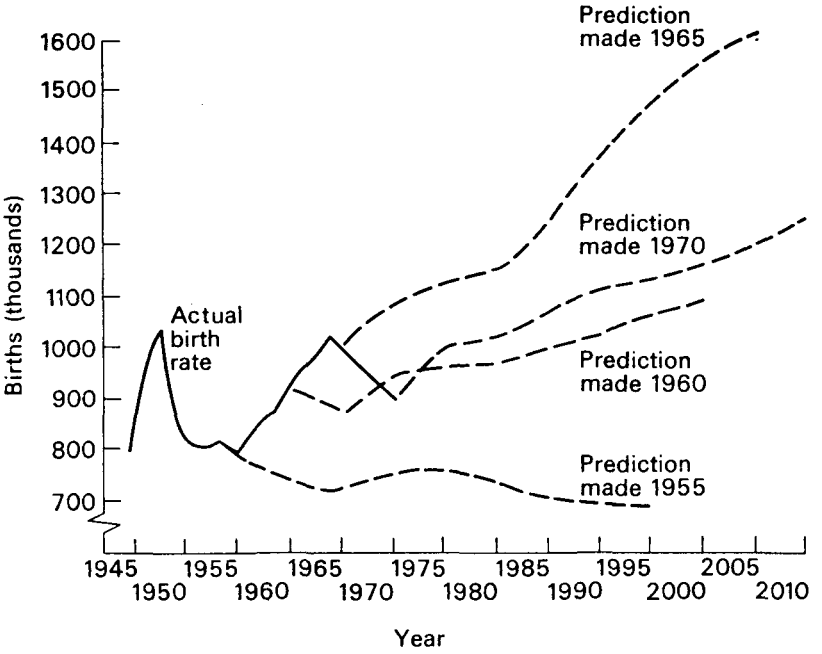


Text-fig. 3. Changes in intended number of children, Hull Family Survey.

One important advantage of this greater predictability in family building intentions is that it may enable us to make better population forecasts than formerly. Successive population forecasts in this country have, as shown in Text-fig. 4, been proved wildly wrong in the event because of our failure to anticipate the gap between intentions and events. This gap is now a narrow one and successive longitudinal studies should enable demographers to estimate with considerable accuracy long-term population trends.

The new rationality in family planning is best seen perhaps in the reduction in the proportions of unplanned pregnancies. As recently as 10 years ago and in a city as family planning conscious as Aberdeen it was found that two-thirds of all pregnancies occurring in the first 5 years of marriage were unplanned (Thompson & Illsley, 1969). In the Hull study only one-third of the total pregnancies were unplanned and the majority of these resulted, not from contraceptive non-use, but from risk-taking amongst contraceptive users.

A situation in which even a third of all pregnancies are unplanned is, of course, a situation capable of improvement and we are in a position to speculate, against the background of our survey findings, the direction in which these improvements might be achieved. For example, if we look more closely at the unplanned preg-



Text-fig. 4. Official population projections, 1955–70.

nancies we find that these increase with parity and that amongst fifth and subsequent pregnancies the proportion unplanned amounts to 56%. In other words, the problem of hyperfertility still exists and it exists, moreover, at the bottom of the socio-economic scale. Yet Social Class IV and V couples actually *want* fewer children on average than those in Social Class III. There is a family planning 'problem' still in attempting to close this gap and it is a community problem as well as a personal problem for the couples concerned. We have overwhelming evidence that children from large families are at a serious disadvantage, physically and socially and in ways which manifest themselves even before birth and which persist through successive generations of hyperfertile parents.

These were the couples whom the early birth control clinics set out to help but, and here our survey data are helpful once again, the preferred methods of contraception in this country are predominantly male methods. The astonishing demand for vasectomization, once the Simon Population Trust decided to defy the legal hazards, is an indication of one potentially useful method of contraception which, as has been pointed out, we have hardly begun to exploit. And quite recent evidence (Deys, 1973) suggests that this birth control technique would, if it were less expensively available, find ready acceptance at this level. Domiciliary birth control schemes which, a few years ago, seemed to offer so much promise in assisting this stratum of the population, suffered from the same handicaps as the traditional family planning clinics—they were female oriented and doctor operated.

A second problem area which will have to be faced in the coming decade is the problem of illegitimacy. I think the fact that the large number of terminations carried out in this country since the 1967 Act became operative has had such a small impact on the illegitimacy rate has been a surprise and a puzzle to everyone. As I have suggested, we now know a good deal about the sexual behaviour and contraceptive practices of married couples. Our knowledge of the sexual behaviour of the unmarried, despite Michael Schofield's pioneering study (1965), is virtually non-existent. There are plenty of theories and conjectures about teenage promiscuity and pre-marital sexual behaviour but none of these is based on recent factual findings, simply because we do not have any.

With these two problem areas remaining, I am suggesting that the 1960s saw the battle for birth control virtually conceded in this country. I think that the 1970s will be the decade of abortion and already one can distinguish some similarities in the way in which events are developing—the initial reluctance of doctors to have any part in the procedure and their subsequent fear that the technique may pass out of their hands; the reluctant admission that abortion has been very much more widely practised than had formerly been acknowledged and the problem of devising some administrative means whereby what is readily available to the wealthy can be brought within reach of the poor. The Bishop of Durham's address to the Annual Clinical Meeting of the British Medical Association in April this year is an added reminder that, on the question of birth control, the churches were often in advance of the medical profession.

If the abortion debate is settled as rationally and humanely as the birth control issue was settled and if we can accept that a comprehensive family planning service requires that contraception should be backed by adequate access to abortion then, by the end of this decade, we may be in a position where both parents and the community are relieved of the burden of the 'unwanted pregnancy'. Moreover, whatever we can do towards this end in this country will have implications for the rest of the world. The problem of differential fertility in England portrays in microcosm what, on the world scale, is implied by the population explosion. For it is precisely those countries which are least able to afford and sustain rapid population growth, which are economically underdeveloped, agriculturally inefficient and low in per capita income, in which the highest birth rates occur. And though the potential developments about which Dr Potts has talked are exciting and encouraging he would, I think, be the first to admit that they are long-term possibilities for the underdeveloped world. The widespread use of prostaglandins is bound to be delayed for many years by the testing requirements of the various national committees on drug usage; menstrual extraction, on the other hand, is likely to remain a medical or paramedical procedure for some years to come. In the meantime, the most useful expertise we can provide to the underdeveloped world is the knowledge on motivation and barriers to motivation which we have gained from studies in this and other advanced countries.

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Biosocial Aspects of Life in Britain

SOCIAL MOBILITY AND THE GENETIC STRUCTURE OF POPULATIONS

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Summary. In addition to geographical heterogeneity for major genetic markers in the population there is also vertical differentiation in behavioural and physical characters with significant heritabilities. This vertical differentiation arises from social stratification of the population based on occupational status.

IQ has a significant heritability, is positively correlated with social class and is related to social mobility.

Laboratory experiments have confirmed the hypothesis that social mobility dependent to some extent on a variable with a significant heritability will lead to genetic differences between groups.

It is argued that both genetic and environmental factors must be considered in any explanation of social class phenomena.

The reported associations between some major genetic markers and various quantitative characters suggest that both discontinuous and continuous genetic variation should be taken into account in future investigations concerned with genetic aspects of social stratification.

Spatial heterogeneity

Discussion of the genetic aspects of the population structure of the British Isles usually focuses attention solely on geographic variation in the frequencies of genes concerned with discontinuous variation. Indeed there is ample evidence for spatial heterogeneity in the frequencies of the genes determining blood groups (Kopeć, 1970) and for some other major genetic markers.

Three possible sources of variation need to be considered to explain this geographic genetic variation. First, the accumulation of sampling fluctuations that have occurred generation after generation give rise to random genetic drift such that part of a population may differ markedly from another part in the frequencies of genetic factors. Second, differences in the environment between parts of the population will bring about different forms of selection in different geographical areas and,

third, historical events, for example both peaceful and aggressive migration, can produce genetic heterogeneity of populations.

The effects of migration are usually invoked to explain a substantial part of the geographic variation in ABO blood group frequencies in the British Isles. The invading Saxons, Danes and Vikings did not just fight and run away, but some introduced samples of their genes into the local populations. It is likely that both random genetic drift and selection were also factors but evidence for these is difficult to obtain.

There is little doubt that the present population is not in an equilibrium state. The complex patterns of both long- and short-range migration together with changes in the environment, for example the spread of urban life styles, will have effects on the genetic structure of the population.

Vertical differentiation

In addition to the horizontal spatial heterogeneity in the population there is a vertical differentiation arising from social stratification. The adult working population can be sub-divided into a number of occupational or socio-economic classes. As a classification of occupations is related to qualifications and skills, and hence to level of education, it is not surprising that positive correlations between school attainment, ability, creativity, IQ and class have often been reported for adults. In the case of IQ the reported correlations range from 0·4 to 0·7 (Table 1). In addition to these psychological characters it is also found that the incidence of certain diseases differs between the social classes and the indexes of death rates for men are considerably lower in Class I than in Class V.

Table 1. Mean IQs of parent and child according to socio-economic class of parents (from Burt, 1961)

Socio-economic class	Parent	Child
Non-manual		
I Higher professional	139·7	120·8
II Lower professional	130·6	114.7
III Clerical	115·9	107·8
Manual		
III Skilled	108·2	104·6
IV Semi-skilled	97·8	98·9
V Unskilled	84·9	92·6

The socio-economic classes clearly reflect many environmental influences. Family incomes, for example, are positively correlated with socio-economic class

and will have some effect on the home environment. Recently Davie, Butler & Goldstein (1972) have described the abilities, behaviour, physical development, health, home environment and birth history of a large representative sample of 7-year-old children in England, Scotland and Wales. Their very extensive data clearly demonstrate social class differences in both behavioural and physical characters amongst these children. A few examples taken from their results will serve to illustrate the extent of this social stratification. Children in Social Classes I and II were, on average, 3·3 cm taller than those from Social Class V. Teachers' ratings of the children's creativity, oral and reading abilities were more often below average or markedly poor for children in manual than in non-manual social classes. Both maternal and paternal interest in the child's educational progress, again as assessed by the teachers, declined from Social Class I to V. An indication of some of the more subtle environmental differences between the social classes is provided by the observation that the percentage of children who were deprived of the protection afforded by immunization against polio increased from 1% in Class I to 10% in Class V. A similar pattern was found when immunization against diphtheria was considered.

Social mobility

Thus there is ample evidence for differences in behavioural and physical characters amongst both parents and their children in the different socio-economic groups. Some of the variance in some of these quantitative characters is known to have a genetic component. IQ, on which most research has been done, is an example of such incompletely inherited characters (Erlenmeyer-Kimling & Jarvik, 1963) and thus there will be differences between the IQs of children and their parents. It follows that if the relationship between IQ and socio-economic class is maintained over generations, and there is evidence that it is, then a proportion of children in each generation must move from the social class in which they were born into a different occupational group to reconstitute the adult distribution.

Burt (1961) tested this hypothesis in a general population sample by comparing the IQs of fathers and sons and relating the differences to both upward and downward inter-generational social mobility. He found that a large proportion of social mobility was indeed related to IQ. Three pilot inquiries carried out in Cambridge have produced consonant results. The experimental design has varied, as in each case there was an interest in some other questions besides social mobility, but all of the three surveys involved interviews and the use of the same intelligence tests with both fathers and sons; the results are summarized in Table 2. The results show that the movement between classes has more than restored the correlation between IQ and class that there was in the fathers' generation—this perhaps being due to the changes in educational opportunities. All three surveys also showed that if the distance of movement was measured on a 6-point class scale, and related to the

Table 2. Correlation coefficients between IQ and socio-economic class in two generations

	Father's IQ/ class	Father's IQ/ son's IQ	Son's IQ/class	
			Before mobility	After mobility
Survey 1	0·46	0·79	0·40	0·70
Survey 2	0·46	0·69	0·37	0·57
Survey 3	0·45	0·64	0·33	0·66

extent of the differences between the IQs of fathers and sons, the greater the difference in IQ the greater the distance of movement. In families in which the IQs of the father and two male sibs were known it was also found that the upwardly mobile sibs tended to have higher IQs than the non-mobile or downwardly mobile sibs (Gibson, 1970). Both verbal and performance components of the IQ were related to this social mobility (Gibson & Mascie-Taylor, 1973).

Genetic differences between social classes

As IQ has a significant heritability the observation that it is correlated with social mobility suggests on theoretical grounds that social mobility will give rise to a non-random transfer of IQ genes from class to class on the assumption that the relationship between IQ phenotypes and social mobility implies some significant relationship between IQ genotype and social mobility. Thus the classes will be expected to become genetically differentiated to some extent. In addition the classes will also differ for immediate environmental reasons due to differences in educational opportunities, nutrition and home backgrounds, etc.

Thoday & Gibson (1970) have pointed out that 'the problem is to decide whether and to what quantitative extent environmental factors directly affecting contemporary individuals cause the class differences, and to what extent the differences are caused by genetic differences that have arisen because differing genotypes have in the past moved into different classes. Measurements of the relative contributions of these two causes can be made only if measurements of the between class heritability can be obtained.' The crux of the problem is that although we know that IQ has a significant heritability within groups we cannot extrapolate from these values to obtain estimates of the between group heritabilities. If the variation were of the discontinuous kind it would be possible to classify all individuals into genotypes and then compare the estimates of gene frequencies obtained in the different classes. At the present time there is no way in which we can deal with this problem of continuous characters in human populations and thus we are unable to decide what proportion of the differences in the average values of characters in different social classes is genetic and what proportion is environmental (Thoday, 1969).

Model experiments

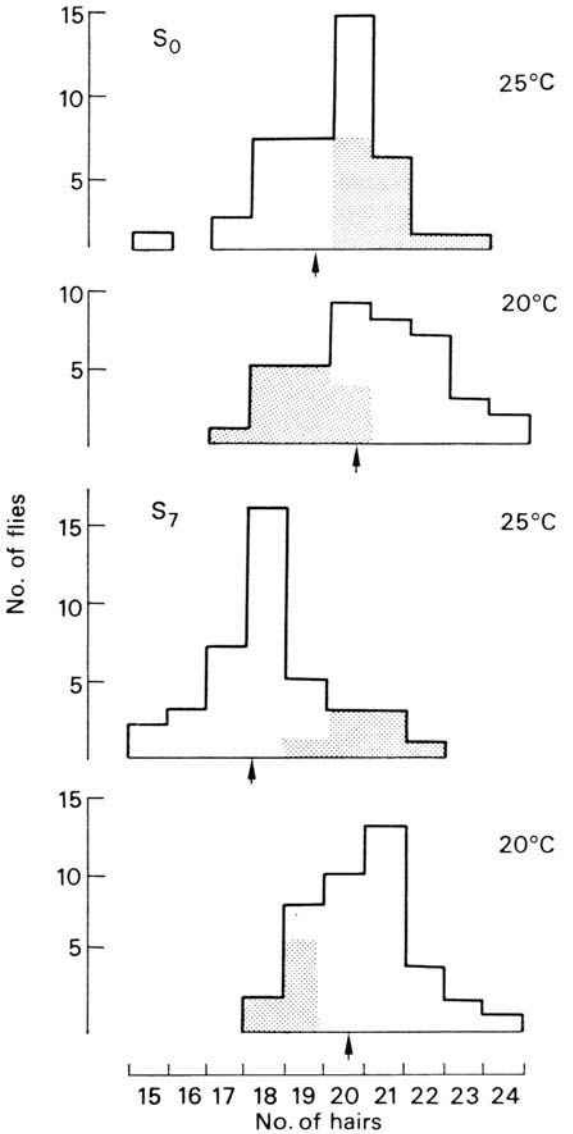
With experimentally more amenable organisms than man, between group heritabilities can be derived from the results of transplant experiments. Thoday & Gibson (1970) tested the theoretical argument discussed above by means of the transplant technique in a model experiment using the fruit fly *Drosophila melanogaster*.

In their experiments the character used, number of hairs on a certain part of the fly, was chosen as an example of an incompletely inherited quantitative character. Of the many identified environmental factors influencing the number of hairs, temperature is the most easily controlled and flies which develop at 20°C have on average more hairs than flies which complete development at 25°C. The experimental design was simple: random samples of flies from the same stock were set up in culture bottles at these two temperatures and from amongst the progeny of each bottle the hairs were counted on each of ten virgin females and ten males. Of the twenty flies assayed, the ten with the highest number of hairs were used as parents of the 20°C culture and the ten with the lowest hair numbers were used as the parents of the 25°C culture. This process was repeated each generation. Overall there was no selection, for all the flies assayed were used as parents for the next generation. 'Social mobility' was represented by the percentage of flies that, because of their hair numbers, changed culture conditions in each generation. In the first generation that the flies were cultured at the two temperatures the difference in mean hair number was 0·9 per fly which represents solely environmental differences between the two cultures. Results for subsequent generations (Table 3 and Text-fig. 1) showed that the 20°C culture always had a higher mean than the 25°C culture

Table 3. Mean numbers of hairs of two groups of flies, and inter-group mobility

Generation	Group		Difference	Mobility (%)
	20°C	25°C		
0	19·8	18·9	0·9	
7	19·9	17·7	2·2	20
8	19·9	17·4	2·5	30
9	19·8	17·4	2·4	20

but the mean difference between the two cultures increased over the generations from the original 0·9 to 2·5 hairs per fly. The 'social mobility' was always less than the 50% expected if the two cultures were not different in mean hair number. The important question, to what extent did the 20°C and 25°C cultures differ for genetic or 'cultural' reasons, was answered by transplant experiments. Samples of the high hair number flies were grown at 25°C and samples of the low hair number flies were grown at 20°C.



Text-fig. 1. Distributions of hair numbers in quadruplicate assays of female flies grown at 25°C and 20°C. The upper two distributions are taken from the base population and the lower two distributions from Generation 7. Shaded portions represent flies that, because of their hair numbers, would change culture conditions in the next generation. The mean hair number at each temperature and generation is indicated.

The difference in mean hair number between the two groups when they were grown in their own cultural conditions was 2·5 hairs per fly but the difference was reduced to an average of 1·15 hairs per fly when the groups were grown at the same temperature (Table 4). These data gave an estimate of the between group heritability of $1{\cdot}15/2{\cdot}5 = 0{\cdot}46$ (in the original paper this sum was miscalculated and a value of 0·42 was reported).

Table 4. Transplant experiment: mean number of hairs of flies of Generation 8 raised in two environments

Environment	Progeny of flies with high number of hairs	Progeny of flies with low number of hairs
20°C	19·9	18·5
25°C	18·3	17·4

Table 5. Components of variance (exclusive of the between-sexes variance) as percentage variance

Source of variance	Phenotypic variance	Heritability	Genetic component	Environmental component
Between groups	60·4	0·46	27·8	32·6
Within groups	39·6	0·13	5·1	34·5

In separate tests the within group heritabilities averaged 0·13. The partition of variance is summarized in Table 5 and it is clear that the proportion of the difference between the groups that was genetic was larger than the proportion of the within group variance that was genetic.

This experiment, together with similar ones carried out using other environmental conditions, has confirmed the hypothesis that social mobility dependent to some extent on a variable with a significant heritability does lead to genetic differences between groups. The 'social mobility' in these experiments sorted out the genetic variance so that it became largely between group rather than within group variance.

Discussion

Clearly the human situation is much more complex in many respects than this laboratory experiment. But the results of this experiment serve to emphasize that both genetic and environmental factors, including cultural effects, must be con-

sidered in any explanations of social class phenomena. The social class stratification in both behavioural and physical characters referred to above is likely to reflect, to some extent, genetic differentiation of the population.

In view of this suggestion of vertical genetic differentiation of the population it is surprising that there is little published information on the social class distribution of major genetic markers, some of which have been found to be associated with quantitative characters. For example, there is evidence that susceptibility to certain diseases, such as stomach cancer, duodenal and gastric ulcers, is differentially associated with the ABO blood groups (Clarke, 1964). Cattell, Bourtourline Young & Hundleby (1964) have claimed that the personality factor 'tender-minded versus tough-minded' also shows some association with the ABO system although the conclusions they drew from their data have been criticized on statistical grounds (Weiner, 1965; Norton, 1971). Parker, Theilie & Spielberger (1961) found that O type blood occurs more frequently in manic-depressive patients than in either psychoneurotic depressive patients or in the general white population in the USA.

Some diseases and personality factors could be significant in affecting intra-generational occupational mobility and might lead to non-random transfer of the relevant genetic factors from one social class to another.

Moran (1965) has suggested that the social class distribution of schizophrenia might well be an example of this phenomenon. There is ample evidence that genetic factors play a substantial part in the aetiology of schizophrenia although there is no agreement on the exact mode of inheritance (Kallmann, 1953; Slater, 1958; Gottesman & Shields, 1967). However, the frequency of the trait is much higher in manual than in non-manual occupational groups (Hare, 1962). It seems likely that this distribution arises partly from the fact that the nature of the illness and its treatment, often requiring periods in hospital, fosters downward social mobility. Thus in the manual occupational groups there is a higher frequency of the genes involved in the aetiology of schizophrenia and probably also the relevant genotypes are more often manifest in the adverse environment.

The recent discovery of widespread polymorphisms for genetically determined electrophoretic enzyme variants has greatly increased the number of readily screened genetic markers available in human populations. This must encourage those who feel that more precise information about the genes affecting quantitative characters in human populations can theoretically be obtained by modification of the location techniques developed in more experimentally amenable organisms (see Thoday, 1967a,b). Only if and when the genes of such incompletely inherited characters as IQ can be identified will it be possible precisely to answer questions about the proportion of the differences between social classes that is genetically determined. For this reason it is hoped that future investigations of quantitative characters in human populations will be combined with investigations of the segregating genetic markers.

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Biosocial Aspects of Life in Britain

NATURE AND DISTRIBUTION OF GENETIC ABNORMALITIES

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Summary. Chromosomal anomalies causing significant disease have a total frequency of about 5 per 1000 total births, and this frequency shows little geographical variation within Britain.

Conditions due to mutant genes of large effect probably have a total frequency of about 10 per 1000 total births. Dominant conditions with low reproductive fitness show little regional variation in frequency, but milder conditions may show variation as a result of founder effect or genetic drift. Recessive conditions may show striking differences in birth frequency as a result of heterozygote advantage, for example the high frequency of sickle-cell anaemia in immigrants to Britain from West Africa or the West Indies. The high frequency of cystic fibrosis over most of Europe is also probably due to heterozygote advantage. Regional variation on a smaller scale may also occur, for example, the threefold variation between the south-east and the north-west of Britain for phenylketonuria. X-linked conditions, like dominant conditions, appear to show little regional variation within Britain.

The common congenital malformations have a total frequency of about 25 per 1000 total births. Their aetiology depends both on polygenic predisposition and on environmental triggers, though the details in most instances are not known. While congenital malformations of the heart appear to show little variation in birth frequency, those for the central nervous system show a striking variation with an increasing frequency from the south-east to the north-west of Britain.

Introduction

There are three types of genetically determined abnormalities in human populations: those due to chromosome abnormalities, those due to mutant genes of large effect, and those that are polygenically determined. The total birth frequencies of each class are approximately 5, 10 and 25 per 1000 births respectively. But these frequencies are much dependent on the conditions included and their severity.

Chromosomal anomalies

Among those due to chromosomal anomalies a distinction may be made between those involving the sex chromosomes (XY in males and XX in females) and those involving the remaining chromosomes which are collectively called the autosomes. The birth frequencies of abnormalities of sex chromosomes and of autosomes are each about 2·5 per 1000 live births.

(a) *Autosomal*

The most frequent autosomal anomaly at birth is trisomy 21 which is responsible for the well-known condition Down's syndrome (or mongolism) in which mental retardation is associated with a number of physical characteristics, which enable the patient's condition to be readily recognized even before confirmation by chromosome studies. In some 95% of instances the third chromosome 21 is free (regular trisomy) and the anomaly is assumed to arise by non-disjunction at germ cell formation. In the remaining 5% the third chromosome 21 is attached to another chromosome, usually chromosome 14 or chromosome 22.

The frequency of trisomy 21 among live births has been found by competent British, European, Australian and American surveys to be of the order of 1 in 600 to 1 in 700. This is probably somewhat of an underestimate since the condition will sometimes remain undiagnosed, especially among those who die in infancy. The striking feature of the birth frequency of the regular trisomic patients is the well-known variation with maternal age, rising from a birth frequency of about 0·5 per 1000 live births for mothers under 25, to 10 per 1000 for mothers over the age of 40 years.

There are no indications of any regional variation in birth frequency in Britain or indeed, in so far as data are available, between different races of man, when allowance is made for the variation in maternal age distribution. At least one instance of 'trisomy 21' has been recognized in a chimpanzee. However, the prevalence at school age of patients with trisomy 21 may well vary in different parts of Britain, since the areas with the lowest rate of infant mortality will show the highest proportion of trisomy 21 patients surviving to school age. In London the prevalence at age 10 is about 1 in 1000.

Other autosomal trisomies which are well recognized are those of chromosome 18 and of chromosome 13. The birth frequencies of both of these are of the order of 0·2 per 1000 live births, but few patients survive infancy and so the load on the health and educational services is small. Again, both these trisomies show a maternal age effect but there is no indication as yet of regional or racial variation.

No undoubted examples of autosomal monosomies are known among live births, but partial trisomies and partial monosomies due to structural anomalies of autosomes are known. One of the most frequently recognized is the cri-du-chat syndrome, named after the peculiar cry of the patients in infancy and associated with a loss of part of the short arm of chromosome number 5.

It is a feature of autosomal anomalies that they cause syndromes, a constellation of physical abnormalities characteristic for each type of autosomal anomaly with almost invariably some degree of mental retardation. The frequencies of autosomal anomalies causing clinical abnormality are summarized in Table 1.

Table 1. Frequency of unbalanced autosomal anomalies per 1000 live births

Trisomy 21 (Down's syndrome)	1·8
Trisomy 18 (Edward's syndrome)	0·2
Trisomy 13 (Patau's syndrome)	0·1
Miscellaneous (mostly unbalanced translocations)	0·4
Total	2·5

It should be noted that studies in spontaneous abortion indicate that other autosomal trisomies are common at conception, but result in first trimester abortions. For example, trisomy 16 may have a frequency at conception of nearly 10 per 1000, but has not been recognized in a full-term birth. Trisomy 21 is also not uncommon among abortuses and the frequency at conception is probably about twice that among live born. The total frequency of chromosomal anomalies at conception is probably as high as 70 per 1000.

(b) *Sex chromosomal*

The sex-chromosome anomalies differ in that a fetus with monosomy—the possession of a single X chromosome and no second sex chromosome (usually written XO)—may survive to term. The frequency at conception of the XO genotype is perhaps as high as 10 per 1000, but there is a high fetal loss and the birth frequency is only of the order of 0·2 per 1000 live births, implying about 98% fetal loss. The affected girls do not develop secondary sexual characteristics, are short in stature, and have a number of characteristic physical signs, including webbing of the neck, shield chest and a triangular face. The ovaries are replaced by streaks of fibrous tissue.

In contrast, the trisomies of the sex chromosomes, which are of three kinds, XXX, XXY and XYY, do not appear to result in excessive fetal loss and are each not uncommon among live births. Their relatively mild clinical effects probably depend on the fact that any X chromosome, additional to one, becomes inactive early in development, as in a normal female, and that the Y chromosome carries little but virilizing genes. All these trisomies tend to cause some degree of mental handicap, usually mild, but in general terms involving a shift of the IQ distribution about 10 points to the left. The XXX genotype causes little further anomaly apart from some reduction in fertility and ovarian function. The XYY genotype causes little further physical anomaly except for an increase in height and in bone density.

It does, however, sometimes lead to exaggeration of the male behaviour characteristics, of aggressiveness and impulsiveness which make men much more likely than women to fall foul of the law. The XXY genotype causes testicular dysgenesis and sterility. In addition, some patients have a eunuchoid body build. They account for about 10% of males attending sterility clinics. Patients with mosaicism, that is two cell lines for sex chromosomes, are not uncommon; for example, XO/XXX, XO/XY, XX/XY, XXX/XX and others are known. Less commonly, patients with tetrasomy of the sex chromosomes are found, for example XXXX, XXXY and XXYY.

The birth frequency of the sex-chromosome trisomies is of the order of 1·0 per 1000 girls for XXX, 1·4 per 1000 boys for XYY, and 1·2 per 1000 boys for XXY. The birth figures for both sexes combined are summarized in Table 2. The miscellaneous anomalies include mosaics and tetrasomics.

Table 2. Birth frequencies of sex-chromosome anomalies per 1000 live births (both sexes)

XYY (extra Y syndrome)	0·7
XXY (Klinefelter's syndrome)	0·6
XXX (triple X syndrome)	0·4
XO (Turner's syndrome)	0·1
Miscellaneous (including mosaics and structural anomalies)	0·6
Total	2·4

Both the XXY and XXX genotypes show an increasing birth frequency with rising maternal age but this is not true of the XYY and the XO genotypes. There is no indication of any regional variation in birth frequencies of sex-chromosome anomalies, compatible frequencies having been reported for example from London, Edinburgh, Switzerland and Canada.

Mutant genes of large effect

Among the disorders due to chromosomal anomalies there are, as we have seen, some half-dozen which predominate, each with a relatively high birth frequency in all populations. In contrast, the number of different disorders due to mutant genes of large effect is some 100 times greater, but most of them individually are rare. This is essentially because gene mutation rates are very much lower than the frequency with which non-disjunction of chromosomes occurs. Accordingly it is very difficult to estimate at all precisely the total birth frequency of conditions due to mutant genes of large effect. Further, with these conditions, in contrast to those due to

chromosomal anomalies where very few of those affected have children, fitness may be only slightly reduced. Mild conditions, such as red–green colour blindness or Dupuytren's contracture of the palmar fascia, may reach high birth frequencies of the order of 50 per 1000. Excluding these and including only conditions of at least moderate severity, the total frequency due to mutant genes of large effect may be of the order of 10 per 1000 live births in many European and European-derived populations, including that of Great Britain. This is about twice the birth frequency of those due to chromosome anomalies. There are, however, individual populations where for special reasons single individual recessive conditions, though severe, may by themselves reach a birth frequency of 10 per 1000. An example is sickle-cell anaemia in West Africa.

Conditions due to mutant genes of large effect are conveniently divided into autosomal dominant, recessive and X-linked. Autosomal dominant conditions in medical genetics terminology are those in which those affected are heterozygotes for the mutant gene concerned (that is have only a single dose of the gene). There may well be evidence that homozygotes for the gene are much more severely affected, but since the heterozygote has reduced reproductive fitness homozygotes are exceedingly rare. In the 1971 edition of McKusick's catalogue of single gene determined phenotypes, 415 dominant conditions are listed and a further 528 in which dominant inheritance is possible. Some of the conditions listed are best regarded as normal variants, and some are exceedingly rare. The majority, however, will have been seen at least once by an experienced medical geneticist in the course of his daily work. Estimated birth frequencies for some of the more common dominant conditions in England and related populations are given in Table 3. These frequencies

Table 3. Birth frequencies of some dominant conditions in European populations, per 1000 live births

NERVOUS SYSTEM	
Neurofibromatosis	0·30
Huntington's chorea	0·10
Tuberose sclerosis	0·02
Myotonic dystrophy	0·02
INTESTINES	
Multiple polyps of colon	0·12
SKELETON	
Marfan's syndrome	0·02
Classical achondroplasia	0·02
HEARING	
Deafness—dominant forms	0·14
SIGHT	
Blindness—dominant forms	0·14

must not, however, be taken as typical of the 400-odd dominant conditions, most of them, if not all, seriously incapacitating, which will have frequencies of between 0·01 and 0·001 per 1000 live births.

There is at present no reason to suppose that gene mutation rates will differ significantly in different populations. Some dominant mutations show a paternal age effect, that is increasing frequency with increasing paternal age. Some variation in birth frequency then may be expected to depend on paternal age distribution. Dominant conditions which severely limit reproductive fitness, and thus birth frequency, are largely dependent on fresh mutations and will not be expected to have different frequencies in different populations. However, reproductive fitness may well be different in different areas, such that each mutation may affect more generations in some areas than in others. Also, in relatively small populations there is scope for chance drift whereby a dominant mutant gene happens to be relatively frequent in one small population and rare in another by the chance variation of reproductive performance of individuals who possessed the gene some generations back. A well-known example of such founder effect is the high frequency of porphyria in South Africans of Dutch descent and there are suggestions of such local variation in Britain for Huntington's chorea.

In addition to clear-cut dominant conditions there are indications that there may be several genes which, in the heterozygous state, pre-dispose to, but do not necessarily result in, common diseases of adult life. Thus while homozygotes for the gene for familial hyper-β-lipoproteinaemia usually die of ischaemic heart disease before the age of 20, the male heterozygotes in Britain have about a 50% risk of death before the age of 55 years from coronary artery occlusion. The frequency of heterozygotes is not established but is perhaps of the order of 4 per 1000. Again, while homozygotes for the gene for α-antitrypsin deficiency have a substantially increased risk of developing chronic bronchitis and emphysema in early middle-age, the heterozygotes who are no less than 10% of the population, may also have some increased risk of bronchitis and emphysema, especially if they are cigarette smokers.

Autosomal recessive conditions in medical terminology are those in which affected individuals are homozygotes for the mutant gene concerned (that is have a double dose of the gene concerned). Both parents are heterozygous carriers of the gene but are clinically normal. With such conditions the path between the actual gene mutation involved and the homozygous patient may be a long one. A mutant gene will occur in a germ cell and then be transmitted for many generations in carriers before it meets a similar mutant gene in an affected child. The likelihood of both parents carrying the same recessive gene is increased if they are cousins or other blood relatives. In general, autosomal recessive conditions are more severe than autosomal dominant and so there is less likelihood of regional variation in birth frequency from differences in survival. However, in contrast to dominants, the birth frequency of recessive disorders will be affected by changes in the rate of

cousin marriage and, more important, by any selective advantage of the heterozygous carrier.

The importance of parental consanguinity is often overestimated. It is changes in the amount of inbreeding that matter. In general the rate of consanguineous marriage has fallen sharply in developed countries over the past century, and this will have temporarily reduced the birth frequency of recessive conditions. In certain immigrant communities which have come from large outbreeding populations but are intermarrying in the smaller immigrant group, the frequency of recessive conditions will be temporarily increased.

Heterozygote advantage is probably an uncommon phenomenon but accounts for the strikingly high birth frequency in certain populations of a few recessive conditions which are lethal in childhood. A small advantage of the relatively many heterozygous carriers of the gene balances the selective elimination of the mutant gene in the homozygotes dying of the disease.

The total number of autosomal recessive conditions in McKusick's catalogue (1971) is 365, with another 418 listed as possibly recessive. Again this includes some innocuous near-normal variants and some exceedingly rare conditions, but the majority of the 365 will be familiar to a medical geneticist. In Britain as a whole there is one autosomal recessive condition, cystic fibrosis, which is sufficiently common to indicate heterozygote advantage. In this condition there is a tendency both for the small ducts in the lungs to block, giving an increased risk of pneumonia, and for the small ducts of the pancreatic gland to block, giving a reduced amount of digestive enzymes secreted into the intestinal tract. It is possible to compensate for the latter defect by giving pancreatic enzyme by mouth, but the liability to lung infection persists. Up till 1960 the great majority of patients died in infancy or childhood but careful management is now causing an increasing proportion to survive into adult life and some girl patients have already had children. The birth frequency in Great Britain appears from surveys in Wessex and Yorkshire to be of the order of 1 in 2000. This makes it much the most common of all lethal conditions due to mutant genes of large effect in Britain, and implies a heterozygous carrier frequency of a little under 1 in 20. The same birth frequency probably holds over most of northern and central Europe, and in derived populations such as that of Australia; the frequency is probably lower in southern Europe and very much lower in Mongolian and African populations. In addition, individual populations in Britain will have higher frequencies of particular recessive conditions; for example, the West Indian and Nigerian immigrants are likely to have a birth frequency of homozygotes for sickle-cell anaemia of about 5 per 1000, and Cypriot immigrants a frequency of β-thalassaemia of the same order, even though both these conditions are usually fatal in childhood. If one assumes a population in Britain of 1 million derived from West India and West Africa, and 160,000 derived from Cyprus and Malta, this would give a frequency of sickle-cell anaemia in Britain of 0·10 per 1000 and β-thalassaemia of about 0·02 per 1000. Similarly in the

Ashkenazi Jewish population in Britain the birth frequency of Tay–Sach's disease is probably about 0·3 per 1000, whereas it it only about 0·01 per 1000 among the non-Jewish. With the break up of these isolates as a result of intermarriage with the native English these are likely to become rare conditions. Birth frequencies of some of the more common recessive conditions are listed in Table 4. In almost all cases the reproductive fitness of patients with these conditions was near zero until very recent measures of treatment were introduced. Again, the frequencies of the conditions tested must not be taken as typical of all seriously handicapping recessive disorders.

Table 4. Birth frequencies of some recessive conditions in Britain, per 1000 live births

METABOLISM	
Cystic fibrosis	0·50
Classical phenylketonuria	0·10
NERVOUS SYSTEM	
Neurogenic muscular atrophy	0·15
RED BLOOD CELLS	
Sickle cell anaemia	0·10
β-thalassaemia	0·02
ENDOCRINE GLANDS	
Adrenal hyperplasia	0·05
HEARING	
Severe deafness—recessive forms	0·50
SIGHT	
Blindness—recessive forms	0·40
MENTAL RETARDATION	
Severe—recessive forms	0·50

For recessive conditions, in addition to the differences between large populations and between natives and immigrants, there are indications of differences within the native British population. The best data are for classical phenylketonuria. In this disorder a failure to metabolize phenylalanine causes mental retardation unless the patient is on a diet low in this amino acid. Some years ago it was noted, in patients attending the Hospital for Sick Children in London, that an exceptional number appeared to have Irish surnames. A study of parental and grandparental birth places of patients with phenylketonuria born in south-east England showed that, compared with controls, the parents, and even more the grandparents, were exceptionally often born in Ireland or west Scotland. Now routine screening programmes on new born infants are making it possible to examine this regional variation directly. Some of the findings are shown in Table 5. There are indications of a cline of

Table 5. Regional variation in birth frequency of classical phenylketonuria in the United Kingdom

Region	Observed frequency	Frequency per 1000 live births
Belfast	15 in 112,383	0·13
Glasgow	56 in 449,021	0·12
Liverpool	11 in 143,666	0·08
Manchester	23 in 169,211	0·14
Birmingham	13 in 185,823	0·07
Bristol	8 in 117,305	0·07
NE and NW London	10 in 216,116	0·05
SW London	6 in 149,441	0·04

increasing frequency from the south-east to the north-west of Britain with a three-fold difference at the extremes.

The number of conditions due to mutant genes on the X chromosome is naturally much less than those on the autosomes. It is estimated that the X chromosome is about one-sixteenth of the genome. In McKusick's catalogue sixty-eight conditions are listed as clearly X-linked and another sixty-four as possibly X-linked. Again, some of these are normal variants, for example the Xg blood group and colour blindness, but the majority are diseases familiar to the medical geneticist. X-linked conditions are in some ways intermediate in behaviour between autosomal dominants and recessives, since a woman with two X chromosomes can be a symptomless carrier of a mutant gene on one of her X chromosomes. A male, however, with a mutant gene on his one X chromosome will be clinically affected. Where a gene mutation occurs on an X chromosome in an ovum and it is fertilized by a Y-bearing sperm the resulting child will at once be affected as with an autosomal dominant. A girl receiving a fresh mutation either from her mother's ovum or her father's X-bearing sperm will be a symptomless carrier, if the mutant gene is recessive, and on average half her sons are affected and half her daughters are carriers. Estimates of the frequencies (in males only) of some X-linked conditions in Britain or in related populations are shown in Table 6.

As with dominants, variation in birth frequencies for severe X-linked conditions is hardly to be expected as the link between mutation and patient is pretty direct.

Regional surveys in Britain have in fact shown similar frequencies for Duchenne type muscle dystrophy in Oxford, Yorkshire and Northern Ireland, and no striking differences have been noted in the work per head of population of the various regional centres in which the treatment of haemophilia is concentrated. One X-linked condition, due to an alteration in the enzyme glucose-6-phosphate dehydrogenase in red blood cells, is relatively common in West Indian and West African immigrants. The reason is that as with sickle-cell anaemia the condition confers some resistance to malaria. The form of the condition in Negroes, however,

Table 6. Birth frequencies in males in some X-linked recessive conditions per 1000 live births

MUSCULAR SYSTEM	
Muscle dystrophy—Duchenne	0·20
Muscle dystrophy—Becker	0·01
BLOOD CLOTTING	
Haemophilia A	0·10
Haemophilia B	0·03
SKIN	
X-linked ichthyosis	0·16
Anhidrotic ectodermal dysplasia	0·01
SKELETON	
Rickets (hypophosphataemic form)	0·01
MENTAL RETARDATION	
Severe X-linked forms	0·20

causes little trouble unless the patient is treated with certain drugs, such as primaquin used to suppress malaria.

Multifactorial conditions

These include most of the diseases which are now most common, schizophrenia, manic-depressive psychosis, duodenal ulcer, coronary artery disease and the common congenital malformations. Since there is a substantial environmental component in the aetiology of these multifactorial conditions, regional differences in birth frequency may be due to environmental differences or to genetic differences, or to both. For example, while there is a substantial genetic component in the aetiology of early onset coronary artery disease it has become clear recently that some of the regional differences in frequency are due to differences in the hardness of the water supply.

Birth frequencies of the more common congenital malformations are shown in Tables 7(a) and 7(b). The total birth frequency of congenital malformations depends on just what is included, but is of the order of 25 per 1000.

For most of the common congenital malformations there is no indication of regional differences within Britain or related populations. The most complete population data for Britain are from Birmingham, but population data from Liverpool and hospital data from other parts of Britain are mostly compatible with each other. The birth frequency of congenital heart malformations has been shown to be similar in Birmingham, Liverpool, Sweden and the USA.

The exceptions to this uniformity are the neural tube malformations, spina bifida cystica and anencephaly which show a striking cline across Britain. This is

Table 7(a). Congenital malformations having a birth frequency of at least 1 per 1000 total births

HEART	
Malformations—all types	6·00
INTESTINES	
Pyloric stenosis	3·00
CENTRAL NERVOUS SYSTEM	
Spina bifida	2·60
Anencephaly	2·00
FACE	
Cleft lip (± cleft palate)	1·30
SKELETON	
Dislocation of hip	1·00
Club feet (all types)	1·40
Extra fingers and toes	1·10

Table 7(b). Congenital malformations having a birth frequency between 0·1 and 0·9 per 1000 total births

INTESTINES, ETC.	
Diaphragmatic hernia (not hiatal)	0·50
Atresia of small intestine	0·20
Rectal atresia	0·40
SKELETON	
Webbed fingers and toes	0·70
FACE	
Cleft palate (mid-line)	0·60
KIDNEYS	
Renal agenesis	0·40
Cystic kidneys	0·10
Horseshoe kidney	0·10

best established for anencephaly where, since the introduction of notification of causes of still births, regional statistics are available for the whole of Britain.

Some 10% of anencephalics are recorded as infant deaths, but there is no regional difference in the practice, except for Ulster where some 20% are recorded as infant deaths. The regional differences for anencephaly are shown in Table 8 and there are indications from local surveys that regional differences in the birth frequency of spina bifida parallel those of anencephaly.

Table 8. Variations in frequency of anencephaly (still births) per 1000 births, Regional Hospital Board areas, 1963–69

Scotland	2·6	South Western	1·6
Wales	2·5	Wessex	1·5
Liverpool	2·4	Oxford	1·5
Manchester	2·0	East Anglia	1·3
Newcastle	1·9	SE Metropolitan	1·3
Sheffield	1·7	NW Metropolitan	1·2
Leeds	1·6	NE Metropolitan	1·2
Birmingham	1·6	SW Metropolitan	1·2

The steady increase in frequency as one passes from the south-east of Britain to the north-west is apparent, the figures for Ulster, Scotland and Wales being more than twice those in the south-east. The cline is similar to that for phenylketonuria. The discovery of the cause of these variations will be of great practical importance. To some extent differences may be due to genetic differences, but it is improbable that these are sufficient to account for all the variation. The birth frequency of these conditions is known to vary with social class, birth order and maternal age, but again this could not entirely account for the difference.

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Biosocial Aspects of Life in Britain

BIOLOGICAL EFFECTS OF CURRENT PATTERNS OF OCCUPATION

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Introduction

Occupation is used in the title as a synonym for work, which is defined as an occupation directed towards a definite aim, be this monetary gain or personal satisfaction. It is clearly an all-embracing term, but today is used to describe a state of employment where the individual is paid to carry out certain actions or duties. The number of self-employed persons has declined and is now only a very small proportion of the working population. The percentage of the population engaged in work is shown in Table 1, and in Table 2 the percentage of women employed is given, showing a considerable increase particularly in recent years. These tables illustrate a weakness in that the majority of the women not included are certainly not idle, they are housewives engaged in long hours of tiring work (Grieve, 1967, 1972).

In the UK, in round figures, there are 25 million able-bodied persons engaged in some form of work, and in Table 3 the main divisions of occupation are shown with the proportions engaged in each. Under each heading there is a great variety, i.e. office work, including administration and managerial which is essentially sedentary, and physically demanding work both skilled and unskilled. In Table 4 a rough attempt has been made to classify work in terms of physical activity. Rather more than a quarter are engaged in sedentary work, the remainder are in occupations in which

Table 1. The percentage of the UK population engaged in work in 1968 (ILO, 1971)

Age (years)	Workers (millions)	
	Male	Female
15–19	1·51 (70%)	1·38 (66%)
20–64	14·30 (96%)	7·40 (48%)
65+	0·59 (23%)	0·27 (6·5%)

Table 2. The proportion of men and women engaged in work (ILO, 1971)

Year	Population aged 15+ years	
	Male	Female
1911	93·5	35·3
1921	91·8	33·7
1931	90·6	34·2
1951	87·6	34·0
1960	87·6	39·7

By 1970, approximately 50% of women were working

Table 3. The proportions of the working population in the major occupations (ILO, 1971)

Occupation	%
Manufacture	35·0
Services*	27·0
Commerce	16·0
Construction	7·7
Transport	6·6
Agriculture	3·0
Mining	2·3

* Includes firemen, police, domestic service, barbers, launderers, photographers, etc.

Table 4. An approximate classification of work (ILO, 1971)

Type of work	%
Sedentary work	26·4
Shop work	9·6
Services*	12·0
Active	50·0

* See Table 3 footnote.

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either much or most of the day is spent upright (shop assistants), or light physical work (bus and lorry drivers), moderate work (police, foremen, domestic servants) or heavy physical work (miners, dock workers, labourers).

The biological consequences of occupation will depend upon the type of work performed, the environment during work, and the duration of work and may be modified by age, sex and experience, The term 'biological' includes not only physiology but psychology, biomechanics, and anthropology. Social factors interact with biological and cannot be ignored in any effective study, so it is not surprising to find very little information available. Since such a comprehensive view is required and is not at present evident, in this paper all that will be attempted is a general account with suggestions about biological consequences which might be examined. Nevertheless, this is not a neglected field; the successful development of ergonomics in the last 20 years has meant that many of the biological aspects of work have been identified and studied. The description of 'ergonomics' given by the Ergonomics Research Society is 'the physiological, psychological and anatomical features of man in his working environment'. An introductory account of ergonomics has been given by Edholm (1967) in *The Biology of Work*, and reference will be made to some of the relevant findings in the present paper. The ergonomic approach is primarily concerned with establishing the optimum conditions for work, in terms of posture, work space, lay-out, design of equipment, presentation of information, environment and muscular effort. These are all relevant to the problem of identifying biological consequences, although mainly in relatively short time periods. It is essential to examine cumulative effects of work. Most men and many women expect to work from the time of leaving school up to the age of 60–65. Biological effects manifest at any particular age represent the integrated experiences of a lifetime. The long time lag before obvious effects of occupation are evident is commonly observed in various industrial diseases, so another important source of information concerning biological consequences is the considerable literature dealing with the hazards of occupation.

Biomedical hazards

Pathological and physiological changes cannot be separated, except by arbitrary rules or definitions. Some types of industrial disease can be excluded on the grounds that they are specific for a particular industrial hazard. These include the conditions due to inhalation over many years of dusts with a varying degree of pathogenicity resulting, for example, in pneumoconiosis in coal miners and asbestosis in those working with asbestos. There are the many toxic hazards associated mainly with the chemical industry.

On the other hand, there are many diseases prevalent throughout the country but where the incidence may be significantly higher or lower in particular industries. Such differences may indicate biological aspects, which can be of importance in determining the aetiology of the disease in question. One example is coronary heart

disease, a major cause of death or incapacity in men. There is evidence suggesting that physically active individuals are less likely to suffer a coronary heart attack than those who are sedentary. Morris, Heady, Raffle, Roberts & Parks (1953) showed that bus conductors had a significantly lower incidence of coronary heart disease than bus drivers. Conductors are physically more active than drivers, and the same difference between otherwise comparable groups of workers was found by Morris *et al.* when they examined the incidence in post office personnel, those who sorted mail and postmen delivering mail on foot, the latter having a significant advantage. These findings have stimulated many to examine the effects of physical activity on coronary heart disease. The reported results are not unanimous, but there is considerable support for the view that sedentary men are more vulnerable than those who do muscular work. The beneficial effect of activity can serve as a reminder that not all the biological consequences of occupation are harmful.

Chronic bronchitis is another wide-spread disease of multiple causation but with a substantially higher incidence in Social Groups IV and V compared with Groups I, II and III. These susceptible groups include unskilled and semi-skilled labourers many of whom frequently have to lift heavy loads. Davis & Jackson (1962) examined the possible relationship between chronic bronchitis and heavy manual labour involving lifting, since large rises of pressure occur within the thorax during lifting. They studied two groups of dockers at the port of Hull, one group handling general cargo and the other concerned mainly with timber. The two groups both carry heavy loads, but the timber dockers commonly lift and carry in the erect posture and the general dockers habitually stoop to lift. It is the latter action which is responsible for causing sudden large changes of intrathoracic pressure, so it was postulated that the general dock workers would have a higher incidence of chronic bronchitis, and this proved to be the case, the difference being nearly twofold. A causal relationship between lifting heavy weights and chronic bronchitis cannot be said to have been proved by these observations but the difference between the two groups of dockers is impressive, especially as other factors appear to have been similar.

The two examples of chronic bronchitis and coronary heart disease are not the only pathological conditions which may be due in part to conditions of work. However, other illnesses will be considered in a more general way. The number of working days lost due to illness is very large, amounting to about 300 million days each year. About 100 million days are accounted for by bronchitis, rheumatism and psychoneuroses, these being terms used on the sickness certificates. The word 'rheumatism' so used covers a wide variety of conditions, including such vague descriptions as back-ache. Anderson (1971) has reviewed the subject of 'rheumatism in industry' and states that in 1963 some 10·3% of all incapacity was due to 'rheumatism', or approximately 30 million working days. This is, of course, much more than the time lost due to industrial disputes. If time lost by industrial disputes is indeed the cause of great economic loss (which appears to be widely believed) then it would

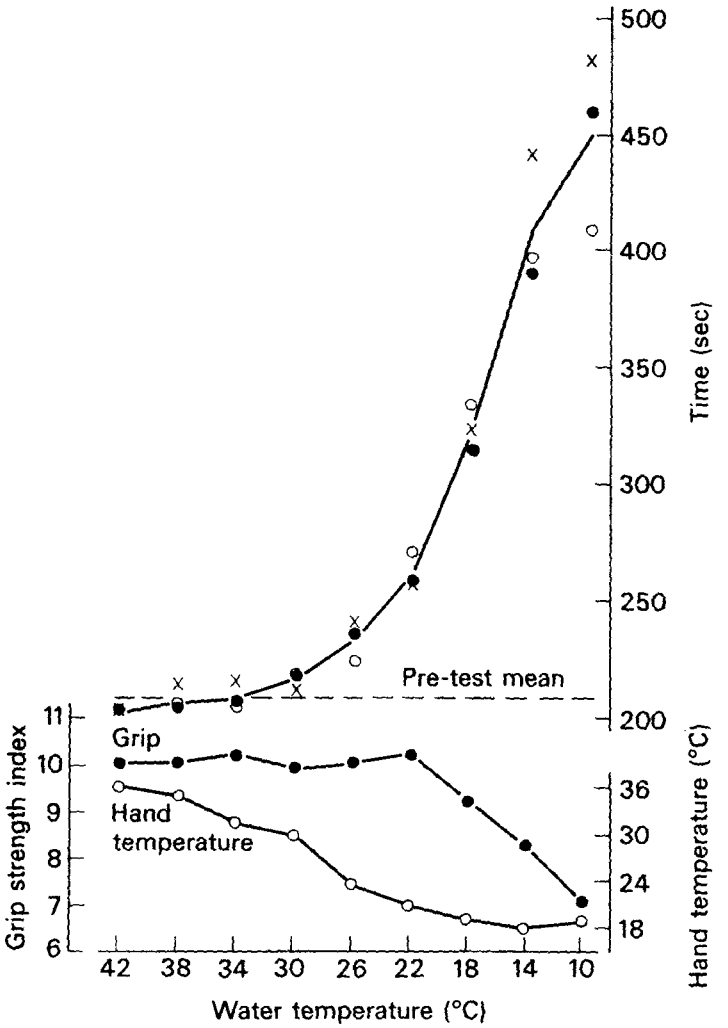
seem worth while examining the much greater loss of working time due to illness. Disability of varying degree due to back injuries and back pain is very common and this is related to occupation. Coal miners and unskilled labourers have from three to four times higher incidence of such conditions than office workers (Anderson, 1971). Troup, Roantree & Archibald (1970), while emphasizing the dangers in handling loads and the need for special training courses, point out that there is still considerable ignorance of the mechanisms of injury. Nevertheless, the success achieved with suitable training, combined with ergonomic evaluation and re-design of jobs, indicates that with present knowledge considerable improvement can be achieved. Although the incidence of back pain is much lower in office workers than in coal miners, nevertheless there is still a considerable loss of working time and efficiency in sedentary workers, much of which is due to bad posture and the bad design of office furniture and equipment.

Environmental factors

The pathological effects of inhaling dusts and toxic vapours have been mentioned briefly. The consequences of working in hot, cold or noisy environments have been studied in considerable detail and many relevant books and papers have been published (for a short bibliography see Edholm, 1967). Hot conditions are still prevalent in a number of industries, mainly in steel mills, glass works and ceramics, as well as in some coal mines. And physical work in hot conditions results in a degree of heat acclimatization proportional to the intensity of exposure or, rather, to the increase in body temperature evoked by the combination of muscular work and heat. This is one of the most dramatic examples of the ability of the human body to adapt to the environment. There are many practical problems concerned with work in hot conditions, but they are well known and preventive measures are, in general, effective.

Work at low temperatures is becoming commoner with the rapid growth of the frozen food industry. The evidence regarding acclimatization to cold in man is still equivocal, with the exception that local acclimatization in the hands and fingers has been clearly established. Protection from the effects of cold is certainly far more important than acclimatization. The moderate cold exposure experienced by outdoor workers during the winter months can affect performance, especially of skilled manipulative tasks. Work indoors in buildings inadequately heated can also be affected by cooling of the arms and hands. Text-fig. 1 shows the effects of temperature on typing and emphasizes that there is an important aspect of work efficiency in relation not only to the extremes of heat or cold but to quite small changes in temperature.

The effects of noise on performance can be considerable, and when particular noise levels are exceeded there will be temporary hearing loss which can become permanent if the exposure is prolonged or the intensity is severe. People adapt or



Text-fig. 1. The effect on copy-typing speed of immersing both hands and forearms for half an hour in water at temperatures ranging from 10 to 42°C. (From Fox, 1961.)

become used to noise but this is partly due to some hearing loss. It is difficult to know the precise effects of noise with time, as there appears to be a general loss of hearing with age which may be due entirely to ageing or to the cumulative effect of exposure to noise levels which all people experience. It has proved hard to find populations for testing who live in a quiet environment.

This difficulty of assessing a normal or usual ageing process illustrates the problem of determining the effects of particular environments over a long period of time. Although the phenomenon of heat acclimatization is well understood, it is not easy at present to decide whether there is a price to pay for maintaining such acclimatization over many years.

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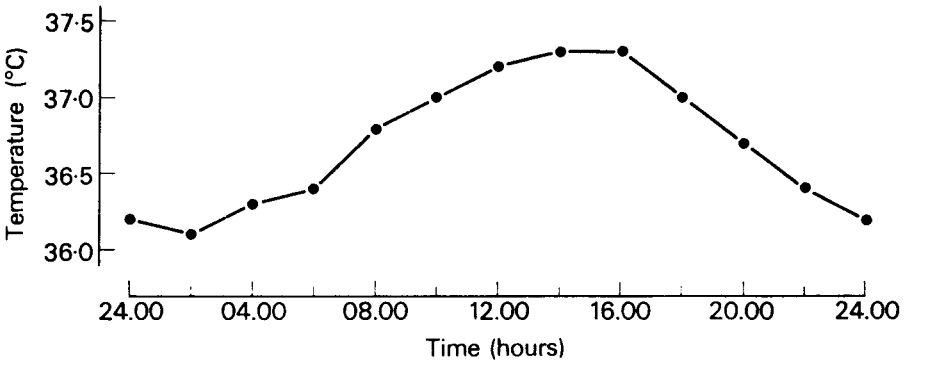
Hours of work

There are two ways by which time affects work. These are shift work and the duration of work, and biological consequences might be predicted in certain circumstances from both.

Shift work

In many industries, including coal mining, chemical plants, electricity generating stations, etc., shift work is usual. It has been estimated (Walker & de la Mare, 1971) that in the manufacturing industries 12½% were engaged in shift work in 1954 and by 1968 this had increased to 25%. There are obvious social problems caused by shift work but there are also important biological consequences. A large number of physiological functions exhibit a fairly regular diurnal or circadian rhythm which can be illustrated by the daily rhythm of body temperature (Text-fig. 2). These



Text-fig. 2. Daily variation of body temperature in fifteen men engaged in light work.

rhythms are affected by environmental conditions but are essentially intrinsic. When a change is made from day to night work these rhythms persist in their original form for varying periods. The temperature rhythm, for example, may persist for several days before adapting to the new pattern of activity and sleep; other rhythms may change over more quickly or more slowly. All circadian rhythms which have been studied ultimately adapt, but this may take weeks.

It may be asked whether these disturbances of circadian rhythms have any demonstrable consequences. Colquhoun (1971) has summarized the results of studies carried out by his colleagues and himself at the Applied Psychology Unit at Cambridge, in which it was shown that performance was related to the circadian rhythm of temperature. It might have been expected that sleep patterns would be disturbed in shift workers but Tune (1968) did not find any difference in the number of hours sleep between shift workers and a control group. There is no evident effect of shift work on sickness (Walker & de la Mare, 1971) although Dirken (1966) found a small but significant increase in the number of complaints made by shift

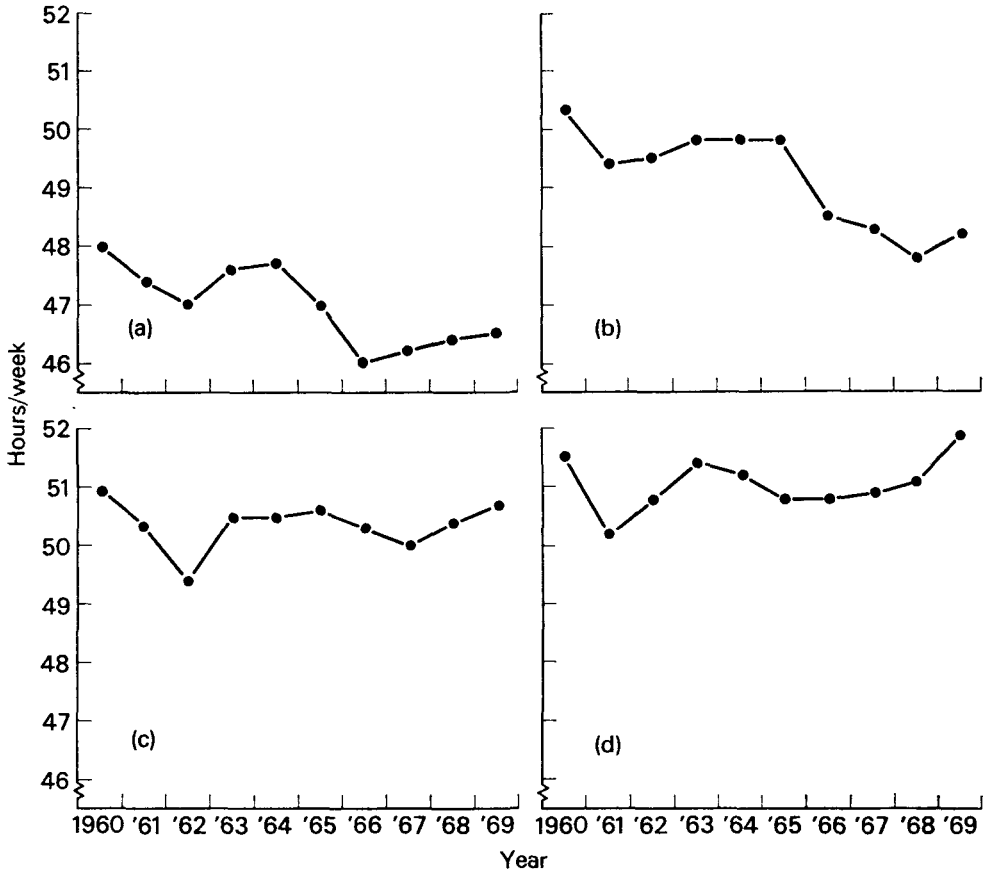
workers in comparison with a control group. If shift work were organized purely from a physiological point of view, shift changes would be made at relatively long intervals of not less than 4 weeks, since complete adaptation takes a considerable period of time. However, the most socially acceptable pattern is to have rapid changes with 2–3 days on each shift. It appears that social factors dominate and any physiological disadvantage is ignored. Nevertheless, since shift work is increasing, the biological consequences must be kept in mind, and particularly the assessment of long-term effects of many years of shift work.

Related to the question of shift work is that of irregular working hours, and this is exemplified by the problems of the transport industry. Both on railways and on the roads, work continues throughout the day and night but it is impossible to organize this on a strict shift system as in a factory. The work patterns of railway drivers have been studied by Tredre (personal communication), who found that over a period of 4 weeks all drivers worked at all hours of the day but in a very irregular pattern. Hours of work were also variable, ranging from 40 to 56 hours each week. Road transport is increasing as railway traffic decreases, but conditions of work are less well documented. Although there are regulations governing maximum hours of driving and rest periods, it seems probable that these are frequently ignored. In a Canadian study, it was found that the average hours of work of long-distance truck drivers averaged 56/week, but 29% worked more than 60 hours/week. Such figures may not apply in the UK, but it is reasonably sure that many truck drivers have long and irregular working hours. Driving even a heavy truck only requires a low rate of energy expenditure but demands a high level of arousal and vigilance. At present, there is no evidence about the possible cumulative effect of such work over a period of years.

Duration of work

Hours of work have fallen in the last 10 years, as shown in Text-fig. 3, but the fall is not steep and in 1969 the average hours worked in British industry were 46·5/week. In many industries there are longer hours; in mining 51·9 hours/week in 1969, whereas in manufacturing it was 45·7 hours/week. It is widely believed that there is an increasing problem of leisure rather than work, but in an average of 46·5 hours/week there is not much time for leisure since this implies 5 days of 8 hours of work, with 6½ hours on Saturday, leaving Sunday only as a day of rest. On the same basis, an average of 51·9 hours/week for a miner implies only half a day's leisure each week. Frequently work is not divided in this way, but when time spent in travelling to and from work is added, it is evident that for many leisure hours are few indeed.

It would probably be generally agreed that shorter hours of work than those quoted would be desirable, perhaps mainly on social grounds but also because it might be predicted that health would be better. During World War 2, when invasion was expected, there was a strong motivation for hard work in the factories and, in



Text-fig. 3. Average number of hours of work 1960–69: (a) male workers; (b) construction industry, i.e. building, road and bridge construction; (c) transport, including road and rail workers; (d) miners, including quarry workers. (Data from ILO, 1971.)

general, the decision to work up to 7 days a week with longer hours each day was widely accepted. These long hours eventually resulted in a drop in production and increased illness. In part, the deterioration was probably due to cumulative fatigue and possibly cumulative sleep loss. But it is still not obvious why continued long hours of work should be deleterious. We talk loosely about people being 'worn out' by a lifetime of labour, but this process is far from being understood.

Fatigue

The suggestion that cumulative fatigue might have been responsible for some of the deterioration due to continued long hours of work makes it necessary to discuss the meaning of fatigue. It is a word used in different ways; the description in the Oxford English Dictionary includes 'weariness after exertion' and the synonyms are 'tired', 'exhausted'. There are two main varieties of fatigue, muscular and

mental. The mechanism of muscular fatigue has been widely studied and much is known about the physiological aspects. It is an important phenomenon in the biology of work, but it is quite separate from 'mental' fatigue. The feelings of tiredness and weariness after a day's work are familiar to most people, even when the work has not involved any muscular activity other than that required to stay in a chair. As yet, little is known about the physiological basis of mental fatigue, although the effects can be described and causes indicated. Different tasks vary in their susceptibility to fatigue; tests of vigilance show rather a rapid decline in performance. Repetitive tasks, if self-paced, may be maintained at about the same average rate throughout the working day, but if the task is machine-paced performance can fall off rapidly. As vigilance declines or fatigue increases there is a greater variability in performance; with self-pacing an operator can balance his performance, but with a fixed pace this is impossible. Bartlett (1951) emphasized that as fatigue developed, mental 'blocking' or lapses occurred with increasing frequency, leading to errors or missed signals. Nevertheless, even the severely fatigued subject can make a determined effort and produce an excellent performance, but this can only be done for a short time, then errors and failures increase rapidly again. Vigilance tasks and repetitive tasks are not only affected by fatigue, they are also sensitive to the environment, that is, to temperature, lighting, noise and vibration. There are many varieties of vigilance tasks throughout industry and an increasing number are employed in tasks such as inspection, or in watch-keeping jobs where the worker has to monitor dials and indicators, only taking action when readings exceed certain values. This is one reason why it is widely believed that work is getting lighter and easier. However, such tasks, not involving muscular effort, can be very fatiguing and the fatigue can probably be cumulative which may be responsible for many cases of mild ill-health with vague and variable symptoms (Symposium on Methodology of Fatigue Assessment, 1971). It is in this field of non-specific ill-health, frequently described or dismissed as absenteeism, that improvement is urgently needed.

Apart from specific industrial diseases, the biological effects of work or occupation are still obscure. To achieve a better understanding, a multidisciplinary approach is needed, including an estimate of social factors. The features which have been mentioned briefly include duration of work, shift work, the fatigue associated with so-called light tasks, and the high incidence of back injuries and back pain. Much has been written about the stress of modern living; how far some of these features may account for the general level of stress cannot be accurately assessed. There is a wide-spread belief that work is progressively becoming lighter and easier, but the changing pattern of industrial occupations is poorly documented.

The study of the social and human aspects of the effects of occupation seems to be neglected. There are excellent accounts of the Industrial Revolution and Victorian developments, but very little covering the period since World War 1. In his portrait of a Suffolk village, *Akenfield*, Blythe (1969) has vividly recorded the

changes that have occurred in farm work during this century. Perhaps others will attempt the same approach by examining the changes in a mining village or an industrial town. Such studies could help to identify relevant problems. There is little doubt that part of the necessary solution of many of our social and medical ills lies in a much more determined effort to understand and improve working conditions.

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Biosocial Aspects of Life in Britain

THE GEOGRAPHY OF LIFE AND DEATH

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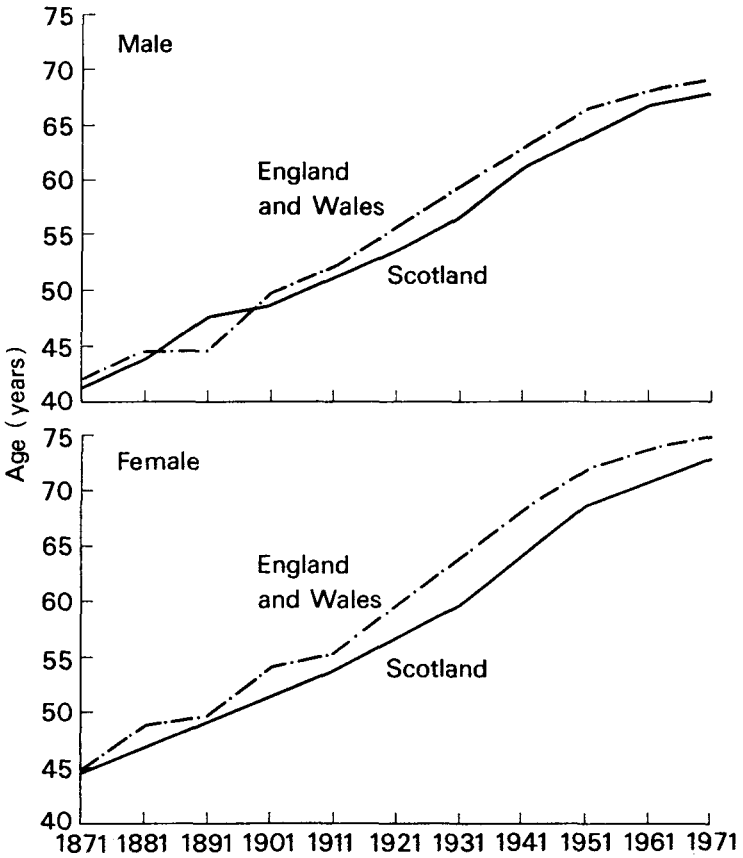
Introduction

Life tables published by the Registrars General indicate that the expected lifespan at birth of a male child is 69 years in England and Wales (Registrar General, 1972) and 67½ years in Scotland (Registrar General for Scotland, 1971). For females the lifespans are 75 years and 73½ years respectively, i.e. 6 years longer than for males (Text-fig. 1). Such figures would seem to suggest that life expectancy is more or less the same throughout the country. In actual fact the reverse is the case. Mortality from the main killing diseases displays remarkable geographical variability. In place of the expected homogeneity there is considerable heterogeneity which in its turn must inevitably carry with it important consequences for regional and national population trends.

The present paper provides a cartographical appraisal of regional variations in life expectancy as represented by infant mortality, by mortality from arterio-sclerotic heart disease (including coronary disease), vascular lesions affecting the central nervous system, chronic bronchitis, lung-bronchus cancer and stomach cancer respectively, and by mortality from all the individual causes combined.

Except for infant mortality (Text-fig. 3), for which death rates (for children under 1 year; both sexes combined) are used, mortality for the selected major causes (Text-figs. 4–7) and for all causes (Text-fig. 8) is expressed in terms of standardized mortality ratios (males only). The standardized mortality ratio (SMR) provides probably the most satisfactory method of comparing, by means of a single figure, mortality in local areas with that of the country as a whole. It allows for peculiarities of age structure of local populations by a process of indirect standardization (see Howe, 1970a) and is a more reliable index than is the crude death rate. The standardized mortality ratio is expressed in terms of the standard rate for the whole country taken as 100. If, for instance, the standardized mortality ratio for a local area is 100 then that area experienced, in the period under review (1959–63), a mortality rate equal to that for the country as a whole; if the standardized mortality ratio is 200 then the mortality rate is twice as great as the national average.



Text-fig. 1. Expectation of life (in years) at birth in Britain 1871–1971 (taken from Howe, 1972).

The infant death rates and the standardized mortality ratios are presented cartographically on both geographical and demographic base maps. The geographical base map relates the mortality data to places or localities, the demographic base map relates the data to the 'populations at risk' in those places or localities. Geographical base maps give prominence to mortality rates or ratios of extensive sparsely and unevenly populated areas of the country, e.g. Montgomeryshire, Westmorland, Ross and Cromarty, but provide insufficient weighting in the case of limited and localized areas of dense population associated with, say, the metropolitan boroughs in London, Birmingham or Glasgow. An incorrect visual impression of regional intensities of mortality incidence may thus be created. Demographic maps, in which, in the present instance, the areas of 'squares' (which represent the metropolitan boroughs, county boroughs and aggregates of municipal boroughs and urban districts) and 'diamonds' (which represent the rural aggregates of administrative counties) are proportional to the populations at risk

(see key map, Text-fig. 2), show the main centres of population in increased proportions, and the large counties with numerically small populations reduced in area relative to Britain as a whole. The two kinds of maps are thought to be complementary and are used here jointly to provide a more comprehensive presentation of the mortality patterns than would have been the case if either kind had been used separately.

Infant mortality

The range of mortality values for 1970 is very great (Registrar General, 1972; Registrar General for Scotland, 1971). It runs from 33 per 1000 live births in Burnley in Lancashire to 12 per 1000 live births in Caernarvonshire and the rural districts of East Sussex. The average for England and Wales is 18 per 1000 live births, for Scotland the figure is 20 per 1000 live births. The most striking single feature of the distribution pattern is the contrast between the generally high mortality levels in the north and west of Britain and the low levels in the south and east (Text-fig. 3). This represents serious regional inequality, due possibly to poverty—which is high in the slum areas of the large cities in the north of England and Scotland. These northern urban areas are characterized by high levels of unemployment, relatively low wages and large families. There is, in consequence, over-crowding, poor hygiene and faulty diet, with inevitable adverse effects on infant mortality rates.

Arteriosclerotic heart disease, including coronary disease

This is the major cause of death in males in Britain. A line drawn from the Severn estuary to the estuary of the Humber divides the country into two contrasting regions (Text-fig. 4). The southern half of the country has low mortality ratios for arteriosclerotic heart disease, the northern half has high ratios. The areas of particularly unfavourable mortality experience include Scotland, Tyneside–Teesside, Lancashire, the West Riding of Yorkshire and south Wales.

Eight or more factors have been deemed significant in cardiovascular disease: high blood lipid levels (lipid being a general term that includes fats and fat-like compounds), hypertension, cigarette smoking, physical inactivity, increase in weight, nervous stress, diabetes mellitus and genetic factors (WHO, 1965). Much speculation exists as to the role played by each of these factors and their relative importance. The obese are more prone to diabetes; people under stress take little exercise; racial and genetic differences are often associated with differences in diet. Obesity, exercise and diet are themselves all inter-related. When examining the correlation between disease and environmental and/or genetic factors it is more or less inevitable that other factors will interfere with conclusions. Causes of disease are rarely simple or even static, they are invariably multifactorial.

COUNTIES

AB	Aberdeen
AG	Anglesey
AH	Armagh
AN	Angus
AR	Argyll
AT	Antrim
AY	Ayr
BA	Banff
BD	Bedfordshire
BE	Berkshire
BK	Berwick
BR	Breconshire
BT	Bute
BU	Buckinghamshire
C	Caithness
CA	Caernarvonshire
CB	Cambridgeshire
CD	Cardiganshire
CH	Cheshire
CL	Clackmannan
CM	Carmarthenshire
CO	Cornwall & Isles of Scilly
CU	Cumberland
D	Denbighshire
DB	Derbyshire
DE	Devon
DM	Dumfries
DN	Dunbarton
DO	Dorset
DU	Durham
DW	Down
E(I)	Isle of Ely
EX	Essex
F	Flintshire
FE	Fermanagh
FI	Fife
GC	Gloucestershire
GM	Glamorgan
HA	Hampshire
HE	Herefordshire
HF	Hertfordshire
HU	Huntingdonshire
IN	Inverness
K	Kent
KI	Kincardine
KR	Kinross
KU	Kircudbrightshire
LA	Lancashire
LC	Leicestershire
LK	Lanark
LO	Londonderry
L(H)	Lincolnshire (Parts o Holland)
L(K)	Lincolnshire (Parts of Kesteven)
L(L)	Lincolnshire (Parts of Lindsay)
L(E)	East Lothian
L(M)	Midlothian
L(W)	West Lothian
M	Moray
ME	Merionethshire
MO	Monmouthshire
MT	Montgomeryshire
MX	Middlesex
M(I)	Isle of Man
N	Nairn
NF	Norfolk
NO	Northamptonshire
NR	Northumberland
NT	Nottinghamshire
OR	Orkney
OX	Oxfordshire
P	Pembrokeshire
PB	Peebles
PE	Soke of Peterborough
PR	Perth
R	Radnorshire
RE	Renfrew
RO	Ross and Cromarty
RU	Rutland
RX	Roxburgh
SE	Selkirk
SH	Shropshire
SO	Somerset
SR	Stirling
ST	Staffordshire
SU	Sutherland
SY	Surrey
S(E)	East Suffolk
S(W)	West Suffolk
SX(E)	East Sussex
SX(W)	West Sussex
TY	Tyrone
WA	Warwickshire
WE	Westmorland
WG	Wigton
WI	Wiltshire
WO	Worcestershire
W(I)	Isle of Wight
Y(E)	Yorkshire (East Riding)
Y(N)	Yorkshire (North Riding)
Y(W)	Yorkshire (West Riding)
Z	Zetland

COUNTY BOROUGHS (Counties of Cities in Scotland)

AB	Aberdeen
B	Bournemouth
BB	Blackburn
BD	Bradford
BF	Belfast
B.F.	Barrow in Furness
BG	Brighton
BH	Bath
BI	Birmingham
BK	Birkenhead
BN	Barnsley
BO	Bootle
BP	Blackpool
BR	Bristol
BT	Bolton
B.T.	Burton upon Trent
BU	Burnley
BY	Bury
C	Canterbury
CA	Carlisle
CD	Cardiff
CH	Chester
CO	Coventry
CR	Croydon
DA	Darlington
DB	Derby
DC	Doncaster
DD	Dudley
DU	Dundee
DW	Dewsbury
E	Exeter
EB	Eastbourne
ED	Edinburgh
EH	East Ham
GA	Gateshead
GC	Gloucester
GL	Glasgow
GY	Grimsby
H	Hastings
HF	Huddersfield
HX	Halifax
IP	Ipswich
KH	Kingston upon Hull
L	Lincoln
LC	Leicester
LE	Leeds
LI	Liverpool
LO	Londonderry
M	Manchester
MI	Middlesbrough
M.T.	Merthyr Tydfil
NE	Newport
NO	Northampton
NT	Nottingham
N.T.	Newcastle upon Tyne
NW	Norwich
O	Oxford
OL	Oldham
P	Portsmouth
PL	Plymouth
PR	Preston
R	Reading
RC	Rochdale
RO	Rotherham
S	Southport
SA	Salford
SD	Southend on Sea
SF	Sheffield
SH	St. Helens
SL	Sunderland
SM	Smethwick
SN	Southampton
S.o.T.	Stoke on Trent
SP	Stockport
S.S.	South Shields
SW	Swansea
T	Tynemouth
W.B.	West Bromwich
WG	Wigan
W.HL	West Hartlepool
WH	West Ham
WK	Wakefield
WL	Walsall
WO	Worcester
WR	Warrington
WV	Wolverhampton
WY	Wallasey
Y	Great Yarmouth
YO	York

METROPOLITAN BOROUGHS

1 City of London	10 Greenwich	20 Poplar
2 Battersea	11 Hackney	21 St. Marylebone
3 Bermondsey	12 Hammersmith	22 St. Pancras
4 Bethnal Green	13 Hampstead	23 Shoreditch
5 Camberwell	14 Holborn	24 Southwark
6 Chelsea	15 Islington	25 Stepney
7 Deptford	16 Kensington	26 Stoke Newington
8 Finsbury	17 Lambeth	27 Wandsworth
9 Fulham	18 Lewisham	28 Westminster
	19 Paddington	29 Woolwich

Text-fig. 2. Key to the demographic maps in Text-figs. 3–8.

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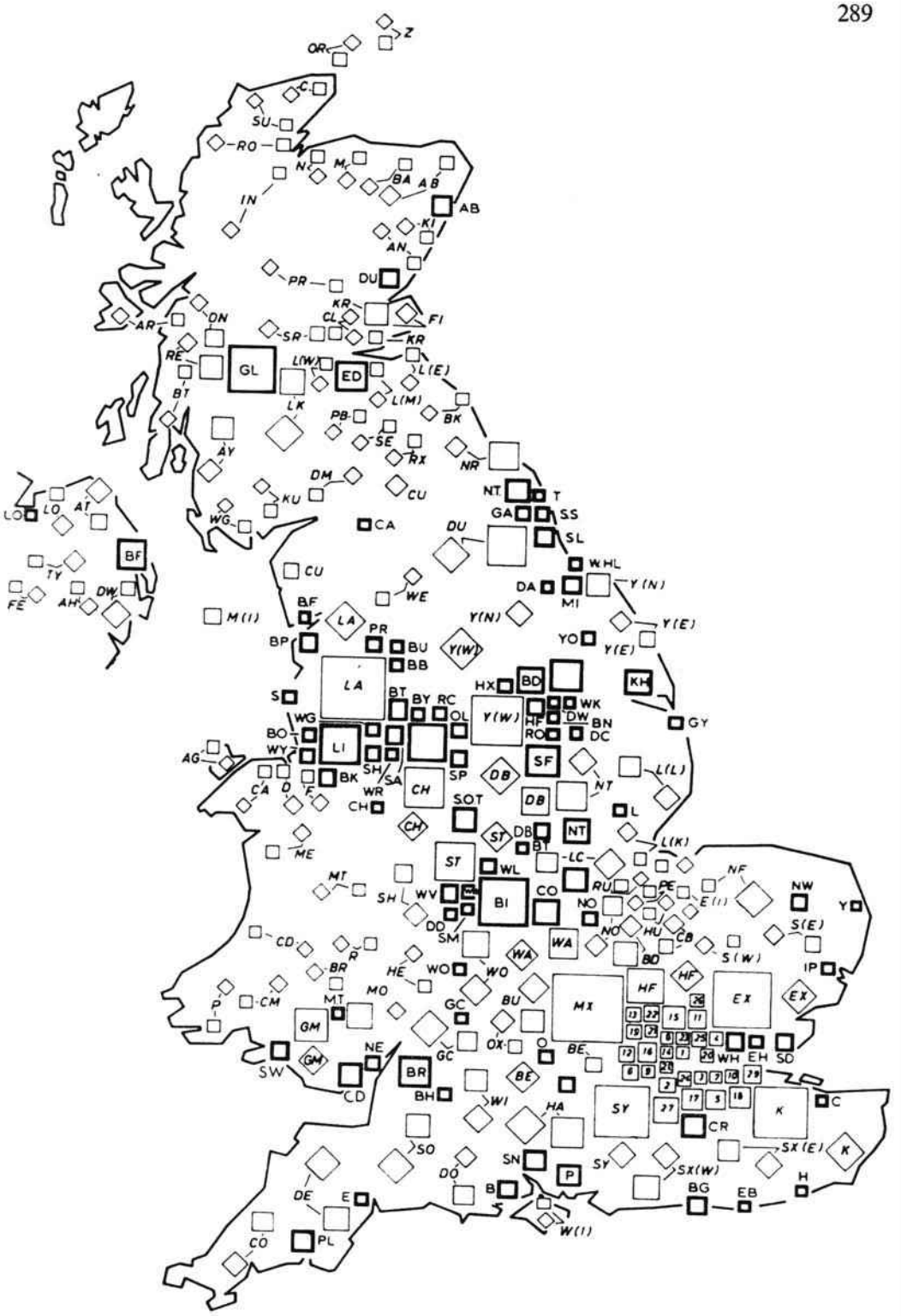

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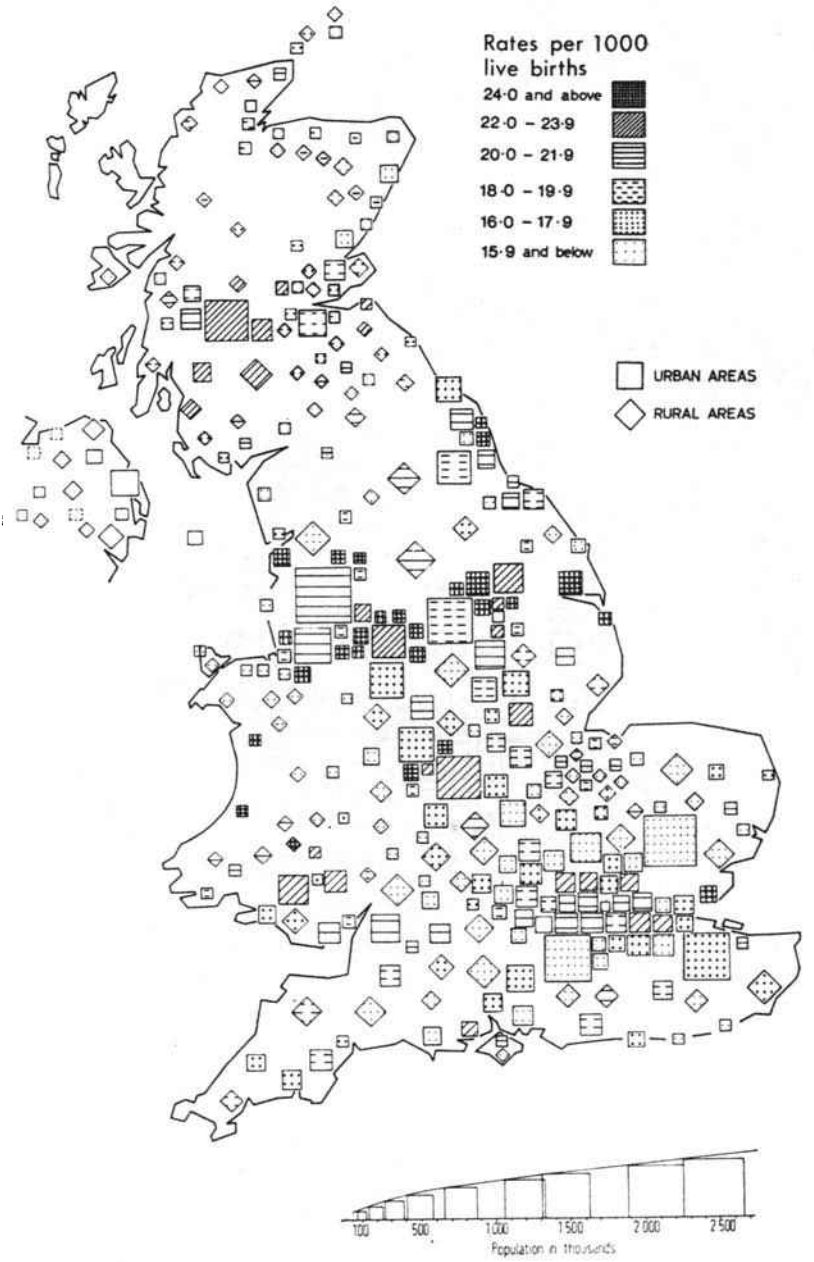

Text-fig. 3. Infant mortality in Britain, 1970.

Note: For Text-figs. 3–8 the demographic sketch-map is on the left and the geographical map is on the facing page; the inset map shows the London boroughs.

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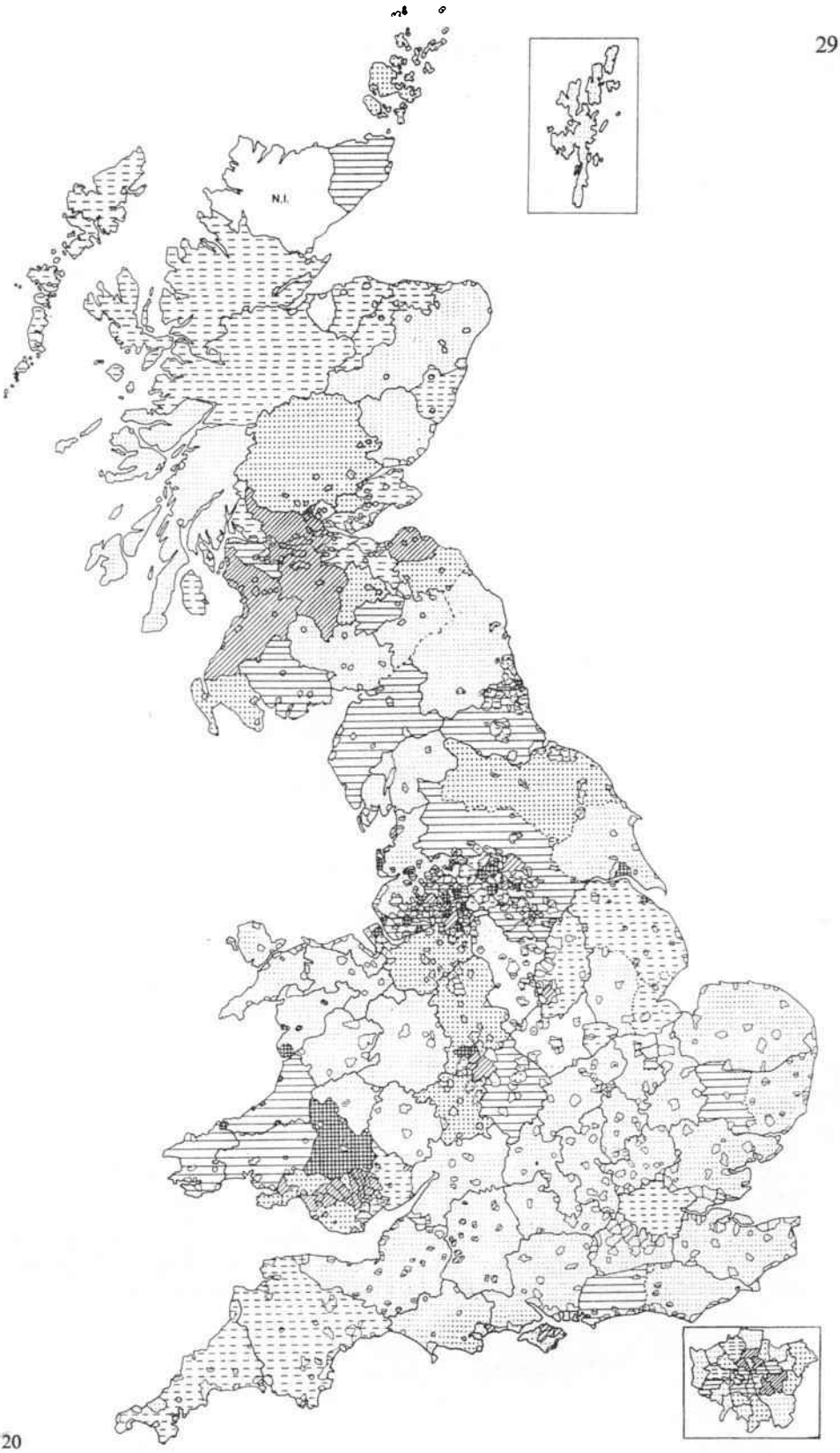

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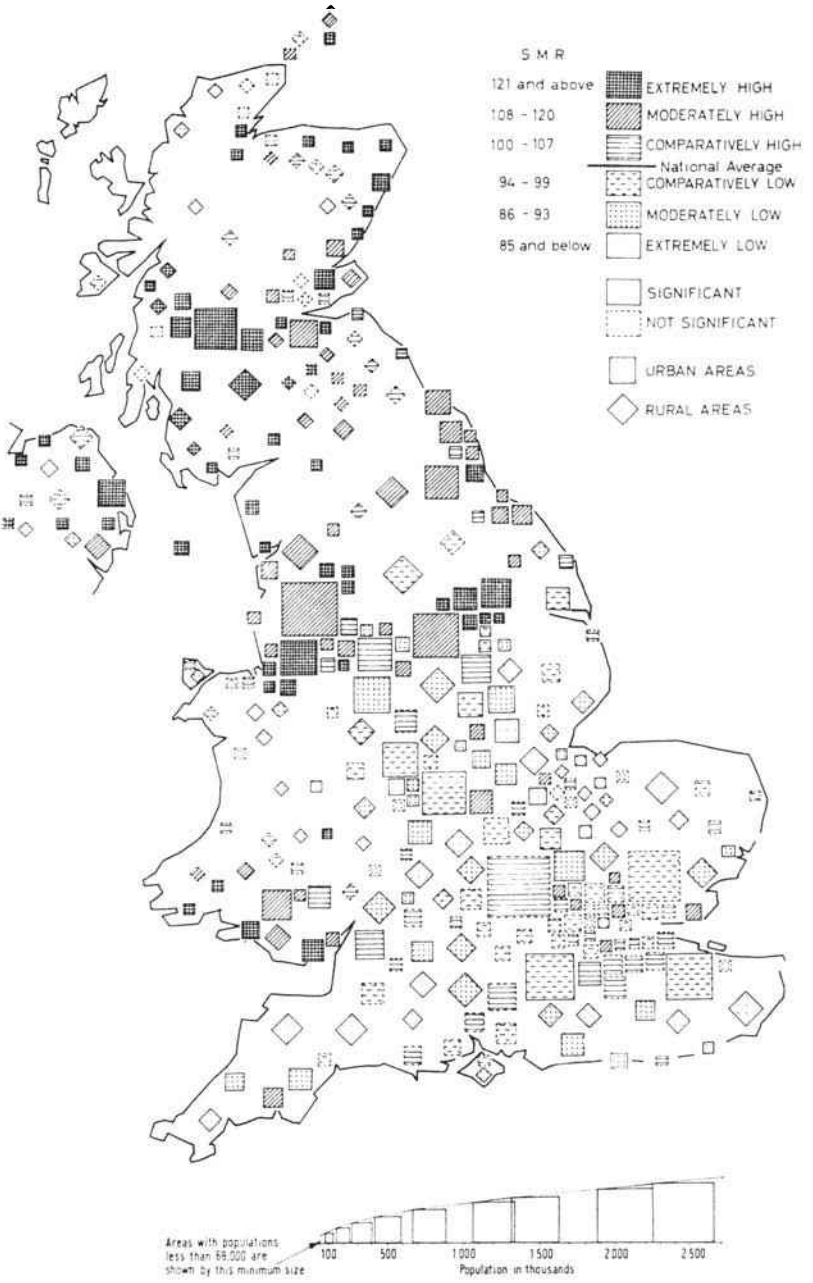

Text-fig. 4. Arteriosclerotic heart disease including coronary disease: distribution of mortality in Britain, males, 1959–63 (based, in part, on Howe, 1970a). The national rate (standardized mortality ratio 100) is 26·1 male deaths per 10,000 living.

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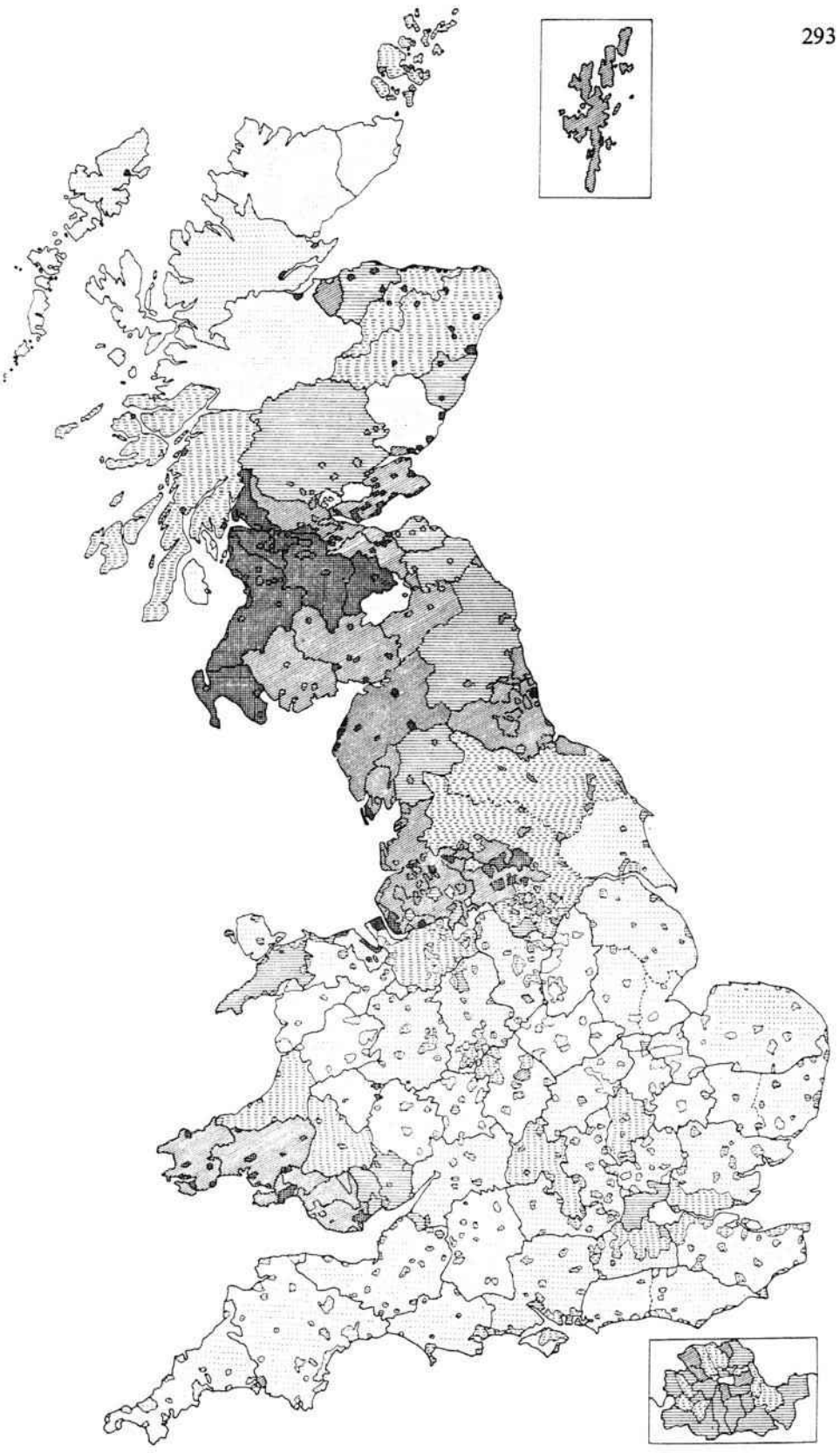

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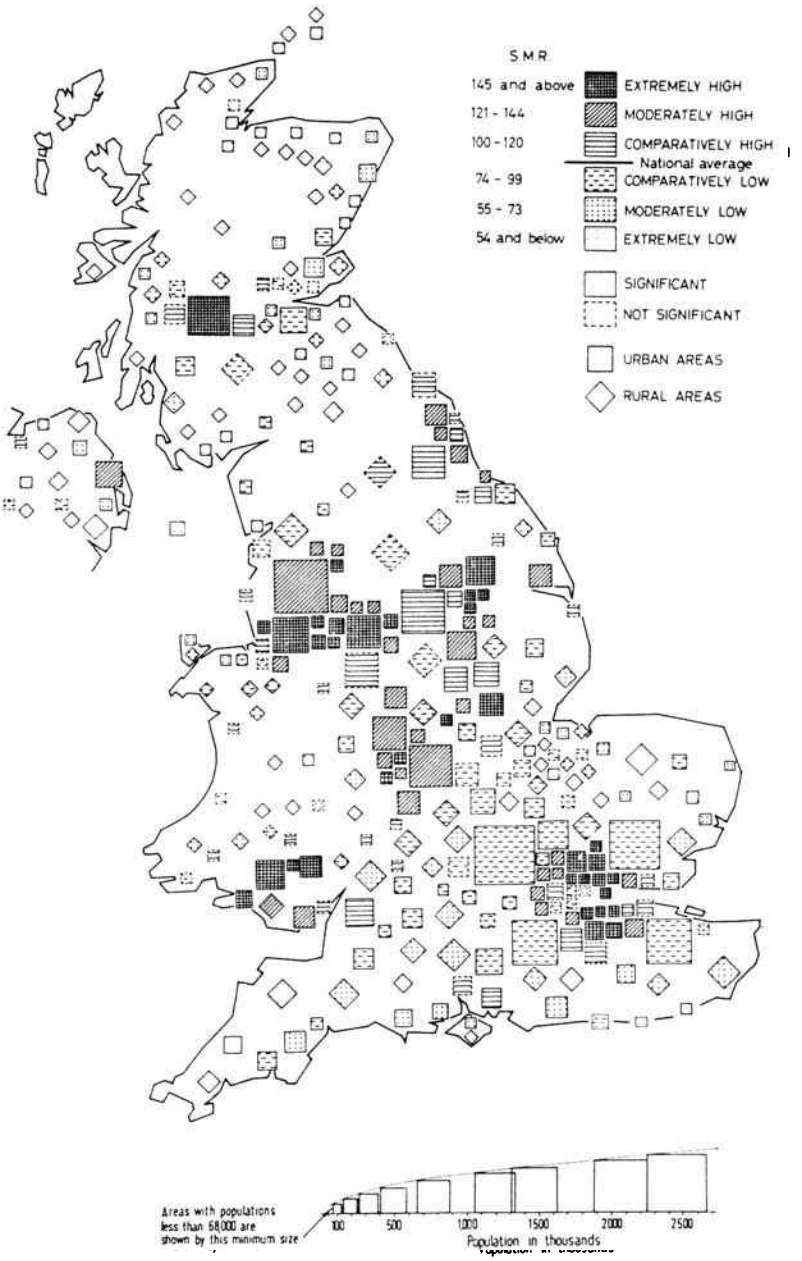

Text-fig. 5. Chronic bronchitis: distribution of mortality in Britain, males, 1959–63 (based, in part, on Howe, 1970a). The national rate (standardized mortality ratio 100) is 9·47 male deaths per 10,000 living.

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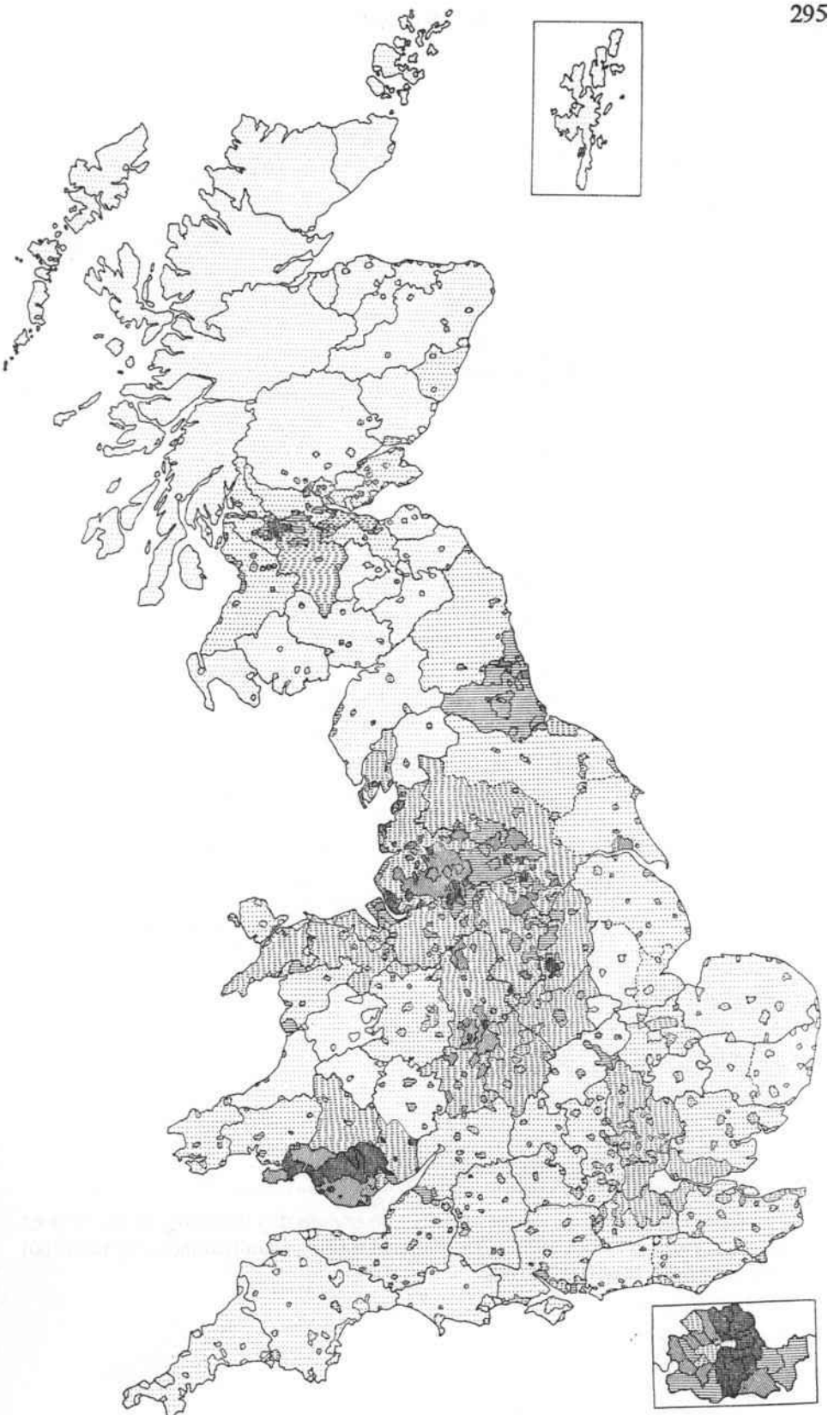

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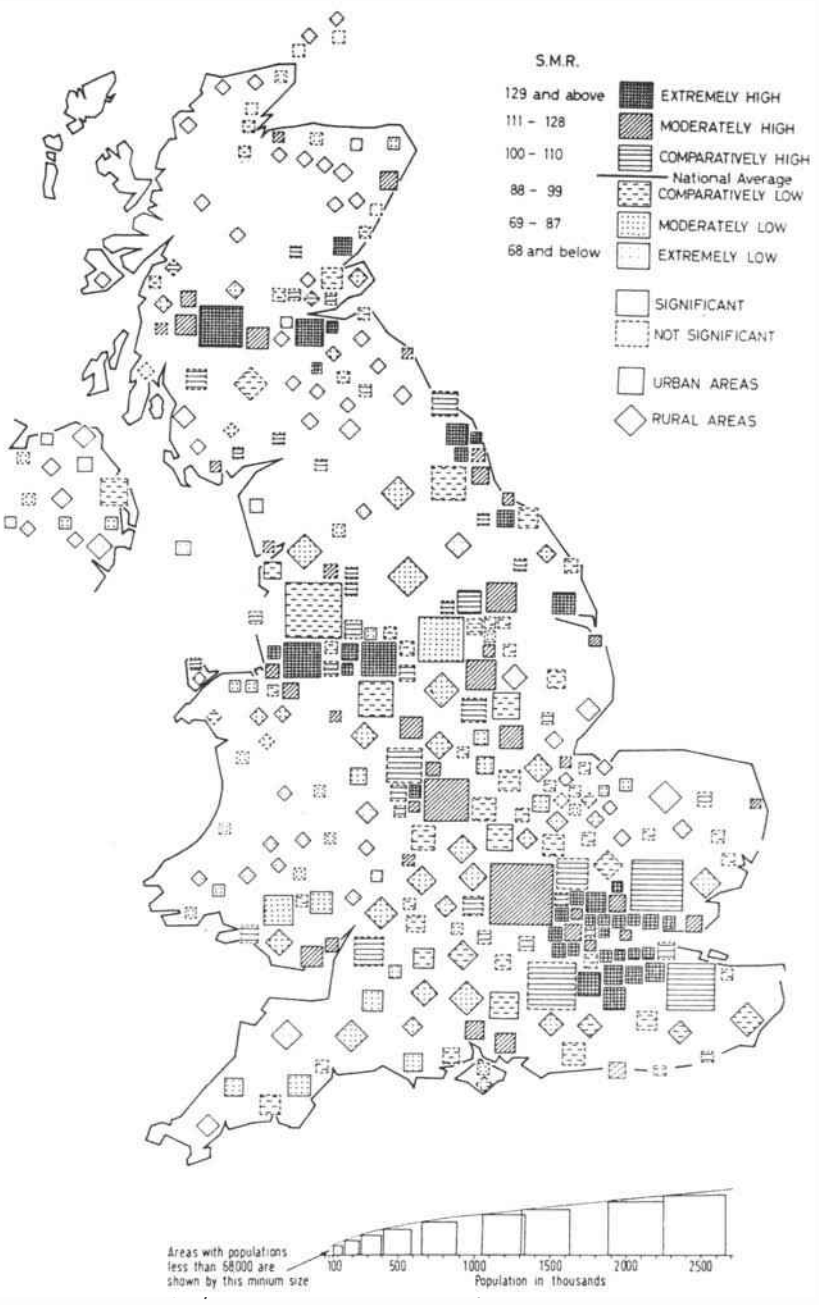

Text-fig. 6. Lung-bronchus cancer: distribution of mortality in Britain, males, 1959–63 (based, in part, on Howe, 1970a). The national rate (standardized mortality ratio 100) is 8·6 male deaths per 10,000 living.

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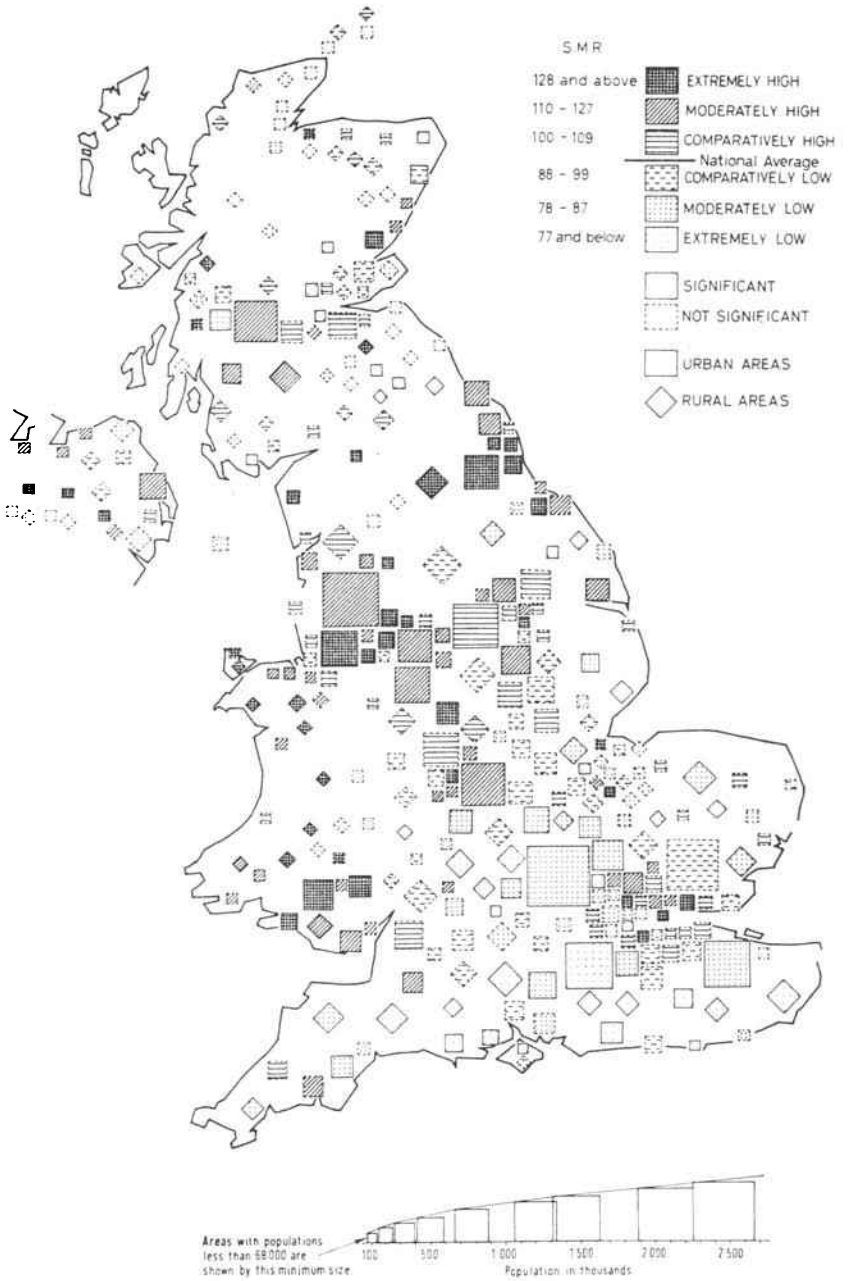

Text-fig. 7. Stomach cancer: distribution of mortality in Britain, males, 1959–63 (based, in part, on Howe, 1970a). The national rate (standardized mortality ratio 100) is 3·48 male deaths per 10,000 living.

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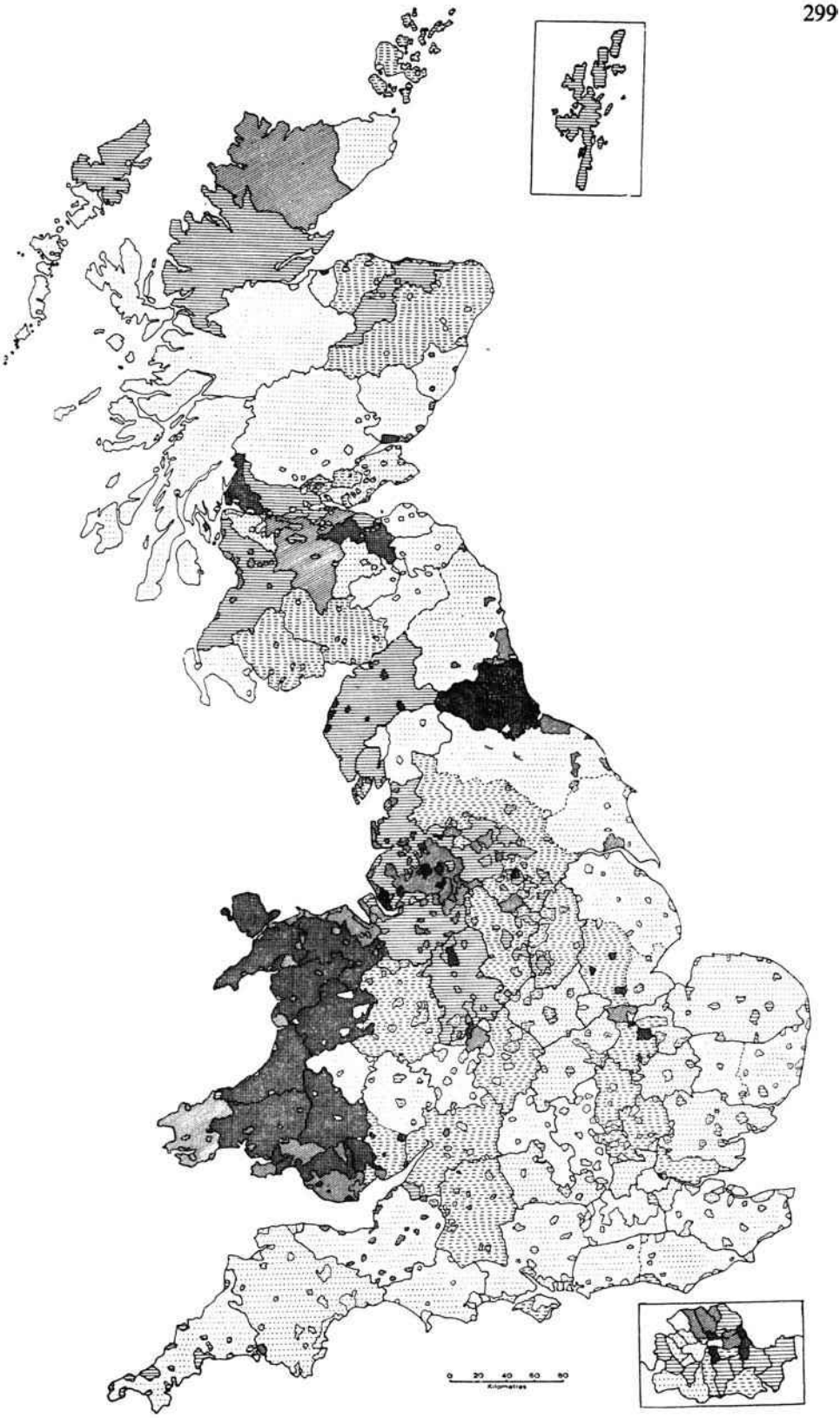

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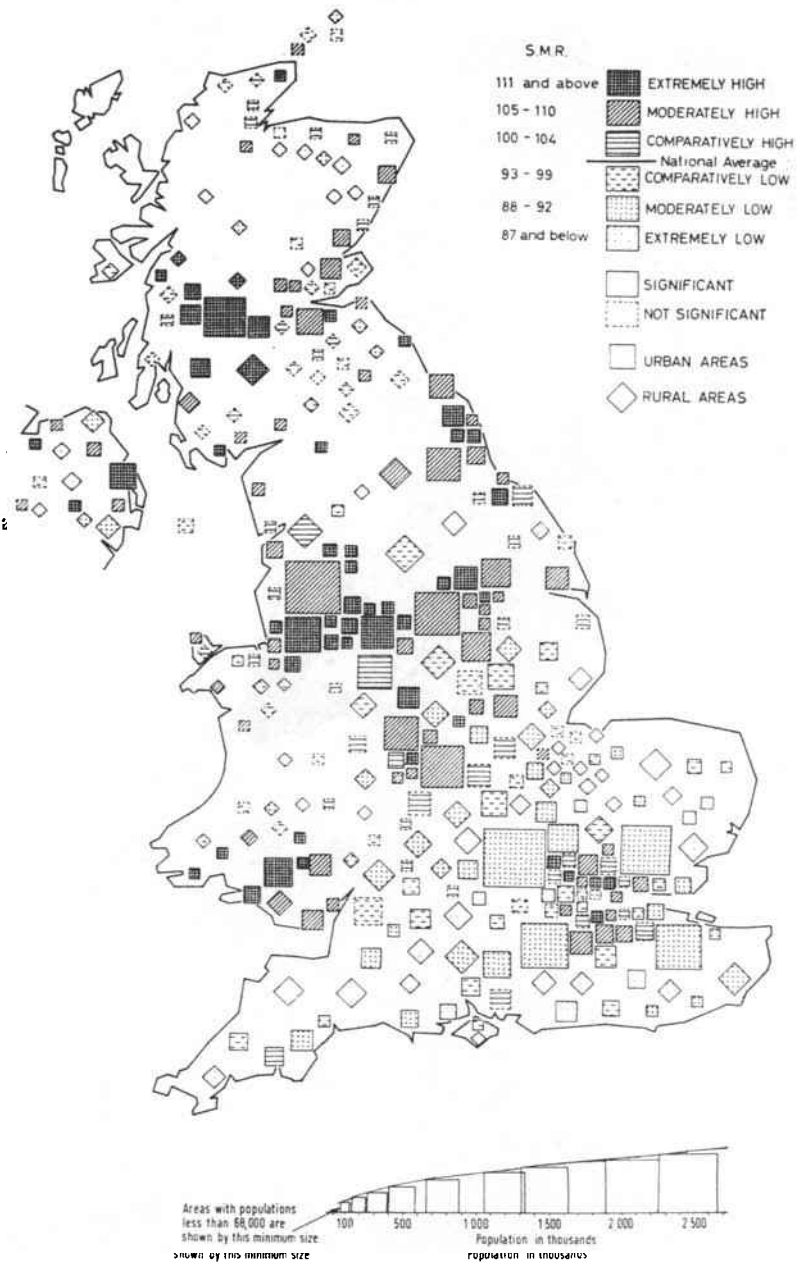

Text-fig. 8. All causes: distribution of mortality in Britain, males, 1959–63 (based, in part, on Howe, 1970a). The national rate (standardized mortality ratio 100) is 125·8 male deaths per 10,000 living.

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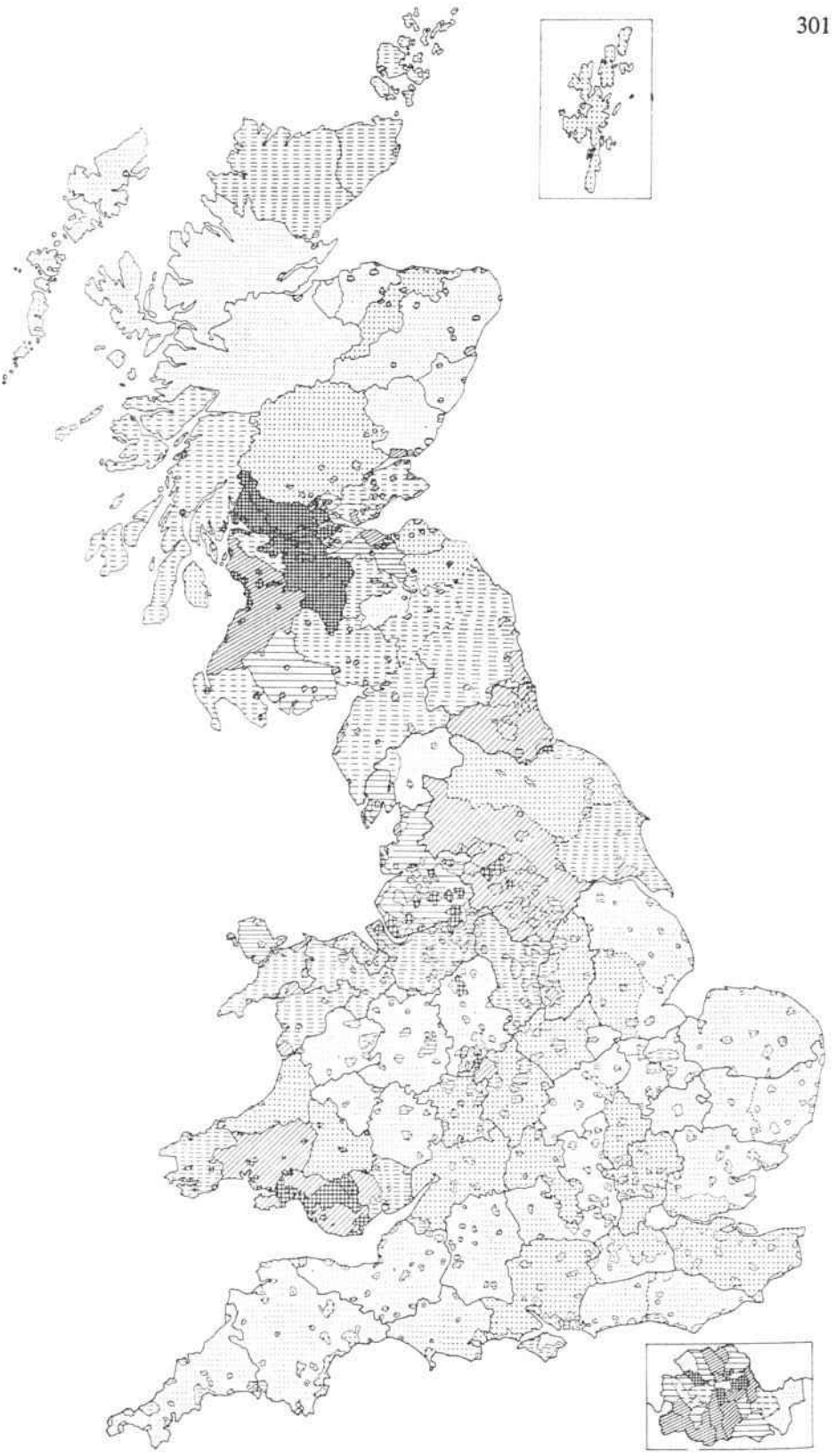

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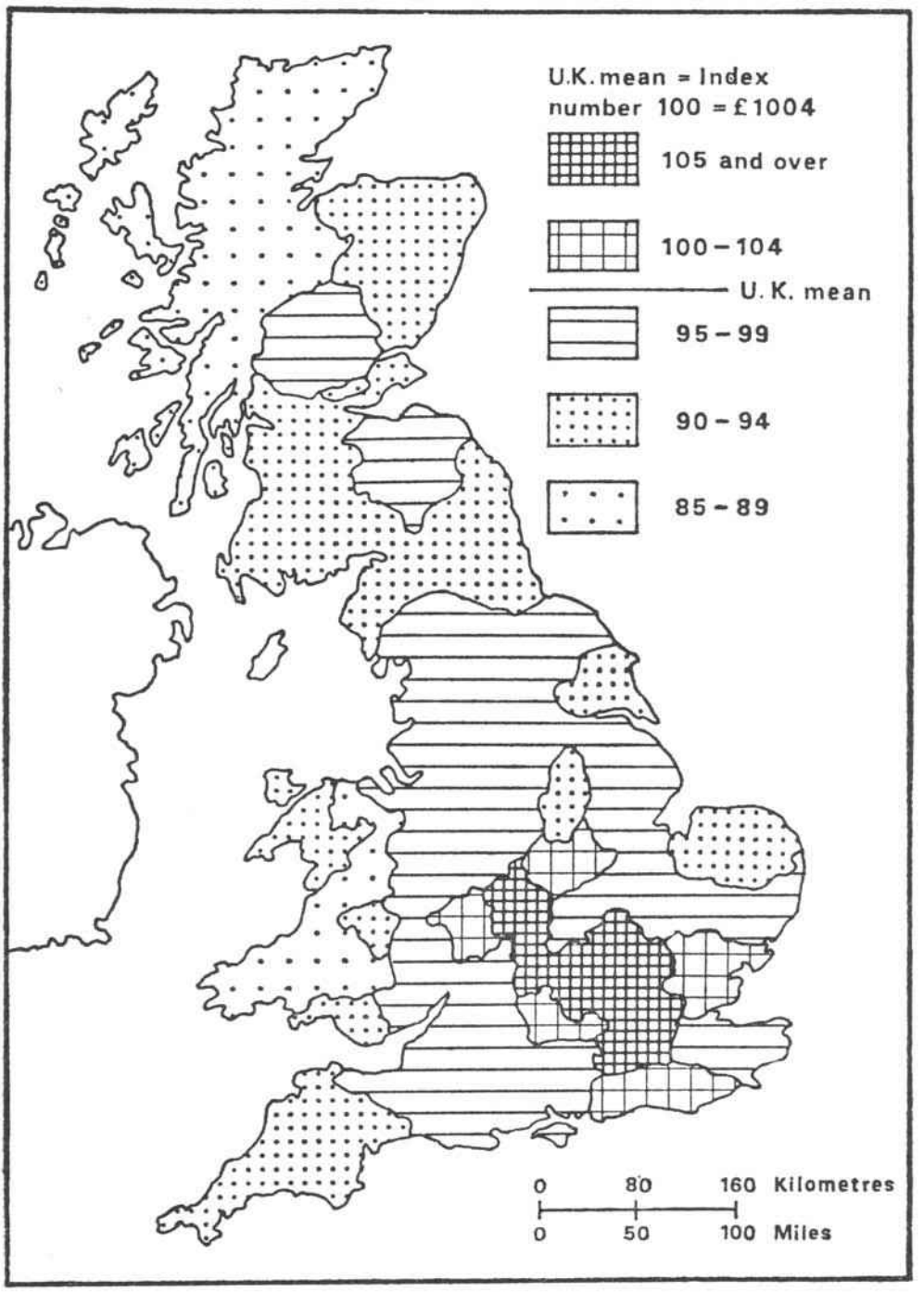

Text-fig. 9. Affluence, as indicated by total net income, 1964–65 (based on Fig. 2. 1c, Coates & Rawstron, 1971).

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Cerebro-vascular disease

The distributional pattern of mortality from cerebro-vascular disease, the second most important cause of death in males in Britain, is somewhat similar to that for arteriosclerotic heart disease. This is not altogether surprising since high blood pressure and atherosclerosis both play a part in each condition. Mortality ratios from 'stroke' are above the national average in the north and west of the country and below in the south and east. Some of the regional variations in cerebro-vascular disease may reflect variations in clinical diagnosis or the availability and/or use of treatment for high blood pressure.

Chronic bronchitis

The spatial pattern of standardized mortality ratios for chronic bronchitis, the third most important cause of death in males, is dominated by extremely high values in parts of London, south-west Lancashire and Merseyside, the Midlands, the West Riding of Yorkshire, south-west Wales and Clydeside (Text-fig. 5). Throughout the country the county boroughs stand out consistently as areas of higher mortality among the more rural county areas immediately surrounding them.

The aetiology of chronic bronchitis is not fully understood but the evidence of the geographical pattern suggests that the disease is associated with urbanization and/or industrialization. In the industrialized areas the atmosphere is polluted by smoke from domestic and factory chimneys and gaseous effluent from a wide variety of factories, motor vehicles and diesel locomotives. It has also been observed that unskilled workers and their wives suffer the highest mortality, the rate falling progressively to the lowest among professional men and their wives. Does the high bronchitis mortality of certain of the towns and cities depend on urban atmospheric pollution or urban class structure and associated social conditions? Cigarette smoking, a habit indulged in universally by both males and females throughout the country, has long been associated with chronic bronchitis. Seemingly there is less controversy over this postulated cause than over the likely link between bronchitis and the urban way of life.

Lung-bronchus cancer

The distributional pattern for lung-bronchus cancer, the fourth most important cause of death in males in Britain, shows four major areas of unfavourable mortality experience: Greater London, Merseyside–south-east Lancashire, north-east England and central Scotland (Text-fig. 6). There are two lesser concentrations of high mortality in West Bromwich and in Kingston-upon-Hull.

A marked urban–rural gradient in mortality ratios is evident in lung-bronchus cancer as with chronic bronchitis (though with subtle differences) and, in the main, people living in areas of heavy industry are most severely affected. Smoking habits, industrial carcinogens, atmospheric pollution and diagnostic facilities are among

the multiplicity of factors thought to contribute to lung-bronchus cancer and to the geographical pattern shown in Text-fig. 6.

Stomach cancer

The regional distribution pattern of mortality from stomach cancer is markedly different from that for lung-bronchus cancer. Lancashire–Cheshire, north-east England, Wales and north Staffordshire are major areas of generally unfavourable mortality experience from stomach cancer, the sixth most important cause of death in males in Britain. Some high mortality ratios also occur sporadically in the London area, the Fenlands, the Midlands and Scotland (Text-fig. 7).

No urban or rural association is suggested by the distribution patterns and the relationship with stomach cancer, be it direct or indirect, would seem to be with a factor or factors common to both urban and rural environments. Stomach cancer is almost certainly a disease of many causes. A range of factors has been postulated as being associated with the disease in different parts of the world. It includes trace elements in soil and water and hereditary predisposition (Howe, 1970b, 1971).

All causes

Text-fig. 8 presents a synthesis of the geographical distribution of the standardized mortality ratios for all the several causes of male deaths in Britain for the period 1959–63. Mortality experience is generally favourable in the south and east of England, in central and north Wales, Derbyshire, Nottinghamshire and Lincolnshire and the greater part of southern and northern Scotland. Lifespans in these areas tend to be somewhat longer than the national average. Elsewhere, compared with the national average, lifespans are generally shorter. This distributional pattern represents the summation of community responses to the total complex of environmental hazards in the different parts of Britain, to ways of life of early 20th century Britain and to the medical and public health services available at the time.

The pattern shows that, from the health and longevity viewpoint, some parts of Britain are more favoured than others. Apart from the more sparsely populated areas of Wales and Scotland, it is remarkable that the densely populated south-east quadrant of England should be, in general, so favoured in its mortality experience. One is tempted to speculate that this might be the effect of longer lasting prosperity in the south-east compared with other densely populated areas of the country which have experienced many vicissitudes and economic depressions. Has the general wealth of the region (Text-fig. 9) purchased health through better housing, better diets and social conditions compared with the remainder of the country and possibly also through better medical and health facilities? In other words 'Does wealth buy health'?

It is necessary to take full cognizance of these gross regional disparities in mortality experience in Britain and to urge sociologists, biologists, medical scien-

tists and public health workers to strive to provide answers to the question 'Why do such disparities exist?'. The answers should enable planners and government to provide for the future a more equitable distribution of social well being, as represented by longevity, than appears to exist in present-day Britain.

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J. biosoc. Sci. (1973) **5**, 307–308

Biosocial Aspects of Life in Britain

DISCUSSION

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During the course of two mornings we have heard a fascinating series of papers dealing with highly topical and relevant aspects of the biology of modern living. I propose to comment briefly upon each of the contributions in turn and then to invite questions and discussion from the floor.

Dr Potts and Dr Peel clearly outlined the situation currently existing for reproductive capacity and performance in Britain. By conscious individual volition, assisted and directed by family planning clinics and their expertise, it would appear that there is a considerable measure of effective social control of reproductive potential in this country at present. An associated point of importance immediately arises, namely the application and implementation of this type of control in the underdeveloped world. Is it possible that the dramatic decline in the birth rate which occurred in post-1878 Britain might be emulated in the third world? It is interesting and vitally important to consider the long-term effects of implementation, or indeed non-implementation, of these policies and practices in countries where population explosions of unprecedented magnitude are now occurring. The economic, social and political effects are of the utmost concern and one can but hope that the experience of countries such as the United Kingdom in this respect might be helpful to others.

Dr Gibson competently traversed the razor's edge separating the genetic and the social determinants of attributes including IQ and the like. Recently Geoffrey Wansell wrote in *The Times:* 'Since Professor Arthur Jensen, the American psychologist, first publicly suggested that intelligence was determined primarily by heredity three years ago, he has probably become the most controversial academic in the world'. Again, Professor Eysenck has been involved in the 'Jensenist heresy' in books such as *Race, Intelligence and Education*, gaining a measure of notoriety thereby. Dr Gibson carefully wended his way through such difficult and emotive material, basing his argument upon essential facts including the IQ/social class correlation of 0·4–0·7 (usually of the order of 0·6), in his discussion of the relationship between the genetic constitution and environmental similarity of each of the social classes. However, although the relative contributions of genetic and environmental factors may be demonstrated with flies, the determination of their relative

importance in humans is very much more difficult, particularly where polygenic characteristics are involved. One wishes that Dr Gibson had had time in which to elaborate upon the techniques which he has been utilizing in this context.

I have long been impressed by Professor Howe's beautiful demonstrations of the regional variation of disease incidence and of factors such as the standardized mortality ratio in the United Kingdom. There is, of course, no disputing the fact that geographical variation does exist but it is very interesting to pose the question 'Why'? How large a role is played by genetic constitution, socio-economic class, trace elements and overcrowding, among other factors, in establishing and maintaining this variability? By comparison, Dr Carter was on somewhat safer ground since the abnormalities of which he spoke are, in each case, under direct genetic control. However, with conditions such as phenylketonuria, the incidence of which varies regionally within the United Kingdom, one again asks why this is so. Is there a major environmental interaction or is the gene pool, owing to random drift and the like operating in small effective populations, very distinctive in different parts of the country? Again the social problems posed by many of the abnormalities are very considerable particularly when considering what might best be done with or for the affected individuals. Diagnosis during embryonic development followed by immediate action would of course help in this connection and should surely be socially acceptable. The proper treatment of the severely abnormal after birth is more problematical as Dr Carter suggested in the case of spina bifida.

Dr Edholm's paper was fascinating in that it brought together facts and ideas from a wide range of sources, all relating to occupational patterns and their associated hazards. The fact that very many individuals still work for enormously long hours was clearly indicated and these protracted periods of labour must impose great strain upon the people concerned. It is, of course, to be recognized that the stresses are in a sense largely induced by voluntary overtime though the need to work long hours for extra wages may simply be regarded as a product of the affluent society in which cash is required in ever greater sums for consumer goods and conspicuous consumption.

The Presidential Address dealt with the natural environment in which man exists and with the human biological conditions both now and in the past. It is a highly competent paper which draws together many of the matters more particularly raised in the other contributions, and much more besides. The Address is a consideration of man the biosocial species, and therein lies its interest and profundity since the biological and social aspects of man's existence are all too often divorced. It is very regrettable that Dr Harrison, owing to illness, was unable to be present at Leicester personally to deliver his paper and to participate in the discussion. However, his paper has given us much upon which to reflect and I wish to record our collective appreciation of his valued address.