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CALORIES AND BYTES: TOWARDS A HISTORY OF THE AUSTRALIAN ISLANDS

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As Mr Wentworth (1819) said in his first book, written while still an undergraduate at the University of Cambridge:

'The Aborigines of this country [Tasmania] are, if possible still more barbarous and uncivilised than those of New Holland. They subsist entirely by hunting, and have no knowledge whatever of the art of fishing'. (115)

Published in 1819, this was not of course the work of William Charles Wentworth the Fourth, in appreciation of whose contribution to Aboriginal studies this lecture series has been inaugurated, but of William Charles Wentworth the First**,** another 'Great Native'. He continues about the Tasmanian Aborigines that:

'Even the rude bark canoe which their neighbours possess, is quite unknown to them; and whenever they want to pass a sheet of water, they are compelled to construct a wretched raft for the occasion…The woomera, or throwing stick, which enables the natives of Port Jackson to cast their spears with such amazing force and precision, is not used by them. Their spears too, instead of being made with a bulrush, and only pointed with hardwood, are composed entirely of it and, are consequently more ponderous'. (115-116)

Exactly 150 years later in 1969, in his Presidential address to the Anthropology Section of the Australian and New Zealand Association for the Advancement of Science Congress in Adelaide, Mr Wentworth touched on similar matters, but within a different perspective – the perspective offered to us by contemplating Aboriginal society on a continental-wide basis and with the bright shafts of prehistoric sunlight beginning to illuminate its vast history. How did people make the minimum 60 kilometre water crossing that there was among the water gaps on the way from Asia? Were the Tasmanian reed boats some last remembrance of the original machines that had allowed woman and man to claim 10 million square kilometres of empty space? Had there been in Australia technological blossoming 20 millennia ago? Australian, an island and largely isolated, offers the best situation in the world to study a society of man under an economic regime of hunting and gathering, one in which

'…humanity has passed most of its existence…the post-agricultural phase, with its larger units and depersonalised orientations occupying only less than one percent of human history', so that 'if there is an ingrained human propensity for organisation, it must relate to man's experience in that other 99 percent of his time.' (6)

These things, in Mr Wentworth's view, the study of Aboriginal society in its broadest context - its economy, genetics, language, music, art and prehistory '…places upon Australian Anthropology its unique responsibility and makes it, from a world standpoint, by far the most important academic project in Australia', and furthermore that 'the loss from the failure to record the facts of Australian Aboriginal life is

irreparable. Because of this, humanity may lose forever the best chance of an insight into the forces which guide all human societies; the real nature of men everywhere.' (8)

The early men of Saint Germain

In 1753, while walking through the forest of Saint Germain, Jean-Jacques Rousseau (1753) sought and found the primitive times, the history of which he proudly traced, the result being his great Discourse on the Origin of Inequality Among Men, one of the foundational works of prehistory. The first men, said Rousseau (72)

'…wandering up and down the forests, without industry, without speech and without a home', produced a situation where…'every art would necessarily perish with its inventor; and generations succeeded generations without the least advance…each always setting out from the same point, centuries must have elapsed in the barbarism of the first ages; when the species was already old, and man remained a child'.

This brilliant vision, which has been seared onto the European imagination ever since, does however, run foul of the Second Law of Thermodynamics, since it postulates a cyclical process running through time but returning always to its initial state - a situation never found in nature.

A Carnot Cycle tour

In every change in a closed situation from one state to the next, there is always an increase in entropy. Entropy measures the amount of unavailable energy in a system. That is, whereas hot and cold water mixed together always results in tepid water, we never get the reverse – a situation of a bowl of water, half of it spontaneously boiling so that the other half freezes. Since irreversible processes are continually going on in nature, energy is continually becoming unavailable for work - what is idiomatically termed 'running downhill'. Entropy can also be thought of as a measure of the degree of disorder, and since a state of order in nature is highly unlikely, energy in Boltzmann's (Hasenohrl 1909) general formulation is a function of the probability of a given state, a general philosophical concept of enormous scope, as well as formally defined as a law in physics.

Information, the transference of a set of messages – a series of binary choices, one-two, one-two, one-one, one-two, one-one, two-one etc. – from one centre to another without loss of initial order (what in human terms you might call 'meaning') is a highly improbable situation. The more complex the information, the less probable is its state. Information can be thought of as analogous to negative entropy, a measure of order or organisation, and which in a closed system, will always tend to move towards less order and more disorganisation.

Biologists faced in nature with highly complex living systems, indeed ones which through time have become more complex not less as expected from the Second Law, have the dilemma solved when it is realised that entropy like mass can be added or taken away. In an open system, the system itself can loose entropy – that is, become more complex, but only at the expense of a wider universe where the total entropy of system and universe has increased. Eating a steak to power myself to transfer this message involves the degradation of low-entropy chemical energy through to high-entropy heat, which is why I am sweating here to-night! The initial organisation of that chemical energy was however bought at the price of a total increase of entropy in the processes of photosynthesis, the digestive systems of the bullock, and so on.

Archaeologists can study energy in the past by analysing middens, converting bone counts to the original animals and hence their calorific value. Shawcross (1967) had the combined shellfish of his Galatea Bay midden powering a Boeing 707 through take-off for a few seconds until it ran out of the shellfish, pipis. In Meehan's (1975) study with the An-barra Aboriginal community of Arnhem Land we see the flow of 14 million shellfish from their beds through a human society to power the 35 people for some seven percent of their energy needs; and then, like the waste gases of some industrial process, proceeding to a state of maximum disorder as ten cubic metres of scattered midden heaps on the landscape. This is the stuff onto which we archaeologists must re-impose some analytical order so that we may perceive a dim history.

The second half of my title - 'bytes' - refers to a unit of computer technology consisting usually of eight 'bits', the basic unit of information - the zero/one, the yes/no of the binary system. But, veracity as usual being sacrificed for art, I decided to maintain a consistent gastronomic flavour.

To make tools requires a body of organised information - ideas inherited from the past, copied from neighbours and transferred to future generations. Archaeologists study changes in the form of ancient tools and from consistent patterns of their shapes, postulate the existence of traditions and cultures. Typology, the study of artefacts, is an analysis of the coherence of the transfer of technological information from one generation to the next. It is a study of entropy.

Chaos

Chaos was the ancient European model for the hunting world. Lucretius (1951), 2000 years ago, when imagining the earliest men, said that:

'…they lived out their lives in the fashion of wild beasts roaming at large…stayed their hunger amongst the acorn-laden oaks…lived in forests and hillside caves and stowed their rugged limbs among bushes when driven to seek shelter from the lash of the wind and rain. Here were no rules governing location and no social constraints. Venus coupled the bodies of lovers in the greenwood. Mutual desire brought them together, or the males' mastering might and over-riding lust.' (219-220)

Such was the cultural memory with which to try and comprehend the vast forests of the New and Pacific worlds with their mirrors of mankind staring back from the edge of the trees.

'Dy gastell ydyw'r gelli,
Derw dol yw dyrau di.

Da yw ffin a thref ddinas,
Gorau yw'r glyn a'r graig las.

Gwylia'r trefydd, cynnydd call,
A'r tyrau o'r arall.'

sang the 15th century poet Tudur Penllyn (Parry 1962: 169-70)) to the Lancastrian bandit David Jenkins of the Conwy Valley -

'Your castle is the copse,
Oaken glade your towers.

Good the urban edge of cities,
Better the glen and the shining rock.

Watch those towns, formal and fat,
And turrets from inside out.'

- showing rare appreciation that landscapes can be conceived of in obverse ways, depending on the point of view of the observer. But to most travellers on the alien beaches, it seemed as if they were witnesses of primeval anarchy, the natal soup of man.

The process of imposing order on 'tumult and confusion' as Governor Phillip (1789) put it, gave no greater satisfaction than when

'…a settlement of civilized people is fixing itself upon a newly discovered or savage coast. The wild appearance of the land, the close and perplexing growing of trees, bare rocks, weeds, flowers, flowering shrubs or under wood, scattered and intermingled in the most promiscuous manner.' (132)

As with the backdrop, so too with the actors. President de Brosses of Dijon (1967) wrote of Tierra del Fuegians that they were '…without religion or policy or the least regard to decency' and Crozet (1891), remembering the killing of his leader Du Fresne in the Bay of Islands, satirised the 'Children of Nature now so much extolled and praised as having more and less than those we called cultured' as 'within the same quarter of an hour…chang(ing) from childish delight to the deepest gloom, from complete calmness to the greatest height of rage, and then bursting into immoderate laughter the moment afterwards.' (87) We are with the Marquis de Sade's fellow inmates in some ethnographic madhouse, laughing as the oblique iron blade drops at the capricious whim of a Committee for Public Safety.

In Sydney at Government House in 1811, the convict poet Michael Massey Robinson (Mackaness 1946) declaimed in his Ode for the Queen's Birthday, that in Australia over a vast period 'Nature scarce owned the unproductive waste' and the Aborigines had been:

'For Ages Doom'd in Indolence to roam,
The rocks their Refuge and the Wilds their home!
Lost to each social Interchange of Thought,
Their Youth neglected and their Age untaught.'

In its moral aspects, this is a view of man without social rules and in its spatial manifestation we have men wandering about without pattern or purpose, like molecules of gas according to the kinetic theory in perpetual random motion. Knowing the number of men within the Australian container and the velocities of their travel, one could calculate the probable frequencies of their collisions that in such a state of disorder, would pass for social intercourse. This view of man - 'sans roi, sans loi, sans foi' (without king, law or faith) - was a postulation of humanity in a state of maximum entropy.

Crystal Society

Very quickly after the establishment of the British settlement at Sydney it became apparent however, to the more perceptive observers such as Hunter (1793) and Collins (1802), that the movements of Aborigines along the shores of the harbour and past the outlying farms, while irregular in detail, did indeed have an underlying pattern and consistency to them. In Tasmania, that prince of historians, John West, said in 1852 of the by then almost vanished Tasmanians that:

'…the tribes took up their periodic stations, and moved with intervals so regular, that their migrations were anticipated, as well as their return. The person employed in their pursuit, by aid of his native allies, was able to predict at what period and place he should find a tribe, the object of his mission.' (3)

We now realise that Aboriginal society was bound to the land by profound religious ties, that there was and is an intensity of knowledge about place and ownership, resources and their flux through the seasons, such that people who do not live by hunting have forgotten. Only in Australia are we given that overview of the relationship of hunters to landscape on a continent-wide scale.

In his 1953 paper Birdsell showed that a highly significant negative correlation exited between areas of inland Australian tribes and rainfall. Since tribal populations were normally distributed with a mean of some 400 to 500 people, this meant that Aboriginal population density was roughly related to the rate of primary production of plant material. Despite all the glosses and errors of the original data this is a profound statement, especially if we add the rider '…and not technology'.

The highest population densities of all were found along rivers and inland lakes, and around that part of the coastline where the land behind is well-watered, so that there are numerous river mouths, lagoons and other wetlands with a high biomass and great diversity of species of plants and animals. These areas were omitted from Birdsell's study because these biological factors were then considered to be too difficult to measure.

Tasmania
For Tasmania I calculated the Aboriginal population density using the numbers and locations of named Aboriginal bands according to field journals of George Augustus Robinson (as analysed by N.J.B. Plomley 1966), together with other information from Peron (1809), Labillardiere (1800) and general estimates of settlers and other scholars. In my opinion, there were some 4000 people in Tasmania and that the basic social and ecological unit was the band of some 50 people of whom half might have been adult**,** there being 80 such bands in the whole of Tasmania.

Each band on average had primary ownership of 500 to 600 square kilometres of land, or on the coast they were spaced out every 50 kilometres or so in a remarkably regular pattern. These bands were agglomerated into larger social units that spoke the same language, shared the same material culture and other traits such as art and burial customs; had a pattern of co-operation, marriage and seasonal movements within as opposed to non-cooperation and even of enmity without, so that we may legitimately think of them as 'tribes' in the loose Aboriginal sense of the term. There were nine such tribes in Tasmania ranging in size from 175 to 500 but most of them at about 450.

In relating such population densities to resources we have two kinds of ecological zones to consider namely, the land and the seashore. For each tribe I examined the area of land per person against the length of coastline per person. This calculation showed a strong negative correlation that was significant. With no coastline it took 20 square kilometres to support one Tasmanian, and with no land – that is, purely the strand itself – it took two kilometres to support one person. It appeared that these different resource potentials were added up together, like bricks of two different sizes, to form total units – that is, 'tribes'. These were relatively uniform in final size. Tribes with large inland areas had small coastlines, while those with long coastlines were small in land area. What is fascinating here is that, in terms of spatial organization, it is as though this society tried to maintain a uniform tribal population as a prime objective.

Add to this Peterson's (1976) demonstration that Tasmanian tribal boundaries corresponded extremely well with some of the major drainage basins, and that other factors such as access to important resources like ochre and shells, or the location of main seasonal travel routes, tended to give, as Tindale once suggested, maximum access with minimum trespass, then in Tasmania we have this beautiful pattern of the integration of cultural imperatives onto a mosaic of land and sea. But the crucial point remains that, although man's population density is a function of bio-production, the organisation of his social groups, as much as possible, conforms to his own template to meet his own social and cultural needs.

Arnhem Land
The same is true of Arnhem Land. The relationship of population density to coastline and area has the same form as in Tasmanian, except that the actual number of people is some four times as great – eight people per kilometre of coast in places – reflecting not only the greater biological richness of this tropical coast but also the more even distribution of resources throughout the year, highly important to an economy without much capacity for storing food. This high population density is however, deployed on the ground in terms of many small units rather than a few large ones. It is reflected in diversity – linguistic, genetic and in kinship terms – not in size.

Calories
A kilocalorie is the heat required to raise the temperature by one degree Celsius of a kilogram of water. On average a person needs to obtain some 2000-2500 kilocalories of energy per day to live. That is more or less the heat required to raise the temperature from 0% to 100% of 20 kilograms of water, some four gallons.

Relating this to the Tasmanian demographic pattern described earlier, this means that along the coasts the Aboriginal society was extracting energy to drive itself at the rate of one kilocalorie per day per metre of coast – say, a fish a year. Taking the land itself, one kilocalorie per 10,000 square metres per day. This is only one part in 100,000 of the total plant primary biomass production. To calculate the total energy requirements of Tasmanian hunters, we would also have to take into account their use of firewood for heat

and cooking which, if it was used at the same rate as amongst the An-barra of Arnhem Land, would be some 20-30 kilograms per hearth group per day, indicating of the order of some 10,000 kilocalories per head per day. That is something like five times the energy used in the body's internal chemo-dynamic processes. This total of some 12,000 kilocalories per head per day can be compared with the 200,000 kilocalories per head per day of modern industrial societies.

This energy was obtained from killing animals and digging and collecting edible parts of plants. The An-barra in 1972-73 ate some 120 species of fish, shellfish and crustacea, 50 species of land animals and birds, and 50-70 species of plant foods. In terms of calorific intake, shellfish contributed some seven percent, fish 24 percent, the reptiles, birds and mammals some 16-17%, fruits and nuts two percent and vegetables five percent (Meehan 1976). The remaining 40-50 percent came from carbohydrate foods that were bought from the supermarket at Maningrida, mostly flour and sugar. Before the arrival of Europeans some 20 years ago, the Aborigines said women used to get this fraction from collected vegetable foods. Nowadays they work less hard than they used to. Even so, roughly half of the energy came from animal flesh, and Meehan (1976) thinks that the present fashionable trend towards seeing Australian hunters as largely vegetarian is a gross exaggeration.

Aborigines were to a substantial extent meat-eaters, the An-barra men, women and children eating over one kilogram of meat per head per day. According to our friend, the Second Law, it is obvious that meat being higher up the food chain, is less plentiful in absolute terms but on the other hand, more highly concentrated, red meat having 3000 kilocalories per kilogram as opposed to shellfish at about 800. To obtain this energy work must be done. The yield in terms of kilocalories gained per person hour of effort for various targets can be calculated against the probability of success on any particular trip aimed at getting food. These calculations are based on data collected by Meehan (1975) and myself (1975) with the An-barra over a year. There is a strong inverse correlation between a high yield and the probability of getting it. Men get those foods that usually require highly athletic activities involving physical power and skill, the difference of a few centimetres in trajectory or a few seconds' hesitation in throwing of a spear can mean no food or a glut. On one foray there may be only one such occasion, one such opportunity, lasting for a few seconds only. The women on the other hand, have a lower yield per effort but their work is highly reliable, their yield being almost directly proportional to the effort invested.

The best combination of high yield and adequately high reliability was fishing with fish traps (an-gujechiya). These were owned and used by mature or older men who also had a monopoly of the strategic places on tidal creek banks where the traps could function efficiently. The An-barra hunting strategy was to combine the two types of foraging – high yield/low probability with those giving low yield but high probability of success. This mixing took place on a daily basis with people of different sexes and ages embarking from camp on their various kinds of tasks. On average, roughly half the food energy was contributed by men but their actual work input in terms of hours was much less than that worked by the women. Three types of women's work - collecting shellfish, digging for yams and the collecting and processing of Cycad fruits (Cycas angulata or ngacha) – gave remarkably similar results, roughly 1000-1400 kilocalories per woman hour. Even this, the lowest meant that a woman could feed herself with two hours of work per day.

The total amount of food energy potentially available in vegetable food is much greater than in the animals that feed from it and, in the case of the An-barra landscape there were several suitable edible plants. Cycas media in Cape York, according to Harris (1975), has a potential yield from its kernels of 130 kilocalories per square metre and such trees exist on the eastern bank of the Blyth River as the dominant under storey of eucalypt forests extending over an area of some 25 square kilometres. These lie within easy reach of the An-barra and other Gu-jingarliya camps offering enough food there to feed some 5000 people. One limiting factor in the processing of Cycad might be the lack of water during the late dry season for leaching the kernels, but there are other foods such as the spike rush (Eleocharis dulcis or gulach) which forms a dense mass filling in all the prior ancestral meandering stream beds of the Blyth River. In addition to these there are Dioscorea yams, the Polynesian arrowroot (Tacca leontopetaloides), a species of true rice (Oryza rufipogon), some Ipomoeas, possibly taro (based on a single identification) and the trees Pandanus,

Terminalia, Eugenia and several palms, all of which are either staples or important domestic foods amongst the horticultural peoples of the coast of Melanesia, the Pacific and parts of South East Asia.

The question - Why did the Aborigines not have agriculture? – is too vague for investigation but it can be re-phrased. What were the mechanisms that allowed Aboriginal man's foraging strategies to reap continually a substantial part of their food from the high-value high-weight spectrum meaning that high-labour input was restricted largely to women and even then was kept within reasonable bounds?

It is with the aid of technology that we gain energy from the environment and viewed as a whole, wandering through ethnographic rooms of museums we are presented with Aboriginal technologies as if they related to specific areas and problems – the nets, the stone fish traps of the Darling River for Murray cod and black duck; the boomerangs and grinding stones of Cooper's Creek for desert euros and the seed nardoo; the multi-pronged fish spear and the light spearthrower of Arnhem Land coast as a machine to impale and disable a barramundi until a fist can be inserted through its gills and its paroxysms stilled by a blow to the skull.

Subtler are the refinements. When the lightwood tree (Acacia sophorae) flowers it is time to go to the Tasmanian islands for mutton bird; on the one day of the year at the end of the west season in Arnhem Land when the new moon high tides correspond to the last draining of fresh water back to the rivers the marine Striped Butterfish (jin-gol or Selenotoca multifasciata) is plucked from between aerial roots of mangroves by excited hunters; knowing when an arm is fully committed down a hole whether it is a king brown snake or a goanna one is feeling; tying a spider's web onto a bee's foot so that it may guide the hunter, gossamer like, back to the hive. None of these strategies require material objects. They are the result of knowledge stored in the brain, not lumps of wood wielded by the hand.

Given that a single type of spear does an effective job, why therefore have five or ten, all slightly differently barbed and named? Why all the variation in clubs and baskets? There is a bewildering redundancy in Aboriginal technology, particularly the technology of men, which cannot be explained in simple ecological terms. A clockwork view of Aboriginal economy is not a sufficient explanation.

An outline of Australian prehistory

Australia is an island and therein is the key to its prehistory. It is not a single island but rather an archipelago on a continental shelf dominated by the huge mainland. But Tasmania, New Guinea, Kangaroo Island, the Furneaux Group, Deal Island, the Torres Strait Islands and Aru all share a common historical heritage since periodically during times of low sea level, at the height of the last ice age, they were all joined into a single continuous land mass. These Australian islands form but the southern half of the greatest archipelago in the world extending 8000 kilometres to the southeast of Asia. However, between the Australian and Asiatic islands are a series of deep sea channels which have not been dry for many tens of millions of years. This great sea barrier blocked the southward thrust of the placental mammals and allowed in relative isolation the continued evolution and radiation of the marsupials. Only rats, mice, bats and man on their own, made this crossing.

However, even the smallest probability of success, given enough time, eventually becomes a certainty. We may have to think of the initial colonisation of Australia in terms of a large number of random and probably accidental aquatic departures from the mangrove shores of Asia perhaps over a period of tens of thousands of years until finally the right combination occurs of a safe journey, two sexes and – if the colonising group is very small, a few individuals only – a great deal of good luck in sex ratios of the children born, the fertility of the mothers and a minimum of accidents over a period of many generations, perhaps hundreds of years, until a demographically viable group is established on the new continent. The first Australians like most of the first European Australians probably came here involuntarily.

At least 35,000 years ago and probably considerably earlier, man had through a combination of technological advancement and chance claimed Australia – 10 million square kilometres of empty space – one of the great leaps in the expansion of the human geographical range. Birdsell (1953) has shown that it would have been possible to fill this with people in a few thousand years, especially if initially some degree

of differential preference was shown for the better-watered areas first, as Bowdler (1977) has suggested. Certainly by at least 25,000 years ago man was occupying the entire southern swathe of the continent and in the opposite direction, at 2000 metres in the New Guinea highlands. Such is the span of time involved that man was the witness of great climatic and environmental changes, even to the shape of the land itself – all aspects of the vast energy oscillations of the last ice age.

(Slide) Some 25000 to 30000 years ago on the shores of Lake Mungo, then full of water, we get a glimpse of men and women camping on the beach catching fish, mussels and crayfish, collecting emu eggs and hunting a range of small marsupials. They use ochre and cremate their dead by smashing the bones and burying them in shallow pits near the camp. Did they also hunt the three metre high giant Procoptodon, now known from the work of McIntyre and Hope (McIntyre and Hope 1978, Hope 1978) to have shared their dunes with them? Were they indeed responsible to some extent for the extinction of the giant marsupials (some rhinoceros- and bear-sized creatures) which made up one third of all genera and which had up to then, or a few thousand years before that, lived on this continent? How long previously had their ancestors lived here? Were the people of Kow Swamp a genetic memory of an earlier phase of colonisation to that of the Mungo people? And did the modern Australian race spring from a union between these two groups? These questions, which deal with crucial adaptations of early man to this continent, arise in the context of a rapid pace of discovery and are obviously beyond the scope of this paper. Their resolution however, is essential to our understanding of what happened afterwards.

At Mungo people left their kit of stone tools. These consisted of heavy, domed, horse-hoof shaped core tools and scrapers with steep, tough edges, planes to chop and smooth wood. Some of these scrapers have rounded edges and others are notched – they are perhaps**,** spokeshaves. Studies on sites as far apart from each other as Lake Burrill on the New South Wales coast and the Dampier Archipelago 5000 kilometres to the west, from Tasmania in the south to Cape York, the Arnhem Land escarpment, and even in the New Guinea highlands in the far north, reveal that similar tools were made throughout the continent and over a time scale of 30,000 years. The 'Australian core tool and scraper tradition', was one of the major technological provinces of the Late Stone Age world, ranking in terms of space and time on the same scale as the European Upper Palaeolithic and carrying information of the same cultural magnitude.

Kangaroo Island has always been a problem in Australian archaeology. Empty of man when Flinders (1801) and Baudin (1974) saw it in 1802, strange stone tools have been found in its ploughed fields, very large horse hoof cores and pebble choppers called Kartan industry by Tindale (1937) and Cooper (1960) in their pioneering studies there. Recent research by Lampert (1972) has confirmed the integrity of this industry and has shown that it must date from a period considerably older than 16,000 years for it has never yet been found in situ.. Lampert (1975) also found with these core tools, large flat roughly bifacially-flaked objects with a pair of indented waists on opposite sides. These 'waisted blades' as they are called are also found in the 26,000 year old site at Kosipe in highland New Guinea, and in many Late Pleistocene sites in South East Asia. They show that this ancient Australian 'legacy' industry must be seen as part of a broader province which encompasses also parts of South East Asia, and that the first colonists across Wallace's Line, hazardous though the journey was, brought with them in their minds, substantial parts of their technology.

We can trace a lineage from these waisted blades to similar objects where the edges themselves are ground. Typologically similar are hatchet heads of igneous rock with ground down cutting edges and again with a waist or groove around their middle. Such axes found in 23,000 year old levels in several sites at the foot of the Arnhem Land escarpment, together with typical steep-edged scrapers, were for many years by far the oldest examples of edge-ground axes in the world (White 1975). Similarly-aged ones have been found now in Japan suggesting that a high antiquity for this technique was a general Late Pleistocene development right throughout East Asia.

For reasons of the size and shape of the tools and general stratigraphic considerations, Lampert (1975) considers that the Kangaroo Island or Kartan type of industry, especially as now quantitatively defined by him, is either ancestral to or represents the initial phase of the Australian core tool and scraper tradition.

This is a re-formulation of what Tindale (1937) said originally. The implication is that it is older than 30,000 years, perhaps much older.

Looking at various assemblages of the core tool and scraper tradition on a continent-wide basis, we can see over a span of 30,000 years what Lorblanchet and I (1979) have called 'direction of the evolutionary trend'. Over time there is a shift from horse hoof and other core tools towards scrapers. There is also a shift within the scrapers from the more ad hoc, steep-edged ones to the finer-made round-edged types and the concave and nosed varieties. Thirdly there is a diminution in the size of individual tools. All these are but different aspects of the same thing – that is, efficiency as expressed in terms of millimetres of edge per gram of material. Millimetres of edge per gram of scrapers, millennium after millennium, slowly and surely, increased at roughly the same rate throughout the Australian continent – approximately half a millimetre per gram 30,000 years ago, doubled to one millimetre per gram at 10,000, two millimetres per gram at 5000 and maintained its accelerated rate to four millimetres per gram 1000 – 2000 years ago Allen 1972). There is a similar trend in Tasmania over the last 8000 years but the final figure reached is only about 55 percent of that achieved on the mainland.

The tools themselves remained the same shape, with their proportions the same, so the tiny domed horse hoof core scrapers from Burke's Cave in western New South Wales 4000 years ago, look like miniatures of the Mungo examples in the same region and 20,000 years older. How was it that cultural information was maintained and transmitted through time, that man fashioned such brute objects of stone to so well-defined average templates of design that the strike of an artisan's hand 10,000 years ago produced an edge twice as effective in terms of unit weight, as some ancestor 800 generations before him and yet only a quarter as effective as his descendants 400 generations still to come?

Archaeology of the Stone Age is crude, yet its message is profound. We are seeing but one tiny aspect of the fundamental discovery of prehistory, that men's technology has been proceeding generally in one direction, towards increased efficiency, increased organisation and in analogous tools, towards miniaturisation. What happened to the horse hoof cores of the Darling Basin over 30,000 years was but an ancient manifestation of what has been happening in the last 30 years with our computers.

These tools were but tools to make tools – the wooden artefacts, of the chase and the dig. They were multi-purpose, often with different kinds of edges on the same blank. They were designed to be versatile and therein lay their functional robustness. They were effective enough to carry men through the great environmental changes which geomorphologists and biogeographers are now showing happened during the time under review, without having any appreciable effect on their design. Some 20,000 to 18,000 years ago the lakes of Mungo dried up. At Lake George the temperature became so low that the evaporation decreased causing the lake level to rise and the water to flow out at Geary's Gap. There were no trees then only grassy plains and relentless cold winds from the west in winter whipped up sand and mantled it on the lee shore. Seventeen thousand years ago mobile desert dunes were active on Kangaroo Island, in western Victoria and in northeastern Tasmania. So also with the major economic shift in Papua New Guinea, which Golson (1977: 154) says gives 'no hint in [the] stone tool technologies of basic changes in substance, from hunting and gathering to agriculture…'.

These tools belong to a design strategy Levi-Strauss (1966) called 'bricolage' – that is, a handyman's understanding that a single object can do many things with minimum alteration rather than, as with contemporary stone tool strategy of western Europe from 30,000 to 10,000 years ago, where for every different purposes, a different object was made. This was a gadget strategy which although typologically dazzling proved in terms of long-term survival vulnerable to the environmental changes at the end of the ice age. These changes were similar in scope though slightly different in time to the ones ridden by the users of the Australian scrapers. We must not allow the monotony of shape, as White (1977) has reminded us, to lead us into the trap of assuming inefficiency.

The small tools

Some 6000 to 4000 years ago there suddenly appears in sequences all over mainland Australia, a plethora of new stone tools – points, backed microliths, adzes – not replacing the scrapers but added onto

inventories. These small geometric objects with blunted backs suddenly appear all over southern Australia at approximately the same time. The dates from the east coast and those from the west near Perth and Dampier are so close that given the so far inadequate sampling and inherent problems of charcoal dating or the possibility of small tools being trodden down into deposits of soft sand, they are almost archaeologically instantaneous though 5000 kilometres apart. In addition the structure of the industries are very similar indeed containing scrapers and the 'little tools' (as Gould 1968 called them), points, backed blades and small adzes. Three sites in Western Australia, one at Burke's Cave near the Darling River, western New South Wales, and one on the east coast – 5000 kilometres apart – are dated to the same time and show almost no differences in assemblages.

In environmental terms these small backed-blades are found on the beaches of Bondi (hence the Bondi Point), in the Blue Mountains, west of the Darling River to the dry saltpans of Lakes Frome and Eyre and beyond to the coastal plains of the Swan River and the salty mangrove shores of Dampier Archipelago in Western Australia. Yet these same tools with such catholic adaptability, were not found on the east coast of Queensland, were not found in the desert region of Tennant Creek nor in rich Arnhem Land, not in Western Australian along the north coast of the Kimberley. Why if so efficacious, along the southern half of the continent, across almost the entire range of Australian environments, and not in their analogues in the north? We could argue the same for the points which are found in northern Australia from Arnhem Land right down the Centre to the south coast but not east or west; small adze slugs are found in the Centre but not on the coast – and so on.

Microliths were set in gum onto a handle as elements of composite tools. They mark, not as Mulvaney (1961) had originally postulated – the introduction or invention of hafting in Australia – but as Dickson (1976) pointed out, a new technique of hafting, holding the bit securely in its handle in a bed of gum allowing a much higher pressure to be exerted on a much smaller stone than can be done if held by the fingers alone or even in a thong made from a vine. In terms of efficiency these tools allow through successive re-sharpening of for example, the adze flakes, a much greater amount of cutting at high pressures to be done from a unit weight of stone than with hand-held scrapers. They increase the efficiency improvement curve discussed previously.

In other cases however, it is hard to see how their performance was better than the tools they replaced. As Peterson (1971: 53) pointed out many years ago, a wooden spear is just as penetrating as one tipped with a stone point. Furthermore, it does not shatter so easily if the throw misses its target. If backed microliths were so efficient, why did they disappear from the New South Wales inventory over the past 2000 years?

To make these small tools, new sources of excellent raw materials were sought and these materials – cherts and chalcedonies – were carried and traded scores and sometimes hundreds of kilometres from quarries to places of manufacture. Local materials such as quartzite continued to be used for the scrapers. Mulvaney's paper in Tribes and Boundaries (1976) contains relevant examples of such trading networks and maybe these expanded in association with the appearance of the small tools.

Mulvaney (1976) has characterised these changes as marking a period when Australian society was 'quickened and transformed'. These transformations can probably be seen in art and disposal of the dead, two of the few aspects of intellectual and religious life capable of being investigated directly by archaeological methods.

The dead in Pleistocene Australia, as in Tasmania throughout its prehistory, were disposed of according to what Hiatt (1966) and Meehan (1971) called 'simple disposal' – that is, through cremation or inhumation or perhaps abandonment. In all cases the act of disposal was a single activity that took place more or less on one occasion, presumably soon after the death of the individual. By contrast compound disposal involved many separate activities, often separated by long periods of time, and requiring not only the co-operation of many individuals but the maintenance of those links over time for performance of ceremonies, the ceremonies themselves being at the very core of the Aboriginal religious system**.** Meehan (1971) has argued that archaeological evidence for compound disposal is restricted to the period of the small tools, and indeed that examples of such tools are found in the same layers as the funerary evidence. New data

from Broadbeach (Haglund 1976) in Queensland, and Roonka (Pretty 1977) in South Australia, provide profound demonstration of the association.

In Arnhem Land the components of a spear not uncommonly originate in widely-separated locations. The stone tip comes from a certain quarry, the gum from a forested area some distance away, the binding from the coastal hibiscus plant, the ochre from a mine perhaps 100 kilometres away in one direction, white clay from 20 kilometres away in the opposite direction. The stone, wrapped in paper bark from a swamp, has travelled along a trade route from one person's curatorship to another's and may be used in men's secret ceremonies. The spear has this in common with compound disposal**: i**n both cases, what previously could be carried out by one person or a small group within a short period of time in one location, is transformed into the co-operative work of many people separated in time as well as in space. They both mark the same phenomenon that there has been a transformation of the organisation from simple to complex, that entropy has been reduced and that consequently the amount of available work put into the system has been increased.

Tasmania

To reach an understanding of Australian prehistory we must however turn to that brooding island to the south – Tasmania. At the height of the last Ice Age, some 24,000 years ago the sea had dropped sufficiently to expose a salty and dry road to the southern mountainous peninsula. Traces of man's occupation of the Bassian plain have been found on its high hills, still above the sea now on Erith, Flinders, King and Cape Barren Islands (Orchiston 1978, Lampert and Jones 1978). By 23,000 years ago he was camping in Cave Bay Cave on Hunter Island, and we have evidence from several sites in Tasmania for his occupation there in glacial times. His tools of stone and bone, were typical of the Late Pleistocene Australian core tool and scraper tradition and he carried over with him other aspects of that cultural tradition such as cremation of the dead and art style motifs. The art – geometric motifs and tracks – are found at Mount Cameron on the northwestern coast of Tasmania.

With the later melting of the ice the sea rose**,** and 12,000 years ago the Tasmanian part of Bass Strait between Wilson's Promontory and the Kent Group, was cut off from the Australian mainland. Men situated on the southern side of this rapidly widening strait were then doomed to the longest period of isolation of any people ever recorded in history.

In between Australia and Tasmania there are large blocks of land**,** some with mountains 700 metres high**,** that never became flooded. These could have supported between 300 and 500 people. Yet when Matthew Flinders saw them they were empty of man and his works. Archaeological work on the islands of Bass Strait indicates the absence of shell middens on the present shore and no sites younger than 8000 to 6000 years old. This suggests that no *significant* relict group was left behind stranded on the islands. These islands were abandoned when the water crossing to Tasmania became too dangerous.

We have then a situation where groups of the same order of size as a modern Tasmanian tribe, made a conscious decision not to be split off from the main bulk of the slowly retreating population. My own analysis here is that wherever the seasonal movements of bands of a tribe were cut off or the straits became too difficult to negotiate, the people themselves decided to relocate themselves on the larger or higher of the two pieces of land being severed. By being unwilling to divide their perceived minimum acceptable social group, they consigned a total of some 10,000 square kilometres of prime coastal country, both in actual and symbolic terms, to the domain of the dead.

Kangaroo Island is a marginal and subtle example of this same process in action. Meticulous fieldwork by Lampert (1972) has shown that some half a dozen sites on this island dating from 8000 to 3000 years ago and thus postdating its separation from the mainland (Lampert pers, comm.; cf. Clark and Lampert 1977: Appendix 1, based on an unpublished paper given at the 48th ANZAAS Congress, Melbourne 1977). Do these represent the tenuous hanging on of a slender strand of humanity, never bigger than a few families or a band, its lines of culture and genes stretched taut for thousands of years like a spider escaping a predator down a long sliding thread until its snaps due to the whims of cruel chance? Or, as I feel was the case, do we have here an example of an island not quite big enough for people to stay on it and thus abandoned at

its severance from the mainland; yet close enough – 14.5 kilometres - to have over thousands of years the odd random human visitor or refugee?

A few months ago on Steep Head Island, less than one square kilometre in area, the mutton bird yield for six weeks work was **10 to the 7th** kilocalories, enough to feed 50 people for one year. On the Bass Strait islands there were plenty of calories but not enough bits!

Tasmania was big enough not to be abandoned by its human population on its severance from the mainland but in cultural terms its inhabitants paid a penalty for their separation in two ways. Firstly, they were cut off from the developments on the continent in mid-recent times – no small tools and associated cultural richness, no dogs. In addition during their long stay away from the rest of the world, there was a steady loss of technology, a diminution of foods eaten, a constriction of the intellectual matrix. What a terrible fate. Of the things lost in Tasmania somewhere between Pleistocene Australia and the 18th century AD we might infer the concept of hafting, of edge grinding axes, boomerangs, barbed and composite spearheads. We might explain these reductions by reference to a general theorem that the number of ideas is proportional to the number of minds interacting or, on a more general note, that a closed system will, according to the terrible Second Law, move always so that entropy is increased, coherence reduced. This has been the fate of all isolated island groups. Cassels (1976) has argued that the distribution of domestic animals in Oceania is better explained by their tendency to go extinct on small and remote islands than by their failure ever to have been brought there by humans and the same, he says, applies to pottery (within the limits of its spread). A similar process happened on the island of St Kilda until one day half the population decided to move to a place on Port Phillip Bay.

Entropy increase is the fate of all isolated human systems. This is the profoundest message that Tasmanian prehistory can give us. Here in Tasmania with the longest isolation, we also had the simplest technology of any known human group. Yet there remains a paradox – that despite the vast quantum of difference between the technologies of 18th century Tasmania and the Australian mainland, the absolute numbers and the organisation of Tasmanians and Australians on the ground, in similar ecological areas, was within the same order of magnitude. What therefore was the role of the basic toolkit of the Tasmanians? And what was the role of that elaboration on the mainland subsequent to the separation of the two blocks of land?

I appreciated Lourandos' (1977) important paper in Archaeology and Physical Anthropology in Oceania. He has shown that population densities in the western districts of Victoria are much higher than in Tasmania. (You could also show they are much higher than say for example, on the southern coast of New South Wales.) He has also shown that the population of western Victoria is similar to those in the tropical north.

In Tasmania there is one fundamental absence – the great religious ceremonies, the elaboration of dance and art, the convolutions of the mortuary process, the lack of designs engraved onto the objects of the chase. Here there are no vistas of hundreds of men acting out vast allegorical plays, no songs in the night under a full moon that control half the hunting capacity of the society for months, no times when the entire society is engaged in the consummation of a single act at the very core of its intellectual creative and emotional energy, an act which reverberates through relationships and tools and ideas and social needs over an area of thousands of square kilometres. These things are here in Tasmania but in a terribly attenuated form, like a coastal pine tortured and bent against its growth by the wind.

Jim Allen has asked the rhetorical question: What was it like to be a Tasmanian, knowing your world was finite and knowing about every other person in it? Perhaps there had even been a loss of cultural memory that there ever existed another world, that their small finite universe consisted of the entire limit of mankind.

I have tried to quantify the size of the Tasmanians' social matrix. The total number of potential face-to-face contacts of adults in Tasmanian society during an annual cycle of seasonal movements, as calculated using all the possible combinations of one against one, was some 300,000. This is the same number as all the handshakes of everybody shaking hands with everybody else in a room containing 650 people. This is

the total maximum potential social matrix in Tasmania year after year, millennium after millennium. If the total number of different face-to-face contacts – 10 to the 3rd, 10 to the 4th, 10 to the 5th – is plotted against different sorts of organisation of 1000 people, a long curve is produced. If you have 200 groups - each one like a family – 200 families separate in space and calculate all the face-to-face contacts of five people against each other; or you have 20 groups of 50 people, or you have five groups of 200 people (which in the Tasmanian situation is the maximum), or you have 1000 people which is what Lourandos (1977) has shown for western Victoria, and is also partly the case in Arnhem Land, keeping 1000 people solid, the total face-to-face contacts goes up in an exponential curve.

We see that there is an exponential relationship between the internal organisation of a single, total-sized group of people and the total number of possible one-by-one combinations. The genius of Aboriginal society was to invent a system of intensification which, while allowing the population to remain more or less constant, invested the necessary energy gained by technological development into an internal re-organisation which satisfied the higher needs of the intellect, art and religion. This lies at the very crux of our understanding of Australian prehistory.

This re-organisation, this intensification of organisation, which involved bringing the maximum possible number of people together in one place for a socially significant period of time, was powered in a number of different ways. Seasonally rich and locationally-concentrated resources were exploited as was the case with the Bogong moth in the Snowy Mountains (Flood 1973) – elements of tribes coming together from hundreds of kilometres from the east and the west. Sometimes such resources did not occur every year but intermittently as is the case with the Bunya pine of southeastern Queensland (Sullivan 1977).

Technological investments were made into the construction of structures or machines which enabled a lot of food to be captured at one time and place – the stone fish traps of Brewarrina in western New South Wales, woven fish traps of the tropical estuaries, the earth dams in western Queensland and, most fascinatingly, the kilometre-long ditches and associated traps for facilitating the movement, catching and perhaps even breeding of eels which Lourandos (1977) has demonstrated for western Victoria. All of these required co-operative action by many people and forward planning to make the device 'now' for some future time. There was nothing of this planning in Tasmania.

Macrozamia nuts leached and baked, were the carbohydrate staple all down the east coast of Australia. A similar product from the related Cycas armstrongii grows in Arnhem Land is so identified with the staff of life that its name in various dialects – ngacha or ngathu – is also the name for all carbohydrate food and the slang name for European flour and bread. Current work by Beaton (1977) has pointed out the terrors of this plant in its unleached form. It not only causes what is called 'zamia staggers', a paralysis of the central nervous system in cattle, but is also probably the greatest cancer-forming agent known in the natural world. Here there is no question of a gradual adaptation to the use of this plant. Once the detoxifying technique is acquired, however, the yield in terms of Aboriginal requirements is almost unlimited**,** being a function only of the work invested. Beaton (1977) has found husks of Macrozamia right to the base of his rock shelters in the southern Queensland highlands back to about 4000 years. These are associated with backed microliths and other small tools and the deposits mark the first substantial and general occupation of the region. Beaton's (1977) theory is that knowledge of how to treat Macrozamia then allowed large numbers of people periodically to congregate in this previously rather intractable area and that the associated microliths and the exotic raw materials from which they are made are, in a sense, just the debris of communication, symptoms of the enlargement of the social network which Macrozamia powered.

Meehan and I (Jones and Meehan 1989: 123-24) could see all these processes at work between July and August of 1972 at the great camp at Ngalijibama near the mouth of the Blyth River. On this sacred ground a small number of men initiated a Gunabiba ceremony, their numbers swelling to hundreds at the climax and including representatives from most languages on the north coast of Arnhem Land. To feed this multitude were the women. Shellfish were gathered on some 70-80 percent of days, compared to only 55 percent in the later domestic dry season camp (Meehan 1975). Women working eight hours a day gathered, de-husked, dried, smashed, leached, ground and, finally baked the ngacha bread from Cycad. This process produced an average of 1400 kilocalories per woman hour. Some women produced 45 kilograms of bread in four or

five working days. Men not engaged in the ceremony dug the wells in which the ngacha was leached and also fished with hooks and lines, low-key activities.

The main limitation on the annual yield of cancer-free bread was a shortage of water for leaching purposes in the late dry season. Man power could have been invested in the construction of dams for the storage of water from the wet season surplus or even the building of aqueducts from the freshwater stretches of the Blyth River, only 15 kilometres away. This was not done and for that reason those people – mostly women and some men who for a few weeks or months had laboured like agricultural peasants – were released from their voluntary bondage. The men, having fulfilled their religious obligations, returned to society and shifted the centre of gravity of the chase back to what it had been before the ceremony had begun. The frequency of shellfish gathering dropped and ngacha became a rare delicacy, like pieces of a wedding cake.

Rousseau (1753) said that:

'…so long as men undertook only what a single person could accomplish and confined themselves to such arts as did not require the joint labour of several hands, they lived free, healthy, honest and happy lives. But from the moment one man began to stand in need of the help of another; from the moment it appeared advantageous to any man to have enough provisions for two, equality disappeared, property was introduced, work became indispensable and, vast forests became smiling fields, which men had to water with the sweat of their brow, and where slavery and misery were soon seen to germinate and grew up with the crops'.

In the ecological world an Aboriginal man could [and can] do all things: get his foods, make his tools. He is self-sufficient. And yet in the religious world he can do on his own almost nothing. In the world of the intellect he has defined himself into a system of reciprocal inequality. Here is an intensification that did not lead to degradation or a diminution of resources. It was an intensification that did not lead to tyranny.

The Wahgi Valley

A year ago I would have finished at this point. However, recent discoveries by Golson and Hughes (1997; Philip Hughes pers. comm.. 1977) have indeed altered our whole interpretation of Australian prehistory. In the Waghi Valley in Papua New Guinea, dominated by mountains rising to some 3000 metres, they have found deep in a swamp a large ditch that they have traced over some half kilometre of its length. It is two metres wide and a metre and a half deep. This ditch is well-dated to 9000 years and Hughes thinks it must extend another one and a half kilometres to an outfall at the Wahgi River. Associated with it are other structures, again dating to 9000 years, almost certainly indicating the horticulture of taro. This was a drainage ditch of huge scale that deflected water away from the swamp.

This is a complex system that must have required a much longer period of adjustment before arriving up in the mountains. Indeed Hughes (Golson and Hughes 1977: 20) has argued that there is very little possibility that it could have arrived there before because of the ice age. We do not know how long there has been horticulture in New Guinea, but soon after the ditch had begun operating, there is evidence of clay washing down from the hills of the swamp catchment as a result of classic Brandwirtschaft or slash and burn cultivation. Here we have co-ordinated horticulture, probably based on the imported plant taro.

What this mean for Australian archaeology. At the time these drainage ditches were constructed in the Wahgi Valley there was a substantial land bridge linking northern Australia to New Guinea. Aboriginal people were living on the plain that was then the northern part of Australia and in New Guinea there existed a fully-functioning taro-producing horticultural system.

In Australia we have for a very long time been able to shrug off the problem of why horticulture did not occur here – it was isolated, it did not come across because of the sea. However, at the time of the Wahgi Valley developments, 9000 years ago, the same situation as this existed in the Fertile Cresent in the Middle East. The archaeological problems associated with having a range from full horticulture through to hunters in the high altitude regions is precisely the same for Australia as it is for the Middle East and Europe.

The question then has to be formulated: Did horticulture and all that it meant in terms of a different style of intensification, not come to Australia because of ecological factors, because we lie south of the closed tropical rainforest? Is it a situation just of time – that is, as intensification was about to sweep across, the water rose and saved Australia as if the sea had made the Bosphorous too wide for boat crossings? Or have we already got within this continental landmass, the distinctive Aboriginal contribution to history – a method of increasing its social intensification without leading to a degradation of resources?

As we observe Tasmania on a larger scale, this is probably the most important thing that Aboriginal history has to tell us. Thank you.

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