



Figure 1 | OTUB1 does it differently. Nakada and co-workers' data² suggest that the deubiquitylating enzyme OTUB1 sequesters the E2 enzyme UBC13 in its ubiquitin (Ub)-loaded form, preventing the formation of ubiquitin chains. (Usually, deubiquitylating enzymes detach ubiquitin from their substrate proteins.) If the cell's DNA is damaged by ionizing radiation, OTUB1 dissociates from UBC13~Ub, allowing the formation of K63-linked ubiquitin chains on substrate proteins in the presence of the E3 enzyme RNF168. Such ubiquitylation of chromatin-bound proteins near sites of DNA double-strand breaks is a signal that recruits DNA-repair factors and cell-cycle regulators.

interaction between OTUB1 and UBC13 has a role in inhibiting DNA repair. Several mechanisms, which are not necessarily mutually exclusive, may be at work. These include, first, direct competition for UBC13 between OTUB1 and the E3 ligase; and second, masking of the lysine side chains of ubiquitin, preventing chain extension. Third, E2~ubiquitin — the thioester-linked ubiquitin, which then transfers ubiquitin to a target lysine — might be masked, preventing the processing of the next ubiquitin molecule.

In all cases, one would expect a stoichiometric, rather than a catalytic, effect, which Nakada *et al.*² indeed observe *in vitro*. Using a molecular mimic of E2~ubiquitin, they

elegantly show that OTUB1 binds preferentially to the E2 enzyme that is primed for ubiquitin transfer, a finding that favours the last of the three possibilities mentioned above (Fig. 1). As the authors suggest, in a physiological context OTUB1 may set the threshold for initiating the signalling that is induced by DNA double-strand breaks.

Together with a growing body of evidence that DUBs have non-canonical activity⁷, this paper² presents an appealing model for how several DUBs that lack the signature catalytic triad (a specific sequence of amino acids involved in catalysis) might nevertheless fulfil essential regulatory functions. Several different E2 enzymes interact with OTUB1 (refs 2, 8) and other DUBs⁸, so these unusual mechanisms might also control the activity of other E2 enzymes.

A key question is how the inhibitory effect of OTUB1 is relieved when acute DNA damage occurs. OTUB1 has multiple phosphorylation sites⁹, which might provide an additional layer of control by allowing its affinity for UBC13 to be modulated. Whether OTUB1 regulates other pathways that rely on UBC13 also remains to be established.

The demonstration that OTUB1 inhibits

DNA repair could have therapeutic relevance. Nakada *et al.* found that reducing the level of OTUB1 expression restores the process of homologous recombination in cells in which ATM kinase is inhibited. Thus, OTUB1 depletion can, in principle, mitigate DNA-repair defects. This observation makes the interaction between OTUB1 and UBC13 an attractive target for therapeutic intervention, with particular relevance for disorders affecting DNA repair and for use in combination with radiation therapy.

April Rose and Christian Schlieker are in the Department of Molecular Biophysics and Biochemistry, Yale University, New Haven, Connecticut 06520-8114, USA.
e-mail: christian.schlieker@yale.edu

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EVOLUTIONARY BIOLOGY

Oh sibling, who art thou?

Andrew Cockburn

Help from earlier offspring in rearing a subsequent brood should evolve more easily when the mother is strictly monogamous. A comparative study of birds provides evidence in support of this view.

Cooperative breeding, in which more than two individuals combine to rear a single brood of young, has evolved repeatedly in animals, and most commonly in insects and birds. This situation poses an evolutionary paradox: because individuals have only two parents, some of the carers in these cooperative societies are helping to raise young that are not their own. The evolutionary biologist W. D. Hamilton famously solved part of the puzzle by pointing out that helping to rear siblings can be completely analogous to rearing your own offspring, as both actions facilitate the propagation of your own genes in subsequent generations.

However, many females are so promiscuous that young will be uncertain whether they share paternal genes with other young produced by their mother. This argument has been used to suggest that the evolutionary transition to and from cooperative care will depend on the extent to which the mother mates monogamously^{1,2}. On page 969 of this issue, Cornwallis and colleagues³ exploit the great variation in the mating systems of cooperatively breeding birds to provide support for this hypothesis (Fig. 1).

The authors' approach involved use of the phylogenetic comparative method, which relates changes in the trait of interest on different branches of the tree of life to changes in potential explanatory factors. This approach is well known and frequently used, but Cornwallis *et al.* estimate the correlation by applying a novel and very general Bayesian statistical technique⁴. The response variable they initially investigated was whether birds bred cooperatively, an activity that they conclude declines strongly with an index of female infidelity — the proportion of broods in which some young are sired by extra-group (or extra-pair) males. The effect works in both directions: transition to cooperative breeding occurs more commonly in monogamous species, and transitions from cooperation to non-cooperation increase with infidelity.

The evolution of mechanisms to detect relatedness would allow potential helpers to overcome the uncertainty that flows from infidelity. However, the strength of evolutionary selection for sophisticated means of recognizing kinship will vary. It is sufficient to have a



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Figure 1 | Monogamy and cooperation. About 10% of birds, including these grey-crowned babbblers (*Pomatostomus temporalis*), breed cooperatively. The research of Cornwallis *et al.*³ indicates that cooperation is more likely to evolve if the breeding female is monogamous.

rule-of-thumb that presumes kinship if the female is always faithful; assuming limited relatedness also works if the female is highly promiscuous. Somewhere in the middle of these extremes, it would pay to know whether you are related or not and to adjust your care accordingly. Consistent with this view, Cornwallis *et al.* found that the ability of birds to vary their investment in offspring according to kinship was most pronounced at intermediate levels of infidelity.

The phylogenetic comparative method can be extremely powerful, but has some limitations. First, particularly with transitions to complex behavioural states, defining whether the transition has occurred is not always straightforward. Cooperative breeding in birds can be confined to family groups, can occur among completely unrelated individuals, or can be a bewildering mixture of the two⁵. Cornwallis *et al.* use a restrictive definition, and define cooperative breeding as applying only to family groups, which is reasonable, as their index of infidelity is defined as mating outside such groups. However, using this definition excludes a lot of the complexity that makes cooperative breeding most interesting, and potentially underemphasizes direct benefits to the provider of help relative to those derived indirectly through kinship.

The second universal problem of using correlations in evolutionary biology is that the direction of causation is often uncertain. For example, in Australian fairy wrens (*Malurus* species), which, despite ubiquitous cooperative breeding, are the least faithful of all birds⁶, females exploit the availability of helpers as an alternative source of care for their young, allowing them to increase the extent to which they cuckold their mates⁷. This indicates that

cooperative behaviour can drive the incidence of fidelity rather than vice versa, and that the coevolution of fidelity and cooperation could be much more complex than is assumed in Cornwallis and colleagues' analysis. Nonetheless, their study provides a welcome and exciting direction for empiricists, who have failed miserably to produce models that predict

the incidence of cooperative breeding.

We are most likely to learn about the forces that lead to cooperation by studying pairs of species sitting close to the point of evolutionary transition. To take a different case, the study of primitively social wasps might tell us more about the conditions that produce sociality in insects than does research on army ants in which the single queen could be attended by a million workers. Likewise, investigations of closely related birds that either lack or exhibit a low level of cooperative breeding might allow the most illuminating direct tests of the monogamy hypothesis. Although such primitively social birds lack the charisma of the most highly developed avian cooperative societies, there is new impetus for adding them to the already impressive array of birds in which molecular tools have been used to dissect patterns of parentage. ■

Andrew Cockburn is in the Division of Evolution, Ecology and Genetics, Research School of Biology, Australian National University, Canberra ACT 0200, Australia.

e-mail: andrew.cockburn@anu.edu.au

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EARTHQUAKES

Double trouble at Tonga

Kenji Satake

A puzzling case is presented by the occurrence of two large but dissimilar earthquakes at almost the same time and place. One must have acted as the trigger, but which one and how did it do so?

One earthquake can set off others. Most triggered earthquakes are aftershocks that result from adjustments on and near the plane of the fault that produced a larger mainshock. In this issue, Beavan *et al.*¹ (page 959) and Lay *et al.*² (page 964) take up the intriguing example of two earthquakes that overlapped in time and were adjoined in location, but differed drastically in mechanism. The authors reach opposing conclusions about which earthquake began first, and how one earthquake triggered the other.

The earthquakes in question occurred on 29 September 2009 in the southwest Pacific, near the Tonga trench. An associated tsunami claimed close to 200 lives across Samoa, American Samoa and Tonga^{1,2}. The earthquakes ultimately resulted from the descent, or subduction, of the Pacific plate beneath the

Australia plate (specifically its Tonga block), in an area where these two plates are moving towards one another at about 20 centimetres per year — faster than at any other plate convergence worldwide. Despite this, the Tonga trench had somehow failed to produce a single great earthquake of magnitude 8 or larger since 1917. That each of the September 2009 earthquakes attained magnitude 8 thus came as something of a surprise to geophysicists.

The main earthquake visible in seismic records was not a typical subduction-zone earthquake. Great earthquakes and associated tsunamis are caused by sudden slip occurring on the plate interface, releasing accumulated compressional strain between the two plates. A recent example of such a plate-boundary earthquake is the magnitude-8.8 earthquake