Chapter Nineteen

Of string bags and birds' nests

Skill and the construction of artefacts

BEYOND ART AND TECHNOLOGY

'Art' and 'technology' are mere words. And as with all words, their meanings are not fixed but have changed significantly in the course of their history. They are still changing. But I believe it remains true of modern – if not post-modern – thought, that the meanings of art and technology are held to be somehow opposed, as though drawn from fields of human endeavour that are in certain respects antithetical. This opposition, however, is scarcely more than a century old, and would have seemed strange to Anglophone ears as late as the seventeenth century, when artists were still considered no different from artisans, when the methods of working in any particular branch of art could be described as 'technical', and when the term 'technology' had just been coined to denote the scientific study of these methods (Williams 1976: 33–4). Etymologically, 'art' is derived from the Latin *artem* or *ars*, while 'technology' was formed upon the stem of the classical Greek *tekhnē*. Originally, *tekhnē* and *ars* meant much the same thing, namely *skill* of the kind associated with craftsmanship (see Chapter Fifteen). The words were used, respectively in Greek and Roman society, to describe every kind of activity involving the manufacture of durable objects by people who depended on such work for a living, from the painter to the cobbler, from the temple architect to the builder of pigsties. This is not to say that customers failed to distinguish between aesthetic and utilitarian criteria in their estimations of the objects produced. But in every case, it was the craft skill of the practitioner that was supposed to ensure a successful outcome (Burford 1972: 13–14).

The connotation of skill is preserved in many words derived from the same roots and that remain in common currency today. On the one hand we have 'technics' and 'technique'; on the other hand such terms as 'artless' – meaning clumsy or lacking in skill – and, of course, 'artefact'. Yet the apparent continuity masks an important shift, towards abstracting the components of intelligence, sensibility and expression that are essential to the accomplishment of any craft from the actual bodily movement of the practitioner in his or her environment. Thus the technique of the pianist comes to refer to the practised ability of his fingers to find their way around the keyboard and to hit the desired notes, as distinct from the inherent musicality of the performance. 'A player may be perfect in technique', wrote Sir Charles Grove, 'and yet have neither soul nor intelligence'. Likewise, we have come a long way from the days when, as in the year 1610, it was possible to eulogise a certain composer as 'the most artificial and famous Alfonso Ferrabosco' (Rooley 1990: 5). As David Lowenthal has observed, 'time has reversed the meaning of artificial from "full of deep skill and art" to "shallow, contrived and almost worthless"' (1996: 209). By the same token, the artefact is regarded no longer as the original outcome of a skilled, sensuous engagement between the craftsman and his raw material, but as a copy run off mechanically from a pre-established template or design. This debasement of craft to the 'merely technical' or mechanical execution of predetermined operational sequences went hand in hand with the elevation of art to embrace the creative exercise of the imagination (Gell 1992b: 56). As a result, the artist came to be radically distinguished from the artisan, and the art-work from the artefact (Coleman 1988: 7).

The decisive break, according to Raymond Williams, came in the England of the late eighteenth century, with the exclusion of engravers from the newly formed Royal Academy, which was reserved for practitioners of the 'fine' arts of painting, drawing, and sculpture (Williams 1976: 33). It was, of course, symptomatic of a general tendency to distinguish intellectual from manual labour, along the common axis of a more fundamental series of oppositions between mind and body, creativity and repetition, and freedom and determination. But the more that 'art' came to be associated with the allegedly higher human faculties of creativity and imagination, the more its residual connotations of useful but nevertheless habitual bodily skills were swallowed up by the notion of technology. For by the beginning of the twentieth century this term, too, had undergone a crucial shift of meaning. Where once it had referred to the framework of concepts and theory informing the scientific study of productive practices, technology came to be regarded as a corpus of rules and principles installed at the heart of the apparatus of production itself, whence it was understood to generate practice as a programme generates an output. Technology, now, did not discipline the scholar in his study of techniques, but rather the practitioner in his application of them. He became, in effect, an operative, bound to the mechanical implementation of an objective and impersonal system of productive forces.[1]

Here, then, lies the source of the now familiar division between the respective fields of art and technology. An object or performance could be a work of art, rather than a mere artefact, to the extent that it escapes or transcends the determinations of the technological system. And its creator could be an artist, rather than a mere artisan, insofar as the work is understood to be an expression of his or her own subjective being. Where technological operations are predetermined, art is spontaneous; where the manufacture of artefacts is a process of mechanical replication, art is the creative production of novelty. These distinctions can be multiplied almost indefinitely, but they are all driven by the same logic, which is one that carves out a space for human freedom and subjectivity in a world governed by objective necessity. As I have shown in Chapter Seventeen (pp. 329–30), it is a logic that operates as much in the field of exchange as in that of production. Thus the modern distinction between the true work of art and the replicated artefact has its parallel in that between the 'pure gift' and the market commodity: the former given spontaneously and motivated (at least in theory) by personal feeling; the latter exchanged in line with impersonal calculations of supply and demand. But in both fields the distinctions are recent, and closely tied to the rise of a peculiarly modern conception of the human subject.

The division between art and technology, as it has come to be institutionalised in modern society, has affected anthropology as much as any other field of inquiry. Until fairly recently, the literatures in the anthropology of art and in the anthropology of technology remained almost completely isolated from one another. Technology was located within the sphere of ecological adaptation, mediating the material relations between human populations and their environments. For assorted cultural ecologists, cultural materialists, and Marxists, the conjunction of environment and technology – if not actually determinant of cultural form – constitutes the foundation upon which the house of culture is built. Art, by contrast, along with such forms as myth and ritual, is supposed to comprise the patterns on the walls, the world of sensory experience as it is refracted through the filters and lenses of the cultural imagination. It mediates a dialogue, not between human beings and nature, but among persons in society. Like language, it encodes meanings. Thus technology works; art signifies: technical action is aimed to produce results in a mechanically determined way, whereas the purpose of art is to communicate ideas. In short, art has been split from technology along the lines of an opposition between the mental and the material, and between semiotics and mechanics (see Chapter Sixteen, pp. 317–18).

Despite the apparent symmetry of this opposition, the respective trajectories of the anthropologies of art and technology have been decidedly asymmetrical. Having been placed beyond the pale of culture and society, as a quasi-autonomous system of productive forces, technology was largely neglected as a subject of anthropological inquiry. Only very recently has the anthropology of technology, as a subfield, begun to acquire a significant momentum of its own. The anthropology of art, by contrast, has long held a secure place in the discipline. But the very reasons that have led to the inclusion of art as an object of study for anthropologists – namely, that it is clearly positioned within a social context and embodies cultural meaning – have also given rise to persistent doubts about the cross-cultural validity of the concept of art itself. How can a concept that carries such strong evaluative overtones, and whose meaning is so closely bound up with widely held ideas about the ascendancy of Western civilisation, possibly be applied without courting accusations of ethnocentrism? Not for the first time, the very credentials that make a phenomenon eminently worthy of anthropological study have cast a pall of uncertainty over whether the phenomenon exists 'as such' at all. It happened with the study of kinship, it happened with the study of art, and now that anthropologists are at last beginning to recognise the social embeddedness of technological systems, it is happening to the study of technology too. No sooner is technology reclaimed for anthropological inquiry, than we cease to know, for sure, what we are dealing with.

The source of the problem, in my view, lies not in the concept of art, nor in that of technology, but in the dichotomy between them. It is this, along with the idea that art floats in an ethereal realm of symbolic meaning, above the physical world over which technology seeks control, that is tainted by its association with modernity. The idea would have made no sense to the craftsmen of Ancient Greece or Rome. They knew what they meant by *tekhnē* or *ars*, and it was a matter neither of mechanical functioning nor of symbolic expression, but of skilled practice. It is my contention that by going back to the original connotations of *ars* and *tekhnē* as skill, we can overcome the deep divisions that currently separate the anthropologies of art and technology, and develop a far more satisfactory account of the socially and environmentally situated practices of real human agents. In what follows I shall pursue three aspects of this task. First, I explain in more depth what I mean by skill. Secondly, I show how the continuity of tradition in skilled practice is a function not of the transmission of rules and representations but of the coordination of perception and action. Thirdly, I show how a focus on skill explodes the conventional dichotomy between innate and acquired abilities, forcing a radical reappraisal of the ways we think about what is 'cultural' and 'biological' in humans. I shall illustrate my argument by way of two examples: Maureen MacKenzie's (1991) study of the looping skills involved in making string bags (*bilum*) among Telefol people of Central New Guinea, and the study by N. E. and E. C. Collias (1984) of the nest building skills of the male weaverbird.

FIVE DIMENSIONS OF SKILL

I begin by drawing attention to five points which I believe are crucial to a proper appreciation of technical skills. The first concerns what it means to say that practice is a form of *use*, of tools and of the body. In one of his dialogues, Plato has Socrates debate with a character called Alcibiades on precisely this question. 'What are we to say of the shoemaker?', asks Socrates, 'Does he cut with his tools only, or with his hands as well?' Alcibiades is forced to concede that he does indeed cut with his hands, and moreover that he uses not just his hands but his eyes – and by extension his whole body – to accomplish the work. Yet he had already agreed, with Socrates, that there is a fundamental difference between the user and the things he uses. So who is this user? If it be man, counters Socrates, it cannot be his body, which is used. Only one possibility remains, it must be the soul. 'So', he concludes, 'do you require some yet clearer proof that the soul is man?' Alcibiades is convinced (in Flew 1964: 35–7).

There is no reason, however, why we should have to follow suit. 'It would be wrong to assume', as Roger Coleman caustically remarks, 'that because Plato was a Greek he knew what he was talking about'. He was no craftsman, and had no practical experience whatever of shoemaking or any other trade. Plato's objective, in forcing a division between the controlling mind and subservient body, was to establish the supremacy of abstract, contemplative reason over menial work, or of theoretical knowledge over practical application, and thereby to justify the institution of slavery (Coleman 1988: 11–12). Resurrected in the Renaissance, Plato's division anticipated the debasement of craft that, as we have seen, came to be one of the hallmarks of modernity. To recover the essence of skill we need a different concept of use from the one invoked by Plato. Instead of thinking of use as what happens when we put two, initially separate things together – an agent with certain purposes or designs, and an instrument with certain functions – we can take it as the primary condition of involvement of the craftsman, with his tools and raw materials, in an environment. In this sense the hands and eyes of the shoemaker, as well as his cutting tools, are not so much used as *brought into use*, through their incorporation into an accustomed (that is usual) pattern of dextrous activity. Intentionality and functionality, then, are not pre-existing properties of the user and the used, but rather immanent in the activity itself, in the gestural synergy of human being, tool and raw material.

My second point follows from this. It is that skill cannot be regarded simply as a technique of the body. This was the position advocated in a now classic essay by Marcel Mauss (1979[1934]). Taking his cue explicitly from Plato, Mauss observed that technique does not, in itself, depend upon the use of tools. Song and dance are obvious examples. The dancer, according to Mauss, uses his own body as an instrument; indeed so do we all, he declares, for the body is surely 'man's first and most natural technical object, and at the same time technical means'. Moreover in the deployment of these means, the human agent experiences the resulting bodily movements as 'of a mechanical, physical or physico-chemical order' (p. 104). This reduction of the technical to the mechanical is an inevitable consequence of the isolation of the body as a natural or physical object, both from the (disembodied) agency that puts it to work and from the environment in which it operates. To understand the true nature of skill we must move in the opposite direction, that is, to restore the human organism to the original context of its active engagement with the constituents of its surroundings. As Gregory Bateson argued, by way of his example of the skilled woodsman notching with an axe the trunk of a tree he is felling, to explain what is going on we need to consider the dynamics of the entire man–axe–tree system

(1973: 433). The system is, indeed, as much mental as physical or physiological, for these are, in truth, but alternative descriptions of one and the same thing. Skill, in short, is a property not of the individual human body as a biophysical entity, a thing-in-itself, but of the total field of relations constituted by the presence of the organism-person, indissolubly body and mind, in a richly structured environment. That is why the study of skill, in my view, not only benefits from, but *demands* an ecological approach.

Granted that the foundations of skill lie in the irreducible condition of the practitioner's embeddedness in an environment, it follows – and this is my third point – that skilled practice is not just the application of mechanical force to exterior objects, but entails qualities of care, judgment and dexterity (Pye 1968: 22). Critically, this implies that whatever practitioners do *to* things is grounded in an attentive, perceptual involvement *with* them, or in other words, that they watch and feel as they work. As the Russian neuroscientist Nicholai Bernstein argued some fifty years ago, the essence of dexterity lies not in bodily movements themselves, but in the responsiveness of these movements to surrounding conditions that are never the same from one moment to the next (Bernstein 1996). Given the freedom of movement of the limbs as well as the elasticity of the muscles, Bernstein had observed, it is just not possible to control the movements of the body in the same way as one might the workings of a machine made up of rigid, interconnecting parts. From a close study of the movements of a skilled blacksmith, hitting the iron on the anvil over and over again with a hammer, Bernstein found that while the trajectory of the tip of the hammer was highly reproducible, the trajectories of individual arm joints varied from stroke to stroke. At first glance the situation appears paradoxical: how can it be that the motion of the hammer rather than that of the limbs is reliably reproduced, when it is only by way of the limbs that the hammer is made to move (cf. Latash 1996: 286)? Clearly, the smith's movements cannot be understood as the output of a fixed motor programme, nor are they arrived at through the application of a formula. The secret of control, Bernstein concluded, lies in 'sensory corrections', that is in the continual adjustment or 'tuning' of movement in response to an ongoing perceptual monitoring of the emergent task.

All this has implications for the way skills are learned, which brings me to my fourth point. If, as Bernstein contended, skilled practice cannot be reduced to a formula, then it cannot be through the transmission of formulae that skills are passed from generation to generation. Traditional models of social learning separate the intergenerational transmission of information specifying particular techniques from the application of this information in practice. First, a generative schema or programme is established in the novice's mind from his observations of the movements of already accomplished practitioners; secondly, the novice imitates these movements by running off exemplars of the technique in question from the schema. Now I do not deny that the learning of skills involves both observation and imitation. But the former is no more a matter of forming internal, mental representations of observed behaviour than is the latter a matter of converting these representations into manifest practice. For the novice's observation of accomplished practitioners is not detached from, but grounded in, his own active, perceptual engagement with his surroundings. And the key to imitation lies in the intimate coordination of the movement of the novice's attention to others with his own bodily movement in the world. Through repeated practical trials, and guided by his observations, he gradually gets the 'feel' of things for himself – that is, he learns to fine-tune his own movements so as to achieve the rhythmic fluency of the accomplished practitioner (for an example, see Gatewood 1985). And in this process, each generation contributes to the next not by handing on a corpus of representations, or information in the strict sense, but rather by introducing novices into contexts which afford selected opportunities for perception and action, and by providing the scaffolding that enables them to make use of these affordances. This is what James Gibson (1979: 254) called an 'education of attention'.

It is because practitioners' engagement with the material with which they work is an attentive engagement, rather than a mere mechanical coupling, that skilled activity carries its own intrinsic intentionality, quite apart from any designs or plans that it may be supposed to implement (see Chapter Twenty-three, p. 415). My fifth point follows from this, and has to do with what we mean by making things. Let me return for a moment to the example of Socrates and the shoemaker. Socrates had asked what it means to say of the shoemaker that he uses tools. The other side of the question is to ask what it means to say that he makes shoes. If use, as Socrates maintained, is what happens when you put an agent having a certain purpose together with objects having certain functions, then the purpose must precede the use through which it is realised. In these terms, to refer to an action as one of making is to refer back to the prior intention that motivates it. It is as though the form of the manufactured object were already prefigured, as a design, in the mind of its maker, such that the activity of making issued directly from the design and served only to transcribe it onto the material. The assumption that every form is the outward expression of design is, as we saw in the last chapter, as prevalent in biology as it is in technology. Thus the form of an organism is said to be given in an evolved design specification, the genotype, in advance of its phenotypic 'expression' in an environment. And in modern architecture the form of a construction is supposed exist in miniature, in models, drawings and plans, before any building work begins (Coleman 1988: 16). To take this view, however, is to deny the creativity of the very process of environmentally situated and perceptually engaged activity, that is of *use*, through which real forms emerge and are held in place. It is the activity itself – of regular, controlled movement – that generates the form, not the design that precedes it. Making, in short, arises within the process of use, rather than use disclosing what is, ideally if not materially, ready-made.

HOW TO MAKE A STRING BAG

Among the Telefol people of central New Guinea, and indeed throughout this region, one of the most ubiquitous and multifunctional accessories to everyday life is the string bag or *bilum*. It is made by means of a looping technique from two-ply string spun from plant fibres. Children are introduced to the techniques of *bilum* making from a very early age. All young Telefol children, both boys and girls, help their mothers and elder sisters in preparing fibres for spinning. 'From the age of about two onwards they begin to experiment with roving, rolling the shredded fibres down their thigh to make a single ply, and progress to experiments with spinning. It is not uncommon to see very young girls, mere toddlers, diligently attempting to loop the string they have made into bilum fabric' (MacKenzie 1991: 101). Boys, as they grow older, do not go on to master fully the skills of looping, for the simple reason that they are soon removed, by the conventions of their society, from the sphere of women's activities. Men have no need to make their own bags, as these are willingly supplied for them by women, who thus maintain an effective monopoly on *bilum* making. Girls, by contrast, remain close to their mothers and other female relatives, and continue to develop their skills, quietly and unobtrusively following in their mothers' footsteps.

All the points I have made about skill, in the previous section, apply to the making of string bags. Apart from the maker's body – and especially her fingers – the only tools used are the mesh gauge (*ding*), made from a strip of leaf, to maintain the constancy of the mesh in an open weave (see Figure 19.1), and the needle (*siil*), made of bone, which is needed for making tightly looped baskets without the use of the gauge (MacKenzie 1991: 73). But in use the needle or the gauge, along with the fingers that hold it, are as much a part of the user as they are used. Moreover the accomplished *bilum*-maker does not experience the movements of her body as being of a mechanical nature. Far from answering to commands issued from a higher source, they carry their own intentionality, unfolding in a continual dialogue with the material. Telefol people liken this movement to the flowing water of a river. Thus the body-in-use is not moved, like a rigid object,

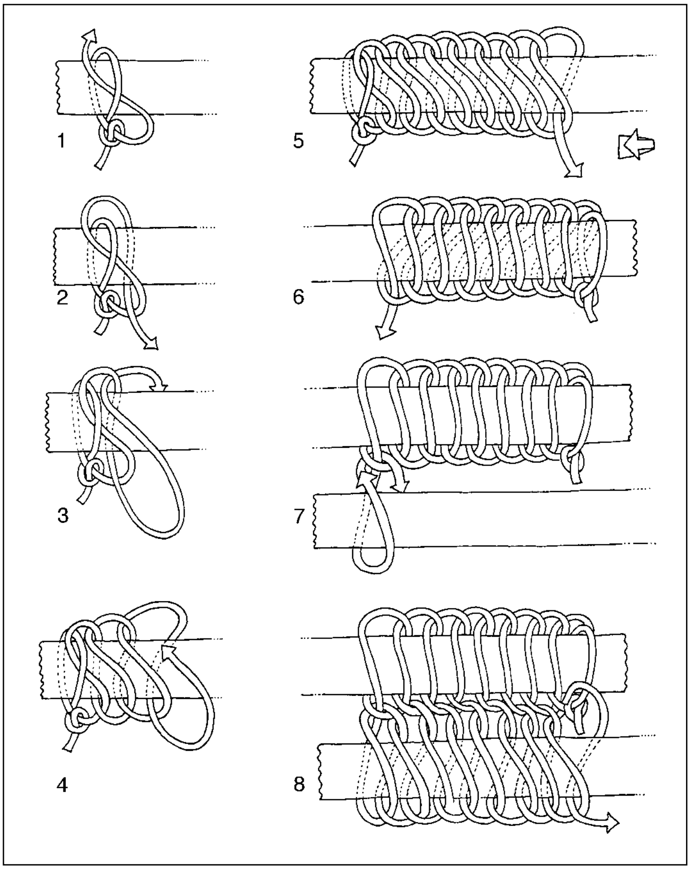

Figure 19.1 The step-by-step procedure for looping a flat strip of 'open, spaced' *bilum* fabric, as practised by Telefol people of central New Guinea. Steps 1–4 show how the first row of loops is constructed around the mesh gauge (*ding*), in a series of figure-of-eight loops with each loop connecting into the preceding one. By stage 5 the first row of loops is completed to the desired width. On completion of each row the work must be turned over so that the working thread is always on the left-hand side. In step 6 the work is thus reversed. Step 7 illustrates how a new strip of *ding* is inserted at the beginning of each successive row. This linear way of working, with each row connecting into the loops of the preceding one, is then repeated (step 8).

From MacKenzie, *Androgynous Objects: string bags and gender in central New Guinea*, published by Harwood Academic, 1991, pp. 86–7.

but rather becomes one with the flow (p. 102). However, in order to maintain the evenness of the string, in spinning, or of the weave, in looping, it is necessary to make continual adjustments in the course of the movement itself. 'By adolescence', MacKenzie writes, 'all girls have mastered the technique of spinning, gaining visual acuity in selecting equal assemblages of filaments during the roving process; and a sensitivity or balance in the amount of pressure applied between palm and thigh during the rhythmic plying motion' (p. 76). As this passage clearly reveals, dexterity in spinning depends on the fine-tuning of visual as well as haptic perception. And it is equally clear that the form of the *bilum* is an emergent outcome of rhythmically repeated, controlled movement in the processes of spinning and looping.

The issue on which I want to focus here, however, concerns how *bilum*-making skills are passed from generation to generation. MacKenzie herself describes this in terms of a fairly conventional model of social learning, according to which 'observation is followed by internalisation and then mimesis' (p. 100). Thus by watching the activity of her mother, a young girl absorbs and assimilates the 'intrinsic rules' of the craft. Once these are firmly implanted in her mind, she can proceed to execute them in the production of her own work. The fact that 'each daughter follows exactly the motor habits and bodily motions of her mother' leads to a remarkable cultural conformity from one generation to the next (p. 103). There is much in MacKenzie's own account, however, to suggest that conformity to tradition is *not* a consequence of the intergenerational transmission of rules or formulae, however intrinsic, but rather the result of a process of guided rediscovery in which the role of experienced *bilum*-makers is to set up the contexts within which novices are enabled to gain in proficiency for themselves, or in other words to 'grow into' the skills of spinning and looping.

First of all, it is clear that to advance in these skills it is not enough for the novice to know how their constituent movements look 'from the outside'; she has also to know how they feel 'from the inside' (cf. Bernstein 1996: 184–5). One young woman, recalling how she learned to loop as a child, told of how she had once tried to carry on with an unfinished *bilum* that her mother had left in the rafters of the house before leaving to work in the garden. She had been carefully watching the way her mother's hands moved as she looped the *bilum*. But on trying it out herself, the result was a disaster. When her mother returned, it took her hours to undo the mess. At first she was angry, but then she lectured her daughter with the following words of wisdom:

> You must practise to get the proper feel of looping. When you've made your first bilum it will be cranky but then we'll throw it in the river. The river will carry your wonky bilum away, and it will wash away your heavy handedness. Then your hands will be good at making bilums, your hands will move easily like running water.
>
> (from MacKenzie 1991: 102)

What does it mean to get the 'feel' of looping? It could mean that the observation on which learning depends is as much tactile as visual, or that the skill is embodied as a rhythmic pattern of movement rather than a static schema, or that the key to fluent performance lies in the ability to co-ordinate perception and action. All three are undoubtedly important, but none more so than the third. For it is this, as MacKenzie herself observes, that makes the difference between clumsiness and dexterity, between having heavy hands and hands that flow. 'Clumsiness, *iluum t'eb'e su* [to be heavy handed], is deemed natural at first, and must be practically worked through' (p. 103).

It seems, then, that progress from clumsiness to dexterity in the craft of *bilum*-making is brought about not by way of an internalisation of rules and representations, but through the gradual attunement of movement and perception. As in any craft, the skilled maker who has a feel for what she is doing is one whose movement is continually and subtly responsive to the modulations of her relation with the material. Conversely, the clumsy practitioner is precisely one who implements mechanically a fixed sequence of instructions, while remaining insensitive to the evolving conditions of the task as it unfolds. The hand that is heavy is experienced as a resistance to be overcome, and has to be moved from position to position in ways that seem contrary to its nature. The light hand, by contrast, finds its way of its own accord. The heavy-handed novice does not, of course, move in exactly the same way as her light-handed mother, nor can she be expected to produce such satisfactory results. This is precisely where the standard model of the social learning of technical skills goes wrong. For in attributing the intergenerational conformity of movements to rules that are transmitted and internalised *in advance* of their practical application in mimesis, the model assumes that practice is a matter of executing identical, rule-governed movements over and over again, leading to gains in speed, efficiency and automation. But a little girl, making her first *bilum*, is quite unable to produce these movements. Rather than repeatedly carrying out the same movements, generated from an already internalised schema, she is repeatedly set the same *task*, generated within the social context of mother–daughter relations. The ability to reproduce her mother's movements with precision, depending as it does on subtle sensory attunement, is not a natural foundation for enskilment but its consequence (cf. Reed and Bril 1996: 438).

Telefol women, according to MacKenzie, place great value on the standardisation of their looping techniques, since this is a way of confirming tribal identity (1991: 103). But I would contend that this standardisation is not brought about, as MacKenzie claims, by conformity to rules. Indeed there appear to be no rules, beyond general exhortations of the kind delivered by the mother to her daughter in the case described above, or vague 'rules of thumb' that help prepare the practitioner for her impending activity but in no way determine its course (Suchman 1987: 52). Like most commonplace practical skills, such as tying shoelaces in Western society, looping resists codification in the form of generative rules or algorithms (Dreyfus and Dreyfus 1987). One becomes aware of this simply by looking at the elaborate diagrams, accompanied by written commentary, by means of which MacKenzie attempts to explain the step-by-step procedure for open-spaced looping (pp. 83–99, and for an example, see Figure 19.1). Though these diagrams are admirable for their intended purpose, of ethnographic description, any attempt by the untutored reader to follow them in practice would likely lead to the same kind of tangle that the inexperienced Telefol girl produces, on secretly attempting to carry on with her mother's work. It would be quite mistaken to suppose that anything remotely equivalent exists in the native mind. But if standardisation does not follow from the application of rules, how are we to account for the persistence of technique from one generation to the next?

Partly in an attempt to answer this question, a group of us in the Department of Social Anthropology at the University of Manchester resolved to experiment with different ways of making knots. One of our experiments was to try making a completely unfamiliar and rather complicated knot, guided only by a manual which provided detailed verbal instructions and step by step diagrams. It turned out to be an immensely difficult and frustrating task. The problem we all experienced lay in converting each instruction, whether verbal or graphic, into actual bodily movement. For while the instruction was supposed to tell you how to move, one could only make sense of it once the movement had been accomplished. We seemed, almost literally, to be caught in a double bind, from which the only escape was patient trial and error. Of course we had resort to the instructions, but far from directing our movements, what they provided was a set of landmarks along the way, a means of checking that we were still on track. If we were not – if the tangle of string in front of us did not match the corresponding graph (and that, in itself, was not easy to discern) – there was no alternative but to unravel the whole thing and start again!

Our experiments seemed to lend strong empirical support for the view that the practices of knotting – which are, after all, among the most common and widely distributed in human societies – cannot be understood as the output of any kind of programme. They cannot, then, be learned by taking any such programme 'on board', as part of an acquired tradition, as if all you needed to know to make knots could be handed down as a package of rules and representations, independently and in advance of their practical application. In our experiments, despite having a manual to consult, we had to develop the necessary know-how from scratch. Generally speaking, of course, this is not a problem that novices face in real life. They are shown what to do by more experienced hands, as we have already seen in the case of the acquisition of looping skills by Telefol *bilum*-makers. But in seeking to emulate the work of the tutor, the novice is guided by the latter's *movements*, not by formal instructions that have somehow been already copied into his or her head. As Merleau-Ponty put it, citing the pioneering work of Paul Guillaume on imitation in children, 'we do not at first imitate others but rather the actions of others, and . . . find others at the point of origin of these actions' (1964b: 117, see also Bourdieu 1977: 87). It follows that the reproduction of movement patterns is a function not of the fidelity with which information specifying these patterns is copied from one generation to the next, but of the co-ordination of perception and action that lies at the heart of practical mimesis.

DISSOLVING THE DISTINCTION BETWEEN INNATE AND ACQUIRED SKILLS

It is obvious that Telefol girls have to learn to make string bags. It is not a skill that they are, in any sense, 'born with'. As MacKenzie notes, 'talent in bilum making, that is, having hands which flow, is [defined as] a physically acquired attribute rather than an inherent pre-disposition in the sense that westerners think of ability and talent' (1991: 103). My concern now is to look more closely at what it means to say that a particular skill is acquired rather than innate. I shall do so by way of another example, this time taken from the animal kingdom. For while we are used to thinking of human skills as belonging to this or that cultural tradition, the skills of non-human animals are commonly regarded as properties of their genetically encoded, species-specific nature. What are we to make, then, of the male weaverbird, which carries out the most intricate knotting and looping with its beak in the construction of its nest? The nest building of weaverbirds has been investigated in a remarkable series of studies by ornithologists N. E. and E. C. Collias, and in what follows I draw on their report (Collias and Collias 1984).

The nest is made from long strips torn from the leaves of grasses, which are intertwined in a regular lattice formed by passing successive strips over and under, and in a direction orthogonal to, strips already laid. It is held together, and attached to the substrate, by a variety of stitches and fastenings, some of which are illustrated in Figure 19.2. The bird uses its beak rather like a needle in sewing or darning; in this the trickiest part lies in threading the strip it is holding under another, transverse one so that it can then be passed over the next. The strip has to be pushed under, and through, just far enough to enable the bird to let go with its beak in order to shift its hold and pull it up on the other side. If the free end is left too short, the strip may spring back; pushed too far, it could fall to the ground. Mastering this operation calls for a good deal of practice. From an early age, weaverbirds spend much of their time manipulating all kinds of objects with their beaks, and seem to have a particular interest in poking and pulling pieces of grass leaves and similar materials through holes. In females this interest declines after about the tenth week from hatching, whereas in males it continues to increase. Experiments showed that birds deprived of opportunities to practise and denied access to suitable materials are subsequently unable to build adequate nests, or even to build at all. Indeed, fiddling about with potential nest material appears to be just as essential for the bird, in preparing itself for future building, as are the first experiments of Telefolmin toddlers in roving and spinning shredded fibres for their future *bilum* making (Collias and Collias 1984: 201, 206–7, 212, 215–20).

It is evident from the Collias' account that all the five qualities of skill which, as I have shown, are exemplified in the making of string bags by people of central New Guinea, are also manifest in the nest building of weaverbirds. Though the needle of the *bilum*-maker is detachable from the body whereas the bird's beak is not, in use both are not so much moved as incorporated into a habitual pattern of movement. The abilities of the weaverbird, just like those of the human maker of string bags, are developed through an active exploration of the possibilities afforded by the environment, in the choice of materials and structural supports, and of bodily capacities of movement, posture, and prehension. Furthermore, the key to successful nest building lies not so much in the movements themselves as in the bird's ability to adjust its movements with exquisite precision in relation to the evolving form of its construction. As Collias and Collias report:

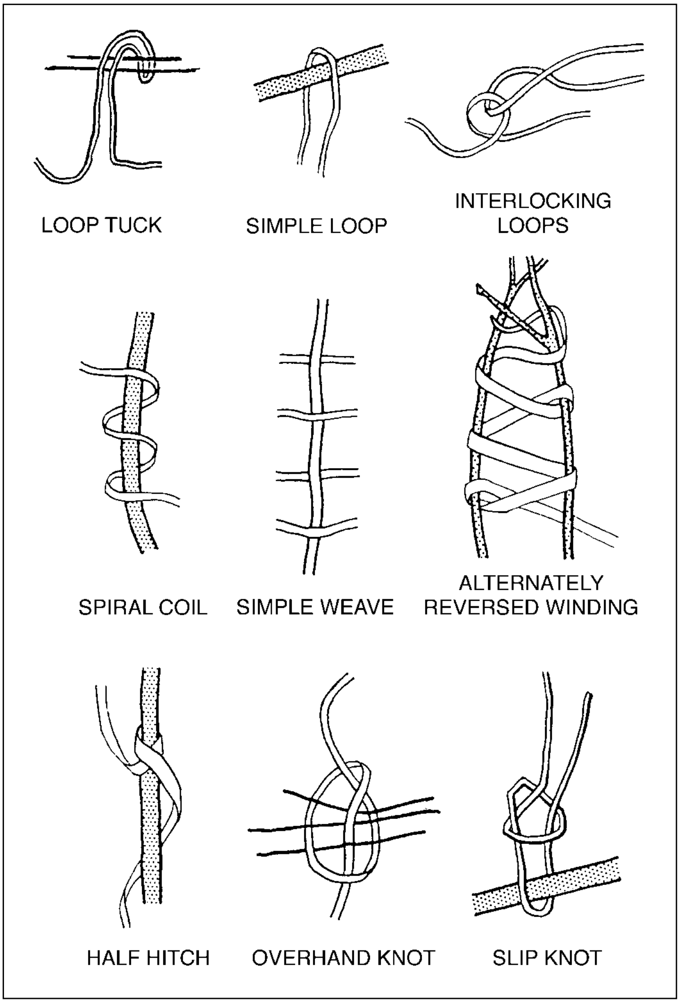

Figure 19.2 Various common stitches and fastenings used by male weaverbirds in constructing their nests.

From N. E. Collias and E. C. Collias, *Nest Building and Bird Behavior*, © 1984 by Princeton University Press, reprinted by permission of Princeton University Press.

> In watching the numerous attempts of young male weavers to fasten initial strips of nest materials and their gradual improvement in weaving ability, it seemed to us that what every young male weaver has to learn is what in subjective terminology one would call ‘judgement’.
>
> (1984: 219)

One can sense the reluctance with which these hardnosed empirical observers find themselves having to resort to a notion of this kind. But the evidence leaves them with no alternative. It is clearly judgement, rather than a programme of instructions or a set of design specifications to be mechanically applied, that the bird acquires through mimetic practice. Finally, the form of the nest results from the iteration of a small number of basic movements, and from the fact that the bird stands throughout on the same spot while it weaves all around – above, below and in front – pushing out the developing shell of the main chamber as far as its beak will reach, and then tilting gradually backwards to complete the antechamber and entrance (1984: 193, 209–10).

Given that weaverbirds, in their nest building, exhibit the same properties of skill as are manifested in the looping techniques of the Telefolmin and their neighbours, wherein lies the difference? The conventional answer is to claim that the human *bilum*-maker follows the dictates of an acquired cultural tradition, while the bird works to a template that is genetically transmitted and thus innate. But if, as our experiments with knot-making suggested, there can be no programme for such tasks as knotting, looping, and weaving that is not immanent in the activity itself, then it makes no more sense to interpret the weaverbird’s behaviour as the output of a genetic programme than it does to interpret the *bilum*-maker’s as the output of a cultural one. In all likelihood the human maker of string bags has an idea in mind of the final form of the construction, whereas the weaverbird almost certainly does not. Yet in both cases it is the pattern of regular movement, not some prespecified design, that generates the form. And the fluency and dexterity of this movement is a function of skills that are developmentally incorporated into the *modus operandi* of the organism – whether avian or human – through practice and experience in an environment.

This last point is absolutely critical. Recall that Telefol girls develop their looping skills at a time of life when their bodies are also undergoing rapid growth. These skills, then, far from being added on to a preformed body, actually grow with it. In that regard they are fully part and parcel of the human organism, of its neurology, musculature, even anatomy, and so are as much biological as cultural. After all, a human being, with its particular aptitudes and dispositions, is a product of neither genes nor culture, nor of both together, but is rather formed within a lifelong process of ontogenetic development. To be sure, the skills of looping are acquired, in the sense that at whatever stage in the life-cycle they may be identified, a history of development already lies behind them. But the same would have to be said of the knotting and looping skills of the weaverbird, and indeed of *any* skill, human or non-human. Moreover one could just as well claim that such skills are innate, in the sense that so long as the necessary environmental conditions are in place (including the presence and activity of already skilled practitioners) they are more or less bound to develop. All Telefol girls learn to make string bags, just as they all learn to walk or to speak. All male weaverbirds learn to make nests, unless opportunities for practice are artificially removed. Conversely, Telefol boys and female weaverbirds never develop full-blown looping and weaving skills, since their respective activities and concerns take them too soon into other fields of practice. In short, whatever the difference between the two sets of skills, avian and human, it cannot be aligned on the axis of a distinction between the innate and the acquired.

This conclusion, however, leaves us with our earlier question unanswered. How, exactly, *do* human skills, such as those exemplified in the making of string bags, differ from those of animals such as the weaverbird? To be frank, I do not pretend to know. I remain perplexed by the question, and have yet to find an answer that is wholly convincing. Once again, however, MacKenzie's study of the Telefol offers a possible clue. It lies in the observation, to which I have already alluded, that Telefol people liken the dextrous manual movements of the fluent *bilum*-maker to running water (MacKenzie 1991: 136). For these inhabitants of intermontane valleys, the current of water in a river or stream is as familiar a part of experience as is the motion of the hands in looping. Now it seems reasonable to suppose, likewise, that the weaverbird has as much of a 'feel' for air currents, while on the wing, as it has for nest materials in building with its beak. However what the bird does not do, so far as we know, is to tie these different strands of perception and action together. If birds were human, they would say that the good weaver is one whose beak seems to 'fly', just as Telefol say that the skilled looper is one whose hands 'flow'. But they do not do this. Human beings, it seems, differ from other animals in that they are peculiarly able to treat the manifold threads of experience as material for further acts of weaving and looping, thereby creating intricate patterns of metaphorical connection. This interweaving of experience is generally conducted in the idioms of speech, as in storytelling, and the patterns to which it gives rise are equivalent to what anthropologists are accustomed to calling 'culture'.

However, culture thus conceived cannot be understood to comprise a system of intrinsic rules or schemata by means of which the mind constructs representations of the external world from the data of bodily sensation, nor can speech be regarded simply as a vehicle for the articulation of these mental representations. Speakers no more 'use' their voice, as Plato would have had it, as the mere instrument of a language-based intelligence, than they 'make' sense by superimposing their pre-existing designs upon the raw material of experience. Rather, in speech, the voice is incorporated into a current of sensuous activity – namely, narrative performance – from which, as it unfolds, form and meaning are continually generated. For speaking is itself a form of skilled practice, and as such, exhibits all the generic properties of skill to which I have already drawn attention. Like any other skill, speech develops along with the growth of the organism, is continually responsive to perturbations in the perceived environment, and is learned through repeated practical trials in socially scaffolded contexts. Above all, it cannot be reduced to the mechanical execution of a rule-governed system, or 'grammar'. Yet speech is no ordinary skill. Weaving together, in narrative, the multiple strands of action and perception specific to diverse tasks and situations, it serves, if you will, as the *Skill of skills*. And if one were to ask where culture lies, the answer would not be in some shadowy domain of symbolic meaning, hovering aloof from the 'hands on' business of practical life, but in the very texture and pattern of the weave itself.

Chapter Twenty

The dynamics of technical change

There is a wonderful footnote in Marx's *Capital* that sets a whole agenda for research. It runs as follows:

> Darwin has aroused our interest in the history of natural technology, that is to say in the origin of the organs of plants and animals as productive instruments utilised for the life purposes of these creatures. Does not the history of the origin of the productive organs of men in society, the organs which form the material basis of every kind of social organisation, deserve equal attention? Since, as Vico says, the essence of the distinction between human history and natural history is that the former is the work of man and the latter is not, would not the history of human technology be easier to write than the history of natural technology?[1]
>
> (1930: 392–3, fn. 2)

This passage suggests three crucial questions. First, what exactly is the difference between the 'history of natural technology' and the 'history of human technology'? In modern usage, we have grown accustomed to referring to the former as a process of evolution while reserving the concept of history for the latter. The question then becomes: how, if at all, can we distinguish between evolutionary and historical change in the field of technical phenomena? Secondly, Darwin was greatly perplexed by the issue of whether there is anything inherently progressive about the process he called 'descent with modification'. His considered conclusion was that progress, of a kind, *has* occurred, but that there is nothing in the theory of variation under natural selection that stipulates that it *must* occur. Is this also the case with technology? Finally, are the mechanisms of technical change comparable to, or quite different from, those that Darwin adduced for the adaptive modification of organic species? In other words, can we account for technical change in terms of a principle of variation under selection? In this chapter, I shall deal with each of these questions in turn.

THE EVOLUTION OF TECHNOLOGY AND ITS HISTORY

Comparing what students of animal behaviour on the one hand, and social and cultural anthropologists, on the other, have to say about technical change, one cannot help noting a curious discrepancy. Looking for the causes of such change, animal behaviourists typically attribute it to the evolution under natural selection of the animal species itself. Tools and tool-using behaviour are regarded as part of the phenotypic expression of an underlying genotype, and they change as the genotype changes – that is, as the species evolves.

Explaining the evolution of animal tool behaviour is thus no different, in principle, from explaining the evolution of those functional attachments – the finch's beak, the crab's pincers, the lion's claws – that remain joined to the body. Anthropologists, by contrast, often treat technology as an aspect of a cultural system that has a dynamic of its own, undergoing progressive development without entailing any further change in the basic biology of the species. It is as if, to all intents and purposes, technical change in humans were fully decoupled from the process of evolution, for the designs that underwrite the making process are supposed to lie in the minds of the makers, not in their genes, and to be encoded in cultural symbols rather than in strands of DNA (Wynn 1994: 137–45).

This seems like a neat way of distinguishing between the history of technicity and its evolution. But it poses a problem that has particularly exercised prehistorians, for it implies that at some point or other, history must have 'started up'. A threshold had to be crossed; our ancestors had to step beyond the old world of nature into a new world of culturally constructed meaning. This image of stone-age hunter-gatherers standing at the dawn of history sounds suspiciously like an imposition onto the Palaeolithic of a decidedly modern political rhetoric. And it has set prehistorians on a frantic and much publicised search for the point of origin of what they nowadays call 'modern humans'. I shall reserve my critique of this notion for the next chapter, and merely note at this juncture the implication that once the breakthrough to culture had been made, the history of technology must have truly taken off, leading from the earliest tools to modern machinery, without entailing any further change in the species-specific form of the human organism. History, as psychologists David and Anne James Premack maintain, consists in 'a sequence of changes through which a species passes while remaining biologically stable', and of all species in the world, only humans have it (1994: 350).

If we are to take this view, however, then we have also to admit that the artefactual products of technological culture cannot be taken as reliable indicators of the fundamental cognitive and biomechanical capabilities of their makers. A prehistorian of the future, surveying the material remains of Western industrial civilisation, would be making a serious error were he to infer that its people were considerably more advanced in their evolved capacities than were their predecessors of earlier millennia. As the linguist Philip Lieberman warns, 'who would think that we had essentially the same biological endowment as the human populations that lived 30,000 or 20,000 or 500 years ago if all he had to go on were the preserved artefacts – stone tools versus the ruins of great cities, dams, interlocking highways, etc.?' (1985: 628).

But the same argument cuts the other way. Who would think that the common human biological endowment was significantly different from that of chimpanzees on the evidence of the striking similarity between the toolkits of contemporary free-ranging chimpanzee populations and those of certain ethnographically recorded populations of human hunter-gatherers? In his controversially entitled book *Chimpanzee Material Culture*, Bill McGrew – one of the most experienced observers of chimpanzees in their natural habitat – attempts a systematic comparison of the subsistence technology of chimpanzee populations inhabiting a number of study areas in western Tanzania with that of the Aboriginal people of Tasmania, as documented in the early years of the nineteenth century. The Tasmanian Aborigines are notorious in anthropological literature for allegedly having had the simplest material culture ever recorded (Jones 1977: 197, see Figure 20.1). I shall not go into the details here of how the comparison was made, though one could have serious reservations about the selection of items for comparison and the terms in which they were rendered commensurable. I merely wish to highlight McGrew's principal conclusion, which is that if we confine our attention to the respective toolkits, although the human hunter-gatherer toolkit is indeed more complicated than that of the ape, 'the difference is far from wide, and the gap between hominid and pongid is bridgeable' (1992: 144).

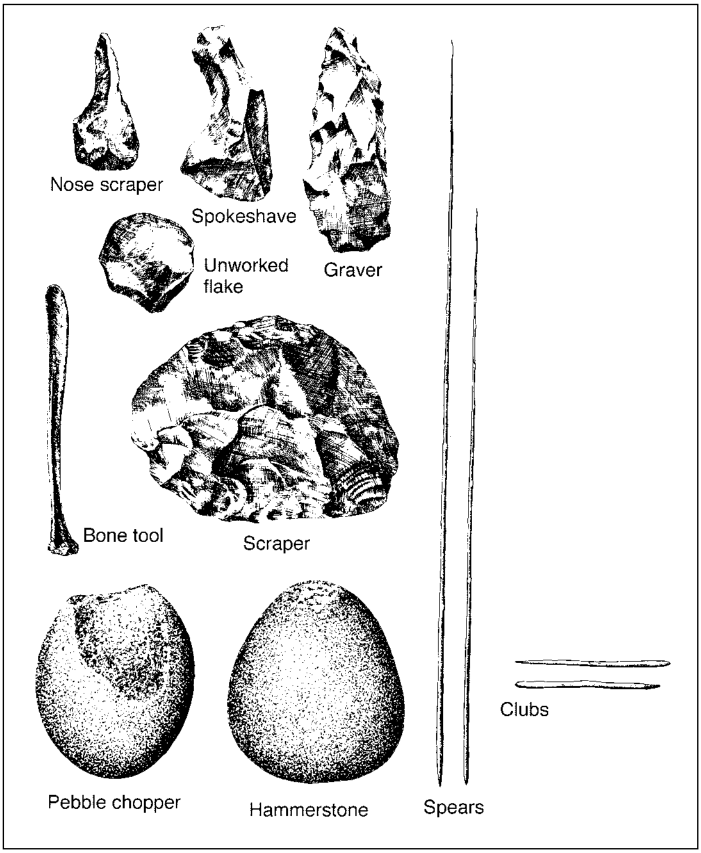

Figure 20.1 The Tasmanian toolkit.

From J. Clark, *The Aboriginal People of Tasmania*, published by Tasmanian Museum and Art Gallery, 1983, p. 22.

Not surprisingly, when McGrew first presented his findings, at a conference devoted to the anthropology of hunter-gatherer societies held in London in 1986, they drew a storm of protest. Was he really trying to tell us that Tasmanian hunter-gatherers had scarcely advanced beyond the apes, that they were stuck in an evolutionary time-warp? In his defence, his intention was no more than to suggest the possibility of an intermediate level of technology in the transition from our ape-like ancestors to the earliest hominid forms. Yet in taking nineteenth-century Tasmanian Aborigines as exemplars of early hominids, McGrew comes close to returning to the overt racism of an earlier era of anthropology, when it was quite usual to regard the 'savage' as representing an earlier stage in human biological evolution, and thus as occupying a half-way stage in the transition from apes to 'civilised' (that is, modern European) humans.

In fact the simplicity of the Tasmanian toolkit, even when compared with that of Aboriginal hunter-gatherers on the Australian mainland, presents an enigma that has never been adequately solved – though it may have something to do with Tasmania's prolonged and total isolation since rising sea-levels cut it off from the mainland some 11,000 years ago (Jones 1977). What does seem incontrovertible, however, is that a Tasmanian Aborigine, transported to the twentieth century and raised in an affluent part of the world, would have no particular difficulty in becoming, say, an airline pilot or a software engineer. But I would not, for my money, take a plane piloted by a chimpanzee! Indeed we are drawn almost irresistibly to the conclusion that behind the apparent similarity of chimpanzee and human hunter-gatherer toolkits there lies a fundamental difference of capacity, a difference that is manifested, above all, in the progression of human technology from the axe, spear and digging stick to the airplane and the computer. Thus while we might reasonably attribute the failure of chimpanzees to operate a complex technology to innate incapacity, we can only attribute the failure of Tasmanian Aborigines to do the same to unfulfilled historical conditions.

Now the development of human technology is very commonly presented as though it could be arrayed on a continuum from the earliest stone tools to modern machinery and electronics. Figure 20.2 is an example of such a figure. Yet if the conclusion we reached in the last paragraph is accepted, to posit such a direct line of continuity from the Oldowan chopper to the space shuttle would be quite absurd. Comparing the finely flaked blades of Upper Palaeolithic hunter-gatherers, dating from around 30–40,000 years ago, with the crude pebble tools used by *Homo habilis* at Olduvai Gorge in East Africa two million years ago, it is hard to deny that the differences reflect real changes in intellectual and manipulative abilities – changes that are also reflected in the increasing size of the brain and structural modifications to the hand. *Homo habilis* was, after all, a very different kind of creature than *Homo sapiens*, in many ways much closer to an ape than a human being. On the other hand, it would appear that once a recognisably human level of competence had been achieved, all subsequent technological change – from Palaeolithic hunting and gathering to modern industry – could take place without any significant further change in the basic biological endowment of the species.

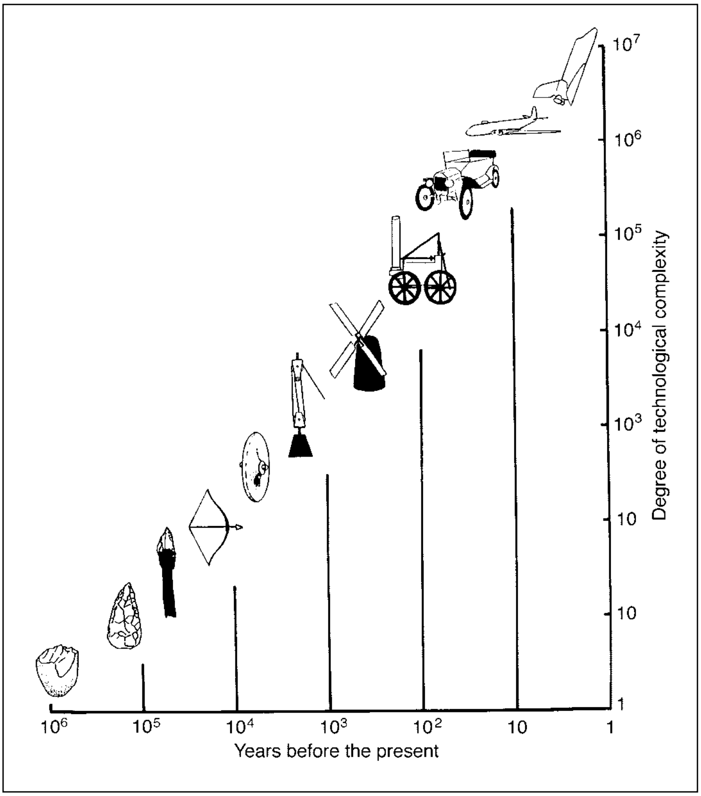

Figure 20.2 The development of material culture.

From B. Cotterell and J. Kamminga, *Mechanisms of Pre-industrial Technology*, published by Cambridge University Press, 1990, p. 9.

In short, it appears that whereas the change from Lower to Upper Palaeolithic tools is a chapter in the story of human evolution, the change from the latter to modern industrial technologies is a chapter of history. When we speak of evolution, it is assumed that changes in tools depend on – and can therefore be taken as indices of – changes in the forms and capacities of the creatures that use them. When we speak of history, by contrast, it is as though technology had broken free from the bonds of genetic constraint, and could henceforth undergo unlimited development without entailing any enhancement of innate human capacities. At what point, then, does the evolution of technology become the history of technology? How can we draw a dividing line between these two processes? Is it possible even in principle, let alone in practice, to distinguish those actions and events that carried forward the movement of human history from those that set it in motion in the first place? We are very far from resolving these questions, but I would like to conclude my discussion of this theme with the suggestion that the processes of evolution and history may not be so distinct after all.

The notion of capacity seems to imply a certain view of human nature, as comprising a set of universal structures or compartments, fully formed in the life of every individual from the start, and waiting to be filled up with all manner of particular cultural content. Thus the capacities are said to be innate, the products of an evolutionary process; the content acquired, changing through history. However my discussion of skill in the last chapter led me to conclude that the capabilities of action of both human beings and non-human animals are neither innate nor acquired but emergent properties of the total developmental system constituted by the presence of the agent (human or non-human) in its environment. In the case of humans, this is as true of the most widely distributed skills such as walking and speaking as it is of those of more restricted distribution such as swimming and writing.

We cannot, then, place universals on the side of evolution and particulars on the side of history. Rather, if history be understood as the process wherein people, through their activities, establish the conditions under which succeeding generations lead their lives, developing as they do the skills appropriate to these various forms of life, then it cannot differ in principle from the process in which organisms, quite generally, establish by their own presence and actions the context of development for their successors. That process is one of evolution. To understand evolution in this sense, however, is to make a clean break with the conventions of modern biology, and with the neo-Darwinian paradigm upon which they are founded. For it is to attribute the changing forms and capacities of living creatures not to changes in an internal programme, design or building plan (the genotype), but to transformations in the whole field of relationships within which they come into being. To take this idea further would be beyond the scope of the present chapter. It is, however, my subject for the next.

MEASURING TECHNOLOGICAL COMPLEXITY

Is there, then, anything progressive about technical change? It is remarkable that although the majority of anthropologists are deeply suspicious of the idea that there is any inherently progressive tendency in the history of human culture, they are inclined to make an exception of technology, and are quite content to talk about peoples with 'simple' and with 'complex' technologies. Precisely how the simplicity or complexity of a technology is to be gauged, however, has remained far from clear. One of the few attempts to construct such a measure has been made by Wendell Oswalt (1976). Oswalt defined the complexity of a tool by the number of 'technounits' that make it up. A technounit is a physically distinct part that makes a particular contribution to the overall implement. It was in these terms that McGrew compared the relative complexity of chimpanzee and human hunter-gatherer technologies. He found that none of the tools used by chimpanzees in the procurement of subsistence comprised more that one technounit, whereas the mean number of technounits (1.2) for the Tasmanian Aboriginal repertoire was very slightly greater. In fact, no Tasmanian implement was of more than one technounit; the raised mean is fully accounted for by two kinds of fixed facility used in hunting, involving two and four technounits respectively (McGrew 1992: 138, 144). By contrast, the Inuit (Eskimo) sealing harpoon shown in Figure 20.3 has no fewer than 26 structurally distinct components.

On the basis of a comparative survey of the toolkits of hunter-gatherers, farmers and herdsmen, Oswalt was able to refute the common assumption that hunters and gatherers have simpler tools than any other human groups. In fact the most complex tools were found among specialised hunters, especially hunters – like the Inuit – of large aquatic mammals, who have to use considerable ingenuity to obtain inaccessible or potentially dangerous prey. The herdsman, who has ready access to comparatively docile animals, faces nothing like the same technical challenges, and his toolkit is correspondingly simpler: thus the lasso, the principal instrument by which the reindeer herdsman catches hold of his animals, is no more than a length of rope tied to a sliding toggle (Ingold 1993b). The equipment of the gatherer tends to be simpler than that of the hunter (plants do not attempt to escape those who 'hunt' them, nor do they have to be outwitted or outmanoeuvred), but again, the tools of the farmer are no more complex. For both gatherer and farmer, the essentials may consist of just an axe or adze, digging stick, and some form of carrying device for transporting harvested produce.

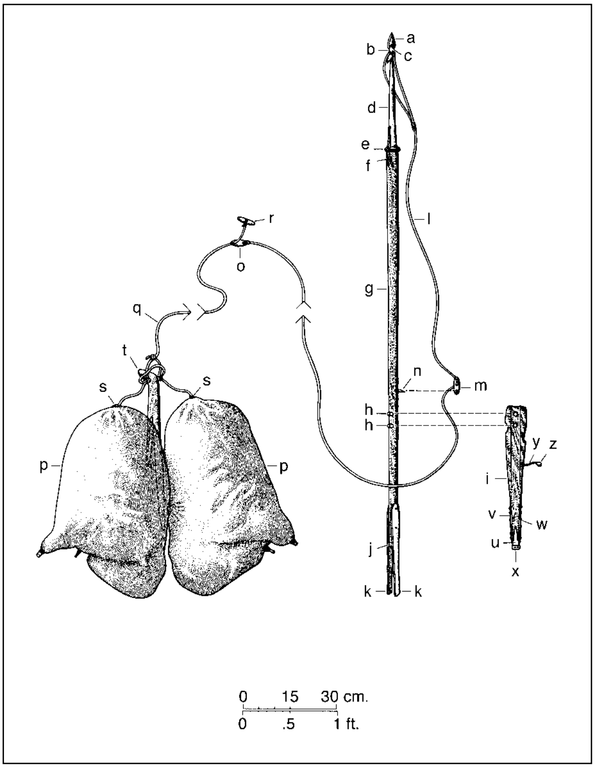

Figure 20.3 Inuit (Angmagsalik) toggle-headed 'feather' harpoon and throwing board for hunting large seals from a kayak.

Drawing by Patrick Finnerty, from W. H. Oswalt, *An Anthropological Analysis of Food-Getting Technology*, published by John Wiley & Sons, 1976, p. 100.

But comparisons based on the structural properties of the tools themselves can be misleading. Returning the objects to the contexts of their use reveals a different picture. The Inuit harpoon is a rather specialised piece of equipment, which is used *only* for sealing. The reindeer herdsman's lasso, by contrast, can be put to use in all manner of different ways. I have seen herdsmen use their lassos for setting traps, for tying animals to sledges for transport home, and for countless other purposes. Likewise among hunter-gatherers with an apparently simple inventory of tool types (including Tasmanian Aborigines), it is common to find that each kind of object is turned to an account for an astonishing variety of different tasks.

Among the Aboriginal people of the Australian Western Desert there is a clear division between men's tools (principally the spear and spear-thrower) and women's tools (principally digging sticks and wooden bowls). The spear-thrower, in the context of hunting, is designed to enhance the flight of the spear by imparting extra angular momentum to the throw. But it has numerous other uses: as a friction stick in making fire, a woodworking tool (with the addition of a hafted stone adze-flake), a mixing tray for pigments or tobacco, a percussion instrument in songs and dances, a device for clearing an area of thorns and pebbles when preparing a campsite, and (when embellished with decorative markings) a mnemonic for recalling the sequence and locations of waterholes and other features of the landscape (Gould 1970: 22, Figure 20.4). The woman's digging stick is similarly multifunctional. It can be used to obtain burrowing animals as well as plants, as a weapon in

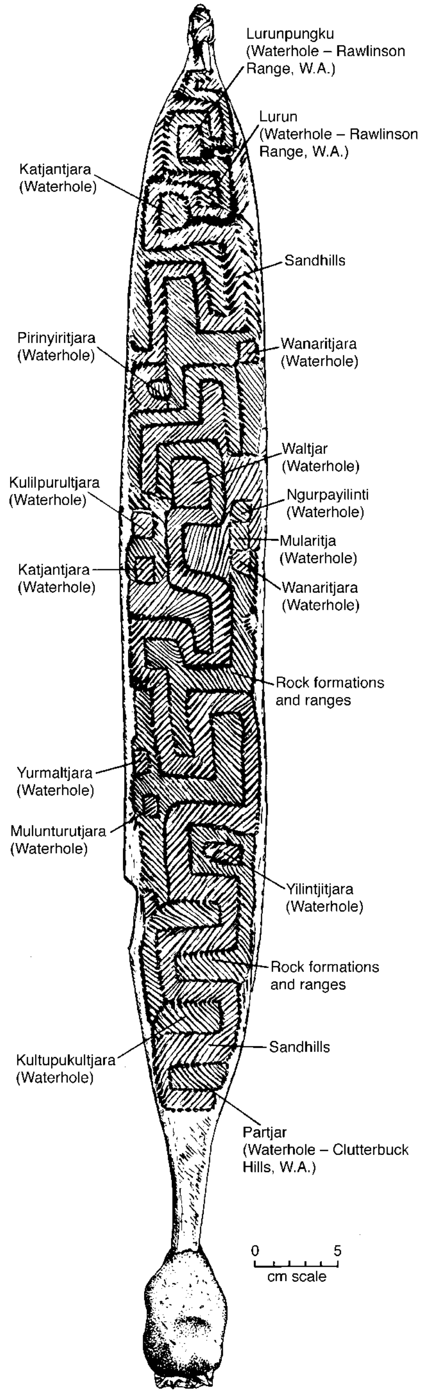

Figure 20.4 Decorated spear thrower from the Nyatunyara people of the Australian Western Desert. Designs depict waterholes and landmarks along the track of a totemic snake.

From R. A. Gould, Spears and spear-throwers of the Western Desert Aborigines of Australia, *American Museum Novitates*, 1970, p. 28. Courtesy of the American Museum of Natural History

small-game hunting and in self-defence. Small wooden bowls can be used to carry produce, but also to shovel away soil when digging. Large bowls can be used to carry both infants and drinking water (Hamilton 1980: 7).

Comparing Australian Aboriginal and Inuit toolkits, it might seem at first glance that the first is extremely simple and the second rather complex. But a more significant difference is between the economy and versatility of the Australian toolkit and the diversity and specialisation of the Inuit one. Australian Aboriginal people have few tools, but use them in whatever way they come in handy, for manifold purposes that we might never come to think of when we classify the objects by function – for example, as spear-throwers or digging-sticks. Inuit have many tools, some of them – like the harpoon – of great complexity and ingenuity, but each is used for a prescribed purpose which governs, at least to some extent, the manner of its construction. It is only because of a peculiar bias that leads us to look for technical operations in the properties of the tools themselves, rather than in the know-how of their users, that we are led to conclude that Inuit are somehow more 'advanced', in the technical sphere, than Australian Aborigines. As I have already shown (Chapter Sixteen, p. 315), the source of this bias lies in the concept of technology itself.

These observations all point towards a single conclusion: that to comprehend the technical accomplishments of hunter-gatherers, or of any other people for that matter, it is not sufficient just to look at their tools. We have to understand their *knowledge*. Tools are of no use if you don't know how to work with them; moreover up to a point, the simpler the tool, the more knowledgeable and skilled you have to be to be able to work it effectively. The reindeerman's lasso is a simple tool, but it requires immense skill to use it effectively. The same could be said of an axe, digging stick, spear or boomerang. The food processor on my kitchen table is, by contrast, an extremely complex tool, with hundreds of interconnected parts. But it took only a few minutes to learn to use it.

As Robin Ridington has put it (1982: 470), understanding technical know-how means focusing on *artifice* rather than *artefacts*, on tool-use as skilled practice rather the mechanical operation of exterior devices. But by artifice we do not mean the kind of objective, generalisable, scientific knowledge which, in its application, might be covered by the modern concept of technology. It is rather knowledge of a very personal kind, partly intuitive, largely implicit, and deeply embedded in the particularities of experience. One grows into such knowledge much as one learns one's country or one's kinship system. It is knowledge that both enables a person to find his or her way in a world of human and non-human others, and that endows them with a specific identity. Thus, as we saw in Chapter Sixteen, it is indistinguishably social and technical.

THE ORGANIC ANALOGY

The idea that in the history of human technology, tools and machines have evolved according to principles similar to those governing the evolution of organic species is an attractive one that has had numerous adherents, from Marx, Butler and Pitt-Rivers in the nineteenth century to contemporary advocates of 'evolutionary archaeology' who argue that mechanisms of variation, differential replication and retrospective selection will account just as well for artefactual as for organic change.[2] All the necessary conditions seem to be present, in the technological domain, to support the analogy. There is *diversity*, which, if anything, is greater than that of species. George Basalla, for example, notes that the number of patents issued in the United States since 1790 (4.7 million) is more than three times the number of species of flora and fauna yet identified (Basalla 1988: 2). There is *continuity*, in the sense that technical change, by and large, seems to be gradual, amassed from a very large number of minor variations rather than punctuated by momentous steps of absolute invention. There is *novelty*, insofar as all making activity, however closely it strives to copy an existing model, is bound to diverge from it to some degree. Replication, in practice, can never be perfect. And finally, there is *selection*, albeit artificial rather than natural, in that it is guided by human intention in rather the same way as in the practice of animal or plant breeding. In other words, the context for the differential replication of technical variants is human, and therefore social and historical (Basalla 1988: 25).

Arguments for the analogy between organic evolution and technical change, though they vary in detail, generally run roughly as follows. In the replication of existing technical designs, innovations of one kind and another inevitably creep in. Some of these may be entirely accidental, and in that respect resemble genetic mutations. Others are clearly stimulated by the particular conditions in which the object or technique in question is to be applied: to the extent that this is the case, the evolutionary process is often said to be more 'Lamarckian' than 'Darwinian'. Another way of putting this would be to define Darwinian evolution as the special case in which the degree of coupling between a novel variation and its environmental conditions of selection is reduced to zero (Ingold 1996b: 196–7). Whether accidental or premeditated, the majority of innovations will probably turn out in practice to be useless or even detrimental. A small proportion, however, bring evident benefits. Variants that work well in the particular conditions prevailing in the environment will tend to 'catch on', through extensive replication, while others will dwindle and disappear. Thus in the long run, the more successful technical designs will undergo a kind of adaptive radiation, splitting into diverse forms suited to specific contexts of use, while others may become effectively extinct.

One of the virtues of the organic analogy is that it suggests a way of explaining how the majority of extant techniques and artefacts have come to be so admirably adapted to current requirements, without our having to suppose that they appeared from nowhere, dreamt up in a moment of inspiration by a designer who was somehow able to see the totality of every problem and conceive its solution in a vacuum. It is no more possible in the history of artefacts than in the evolution of species for new forms to appear out of thin air. Every object, and every technique, comes with a history attached, or as Basalla puts it, 'every novel artifact has an antecedent' (1988: 208–9). True, in the history of artefacts the selection involved carries a component of intentionality: human beings may be able to author their own designs in a way that other animals cannot. What they cannot do, however, is stand outside of history and treat the world as though it were a blank slate. Every designer is a creature of his or her own time, and the objects and practices with which each is surrounded, bequeathed through the activities of predecessors, form a necessary resource for the design process itself. That is why, as Reuleaux pointed out in his *Kinematics of machinery* of 1876, most of what goes for invention in the technical sphere consists in hitting on new uses for old things.

'The first machinal arrangements', Reuleaux argued, 'were of a kind which we may designate as make-shifts'. Cobbled together for one purpose, these arrangements were pressed into service for others, coming up against new demands for improvement which were met by further rearrangements, and so on.

> Very gradually each invention came to be used for more purposes than those for which it was originally intended, and the standard by which its excellence and usefulness were judged was gradually raised. An external necessity thus demanded its improvement, and from this cause machinal ideas slowly crystallised themselves out, and gradually assumed forms so distinct that men could use them designedly in the solution of new problems. These attempts resulted in further improvements, and these in their turn led once more to new applications and more extended use.
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> (Reuleaux 1876: 231)

Only a few years previously, in his treatise of 1862 *On the various contrivances by which British and foreign orchids are fertilised by insects*, Darwin had advanced a precisely analogous argument to account for the evolution of mechanisms in nature. In order to facilitate the transfer of pollen, Darwin showed, the orchid uses whatever parts happen to be available, parts that may have arisen as adaptations to quite different functions.

> Although an organ may have been originally formed for some special purpose, if it now serves for this end, we are justified in saying that it is especially contrived for it. On the same principle if a man were to make a machine for some special purpose, but were to use old wheels, springs and pulleys, only slightly altered, the whole machine, with all its parts, might be said to be specially contrived for that purpose. Thus throughout nature almost every part of each living being has probably served, in a slightly modified condition, for diverse purposes, and has acted in the living machinery of many ancient and distinct specific forms.
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> (Darwin 1862: 348)

As Darwin showed, natural selection, in adapting organisms to their conditions of life, continually puts old structures to work in new ways, having no other materials on which to work. More than a century later we find the same idea echoed in the work of the distinguished biologist, François Jacob. The process of organic adaptation under natural selection, for Jacob, is akin to 'tinkering'. The mammalian ear, for example, is derived from a part of the jaw of the fish, and birds' feathers, with their aerodynamic properties, are derived from hairs once designed for insulation (Jacob 1977).

As with organisms so with artefacts, every novelty is but an expedient solution to a very specific, context-bound, local difficulty: it is a matter of getting by with what is already available rather than producing the absolutely new. Thus it is an illusion to suppose that anything is ever perfectly fit for the purpose to which it is used. 'Every thing we design and make', writes David Pye, 'is an improvisation, a lash-up, something inept and provisional. We live like castaways . . .' (1964: 10). More often than not, the stock of materials available to the maker consists of previously made things, constructed for other purposes but now co-opted for the project in hand. This is the kind of making that Claude Lévi-Strauss famously likened to *bricolage*. The *bricoleur* is someone who delights in making novel contraptions out of the bits and pieces of old ones. The inventory of tools and materials he has to work with, as Lévi-Strauss explains, 'bears no relation to the current project, or indeed to any particular project, but is the contingent result of all the occasions there have been to renew or enrich the stock or to maintain it with the remains of previous constructions or destructions' (1966b: 17). In the history of human technology, perhaps the outstanding example of *bricolage* lies in the so-called 'invention' of writing. Let me pause to say a few words about it.

The nameless inventors of the earliest scripts – and there seem to have been several, who arrived at the same idea quite independently – did not first conceive in the abstract, and then proceed to construct, full-blown, purpose-built writing systems. They did not even imagine the possibility of writing as we think of it now. What they did was simply to hit on the idea that a graph or diagram depicting a thing could be used instead to represent the sound of the word for that thing – a sound which could be homophonous with words or parts of words for other things. This, the so-called rebus principle, has been hailed as 'one of the greatest inventions of human history' (DeFrancis 1989: 50). Yet its significance has been hugely exaggerated by indirect and largely fortuitous consequences of which its originators can have known nothing. All they were doing was pressing into service, on an *ad hoc* basis, well-known and easily identifiable icons for the new purpose of representing speech sounds, in order to solve such limited problems as keeping accounts, recording proper names or divining fortunes. What modern historians rather grandly call 'writing systems' undoubtedly developed as accumulations of expediences of this kind. DeFrancis is right to describe them as 'jerry-built structures' that 'bear less resemblance to carefully constructed schemes for representing spoken languages than they do a hodgepodge of mnemonic clues that adept readers can use to arrive at coherent messages' (1989: 262). In short, they are more like Rube Goldberg devices than the exemplary instances of engineering design that the popular notion of writing as a technology of language would lead us to expect.[3]

Now organisms, it would appear, have evolved in rather the same way as writing systems. Jacob, it will be recalled, likened natural selection to a tinker, and a similar image is invoked by another leading contemporary exponent of Darwinian thinking, Michael Ghiselin: 'organic mechanisms may be shown . . . to have been haphazardly thrown together, out of whatever materials the moment happened to supply' (Ghiselin 1969: 153).

In one respect, however, this kind of image is seriously misleading. For real, living organisms are not pieced together out of ready-made components, however fragmentary, heterogeneous and diverse in origin. Rather, they undergo growth and development in an environment. Thus to be more precise, the tinkering – if such it is – must occur not in ontogeny but in phylogeny, that is in the assemblage, by natural selection, of a *design* or construction blueprint for the organism. This design is what is generally known as the genotype. And if the same argument is to be applied by analogy to the construction of artefacts, we would have to conclude that what is fashioned, through a process of variation under selection, is likewise a design for the tool or machine in question rather than the object itself.

My discussion in Chapter Eighteen, however, led me to question the very idea that the making of artefacts consists of a simple transcription of a prior design onto raw material. I argued, to the contrary, that the forms of artefacts *emerge* through the unfolding of a system of relations comprised by the presence of the artisan in a richly structured environment that could include other persons, other examples of artefacts of the kind that it is desired to make, a selection of materials, and a range of tools and supporting surfaces. Should we conclude, then, that the analogy does not hold; that the processes that give rise to organisms and artefacts are profoundly dissimilar? Could it be, in complete reversal of commonsense understanding, that whereas organisms are built, artefacts grow?

I think not. The analogy is indeed sound. It is, in short, not that organisms are built like artefacts, knocked together out of bits and pieces as the Darwinian model suggests, but rather that artefacts grow like organisms, within the equivalent of a morphogenetic field. Where plans or blueprints exist, as they often do in the fields of architecture and engineering, they are generated within the same, environmentally situated process from which also emerge the forms they are said to specify. But they may not exist at all. Thus where apparently identical objects are made, generation after generation, this is not because each is a replica run off from a template that has been somehow transmitted from ancestors to descendants, independently and in advance of the construction process. It is rather, as we saw in the case of the making of string bags described in Chapter Nineteen, that form-making involves a precise co-ordination of perception and action that is learned through copying the movements of experienced practitioners in socially scaffolded contexts. Making, in other words, *is* copying; it is not the realisation of a design that has already been copied. The same point could be alternatively expressed in terms of a contrast between *reproduction* and *replication*: every artefact, formed as it is within the process of production, is an original, not a replica. And whatever variations may be introduced in the process lie in the dynamics of making, not in errors of transmission.

Now I believe that precisely the same argument may be applied to the growth of organisms. The transgenerational stability of organic form is due to the dynamics of reproduction, not to the mechanics of replication. In each generation the form emerges anew, in the course of ontogenetic development; it is not run off from a pre-existing design specification. Indeed for organisms, there is no such specification. The genotype, conceived as a programme or blueprint for the growth of the organism, does not exist. To recall my conclusion from the first part of this chapter, the forms and capacities of organisms are attributable not to genes but to the properties of developmental systems (of which the genes are, of course, an integral part). An exploration of the radical implications of this conclusion for evolutionary theory is my subject for the next chapter.