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Contemporary Human Diets and their Relation to Health and Growth: Overview and Conclusions [and Discussion]

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Contemporary human diets and their relation to health and growth: overview and conclusions

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SUMMARY

Contemporary human diets are probably as diverse now as they have ever been in the history of mankind. The abundance of food in the western world is in stark contrast to the lack of food and near starvation in parts of Africa, the continent where *Homo sapiens* evolved. The development of agriculture has enabled the population of the world to expand and to colonize almost the whole of its land surface, but the dependence on one staple food has introduced problems. If the staple crop fails, for example because of drought, there may be no alternative, and undernutrition and starvation are the result. Further, if the rest of the diet does not provide the nutrients that the staple food lacks, diseases due to specific nutrient deficiencies become widespread. Vitamin deficiencies among adults are less common now than they were 50 years ago, but even today millions of children in the poor rice-eating areas of the world are blind because their diets were deficient in vitamin A. For physiological reasons infants and young children will suffer most wherever there is a scarcity of food, of water, or of specific nutrients.

1. INTRODUCTION

One of the reasons for man's ability to colonize almost the whole of the world's land surface, including the colder regions, has been his adaptability in the matter of food. His omnivorous nature and his intelligence have enabled him to make use of plants and animals in his surroundings, and to grow and produce a wide variety of foods suitable to the environment in which he lives. He has developed methods of storage and transport so that food materials can be used all round the year and transported to all parts of the globe. The contemporary housewife in the developed countries can forage among the loaded shelves of the supermarket for out-of-season foods and foods from far off lands as well as those from her own, so that she can buy whatever she and her family desire. This is in stark contrast to the woman from drought-stricken Ethiopia searching for a few leaves or berries to help to assuage her own and her children's hunger for one more day. These are the extremes in contemporary food gathering and food consumption. Between them lies an immense range of diets, some nutritionally adequate, others limited in quantity or quality with regard to the foods available, the ability to grow them or the money to buy them and to the religious and other taboos that prevail. It is impossible to deal in detail with them all. This paper will therefore describe, in general terms, the types of diet eaten in different parts of the world today and their effect on health and growth. The extremes will be discussed in more detail, particularly those that are deficient in quantity and lead to chronic or acute undernutrition or starvation, and to diets deficient in quality, that is in specific nutrients, particularly protein and vitamin A. The vital importance of a supply of clean water will be emphasized. In conclusion some suggestions will be made as to how far what has been said about contemporary human diets and their relation to health and growth may have applied to primitive man, and may still apply to the other primates whose foraging habits have been described in previous papers.

2. THE IMPORTANCE OF THE STAPLE FOOD IN CONTEMPORARY HUMAN DIETS

In those parts of the world where agriculture in some form is practised and crops are cultivated, a plant, generally a cereal, has provided the staple food. In affluent countries where a wide range of animal and plant foods is available the staple food contributes less to the total diet than it does in areas where the supply of other foods is more limited in quantity and variety, and where the staple may provide a large part of the energy value of the diet. Here the nutrient composition of the staple food is of great importance, not only the amount of nutrients in the original cereal grain, but also the way in which the grain is treated before being eaten.

Table 1 shows the protein, fat, carbohydrate and thiamin (Vitamin B_1) in 100 g of the most widely used cereals in contemporary human diets. Wheat grows in temperate climates and is the cereal of Europe, North America, Australia, New Zealand and parts of Russia. It also grows at high altitudes in the tropics as in the northern parts of India. It is characterized by its high protein content, but this is largely a matter of plant breeding, and the protein content can vary from 8 to 14%. The values in the table apply to wheat used for

Table 1. *Composition of cereals used as staple foods*

(Data from Paul and Southgate (1978); Holland *et al.* (1988).)

	protein/g	fat/g	values per 100 g carbohydrate/g	energy/kcal	thiamin/mg
wheat flour					
wholemeal	12.7	2.2	63.7	310	0.47
white	12.5	1.4	75.3	341	0.10
rice					
husked	6.7	2.8	81.3	357	0.40
polished	6.5	1.0	86.8	361	0.08
cornmeal (maize)					
whole unsifted	9.8	3.8	71.5	353	0.30
sifted	9.4	3.3	73.1	368	0.26
hominy	8.7	0.8	77.7	362	0.13
millet flour	5.8	1.7	75.8	354	0.68

bread-making where a high protein wheat is required. The effect of milling to produce white flour is to reduce the protein and fat a little because these are more concentrated in the outer layers and germ of the wheat grain than in the white endosperm, but the most important difference is in the thiamin, which is reduced by 80%. Because of this, and because people in Britain prefer white bread, all white flour has been by law enriched with thiamin for over 40 years.

Rice is the staple food of the people of eastern and southern Asia. It is a swamp plant and it grows in the wetter and warmer regions, particularly in the deltas of the great rivers. It contains less protein than wheat used for bread-making and more carbohydrate. A variety of methods are used for husking paddy, the whole rice grain. Hand-pounding is still practised in many parts of the East; the paddy is placed in a small stone or wooden mortar and pounded with a wooden pestle about six feet long. This breaks the outer husk which is removed by winnowing. Some of the germ and pericarp are also removed, but some are retained so that husked rice still contains most of the thiamin. However, mechanized rice mills have operated for many years and these produce a highly refined rice, polished rice, which contains very little thiamin. More of the vitamin may be lost by washing the rice after it has been bought in the bazaar. Thiamin is soluble in water, and is thrown away with the washing water.

There is another method of preparing the rice grain which retains much of the B vitamins, including thiamin, which is known as parboiling. Unhusked rice is first soaked in water and then steamed or boiled. This splits the outer husk, which is then easier to remove and it also increases the amount of thiamin in the part of the grain remaining after milling because parboiling geletinizes the starch in the endosperm and this prevents removal of the germ which contains much of the thiamin in the grain (Hinton 1948).

Enrichment of rice with thiamin was tried in the 1940s in the Philippines; this prevented beri-beri in people eating little else but rice, but the process presents so many technical difficulties that it has rarely been undertaken on a large scale (Food and Agriculture Organization 1954).

Beri-beri, caused by a deficiency of thiamin, was at one time widespread among the rice-eating people of the East (Vedder 1913), where most of the diet consisted of polished rice, with little animal or plant food such as beans which are a good source of the vitamin. The disease is far less common now, and has virtually disappeared from the prosperous eastern countries, Japan, Malaysia and Taiwan, and from the large cities such as Hong Kong, Bangkok and Rangoon. This is due largely to improvement in social and economic conditions and to the consumption of a better all-round diet so that rice makes a much smaller contribution than was the case 50 years ago (Passmore & Eastwood 1986).

Maize is the staple food in Central America where it originated, and in many parts of South America, Mexico and in South Africa. It requires less water than wheat or rice and it gives a high yield per acre.† Sifted maize meal contains about 85% of the original grain, but hominy is a flour made from the starchy endosperm and is used as a porridge in South Africa where it provides a large part of the energy of the diet among the poor black population. In Mexico hominy is made into flat cakes called tortillas.

Maize has two characteristics that differentiate it from other cereals. Yellow maize is the only cereal that is a source of vitamin A. It contains a mixture of carotenoids, all of which have pro vitamin A activity. However, the use of maize as the staple cereal has long been associated with pellagra, a disease caused by a deficiency of another member of the vitamin B complex, nicotinic acid. The reason for this puzzled scientists for many years, for maize was not more deficient in nicotinic acid than other cereals. It was discovered that the nicotinic acid in cereals is in a bound form, consisting of macromolecules, which cannot be converted to free nicotinic acid in the human body (Kodicek 1962; Mason *et al.* 1973). Nicotinic acid can be synthesized from the amino-acid tryptophan, but the major protein in maize, zein, is unlike the proteins of other cereals in that it contains very little tryptophan. Maize therefore has two disadvantages. Not only is the nicotinic acid in it unavailable, but a precursor of the vitamin is also deficient. There is one other point about nicotinic acid and maize. The bound form of nicotinic acid can be converted to the available

† 1 acre = 4046.9 m^2.

form by treatment with alkali (Kodicek *et al.* 1959). In Mexico where maize is used, not as a porridge but as a flat bread, the maize grains are softened in lime water and then ground into a wet dough before being cooked. This explains why pellagra does not occur in Mexico.

Enrichment of maize with nicotinic acid has been used as a method of prevention of pellagra, but the overall economic state of the population has improved; all forms of animal food are good sources of nicotinic acid and as soon as these form part of the diet the deficiency of maize becomes far less important.

Millets are resistant to drought and are grown in dry regions in Africa and in some parts of Asia and South America. They contain less protein than other cereals. The millet grains are de-husked and then soaked and boiled and made into a porridge or ground into a meal. This is done in the home, and refined millet products have not been produced on any large scale.

In some parts of Africa the staple food is not a cereal but a root (cassava or manioc) or a fruit (matoke, a cooking plantain or banana). These contain less protein than cereals, and protein provides only 3–4% of the total energy instead of 8–16% for cereals (Tan *et al.* 1985). Nutritional problems arising from their use will be discussed later (p. 293).

No staple food is by itself adequate for human well-being, whether of adults or still less of children. Cereals contain no vitamin C and only yellow maize contains carotenoids which are a source of vitamin A. They contain no vitamin D, but this may be unimportant to those living in the sunshine of tropical countries except among women who by custom keep themselves completely covered. Cereals also contain too little calcium and sodium for health and growth. Refined cereals are generally a poor source of B vitamins, and also iron. The remainder of the diet must provide these nutrients, and Southgate (this Symposium) has described the main sources of the nutrients that cereals lack. It is when these are not available in adequate amounts that the specific deficiency diseases arise.

3. CONTEMPORARY DIETS IN DEVELOPED COUNTRIES IN RELATION TO HEALTH AND GROWTH

In developed countries the general health of the population has improved and life expectancy has increased over the past 50 years. Children are growing more rapidly and they reach puberty earlier than they did before World War II (Tanner, 1973). This is due in part to better control of infections, especially those that affect young children, but better nutrition has also played a part. This is the positive side, but the abundance and free choice of foods have brought their problems. One is obesity. In most people, and in animals too, the appetite centres of the hypothalamus regulate the intake of energy to balance the expenditure, and this regulation is usually surprisingly exact. However, this is not always the case, and in some individuals the temptation of the sweet foods and foods with 'hidden' fat, so readily available, all highly calorific, overcomes the normal physiological responses of appetite, the individual takes in more energy than he or she expends and the result is obesity. This is characterized by a large excess of fat in cells of adipose tissue in the subcutaneous and deep body sites. Many studies have been made of the causes, effects and treatment of obesity (Royal College of Physicians 1983). One thing is certain; once a person has become obese it is extremely difficult for him, or more usually her, to return to a normal body mass and to maintain it (Garrow 1974).

Fat children tend to grow fast, in height as well as body mass, and they reach puberty earlier than their leaner counterparts. Their extra mass is not entirely due to fat, for they also have a greater mass of lean body tissue (Cheek *et al.* 1970; Forbes, 1987). Although obesity is disabling, and is a causative factor in some diseases, for example diabetes, it is not of itself likely to be a cause of death. In fact rapid deposition of fat in the body is physiological in some circumstances, for example during the suckling period in young mammals, and in preparation for periods of starvation during migration of birds, hibernation of animals, and during lactation in some species of marine mammals.

Several diseases whose incidence has increased over the past 50 years are believed to be associated with some aspect of the contemporary diet of abundance. One of these is cardiovascular disease. Conferences have been held and committees have met from time to time to consider the problem. High intakes of total fat, of fats with a large percentage of saturated fatty acids, of sugar, of cholesterol, of total food and energy and even of soft water have all been implicated as risk factors (Royal College of Physicians and British Cardiac Society 1976; World Health Organization 1982*a*; Department of Health and Social Security 1984). It now seems certain that no one food or nutrient can be singled out as the cause. The aetiology of cardiovascular disease is a complicated one and it involves influences other than food.

In 1969 Burkitt pointed out that cancer of the large intestine, which was common in western countries, was almost unknown in tropical Africa. Burkitt *et al.* (1972) suggested that the large amount of what was called dietary fibre in the largely vegetarian diets of the people in Central Africa prevented the disease by causing a more rapid transit of the contents of the large intestine. The passage of a larger bulk of more watery faeces exposed the intestinal mucosa for a shorter time to any oncogen that might be present than in a person eating a western-type diet with little dietary fibre and producing small amounts of more solid faeces. Burkitt's ideas and suggestions (Burkitt & Trowell 1975) led to a great deal of research into the components of dietary fibre and their role in the physiology and function of the large intestine. In 1980 The Royal College of Physicians published a report on the medical aspects of dietary fibre. It concluded that it was highly probable that increasing the proportion of dietary fibre in the diet of western countries would be nutritionally desirable.

Another disease that has become of concern over the past 50 years is osteoporosis. This is not directly related to diet, or some component of it, but it is more common now because we are living longer. From the age of 30 or 40 years the loss of bone on the inner surface through the activity of the osteoclasts exceeds the deposition of bone on the outer surfaces so that the shaft of the long bones becomes thinner, and the vertebrae also lose bone substance. Men have thicker bones than women, but women lose more bone in later life, particularly after the menopause, and their thinner bones are more liable to fracture after a fall. This loss of bone is part of the physiological process of ageing, and is accompanied by loss of protein, not only from bone but also from the soft tissues, particularly muscle, which loses potassium as well (Cohn *et al.* 1980; Forbes 1989; British Nutrition Foundation 1989). Decline in physical activity is undoubtedly one reason for the loss of hard and soft tissues, but a decrease in the secretion of anabolic hormones is thought also to be involved. Giving additional calcium to the elderly seems to have no beneficial effect (British Nutrition Foundation 1989). It has been suggested that a high intake of calcium during childhood might increase the amount of calcium in the bones and this would be an advantage when bone begins to be lost (Newton-John & Morgan 1968). This has yet not been put to the test.

4. UNDERNUTRITION AND STARVATION

Famines must always have occurred from time to time and there are many records of them in the Bible and other early writings (McCance & Widdowson 1951). They have generally been caused in the first instance by natural disasters, droughts or floods, with consequent failure of the staple crop, but they have frequently been made worse by wars and mass movements of the population. Sometimes deprivation of food has been deliberately imposed, as in the concentration camps of World War II, or self-imposed, as among the men in the Maze prison in Northern Ireland who starved themselves to death a few years ago. Starvation implies that little or no food is available, and is facing millions of people in Africa at the present time. Undernutrition arises when some food is eaten, but the amount is insufficient to meet physiological requirements. It may be chronic, as in parts of India, Africa and Latin America, or the shortage of food may occur suddenly among previously well-nourished people, as for example in The Netherlands during the railway strike in 1945, and in Germany after the end of the war.

In many ways the effects of starvation and undernutrition on the human body are similar and the differences are those of degree. Descriptions are given by Keys *et al.* (1945), Members of the Department of Experimental Medicine, Cambridge (1951), and Helweg-Larsen *et al.* (1952).

In adults there is a decline in body mass, but the organs and tissues lose their mass at different rates. The least essential tissues suffer first, the adipose tissue cells lose fat, which is oxidized to provide the energy necessary for the metabolic processes that must go on in the body if life is to be preserved. Some loss of protein is inevitable, and this comes in large part from skeletal muscle. The muscle fibres shrink, and in an undernourished person the spaces between them and between the empty adipose cells are occupied by an extracellular watery gel. In older persons some of the excess fluid collects in the legs and shows up as hunger oedema. In starvation, dehydration is more likely than overhydration. In undernutrition and starvation the skeleton retains its outward shape, but the fatty marrow disappears from the long bones and the cavity becomes filled with aqueous material. The skin becomes thinner and easily infected, and appears to hang loosely on the bones. The internal organs decline in mass, the liver sometimes a great deal. The heart and kidneys tend to lose mass in parallel with the body but the brain retains its size and structure. The alimentary tract becomes thin, and both mucosa and muscle are affected.

Despite all these structural changes the functions of the organs and systems of the body remain normal until the body has lost a great deal of its mass. The resting metabolic rate per kg of body mass is not greatly reduced in moderate undernutrition, but when the energy deficit is severe and there has been great decline in mass then the metabolic rate per kilogram falls, and also the body temperature. In moderate undernutrition the digestive tract functions normally provided there is no infection, but in starvation diarrhoea may become severe even when there is no intestinal infection, and the dehydration resulting from loss of fluid may prove fatal.

Undernourished children grow, but they grow slowly, and are underweight (wasted) and underheight (stunted) for their ages. Waterlow (1979) emphasized that such children suffer from mental and behavioural handicaps as well as nutritional, because the home where the undernutrition develops is also one where the child receives little or no mental stimulation.

Starving or near-starving children, particularly infants, who lose weight are in far worse plight than adults, for their requirements for energy per kilogram body mass are greater, as are their requirements for water. If the supply of breast milk fails, as it does if a woman is deprived of food for any length of time, the infant will be deprived of water and energy and will die before the adult. The lack of water is a more likely cause of death than lack of other nutrients.

Undernutrition reduces fertility in experimental and farm animals, but how undernourished a human population must be before fertility is reduced is a difficult question. Many of the populations that are increasing in numbers particularly rapidly are not well-nourished. Undernutrition of the mother retards the growth of the foetus, but not by a great deal. Chronically under-nourished women in developing countries often lactate well; this may be due to the custom of frequent breast-feeding which is often practised and which is known to increase the total volume of milk (Prentice 1980). In starvation, secretion of milk fails, and this is accentuated by lack of water.

5. PROTEIN DEFICIENCY AND KWASHIORKOR

In the 1950s and 1960s there was a great deal of interest in a disease of young children being due to a dietary deficiency, and recognized as such in 1932 by

Dr Cicely Williams, a medical officer in what was then the Gold Coast. She suggested that it was due to a deficiency of protein and used the local name for it, kwashiorkor. It was not until after the war, however, that scientific studies of the causes and manifestations of malnutrition among young children began to be made. The situation varied in detail in different countries; kwashiorkor was typically a disease of the weaned child, one or two years old, who was by tradition given the adult type of diet to eat. In Uganda, where kwashiorkor was prevalent, the staple food was matoke, the cooking banana, which provides only 4 % of its energy as protein. The fruit is peeled and steamed and kneaded into a soft mash. The adults eat this with their fingers, dipping each mouthful into a sauce made from plants and some meat or fish. This provides them with additional protein. The newly weaned child has the same food available but is not helped over eating. It manages to eat the matoke but is not able to manipulate this into the sauce. It needs more protein in relation to energy than the adult, but it gets less. The abundant carbohydrate in the matoke at first exerts its well-known protein-sparing effect, but ultimately the characteristic symptoms of protein deficiency appear. The child, often quite fat, becomes grossly oedematous with low serum proteins and other biochemical abnormalities (Trowell *et al.* 1954).

Such children lose their appetites and become utterly miserable. Sometimes they are force-fed with a high carbohydrate food, but this only makes matters worse.

As time went on it was realized that kwashiorkor, due primarily to a deficiency of protein, was one end of a spectrum of malnutrition of the infant and young child, and that marasmus, or near starvation, due primarily to a lack of food and energy, was the other. Between them lay a whole range of deficiencies of both energy and protein, and in any case a marasmic child is short of protein because it is short of food and a child with kwashiokor is short of energy because it will not eat. This whole spectrum of infantile and childhood malnutrition is now covered by the term 'protein–energy malnutrition'.

In 1974 McLaren wrote an article entitled 'The great protein fiasco' in which he set out his views that far too much attention had been paid by relief organizations to protein deficiency among children, so that it was believed that only foods rich in protein would be of any use. The world-wide problem was at the other end of the spectrum, energy deficiency and marasmus. This is even more true today than it was in 1974.

6. VITAMIN A DEFICIENCY, XEROPHTHALMIA AND BLINDNESS

It has been estimated that at the present time three million children under ten years of age are blind because their diets were deficient in vitamin A, and 20–40 million are less severely affected (WHO 1991). It is mainly in the poor rice-eating areas where vitamin A deficiency is most common (McLaren 1986*a*). About half the affected children are in the Indian subcontinent, the others in Africa, South and Central America, near Eastern countries, and China, Burma and the Philippines. Young children are particularly at risk because the growth rate is then most rapid, and vitamin A requirements are closely related to growth. Infections, which are still common among children in these countries, also increase the requirement for vitamin A (McLaren 1986*b*).

Vitamin A, or retinol, is essential for the normal function of the eye, both of the retina and the epithelial tissues of the cornea. In the retina an aldehyde of retinol is a component of the pigment rhodopsin, which is involved in the visual cycle concerned with night vision. In vitamin A deficiency there is insufficient rhodopsin in the retina, and this leads to night blindness. More serious is the effect of a deficiency on the cornea. The cells of the conjunctiva covering the cornea become keratinized; this ultimately leads to a softening and destruction of the cornea, xerophthalmia, and to total blindness (World Health Organization 1982*b*). Once a child has developed xerophthalmia the blindness cannot be cured (World Health Organization 1991). The foods that contain most vitamin A are milk fat, egg yolk, liver and some fatty fish. Carotene, the precursor of vitamin A, is found chiefly in yellow vegetables and green leaves in association with chlorophyll, so that dark green leaves are a good source of carotene, while pale green leaves are not. The only vegetable oil rich in carotene is red palm oil, produced in West Africa and Malaysia. In those countries were vitamin A deficiency occurs young children do not get appreciable amounts of any of these foods. They come from poor sections of the community, they are generally undernourished, and often suffer from various infections. Ignorance is partly to blame; dark green leaves which are usually available, are despised as 'poor man's food' (Pirie 1983).

7. THE VITAL IMPORTANCE OF WATER

Without food an adult can survive for 70 days, but without water in a temperate climate he can only survive for 7–8 days. In a hot environment, when losses of water by the skin are increased, survival time without water is correspondingly less. An infant has a larger turnover of water than an adult. It loses more by the lungs because it breathes a greater volume of air per kg body mass each minute, and more by the skin because it has a larger surface area in proportion to its mass. It also requires a larger volume of water to excrete urea and salts by the kidneys because it cannot concentrate urine to the same extent (McCance 1948). A young infant normally takes about 10 % of its body mass of water each day, which would correspond to 7 l for a 70 kg man. An infant, therefore, will die of dehydration sooner than an adult if deprived of water.

If no clean water is available, as was the case recently among the Kurds who escaped to the mountains and the Bangladeshi people after floods, men, women and children will drink contaminated water rather than none at all. The result is intestinal infection and diarrhoea, sometimes very severe, which accentuates the dehydration. Deaths of children in these situations are inevitable.

8. OVERVIEW AND CONCLUSIONS

In this survey of contemporary human diets, most attention has been paid to excesses and deficiencies, rather than to satisfactory mixtures of foods in optimal amounts, so that those who consume them remain healthy to a ripe old age and their children grow well in height and body mass. The range of foods that can make up a satisfactory human diet is vast. If foods of animal origin are included the diet is more likely to provide all the nutrients required, but a completely vegetarian diet can supply all that is needed except vitamin B_{12} which is contained only in animal foods. The papers presented at this meeting show how the higher primates, including the human species, are still able to forage for a mixture of foods which provide all the nutrients they require. Serious deficiencies of vitamins and other nutrients do not appear to occur, and from the descriptions of the diets they are hardly to be expected, and nor are troubles associated with an excess of energy or a lack of dietary fibre. If food supplies become scarce, however, as they may do if habitats are lost, or water supplies are inadequate, then monkeys and apes, and hunter–gatherers too, will suffer effects of undernutrition and starvation similar to those that have been described. It is to be expected that young animals, like human infants, will be particularly vulnerable, as they will be also if there is not an adequate supply of water. Behaviour is important, for when human beings and animals are hungry they will struggle and even fight for food. This was evident among the Kurdish refugees when relief supplies arrived; women were left behind and children were trampled on as men and older boys pushed forward to get the food. Cheney *et al.* (1988) refer to high mortality among low-ranking female vervet monkeys during periods of food scarcity, which suggests that they also suffered in their endeavour to get food.

The introduction of agriculture and the raising of animals and plants for food introduced a whole new dimension into human nutrition and enabled the world population to expand as it could never have done with a hunter–gatherer way of life. It brought problems however; research has identified the causes, but prevention depends among other measures on education, greater prosperity, freedom from war, and birth control, and these are outside the scope of this meeting.

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Discussion

O. T. Oftedal (*Smithsonian Institution, Washington, D.C., U.S.A.*). It is commonly stated that there are no protein stores as such because proteins in the body invariably perform functions. Yet some animals, such as seals, may mobilize large amounts of protein from tissues to support milk production for their young without apparent adverse consequences. If protein can be lost from the body without adverse effect, is it not, for all practical purposes, part of a 'store'?

E. M. Widdowson. This is a matter of semantics. I presume that the female seal deposits protein in her body during pregnancy just as the rat does and probably also the human female. In the rat the muscles provide the 'store'. This is discussed in detail by Naismith (1981).

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A. Whiten (*Scottish Primate Research Group, University of St Andrews, U.K.*). Dr Widdowson notes that osteoporosis is more common in older people. Might not the increased occurrence of osteoporosis in the settled neolithic people studied by Dr Ulijaszek be the result of that population including a higher number of subjects living to greater ages?

S. J. Ulijaszek (*Department of Biological Anthropology, University of Cambridge, U.K.*). This is difficult to answer, as the assessment of chronological age in skeletal material is prone to large errors above the age of about twenty years, and virtually impossible above the age of forty years. So it is impossible to say whether a greater proportion of people in Neolithic times lived longer than people in pre-Neolithic times. With low life expectancy at birth at both times, it is unlikely that a substantial proportion of the population at either time would have achieved ages at which osteoporosis could be attributed to ageing.

E. M. Widdowson. It may be that the diets of the children of the Neolithic people did not contain sufficient bio-available calcium for the optimal growth and calcification of their bones or perhaps Neolithic women's menopause came at an earlier age than it does today.

PHILOSOPHICAL TRANSACTIONS OF THE ROYAL SOCIETY B BIOLOGICAL SCIENCES