fundamentally irreversible decoherence process, induced for example by scattering a photon from the atoms. As long as this projects the spin state without relaxing it, it could be corrected by the same code. Another is to achieve repetitive correction, something not available in the experiments so far. It would also be very valuable to see a five-atom or a similar code in action, correcting general errors, including relaxation, rather than only rotation about a known axis. ■

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50 YEARS AGO

One hundred, or even fifty, years ago there was far less to understand… but certainly it becomes every day more difficult to find scientists whose interests are wide enough to assist the advance by helping the specialists to understand one another. There is in the Library of Trinity College, Cambridge, a collection of letters illustrating the value of such help. They were written between the years 1830 and 1860 by… Michael Faraday and William Whewell, the great discoverer seeking advice from the most learned scholar of his day. Faraday was in difficulties with his experiments on electrolysis. He needed new terms to describe what he was doing… Whewell…, in a letter dated May 5, 1834, strongly advises the terms 'Anode' and 'Cathode'. The letter continues: "If you take *Anode* and *Cathode* I would prefer for the two elements resulting from electrolysis the terms *Anion* and *Cation*, which are neuter participles signifying *that which goes up* and *that which goes down*; and for the two together you might use the term *ions* instead of *Zetodes* or *Stechions*." And Faraday replies ten days later to say that he has taken Whewell's advice and ends his letter: "I am quite delighted with the facility of expression which the new terms give me and I shall ever be your debtor for the kind assistance you have given me."
From *Nature* 4 December 1954.

Archaeology

Greater expectations

Peter W. Stahl

Evidence of unexpected complexity in an ancient community in Uruguay is a further blow to the conventional view of prehistoric development in marginal areas of lowland South America.

Archaeological research often reveals unexpected results. This is common in South America, especially when archaeologists venture off the beaten track to explore unfamiliar areas. However, our surprise is also a product of our preconceptions. Recent work in the lowlands of tropical South America clearly bears this out, with discoveries of prehistoric complexity in unforeseen places and/or times[1–6]. On page 614 of this issue, Iriarte *et al.*[7] present another example of precocious development in a hitherto little-explored and under-appreciated area. The authors refer humbly to their results as unexpected; but given the profusion of surprises elsewhere, why would they be unexpected in the first place?

The conventional view suggests that little of archaeological importance can be expected of 'marginal' areas — those areas geographically distant from a great Andean "center of inventiveness and social development"[8]. Although the origin of this idea can be traced directly to the *Handbook of South American Indians* (*HSAI*), conceived in 1939, and published between 1946 and 1950, its roots are certainly deeper. With state-of-the-art knowledge at his disposal, *HSAI* editor Julian Steward[8,9] cobbled together a summary of cultural history in South America that used a now-outmoded belief in cultural evolution, culture areas and trait diffusion; environmental determinism; a sketchy archaeological record; and an underestimation of the effects of European conquest on native populations.

How does one understand the bewildering complexity of the humans of pre-Columbian South America? In his tentative historical summary, Steward subsumed indigenous South America under a ranked scheme based on sociopolitical and religious patterns, and shared or missing cultural elements. He sketched out the historical–developmental implications of his classification, putting Central Andean civilizations at the top, and descending through circum-Caribbean/sub-Andean, to tropical forest peoples, and with 'marginal' tribes at the bottom. Steward proposed an Andean centre of development with unlimited agricultural potential (a factor considered essential for establishing large, sedentary populations), from which cultural traits had diffused into other portions of the continent. According to the theory, in recipient areas, cultural elements were varyingly adopted or lost for historical or ecological reasons. In particular, marginal areas fared poorly — some areas were so far removed from the Andean centre that little was passed on. Besides, local environmental conditions were supposed not to be conducive to prehistoric agriculture in these marginal areas, thus necessitating a constant nomadic quest for subsistence.

Although few would buy into these ideas today, Steward's culture history has had an enormous impact on archaeological interpretation, both academic and popular. Using this perspective, 'traditional Indians' are conceptualized as having made ancient ecological adaptations that allowed them to survive relatively unchanged since deep time. In areas or periods where archaeological facts

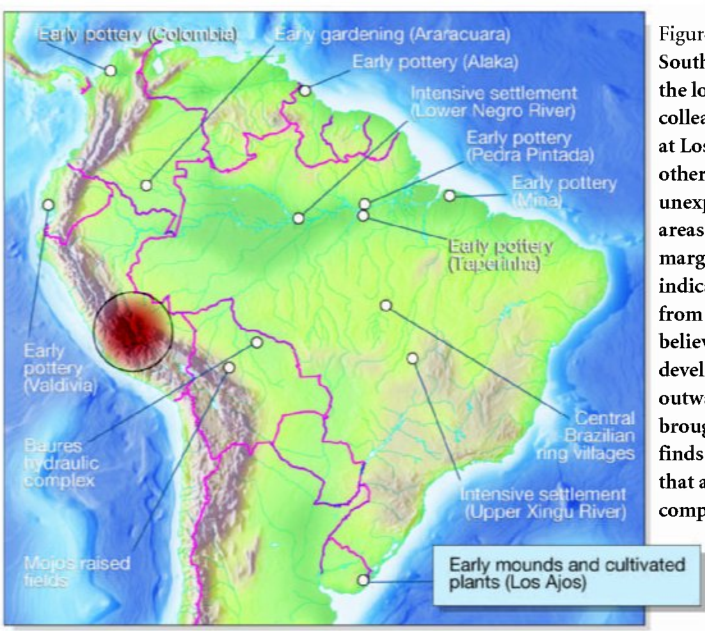

Figure 1 **Marginal or not? South America showing the location of Iriarte and colleagues' investigations at Los Ajos[7] and some other examples[1–6] of unexpected discoveries in areas once considered marginal. The red circle indicates the general area from which Steward[8,9] believed cultural developments spread outwards — a view brought into question by finds in 'marginal' areas that are earlier or more complex than expected.**

exceeded predisposed expectations, external migrations or influences were sought in the form of lost Japanese fishermen, brief intrusions from centres of 'high culture', or the late result of European manipulation. In a curious twist, those who argue that the seeming marginality of some tribes is more probably the recent product of global events are chastised for ignoring the ecological success of indigenous populations or for acting as accomplices to environmental degradation[10,11].

We can surely do better than this today. Iriarte *et al.*[7] demonstrate that we actually do (Fig. 1). Their investigations at Los Ajos in the La Plata Basin of southeastern Uruguay reveal a large formal village plan, consisting of mound and plaza features, at a time (more than 4,000 years ago) and in a place where conventional wisdom would not have expected them to exist. Moreover, subsequent occupation, intentional remodelling, settlement planning and village size indicate both a permanence and a density of population previously unthought of for this area. Innovative analyses of plant microfossils and starch grains extracted from stone tools yield evidence for the early exploitation of maize, squash, beans and root crops in an area that was long considered non-agricultural, at least for prehistoric populations. The findings add another example to a long and growing list of pre-ceramic agricultural sites throughout the world, which reminds us that farmers do not necessarily need ceramic pots. Pottery shards have traditionally been the interpretive touchstone among archaeologists working in South America, and conventional practitioners have slavishly devoted technical and methodological energy to their retrieval and study.

The study by Iriarte *et al.*[7] not only rejects much of the interpretational baggage carried by generations of archaeologists, but also exposes the potential for prehistoric culture in grasslands and wetlands, which were historically viewed as marginal areas[1,12]. Marginality and atrophied development are part of a flawed historic perspective. Our expectations for indigenous achievements should be greater. ■

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Cytoskeleton

Spindle saga

Eric Karsenti

It's generally been thought that, during cell division, only proteins are necessary to assemble the machine that segregates chromosomes. But a new molecular requirement has been discovered.

Arguably the most striking structure a cell can produce is the spindle — a fine meshwork of filaments that carries out a fundamental task in cell division. Before one cell can make two, it must duplicate its DNA; the replicated chromosomes must then be separated and pulled to opposite poles of the cell, which splits into two. The mitotic spindle is the machine that segregates the duplicated chromosomes. It is built from an array of protein tubes — the microtubules — that assume a precise size and bipolar organization.

Several proteins, notably molecular motors and various signalling proteins[1,2], are essential for spindle organization and function, but no other types of molecule were thought to be involved. That view will now change, however, with the paper by Chang, Jacobson and Mitchison on page 645 of this issue[3]. These authors have found that a large, branched, polymeric molecule, known previously for its effects on chromosome structure, is also essential for microtubules to be organized into a functional spindle.

Work over the past 15 years has shown that spindle assembly results from the self-organization of chromosomes, microtubules and molecular motors[4]. While this is happening, some microtubules attach to specialized structures on chromosomes, the kinetochores; both kinetochores and microtubules are required to move chromosomes to the spindle poles[5] (Fig. 1a). This self-organization process involves the collective action of microtubule proteins, motor proteins and signalling proteins[1,2]; Chang *et al.*[3] now find that another type of chemical — poly(ADP-ribose), PAR — also has a key role. ADP (adenosine diphosphate) is a nucleotide, akin to the basic building blocks of DNA; ribose is a sugar molecule.

It is known that ADP-ribose is added in the form of a long branched polymer to some proteins, and in particular to histones — nuclear proteins that help to package chromosomes into a compact state called chromatin. This addition of PAR to histones is done by a family of enzymes called poly(ADP-ribose) polymerases (PARPs); the

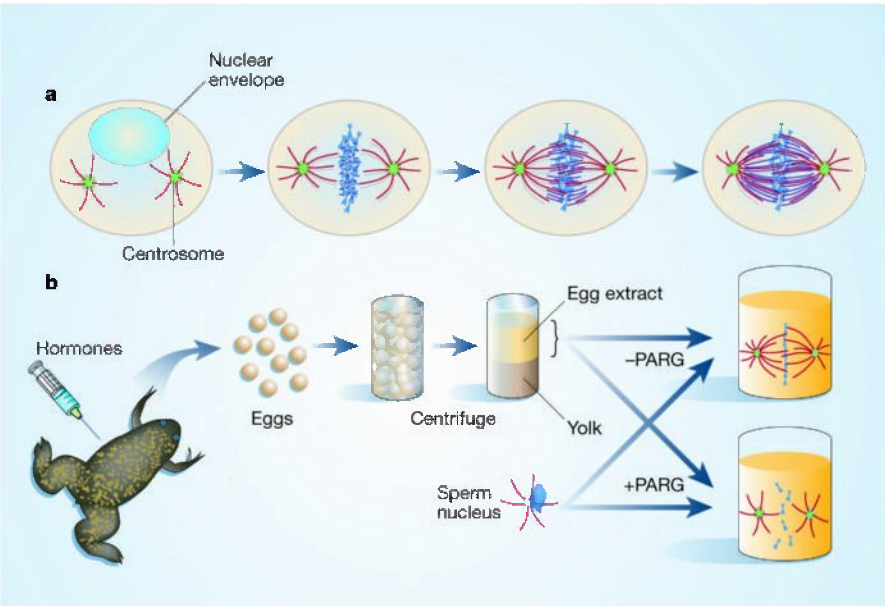

Figure 1 **Spindle assembly — proteins and poly(ADP-ribose).** a, **As cells enter mitosis, the nuclear envelope disappears and microtubules (red), nucleated by centrosomes, become very short. Chromosomes (light blue) condense; new microtubules (purple) start to grow and become stabilized around chromosomes. Molecular motors (not shown) help to organize the microtubules into two antiparallel arrays — the spindle.** b, **This process can be recapitulated with frog egg extracts into which sperm nuclei containing centrosomes are added. Now Chang *et al.*[3] have found a crucial role for poly(ADP-ribose) (PAR). They show that if poly(ADP-ribose) glycohydrolase (PARG) is added to the extract to prevent the addition of PAR to proteins, only asters form around chromosomes, and a bipolar spindle cannot assemble.**