

of the long-term evolution of neutron stars and their interaction with surrounding media. This ignorance can be forgiven because they have had no reincarnated objects from the cosmic graveyard to guide their studies.

What is sorely needed now is a confirmation of the nature of this source. Despite the evidence, scepticism remains. It is disputed as to how well the authors have measured soft X-ray absorption, and that could significantly affect the distance bound. How well they have fixed the position of their source is also in question, and this could affect their conclusion about the absence of counterparts at other wavelengths. Difficult as it will be, spectroscopy may be the final arbiter. If this object is indeed sitting in front of the molecular cloud and accreting from the low-density interstellar medium, it should be surrounded by an ionization nebula, with its own distinctive set of line signatures in the optical<sup>4,6,8</sup> and the infrared. If the neutron star has remained strongly mag-

netized, with a field strength  $\sim 10^{12}$  gauss, there should be a cyclotron emission feature in the hard X-ray band at  $\sim 10$  keV, on top of the soft X-ray continuum<sup>9</sup>.

The final judgement is not in on this source, but its case remains the most compelling to date. This direct evidence for a vast stellar graveyard supports the long held belief that massive stars have been forming and dying ever since our Galaxy came into existence. Instead of theorizing in the dark, astronomers can finally place the study of the long-term evolution of the superdense remnants on a firm observational footing. With more detections, they can also hope to understand better how the interstellar medium of our Galaxy has been enriched over the aeons with all the elements heavier than hydrogen and helium. It is from this enriched medium that subsequent generations of stars and planets — including the Sun and the Earth — evolved.

Whether it be this source or some other, given the current observational and

theoretical efforts, it seems only a matter of time before some member of the graveyard's quiet majority is identified. Such an event would usher in a new era in the study of neutron stars and of Galactic chemical evolution. But what if the quiet majority is actually a silent majority? □

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## ANIMAL BEHAVIOUR

# The question of culture

Christophe Boesch

FOR centuries, the manufacture and use of tools have been taken as the hallmark of humanity. Manufacture, especially, has been considered to be the defining criterion, in that it requires the artificial imposition of a certain shape on an object that might have looked very different in its original form.

On the face of it, then, Gavin Hunt's report on page 249 of this issue<sup>1</sup> of precisely such performances in wild crows tremendously expands the boundaries of human characteristics. Hunt made his observations of the birds in New Caledonia, an island group some 900 miles off the northeast coast of Australia. He collected many discarded tools (both twigs with hooks on and stepped-cut leaves, used to tease out invertebrate prey from holes), and recorded tens of instances of actual tool use and a few examples of tool manufacture.

All current theories about the evolution of mankind rely on tool manufacture and use as being central behaviours that distinguished our early ancestors from apes. There is no evidence of tool use by species of *Australopithecus*<sup>2,3</sup>, and the appearance of tools seems to have coincided with the emergence of *Homo habilis*, some 2 million years ago. Along with enlarged brain capacity, tool use is the most obviously distinctive trait of the genus *Homo*. Nonetheless, the tools associated with *H. habilis* are still quite crude and are not systematically standardized in shape and size. Only when

*H. erectus* appeared, about 1.8 million years ago, did standardization and sophistication in the form of the tools become the rule (for example in the shape of hand axes, which remained stable for about a million years). This imposition of regularity of form following a mental representation of the tool maker has been seen as the hallmark of culture, and it is an argument that has also been applied to other animals using tools, especially chimpanzees<sup>4,5</sup>. The issues, however, are not straightforward.

Hunt suggests that the New Caledonian crows demonstrate three features new to tool-use in free-living, nonhuman animals, and that these features appeared first among early humans during the Upper Palaeolithic. The features are the use of hooks, the production of distinct tool types and a high degree of tool standardization. The crows were observed to use hooked twigs in hunting small invertebrates, and the intentional making of such hooks, as suggested by Hunt, would say a great deal about the crows' resourcefulness. Animal use of hooks has been observed only rarely, the most dramatic example that I know of coming from chimpanzees in Bossou (Guinea) which employed long, hooked branches in order to reach a branch of a fig tree that they could not reach on their own from below<sup>6</sup>.

We should expect distinct tool types to be produced, when a particular technique works, only if the tool fulfils some specific

criteria. For example, digging insects out of a 10-cm-deep hole can be performed only with an elongated object at least 10 cm long and a diameter smaller than that of the hole. Shorter or wider tools do not work, and by trial-and-error learning the tool user can produce distinct tools for this task. Chimpanzees are known to produce task-specific tools that vary distinctly in material, size, length, hardness and weight<sup>4,5</sup>. It is intriguing to see that this might also be the case for the New Caledonian crows, but this aspect of a tool can be more a reflection of the requirement of the tasks performed than a sign of high technical capability.

Evidence of standardization in tool production would be a more decisive step in deciding whether such a capability is indeed being manifested. Standardization can result from two processes: first, an object may be progressively modified until the user can employ it for an intended purpose; or, second, the object may be completely modified for the purpose before use. In the first process a trial-and-error approach, requiring no idea about the shape of the tool, is sufficient. For example, if an animal wants to reach insects within a hole in a tree, a leafy twig does not go deep enough into the hole. It is only by progressively removing the leaves and other parts that the object will become a proficient tool. In the second process, the animal makes all the necessary changes beforehand and it is this process that is considered by some to be the characteristic of the existence of culture.

It is, however, extremely difficult to differentiate between the two processes on the basis of tools collected on the ground after use. Hunt collected 305 tools, but

saw only four instances of tool manufacture. In all four cases manufacture was completed before use, but it is risky to generalize from such a limited sample. By contrast, in one chimpanzee population that I have studied, in 93.5 per cent of a total of 363 sticks modified as tools all of the necessary modifications were performed before use<sup>5</sup>. In this case, standardization resulted from the second process and we can say with some certainty that chimpanzees have a preconceived idea of what shape an object must have to become a tool.

There is also more to the question of whether standardization of tools can be said to be a mark of the existence of culture. Hitherto in this article, the term standardization has been discussed as the result of task requirement combined with sophisticated mental abilities. But the existence of culture as such would also require that the standardization observed is underpinned by social as well as ecological criteria. So there is a third dimension to standardization: in free-living animals we would need evidence of a task that could be solved with at least two different possible types of tool but only one type is used in a given social group. In this case, part of the standardization would result from the tool users following social models. As far as I know, this has been demonstrated only in human beings and, again, chimpanzees — different populations of chimpanzees have been observed to 'dip' for the same species of ants by using sticks of different but discrete sizes, all members of one population producing tools of a single type<sup>5</sup>.

All in all, Hunt's fascinating paper gives much food for thought and argument. Although tool manufacture and use have been observed in many animal species<sup>4</sup>, at the least the work to date on the New Caledonian crows shows that tool use in birds is less stereotyped than previously thought. We can hope that further details will follow in due course. For instance, it would be especially interesting to know how much of the tool behaviour is anticipated and is truly a cultural product of crow society; if, to any extent, this is the case, it would add an important element to our knowledge of culture among animals. □

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## New trick from an old foe

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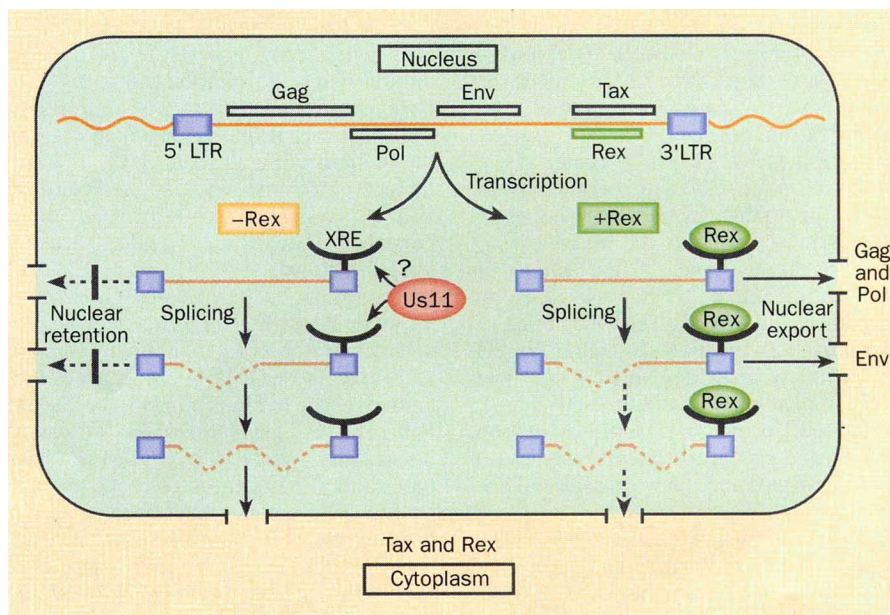
THE complex human retroviruses human T-cell leukaemia virus type-I (HTLV-I) and human immunodeficiency virus type 1 (HIV-1) regulate the order of their own gene expression so that regulatory proteins are made early after a cell has been infected while structural gene expression is delayed<sup>1</sup>. This temporal regulation was unprecedented among retroviruses at the time of its discovery, but it has turned out to be characteristic of DNA tumour viruses, including all herpes viruses.

However, whereas the order of gene expression is transcriptionally regulated in DNA tumour viruses, it is regulated entirely at the post-transcriptional level in HTLV-I and HIV-1 (ref. 1). A study by Diaz *et al.* (page 273 of this issue<sup>2</sup>) shows that the Us11 gene product of herpes simplex virus type 1 (HSV-1) can also post-transcriptionally activate the expression of HIV-1 and HTLV-I envelope structural protein, and thus raises the possibility that this level of regulation is not unique to complex retroviruses.

Transcription of chromosomally integrated HTLV-I and HIV-1 proviruses starts from a promoter located in the 5' long terminal repeat (LTR) and ends in the 3' LTR to give a genome-length tran-

script that also serves as the messenger RNA for synthesis of the Gag and Pol structural proteins (see figure). In HTLV-I, *env* mRNA is derived by splicing out an intron consisting of *gag* and *pol* sequences while removal of a second intron overlapping *env* generates a bicistronic mRNA encoding the Tax and Rex regulatory proteins.

Because HTLV-I replication requires the expression of unspliced, singly spliced and fully spliced transcripts, processing of HTLV-I RNAs is designed to be inefficient and incomplete. However, early after infection these incompletely spliced HTLV-I mRNAs are sequestered in the infected cell nucleus and thus are not translated<sup>3</sup>. Although the reason for this retention remains uncertain, the presence of unused splice sites may induce nuclear retention by cellular factors, termed 'commitment factors', which normally prevent the nuclear export and translation of incompletely spliced cellular mRNAs<sup>4</sup>. Here, their action would block the expression of HTLV-I transcripts encoding the viral structural proteins, but would not interfere with the nuclear export of the fully spliced RNA encoding Tax and Rex.



HTLV-I is a retrovirus — an RNA virus that replicates via a DNA intermediate. Upon infection of a cell, the virus's reverse transcriptase makes a DNA copy of the viral RNA genome, which is integrated into the cell's chromosomal DNA as a provirus. The virus then uses the host's machinery to transcribe its own DNA as one long pre-messenger RNA encoding a number of different gene products. Unspliced or singly spliced 'late' RNAs encode the structural proteins Gag, Pol and Env; a fully spliced 'early' RNA encodes the regulatory proteins Tax and Rex, which must be made early in order to enter the nucleus and increase viral expression. In the absence of the essential Rex protein, the messenger RNAs that encode the viral structural proteins are retained in the nucleus and, hence, not expressed. Rex induces their nuclear export and expression after first binding to the viral Rex response element (XRE) RNA target. The HSV-1 Us11 protein has now been shown also to bind the XRE and to activate the cytoplasmic expression of the late *env* mRNA. LTR, long terminal repeat.