PHILOSOPHICAL TRANSACTIONS OF THE ROYAL SOCIETY B BIOLOGICAL SCIENCES

Traditional Diet and Food Preferences of Australian Aboriginal Hunter-Gatherers [and Discussion]

Kerin O'Dea, P. A. Jewell, A. Whiten, S. A. Altmann, S. S. Strickland and O. T. Oftedal

Phil. Trans. R. Soc. Lond. B 1991 **334**, 233-241
doi: 10.1098/rstb.1991.0112

Traditional diet and food preferences of Australian Aboriginal hunter–gatherers

KERIN O'DEA

Department of Human Nutrition, Deakin University, Geelong, Victoria 3217, Australia

SUMMARY

Until European settlement of Australia 200 years ago, Aborigines lived as nomadic hunter–gatherers all over the continent under widely varying geographic and climatic conditions. Successful survival depended on a comprehensive knowledge of the flora and fauna of their territory. Available data suggest that they were physically fit and lean, and consumed a varied diet in which animal foods were a major component. Despite this, the diet was not high in fat, as wild animal carcasses have very low fat contents through most of the year, and the meat is extremely lean. Everything on an animal carcass was eaten, including the small fat depots and organ meats (which were highly prized), bone marrow, some stomach contents, peritoneal fluid and blood. A wide variety of uncultivated plant foods was eaten in the traditional diet: roots, starchy tubers, seeds, fruits and nuts. The plant foods were generally high in fibre and contained carbohydrates, which was slowly digested and absorbed. Traditional methods of food preparation (usually baked whole or eaten raw) ensured maximum retention of nutrients. In general, traditional foods had a low energy density but high density of some nutrients. The low energy density of the diet and the labour intensity of food procurement provided a natural constraint on energy intake. This, together with the other nutritional qualities of the diet (including high fibre, slowly digested carbohydrate, very low saturated fat, relatively high proportion of the long-chain highly polyunsaturated fatty acids, low sodium and high potassium, magnesium and calcium) would have protected against obesity, non-insulin-dependent diabetes, and cardiovascular diseases, all of which are highly prevalent in westernized Aboriginal communities in Australia today.

1. INTRODUCTION

Prehistorians believe that Aborigines came to Australia from South East Asia at least 40000–50000 years ago (Flood 1983). They were probably then a coastal people, and are believed to have settled first on the northern coast of Australia, before moving slowly south to other parts of the continent. In more recent times, and until European colonization of Australia just over 200 years ago, Aborigines lived as hunter–gatherers all over the continent under widely varying geographic and climatic conditions, ranging from the tropical coastal regions of the north (latitude 11°–20° S), through the vast arid regions of the Centre (latitude 20°–30° S), to the cool–temperate regions of the south (latitude 30°–43° S). The more fertile coastal areas, both north and south, could sustain larger populations than the arid inland or desert areas. Little reliable information is available about the Aborigines of southeastern Australia as their land was the first to be taken over by European settlers for farming, with the Aboriginal population being decimated by battle and introduced diseases such as smallpox. However, it is clear from recent studies of traditional vegetable foods (Brand *et al.* 1983) and the continuing abundance of wild animals (Naughton *et al.* 1986) in uncleared land, that this part of Australia could have supported the greatest population density of Aborigines, consistent with the current concentration of the European-derived population along the southeastern seaboard. The arid inland regions supported much smaller numbers of people. Each tribal group hunted and gathered food in a defined territory that could be as vast as 100000 km² in the desert regions or as small as 500 km² in fertile coastal country (Kirk 1981).

2. ABORIGINAL HEALTH PRE-WESTERNIZATION

Although there is little reliable, quantitative data on diseases in Aborigines with little or no European contact (Basedow 1932), numerous early reports described them as having been lean and apparently physically fit (see table 1). Undoubtedly, the nomadic lifestyle and its associated customs promoted survival of the fittest. In the most remote areas of Australia, small groups of Aborigines continued to live a nomadic lifestyle until 20–30 years ago, and data collected from such groups suggest they were very lean and had no evidence of the chronic diseases that occur in epidemic proportions in westernized Aboriginal communities today (Elphinstone 1971). For example, a group of adult Aborigines from the Great Sandy Desert in

Table 1. *Health of Australian Aborigines as hunter–gatherers*

physically fit
lean (body mass index (BMI) < 20 kg m^{-2})
low blood pressure
no age-related increase in BMI or blood pressure
low fasting glucose
low fasting cholesterol
no evidence of diabetes or coronary heart disease

Western Australia who were examined at 'first contact' in the 1960s by a medical officer had body mass indexes (BMI) ranging from 13.2 to 19.5 kg m^{-2} (Elphinstone 1966). Abbie (1971) reported low BMI (mean of 19–20 kg m^{-2} for the men, and 18–20 kg m^{-2} for the women) and no increase with age in full-blood Aborigines 'living under nomadic or near nomadic conditions' in northern Australia between 1959 and 1963. Indeed, the women showed a trend to reduced body mass with increasing age, consistent with the observations of others that Aboriginal women living traditionally showed 'an obvious loss of subcutaneous tissue beyond early adult life' (Abbie 1966). More recently, as part of a long-term study on the relation between lifestyle and health in small traditionally oriented Aboriginal communities in northeast Arnhemland, White (1985) also reported a relative loss of body mass and subcutaneous fat in the older women compared with the older men. Both Abbie (1966, 1971) and White (1985) have reported low resting blood pressures in adult Aborigines living a traditionally oriented lifestyle and no increase in blood pressure with age in the 20–50 year age group. These observations are consistent with the findings of Lowenstein (1961) in other populations living traditionally, and support his conclusion that increasing blood pressure is not an inevitable consequence of aging, but rather a consequence of western lifestyle.

As part of a long-term study by White (1985) and colleagues on the relation between lifestyle and health in small traditionally oriented Aboriginal groups in northeast Arnhemland, we recently examined several biochemical parameters in the fasting state in one of these outstations, the details of which have been reported previously (O'Dea *et al.* 1988*b*). By standard criteria for BMI, all of the adults were 'underweight', with BMI ranging from 13.4–19.3 kg m^{-2}. Despite this, they displayed no biochemical evidence of malnutrition; none were anaemic and red cell folate levels were all within the normal range for European Australians (a unique observation in itself). In addition, their fasting glucose (3.8 ± 0.4 mmol l^{-1}) and cholesterol concentrations (3.9 ± 0.2 mmol l^{-1}) were low relative to urbanized Aborigines and Caucasians. However, their fasting insulin levels (13 ± 4 mU l^{-1}) were similar to other more westernized young Aboriginal men and higher than those of Caucasian men, both having higher BMIs (approximately 21 kg m^{-2}) (O'Dea *et al.* 1982). These data suggest that, in view of their low BMI (approximately 17 kg m^{-2}) and low fasting glucose levels, their insulin levels were inappropriately elevated. Their fasting triglyceride concentrations (1.13 ± 0.09 mmol l^{-1}), although within the normal range for Caucasians, were higher than would be expected because of their extreme leanness, but consistent with insulin resistance. This indirect evidence for insulin resistance in these people, despite their extreme leanness, regular physical activity (daily hunting and foraging), and traditionally oriented diet suggest that, in common with other Aboriginal communities all over Australia, they may become susceptible to obesity and non-insulin-dependent diabetes mellitus (NIDDM) if they westernize further.

3. HUNTER–GATHERER LIFESTYLE

Most information on the traditional lifestyle of Australian Aborigines has come from the study of groups who continued living as hunter–gatherers well into the 20th Century, in the most remote and, to most white Australians, inhospitable parts of the country in the centre and north of the continent (White 1985; McArthur 1960; Tonkinson 1978; Hiatt & Jones 1988). These studies have produced much detailed information specific to individual groups of Aborigines, but have also revealed a number of quite striking similarities between groups which are a function of the nomadic hunter–gatherer lifestyle.

Aborigines from all over Australia were omnivorous, deriving their diet from a wide range of uncultivated plant foods and wild animals. The composition and diversity of the food supply, and the relative proportions of plant and animal foods, were greatly influenced by both the season of the year and the geographic location. Wherever Aborigines lived in Australia, successful survival depended on an intimate and detailed knowledge of the land, sources of fresh water, and the impact of the annual cycle of seasonal changes on the flora and fauna of their territory (White 1985; Hiatt & Jones 1988; Kirk 1981).

Traditionally, Aborigines lived in bands based on extended family groups usually numbering 20–30 including children. Larger tribal gatherings for traditional ceremonies were only possible if there was sufficient food available to support the larger group. Notable instances where this occurred regularly were in the alpine region of southeastern Australia during the summer months, when the bogong moth provided a plentiful food supply (Flood 1980), in southern Queensland when the nuts from the Bunya pine were ripe, and historically along the Murray river in southeastern Australia where hundreds of Aborigines feasted on freshwater crayfish or fish at different times of the year (Sahlins 1972).

Men and women both contributed importantly, but differently, to food procurement (Tonkinson 1978; Kirk 1981; White 1985). In general, women provided the subsistence diet, gathering plant foods, honey, eggs, small mammals, reptiles, fish, shellfish, crustaceans and insects. They usually hunted in groups, which allowed them to share child-minding and have an enjoyable and sociable time. Although the men participated in these activities from time to time, they were primarily hunters and provided the less regular, but highly valued 'feasts' from large mammals (such as kanga-

roos), birds (such as emu), reptiles (such as turtle or perente) or fish. Men usually hunted alone or in pairs, although there are reports of group hunting – for example, ambushing animals by fire.

Although it has been argued that hunter–gatherers spent less time on average each day ensuring their livelihood (3–5 h) than agriculturalists or the employed in societies such as our own (Sahlins 1972), food procurement and preparation for Aboriginal hunter–gatherers were energy-intensive processes that could involve sustained physical activity: walking long distances, digging in rocky ground for tubers deep below the surface, digging for reptiles, eggs, honey ants and witchetty grubs, chopping with a stone axe (for honey, grubs etc), winnowing and grinding of seeds, digging pits for cooking large animals, and gathering wood for fires (for cooking and warmth).

As a rule, there was one main meal in the day, in the late afternoon when people returned to camp after the day's activities. However, people would eat snacks throughout the day while hunting and gathering: grubs, fruits, gum, honey ants and sugar-bag (honey from the wild bees). Hunters would sometimes cook and eat the liver of a kangaroo before carrying the carcass back to camp. Shellfish and fish were also often cooked and eaten on the spot or, in some circumstances, eaten raw.

4. AGRICULTURE

Although Aborigines did not practise 'agriculture' in the conventional sense of the word, there is no doubt that they interacted with their environment in ways designed to ensure food abundance.

Aborigines in different parts of Australia had practices that could be described as a semi-agricultural approach to several important plant foods (Flood 1983; Kirk 1981). In northern Australia, the long yam (*Dioscorea transversa*) is a dry-season staple, and there are numerous reports of the top of the tuber being left attached to the tendril of the vine when the rest of the tuber was dug out, to ensure that the yam would grow again in the following year. Yams were also planted on off-shore islands, presumably as a 'reserve' food supply.

Fruit seeds spat out at campsites, especially if they landed on the 'compost' of other food debris, may well have been the source of native fruit trees frequently found at regularly used camps.

The seed-collecting practices of Aborigines in the Darling River basin of western New South Wales have been thoroughly documented (Allen 1974). Although they relied on the river to supply their diet for much of the year (fish, shellfish, birds, aquatic plants), in the summer the staple of their diet was the seeds of the native millet. They developed an ingenious method of harvesting, and would gather the green grass before the seed was ripe, leave it in stacks for the seeds to ripen and dry, and then thresh it and collect the seeds. Archaeological evidence shows that seed grinding in the Darling River basin goes back 15 000 years (Flood 1983).

'Firestick farming' is the term used to describe the systematic burning done by Aborigines all over Australia (Jones 1980). Although it was sometimes used as a means of ambushing animals, the long-term consequences were more significant: the promotion of new growth, which both provided food directly and attracted game to the area. There is evidence that fire facilitated the germination of certain seeds. It is also believed to have maintained the vast savannah grasslands in northern Australia, and it has been suggested that fire may have been a critical factor in altering the ecosystem and extending man's habitat (Jones 1980).

It is now recognized that human intervention in the arid zone of central Australia was integral to the maintenance of the fairly fragile ecosystem around many waterholes. Aborigines kept the waterholes patent, and thereby contributed to the survival of the plant, bird and animal life, which depended upon a local water supply.

Reports from both northern and southern Australia refer to the use of a variety of strategies to trap or poison fish (Kirk 1981). For example, sophisticated systems of channels and dams were used to trap fish between the tides; and, in an imaginative hunting strategy, fish in river pools were stunned with poisons derived from plants (usually the root): people in the group could then easily harvest the fish floating unconscious on the surface, but would then avoid drinking water from the poisoned pool for several days, although they were apparently unaffected by eating the fish.

5. ANIMAL FOODS

A comprehensive knowledge of animal distribution and behaviour was essential to the success of Aborigines as hunters and gatherers (Hiatt & Jones 1988; White 1985; Tonkinson 1978; Kirk 1981). They needed to know when mammals, reptiles, birds and fish were most likely to be 'fat', their hibernation and nesting behaviour, where and when eggs were laid, the most propitious time (in the day or year) to find a particular species and where to find it. For example, they knew that the platypus laid eggs, but were not believed by English naturalists! Another illustration of the depth and detail of their knowledge of animals was the complex system of names they developed for species that were important food sources, frequently differentiating between genders (e.g. kangaroo) or different phases of the lifecycle (e.g. barramundi, a prized fish in northern Australian rivers and coastal waters). In contrast, many small birds that were not part of the normal diet were grouped together under a common name that translates as 'small bird' (Hiatt & Jones 1988).

All animals were potential food sources: mammals, birds, reptiles, insects and marine species (mammals, reptiles, fish, crustacea and shellfish). Everything edible on an animal carcass was eaten, including muscle, fat depots and internal organs (although usually not intestinal contents). One of the most striking characteristics of wild (or non-domesticated) animals is the low fat content of their carcasses (Naughton *et al.*

1986). In this they differ strikingly from domesticated meat animals such as cattle, sheep, pigs and chickens which have fat deposits under the skin, within the abdomen and between and within muscles. Wild animals do have discrete depots of fat within the abdomen (primarily surrounding the gonads, kidneys and intestines) and these depots frequently increase in size at particular times of the year. However, they generally tend to be small and usually have to be shared among many people. The meat (muscle) is always lean irrespective of the season and does not 'marble'. Because of this, a high proportion of what little fat is present is structural fat: part of the membranes of the muscle cells, and relatively rich in the long-chain highly polyunsaturated fatty acids (Naughton *et al.* 1986). These polyunsaturated fatty acids have important physiological functions. In addition to being vital components of all cell membranes in the human body, they are essential for normal growth and development of the brain and the retina, and are precursors of a group of chemicals (the prostaglandins) which affect numerous bodily functions including the modulation of blood flow and thrombosis (Neuringer *et al.* 1984; Sanders 1985).

Although on a mass basis, muscle constituted the major edible portion of an animal carcass, fat depots and organs (including emptied intestines and stomach) were also consumed. The organ meats (particularly brain and liver) were rich sources of cholesterol and fat. However, the fat in these organ meats was relatively rich in the long-chain highly polyunsaturated fatty acids (Naughton *et al.* 1986). Even the depot fat on some species was unusually rich in polyunsaturated fat (consistent with its 'softness' relative to beef tallow or mutton fat). Such foods were highly valued.

Animal foods (depot fat, organs) were not only relatively rich sources of polyunsaturated fat, but they also contained both major classes of polyunsaturated fatty acids (*n*-3 and *n*-6) in a ratio of about 1:3 (Naughton *et al.* 1986). The western diet contains predominantly the *n*-6 form (vegetable oils, margarines, etc.) and the ratio is about 1:12 (Sinclair & O'Dea 1990). The *n*-3 polyunsaturates are believed to be important in reducing the risk of thrombosis, in addition to their role in brain and retinal development.

Liver is an excellent source of iron and zinc, and also an unexpected source of nutrients usually associated with plant foods, such as vitamin C and folic acid, and may have therefore been a particularly important food at those times of the year when the diet was derived predominantly from animal foods. It may be significant nutritionally that the vitamin C in liver is in a particularly stable form and is not destroyed by cooking (O'Dea *et al.* 1987).

Insects also provided significant contributions to the diet seasonally, both directly and indirectly. Honey, from wild bees and the honey ant, provided important dietary carbohydrate in season. Witchetty grubs are still a seasonal delicacy in many parts of the country. Interestingly, although they are rich in fat and have a nutty–buttery taste, they have a fat composition very similar to olive oil (Naughton *et al.* 1986)! The bogong moth was so plentiful in the summer months in the mountains of southeastern Australia, that large gatherings of people could be supported while participating in ceremonies.

6. PLANT FOODS

The detailed and thorough knowledge the Aborigines had of the ecology of their environment allowed them to take full advantage of a wide range of plants as sources of food over the year: tuberous roots, seeds, fruits, nuts, gums and nectar. Dietary carbohydrate in the hunter–gatherer diet was derived from uncultivated plants, (tuberous roots, fruits, berries, seeds, nuts, beans) and honey. Cereal grains, the dietary staples of man since the development of agriculture, were not a major component of the traditional Aboriginal diet. The variety of plant foods available to hunter–gatherers in Australia was wide. Relative to many of their cultivated forms, wild plant foods are particularly rich in protein and vitamins. For example, a species of wild plum eaten by Aborigines in northern Australia (*Terminalia fernandiana*) has the highest vitamin C content of any known food (2–3 % wet mass) (Brand *et al.* 1982). A commonly eaten yam in northern Australia (*Dioscorea transversa*) is considerably more nutrient-dense than its modern equivalent, the potato, being higher in carbohydrate, protein, fibre, zinc and iron (Brand *et al.* 1983). The wild vegetable foods are also rich in dietary fibre, low in sodium, but rich in potassium, magnesium and calcium (Brand *et al.* 1983, 1985). The seeds that made significant contributions to the diet of Aborigines in certain seasons were not only rich in protein, but also contained significant quantities of linoleic acid. Although many of the vegetable foods are not rich fat sources (tuberous roots, leafy vegetables, fruits and berries), they nevertheless contain both *n*-6 and *n*-3 PUFA, and the ratio of *n*-6:*n*-3 was often much less than that seen in most seeds (Sinclair & O'Dea 1990).

The carbohydrate in many of these traditional foods has been shown to be more slowly digested and absorbed than the carbohydrate in equivalent domesticated plant foods (Thorburn *et al.* 1987*a*). The lower postprandial glucose and insulin levels elicited by the ingestion of these slowly digested wild plant foods may have been a factor in helping protect these populations from developing type 2 diabetes (Thorburn *et al.* 1987*b*) – a condition to which they are particularly vulnerable when they make the transition from a traditional to a western diet and lifestyle (Wise *et al.* 1976; Bastian 1979; O'Dea *et al.* 1988; O'Dea *et al.* 1990) – although other factors, in particular their low-fat, high-fibre diet, and their leanness and physical fitness, were undoubtedly also important.

Relative to their modern domesticated equivalents, the vegetable foods in traditional hunter–gatherer diets were higher in protein, fibre and vitamins, contributed PUFA from both the *n*-6 and *n*-3 series and contained carbohydrate which is slowly digested and absorbed. In general, the wild vegetable foods were bulky, with high nutrient density but low energy density (table 2). The only carbohydrate source with high energy density was wild honey.

Table 2. *Comparison of lifestyle and diet of Australian Aborigines as hunter–gatherers and after westernization*

	hunter–gatherer lifestyle	western lifestyle
physical activity level	high	low
principal characteristics of diet		
energy density	low	high
energy intake	usually adequate	excessive
nutrient density	high	low
nutrient composition of diet		
protein	high	low–moderate
animal	high	moderate
vegetable	low – moderate	low
carbohydrate	moderate (slowly digested)	high (rapidly digested)
complex carbohydrate	moderate	moderate
simple carbohydrate	usually low (honey)	high (sucrose)
fibre	high	low
fat	low	high
vegetable	low	low
animal	low (polyunsaturated)	high (saturated)
Na:K ratio	low	high

7. FOOD PREPARATION

Methods of food preparation utilized by Aborigines generally resulted in minimal loss of nutrients, particularly micronutrients. It has been estimated that about half of the plant foods eaten by Aborigines in northern Australia were processed in some way before being eaten (Beck 1985), although this is likely to have varied regionally. Many plant foods were eaten fresh and raw – frequently as they were collected – such as fruits, bulbs, nectar, gums, flowers etc. Foods were not processed unnecessarily. Any processing was done to render a food edible, more digestible or more palatable: for example, cooking of starchy tubers or seeds, grinding and roasting seeds, cooking of meat. Some food processing techniques were directed at detoxification of a potentially poisonous food (Kirk 1981; Flood 1983; Hiatt & Jones 1988; Beck *et al.* 1988). For example, the nuts of the cycad palm (*Cycas angulata*) in northern Australia were pounded into a soft pulp and then left in running water for several days, a treatment which removed the characteristic bitter taste, and also substantially removed cycasin, a known carcinogen. It is unlikely that the people concerned were aware of the potential long-term toxicity (although they counselled against eating 'too much' of the bread from the cycad nuts even when it had been thoroughly processed (Beck *et al.* 1988)) – they were primarily concerned about removing the 'bitterness'. A similar processing technique was applied to the 'cheeky' or bitter-tasting yams in northern Australia (e.g. *Dioscorea bulbifera*): they were cut up and left in running water for several days after which time the bitterness was no longer evident and they could be baked and eaten. Other bitter tubers were baked in earth ovens to break down the toxic compounds and make them taste 'sweet' (Kirk 1981; Flood 1983; Hiatt & Jones 1988; Beck *et al.* 1988).

The most common form of food preparation was cooking: roasting on the coals or baking in an earth oven. In many cases this was the only form of processing. Vegetable foods that were not eaten raw were roasted or baked whole, which protected labile micronutrients against oxidation and prevented the leaching out of water-soluble nutrients as happens to a greater or lesser degree when vegetables are chopped up, boiled and the water discarded (a common method of vegetable preparation in contemporary Australian cooking). Small animals (reptiles, birds, fish, Crustacea and other shellfish) were often cooked in a similar manner – roasted whole on the coals – with blood and other juices collecting in the peritoneal cavity and being eaten as a soup along with the organs before the meat was distributed. Such foods were usually only lightly cooked.

Larger animals (kangaroo, emu, turtle etc.) were prepared in a more complex manner, with the hunter taking responsibility (Tonkinson 1978; McArthur 1960; White 1985). From the nutritional point of view, however, the end result was similar in terms of retention of nutrients. In the case of kangaroo preparation in the Kimberley in the present day, the hunter makes a small incision in the stomach, discards intestinal contents but retains the emptied intestine and stomach, and closes the incision with a stick. Back at the camp he prepares a big fire and digs a pit. The kangaroo tail is cut off, the sinews removed and the tail cooked separately on the coals. The liver may also be roasted separately on the coals. The kangaroo has its legs broken at the shoulders and hips to facilitate thorough baking, and the feet are removed. It is then thrown on the fire and singed, which has the function of 'sealing' the cooking vessel. When the fire dies down, the animal is placed on its back in the pit and covered with hot ashes and sand. When it is judged to be cooked, the kangaroo is lifted out of the pit and placed on its back for butchering. The abdomen is opened and all present share in drinking the 'soup' in the peritoneal cavity, a

mixture of blood and juices from meat and internal organs which tastes like a rich beef broth. Some organs are also eaten at this time and then the carcass is carved up, with each cut being given to particular kin of the hunter if they are in camp. Large game, like kangaroo, is always shared. The hunter keeps the head (with the brain), liver and fat depots: not much meat as such, but the richest sources of fat and poly-unsaturated fat and cholesterol.

Cooking procedures for other large game are similarly ritualized. Turtle, for example, is not cooked in a pit, but placed directly on the coals. The cooking process is facilitated by placing hot stones from the fire inside the abdomen after the animal has been gutted. Not all intestinal contents are necessarily discarded from the large turtle, only those below a particular anatomical point. The intestines themselves are roasted directly on the coals and are a delicacy.

8. EATING PATTERNS

Food intake could vary enormously both on a day-to-day and a seasonal basis (O'Dea *et al.* 1988*b*; White 1985; Kirk 1981; Flood 1983). This has been described as a 'feast-and-famine' pattern of food intake. The actual pattern could probably be described more accurately as subsistence interspersed with feasts. As already noted, the women were primarily responsible for the subsistence component, and although the men did assist with these activities, they were primarily hunters, and provided the less regular, but highly valued, 'feasts'.

Food was usually consumed at the time it was available, and wastage was rare. However, in some circumstances foods were processed into forms in which they could be stored. Drying was the most usual form of processing used, and the food was either stored as such or processed further (grinding and cooking of seeds or nuts) and stored as cakes, sometimes wrapped in leaves and buried in the ground or placed in a dry and inaccessable place.

There are numerous reports of Aborigines eating 2–3 kg of meat at one long sitting, taking maximum advantage of an abundant food supply on those irregular occasions when it was available (O'Dea *et al.* 1988). It can be argued that the feasts were critical to the survival of Aborigines as hunter–gatherers as they provided excess energy which could be converted into fat and deposited as adipose tissue, thereby providing an energy reserve to tide an individual over periodic food shortages (O'Dea 1991).

9. FOOD PREFERENCES

The most highly prized components of the Aboriginal hunter–gatherer diet were the relatively few energy-dense foods: depot fat, organ meats, fatty insects and honey. In general, muscle provided the bulk of the energy from a carcass. Although many animals were actively hunted at those times of the year when their fat depots were largest (with Aborigines following the 'fat cycle' (Davis 1989)), the fat depots on most animals were usually small through most of the year and needed to be shared among many people. Thus, high fat foods were either only available seasonally, or were available in small quantities. Similarly, wild honey was available only at certain times of the year, and its procurement was often associated with high energy expenditure.

Nevertheless, it is significant that in a diet that was generally characterized by its low energy density, the foods most actively sought and most highly valued were those that had a high energy density. Clearly this was an important survival strategy. From the foregoing discussion it appears that two important components of the survival strategy of Aborigines as hunter–gatherers were to maximize energy intake and minimize energy output. The reality of the lifestyle, however, resulted in a generally low energy intake (subsistence) in combination with a relatively high energy expenditure. The scenario changed dramatically with westernization.

10. IMPACT OF WESTERNIZATION ON DIET AND HEALTH OF ABORIGINES

After westernization (see table 3), hunter–gatherer food preferences and eating behaviours have been retained by Aborigines in an environment where the availability of energy-dense foods (those rich in fat and sucrose) is no longer limited, and the energy output involved in their procurement is minimal. In the western context, Aborigines have a very high intake of sucrose (primarily as sugar in tea and from carbonated beverages) and fat (from cheap fatty meats from domesticated animals, and more recently from a wide variety of processed foods) (O'Dea *et al.* 1990). If the same eating behaviour is applied to beef and lamb as had been applied to kangaroo meat (2–3 kg at one long sitting), two to four times as much energy would be consumed: 4000–12 000 kcal instead of 2000–3000 kcal! This results from the much greater fat content of meats from domesticated animals relative to wild animals (Naughton *et al.* 1986). The principle is general: if food is there, it is eaten. For example, a dozen eggs will usually not be used slowly over several days, but will be cooked up for one meal, and may even be eaten by one person! When fresh fruit arrives at a remote community – a popular event that may only occur once or twice each month – it will be sold out and eaten within a day or two.

Eating behaviour and food preferences which favoured survival in the traditional hunter–gatherer lifestyle now promote the development of obesity. Obesity occurs with alarming frequency in many westernized Aboriginal communities, with 50–80 % of

Table 3. *Lifestyle-related chronic diseases in Aborigines after westernization*

android obesity
hypertension
body mass and blood pressure increase with age
non-insulin dependent diabetes mellitus
coronary heart disease
elevated triglycerides, low HDL-cholesterol levels
hyperinsulinemia (insulin resistance)

PHILOSOPHICAL TRANSACTIONS OF THE ROYAL SOCIETY B BIOLOGICAL SCIENCES

those over 35 years of age being overweight or obese (O'Dea 1991). When Aborigines gain weight, the fat is deposited centrally on the trunk – an android pattern – in both men and women (O'Dea *et al.* 1990; Rutishauser & McKay 1986). In Caucasian populations, this pattern of fat distribution has been shown to be associated with increased risk of NIDDM, coronary heart disease (CHD), hypertension, hyperinsulinemia and an abnormal lipid profile (increased levels of triglycerides and reduced HDL-cholesterol levels). These conditions frequently cluster together in one individual ('syndrome X' (Reaven 1988)) and may all be linked to the presence of insulin resistance. These 'lifestyle diseases' occur with high frequency in the most westernized Aboriginal communities (table 3) (O'Dea 1991), but are still relatively infrequent in the least westernized, traditionally oriented groups (O'Dea *et al.* 1982; O'Dea *et al.* 1988). The diabetes prevalence among adult Australians of European descent is estimated to be 3.4% (Glathaar *et al.* 1985). Crude prevalence rates two to six times higher have been reported for adults in Aboriginal communities around Australia (O'Dea 1991). However, the lower life expectancy and younger age profiles of Aboriginal communities relative to the wider Australian population invalidate direct comparisons of crude prevalence rates of age-related conditions such as NIDDM and CHD. In the 20–50 year age group, the prevalence of diabetes is ten times higher in Aborigines than in Australians of European ancestry. Although fewer data are available, the prevalence of CHD and hypertension is also considerably higher in Aborigines (Wise *et al.* 1976; Bastian 1979), and hypertriglyceridemia is a striking feature of the lipid profile in all westernized Aboriginal communities in which it has been measured (O'Dea *et al.* 1980, 1982, 1988, 1990; O'Dea 1984).

The diets consumed by Aborigines in remote areas of Australia are frequently very low in fruit and vegetables, and rely very much on the staples of flour, sugar and meat. The dietary problems are compounded by poverty, isolation, paternalism and history – the legacy of the 'stockman's diet' and lifestyle. Until the 1970s it was common in remote areas of Australia for Aboriginal men (and some women) to be employed as stockmen on cattle stations. In the early days they were not paid award wages, but did receive rations for themselves and their families, comprising flour, sugar, tea, meat and tobacco. This diet was selected as much for its keeping qualities as for its simplicity, convenience and low cost. Several innovative programmes across Australia are addressing these food supply issues in community-based programs. However, it is clear that contemporary food and nutrition problems in Aboriginal communities around Australia cannot be separated from their wider social and political context.

11. THE THERAPEUTIC IMPLICATIONS OF THE HUNTER–GATHERER LIFESTYLE

Although most Aborigines in Australia today live a sedentary, westernized lifestyle, many older individuals in remote communities retain the knowledge and ability to survive as hunter–gatherers. Collaboration with such people has allowed us to document the impact on health of a 'reverse lifestyle-change', a temporary reversion of westernized Aborigines (with all the associated contemporary health problems) to traditional hunter–gatherer lifestyle. The dramatic impact of lifestyle change on health is well illustrated by the observation that when overweight diabetic Aborigines made this temporary lifestyle transition for the brief period of seven weeks there was significant weight loss, and striking improvement in all of the abnormalities of diabetes together with a reduction in the major risk factors for coronary heart disease (O'Dea 1984; O'Dea & Sinclair 1985). A comparison of the major characteristics of the diet and lifestyle of Aborigines as hunter–gatherers and following westernization is presented in table 2.

These observations have implications not only for the prevention of obesity, diabetes and cardiovascular disease for Aborigines, but can also be applied more broadly. It has been argued that the hunter–gatherer, or palaeolithic, diet and lifestyle is the one to which we, as modern humans, are genetically programmed (Eaton & Konner 1985), as the human genetic constitution has changed little in the past 40000 years since the appearance of modern man. Thus it is to this diet and lifestyle that we should turn when seeking explanations for (and solutions to) the characteristic pattern of chronic diseases that emerges in all populations when they become more 'affluent' economically (Sahlins 1972) and adopt a sedentary, westernized way of life.

REFERENCES

Abbie A. A. 1971 Studies in physical anthropology. *Aust. Aboriginal Stud.* no. 39 (Human Biology Series no. 3). Canberra: Australian Institute of Aboriginal Studies.

Abbie A. A. 1966 Physical characteristics. In *Aboriginal man in south and central Australia*, pp. 9–45. Adelaide: Government Printer.

Allen, H. R. 1974 The Bagundji of the Darling basin: cereal gatherers in an uncertain environment. *Wld Archeol.* **5**, 309–322.

Basedow, H. 1932 Diseases of the Australian Aborigines. *J. trop. Med. Hyg.* **35**, 177–278.

Bastian, P. 1979 Coronary heart disease in tribal Aborigines – the West Kimberley Survey. *Aust. N.Z. J. Med.* **9**, 284–292.

Beck, W. 1985 Technology, toxicity and subsistence: a study of Australian Aboriginal plant food processing. Ph.D. thesis, Latrobe University, Australia.

Brand, J. C., Cherikoff, V., Lee, A. & Truswell, A. S. 1982 An outstanding food source of vitamin C. *Lancet* ii, 873.

Brand, J. C., Rae, C., McDonnell, J., Lee, A., Cherikoff, V. & Truswell, A. S. 1983 The nutritional composition of Australian Aboriginal bushfoods. 1. *Fd Technol. Aust.* **35**, 293–298.

Brand, J. C., Cherikoff, V. & Truswell, A. S. 1985 The nutritional composition of Australian Aboriginal bushfoods. 3. Seeds and nuts. *Fd Technol. Aust.* **37**, 275–279.

Davis, S. 1989 *Man of all seasons.* London: Angus & Robertson.

Eaton, S. B. & Konnor, M. 1985 Paleolithic nutrition. A consideration of its nature and current implications. *New Engl. J. Med.* **312**, 283–289.

Elphinstone, J. J. 1966 Endemic diseases in natives (Kimber-

leys). In *Report of Commissioner of Public Health Western Australia, Appendix IV*. Perth: Government Printer.
Elphinstone, J. J. 1971 The health of Australian Aborigines with no previous association with Europeans. *Med. J. Aust.* **2**, 293–301.
Flood, J. 1980 *The moth hunters*. Canberra: Australian Institute of Aboriginal Studies.
Flood, J. 1983 *Archeology of the dreamtime*. Sydney: Collins.
Glatthaar, C., Welborn, T. A., Stenhouse, N. S. & Garcia-Webb, P. 1985 Diabetes and impaired glucose tolerance. A prevalence estimate based on the Busselton 1981 Survey. *Med. J. Aust.* **143**, 435–440.
Hiatt, L. R. & Jones, R. 1988 Aboriginal conceptions of nature. In *Australian science in the making* (ed. R. W. Home), pp. 1–22. Cambridge University Press in association with the Australian Academy of Science.
Jones, R. 1980 Hunters in the Australian coastal savannah. In *Human ecology in savannah environments* (ed. D. R. Harris), pp. 107–145. London: Academic Press.
Kirk, R. L. 1981 *Aboriginal Man adapting: the human biology of Australian Aborigines*. Melbourne: Clarendon Press.
Lowenstein, F. W. 1961 Blood pressure in relation to age and sex in the tropics and subtropics – a review of the literature and an investigation in two tribes of Brazil Indians. *Lancet* i, 389–392.
McArthur, M. 1960 Report of the Nutrition Unit. In *Records of the American–Australian scientific expedition to Arnhemland*, vol. 2 (*Anthropology and nutrition*) (ed. C. P. Mountford), pp. 1–143. Melbourne University Press.
Naughton, J. M., O'Dea, K. & Sinclair, A. J. 1986 Animal foods in traditional Aboriginal diets: polyunsaturated and low in fat. *Lipids* **21**, 684–690.
Neuringer, M., Connor, W. E., Van Petten, C. & Barstad, L. 1984 Dietary omega-3 fatty acid deficiency and visual loss in the infant Rhesus monkey. *J. clin. Invest.* **73**, 272–276.
O'Dea, K. 1984 Marked improvement in the carbohydrate and lipid metabolism in diabetic Australian Aborigines after temporary reversion to traditional lifestyle. *Diabetes* **33**, 596–603.
O'Dea, K. 1991 Westernization and non-insulin dependent diabetes in Australian Aborigines. *Ethnicity & Disease*. (In the press.)
O'Dea, K., Spargo, R. M. & Akerman, K. 1980 The effect of transition from traditional to urban lifestyle on the insulin secretory response in Australian Aborigines. *Diabetes Care* **3**, 31–37.
O'Dea, K., Spargo, R. M. & Nestel, P. J. 1982 Impact of westernization on carbohydrate lipid metabolism in Australian Aborigines. *Diabetologia* **22**, 148–153.
O'Dea, K. & Sinclair, A. J. 1985 The effects of low fat diets rich in arachidonic acid on the composition of plasma fatty acids and bleeding time in Australian Aborigines. *Int. J. Nutr. Vitaminol.* **33**, 441–453.
O'Dea, K., Naughton, J. M., Sinclair, A. J., Rabuco, L. & Smith, R. M. 1987 Lifestyle change and nutritional status in Kimberley Aborigines. *Aust. Aboriginal Stud.* **1**, 46–51.
O'Dea, K., Traianedes, K., Hopper, J. L. & Larkins, R. G. 1988*a* Impaired glucose tolerance, hyperinsulinemia and hypertriglyceridemia in Australian Aborigines from the desert. *Diabetes Care* **11**, 23–29.
O'Dea, K., White, N. G. & Sinclair, A. J. 1988*b* An investigation of nutrition-related risk factors in an isolated Aboriginal community in northern Australia: advantages of a traditionally orientated lifestyle. *Med. J. Aust.* **148**, 177–180.
O'Dea, K., Lion, R. J., Lee, A., Traianedes, K., Hopper, J. L. & Rae, C. 1990 Diabetes, hyperinsulinemia and hyperlipidemia in small Aboriginal community in Northern Australia. *Diabetes Care* **13**, 830–835.
Reaven, G. M. 1988 Role of insulin resistance in human disease. *Diabetes* **37**, 1595–1607.
Rutishauser, I. H. E. & McKay, H. 1986 Anthropometric status and body composition in Aboriginal women of the Kimberley region. *Med. J. Aust.* **144**, 8–10.
Sahlins, M. 1972 *Stone age economics*. Chicago: Aldine.
Sanders, T. A. B. 1985 Influence of fish-oil supplements on man. *Proc. Nutr. Soc.* **44**, 391–397.
Seidell, J. C., Deurenberg, J. G. & Hautvast, J. A. G. 1987 Obesity and fat distribution in relation to health – current insights and recommendations. *Wld Rev. Nutr. Diet.* **50**, 57–91.
Sinclair, A. J. & O'Dea, K. 1990 Fats in human diets through history: is the Western diet out of step? In Reducing fat in meat animals (ed. J. D. Wood & A. V. Fisher), pp. 1–47. London: Elsevier Applied Science.
Thorburn, A. W., Brand, J. C. & Truswell, A. S. 1987*a* Slowly digested and absorbed carbohydrate in traditional bushfoods: a protective factor against diabetes? *Am. J. clin. Nutr.* **45**, 98–106.
Thorburn, A. W., Brand, J. C., O'Dea, K., Spargo, R. M. & Truswell, A. S. 1987*b* Plasma glucose and insulin responses to starchy foods in Australian Aborigines: a population now at high risk for diabetes. *Am. J. clin. Nutr.* **46**, 282–285.
Tonkinson, R. 1978 *The Mardudjara Aborigines: living in the Dreamtime*. Sydney: Holt, Rinehart & Winston.
White, N. G. 1985 Sex differences in Australian Aboriginal subsistence: possible implications for the biology of hunter–gatherers. In *Human sexual dimorphism* (ed. J. Ghesquierre, R. D. Martin & F. Newcombe), pp. 323–361. London: Taylor & Francis.
White, N. G., Beck, W. & Fullager, R. 1988 Archeology from ethnography: the Aboriginal use of cycad as an example. In *Archeology with ethnography: an Australian perspective* (ed. B. Meehan & R. Jones). Canberra: Australian National University.
Wise, P. H., Edwards, F. M., Thomas, D. W., Eliott, R. B., Hatcher, L. & Craig, R. 1976 Diabetes and associated variables in the South Australian Aboriginal. *Aust. N.Z. J. Med.* **6**, 191–196.

Discussion

P. A. Jewell (*Physiological Laboratory, University of Cambridge, U.K.*). Periods of food abundance and food shortage occur. Were the shortages ever so extended as to threaten survival? Does Professor O'Dea have any observations that suggest that involuntary fasting was either detrimental or beneficial to the physical well-being of the people?

K. O'Dea. The available data since European contact indicate that severe food shortages did occur in association with prolonged droughts in arid areas of Australia (primarily inland). Food shortage was probably an important component of the process of establishing missions in such areas! There are a number of reports of Aboriginal groups coming into missions during droughts for food early in the colonization process.

Repeated cycles of involuntary fasting may have contributed to improved 'metabolic efficiency' of Aborigines. Recent studies in overweight people who diet regularly show that repeated cycles of weight loss and weight regain are associated with reduced energy requirements and linked with heightened preference

PHILOSOPHICAL TRANSACTIONS OF THE ROYAL SOCIETY B BIOLOGICAL SCIENCES

for high-fat foods. Similar data have been reported in experimental animals. If such adaptation did occur, it would be expected to enhance the putative 'thrifty genotype' and could therefore have had important positive implications to survival of Aborigines as hunter–gatherers.

A. Whiten (*Scottish Primate Research Group, University of St Andrews, U.K.*). We call the mode of foraging 'gathering and hunting', but what proportion of plant foods are in fact gathered and shared at a home base, and what proportion consumed while foraging, in the fashion of non-human primates? And what foods (and proportion of foods) are eaten without cooking?

K. O'Dea. Foods that require long preparation (e.g. winnowing and grinding of seeds, processing of cycad nuts, cooking of large animals) were usually taken back to the homebase and shared there. It is difficult to generalize with any accuracy about the proportion of foods that are either edible raw (fruits, some nuts) or require minimal cooking, that were consumed as they were gathered. Considerable amounts of food are eaten as they are gathered and major meals may also be consumed in this way: fish, small animals, shellfish and anything else that could be cooked quickly on a small fire (even the liver from a kangaroo) would frequently be eaten before returning to camp. However, some food was always carried back to the home base to share with others.

It has been estimated that in one region of northern Australia, more than half of the plant foods require cooking or some form of processing. However, this proportion would vary greatly both seasonally and with geographical location.

S. A. Altmann (*Department of Ecology and Evolution, University of Chicago, Illinois, U.S.A.*). What is known about the heritability of the physiological differences between Australian Aborigines and Europeans?

K. O'Dea. This is a difficult question to answer, mainly because of the problems of excluding potential confounding effects of environmental factors. Although it is widely believed that metabolic factors such as insulin resistance have important genetic components, there is no doubt that they are also influenced strongly by non-genetic factors (diet, lifestyle, etc.). Most of the data suggesting genetic differences in disease susceptibility (e.g. to diabetes) comes from cross-sectional comparisons of populations (Aboriginal, Caucasian) living under very different lifestyle conditions. The most that could be safely concluded at this stage is that proportionally more Aborigines appear to be susceptible to developing conditions such as obesity and NIDDM when living a 'western' lifestyle. Longitudinal family studies are essential to clarify this question. The evidence appears to be stronger with parameters such as body build (presumably largely genetically determined) where there do seem to be consistent differences between Aborigines and Caucasians, with Aborigines having a more 'linear' and lighter body build (relatively long limbs and lighter frame). However, it is possible that differences in nutritional status in early life may also influence these parameters.

S. S. Strickland (*London School of Hygiene and Tropical Medicine, Keppel Street, WC1*). What is known about the lean and fat tissue composition of weight gain and loss over the feasting–fasting cycle?

K. O'Dea. There are no data on this question in Aborigines. In Caucasians there are data suggesting that repeated cycles of weight loss and weight regain in overweight individuals results in enhanced 'metabolic efficiency', possibly secondary to a reduction in the relative proportion of lean body mass. Studies in rats suggest that this enhanced metabolic efficiency associated with weight cycling can be prevented by exercise training. To my knowledge, data on the consequence of major fluctuations in energy intake on body composition in lean, physically active individuals are not available.

S. S. Strickland. Professor O'Dea described the aborigines as 'lean', with a mean body mass index of 16.7, yet a BMI of 20, equivalent to the body fatness of a Caucasian with a BMI of 22–23. Can she comment on differences in body composition and the distribution of body fat between aborigines and caucasians?

K. O'Dea. There is a paucity of good quality data on body composition in Aborigines. However, what data there are indicate that Aborigines have a linear body build, with proportionally longer limbs and shorter torso than Caucasians. This type of body build is consistent with the data reported indicating that for an equivalent BMI young Aboriginal women have more body fat (from measurements of skinfold thickness and bioelectrical impedance) than young Caucasian women. There is now an accumulating body of evidence indicating that both male and female Aborigines develop a central, or android, pattern of fat distribution when they gain weight.

O. T. Oftedal (*Smithsonian Institution, Washington D.C., U.S.A.*). I am intrigued by Professor O'Dea's observation that the Aborigines had detailed knowledge of the seasonal cycles of fat content in their prey. Could she elaborate on this point with regard to types of prey that exhibit such cycles, and the efforts made to procure them?

K. O'Dea. Most types of prey have times of the year when they are fatter than others, with clearly larger fat depots within the abdomen, rather than increased fat content of the muscle. The seasonal movement of Aboriginal groups within their territory was closely related to the fatness of the major animal food sources. The importance of this 'fat-possessing quality' of foods was reflected in the complex language to describe it across the edible fauna: insects, fish, crustacea, molluscs, reptiles, birds and mammals.

PHILOSOPHICAL TRANSACTIONS OF THE ROYAL SOCIETY B BIOLOGICAL SCIENCES