



Underwater air rings. Left, three rings rising vertically; right, top rings become linked.

limited to studying vortices that travel in parallel planes, it does show that vortex linking is easy to demonstrate experimentally.

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AREF REPLIES — I had previously seen pictures of these ‘air-rings’ (usually called ‘vortex ring bubbles’ in the fluid mechanics literature) that divers can produce. There is a recent paper by Lundgren and Mansour³ where such bubbles are studied and these authors mention a photograph in *National Geographic Magazine*⁴. Apparently, whales and dolphins also blow the rings.

I am not sure that what Rivest saw is the same process of linking that we reported in our paper¹. In our study, the intermediate state of interest consists of two rings connected as successive links in a chain, whereas he reports the formation of ‘a single large ring of irregular shape’. The linking that we were interested in is a variant of the more general phenomenon of reconnection, where two rings can, indeed, form a single, irregular ring for a while. I think what Rivest is seeing (see right-hand photo) is more closely related to the type of intermediate state that we have in our Fig. 1*d–e* rather than the linked state in our Fig. 4*d*. We actually believe that the ellipticity of the initial rings is essential for the process. In our simulations we did not succeed in producing linking starting from two circular rings.

I am not sure how one would blow elliptical vortex ring bubbles, but if it were possible, it would make a spectacu-

lar real-world analogue of the numerical solutions.

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Neanderthal dates debated

SIR — We cannot agree with some of Stringer and Grün’s speculations¹ stemming from the re-dating of the late Neanderthal from Saint-Césaire. We wonder why a thermoluminescence date of 36,300 years before present (BP), several thousand years older than previously thought, can justify the contention that “Neanderthals probably went out with a whimper, not a bang”¹.

The new date means that 12,500 years or more may separate Saint-Césaire from Cro-Magnon, the site of the earliest definitive ‘modern’ human crania from western Europe², if these burials are Upper Perigordian and not Aurignacian, as has been suggested³. How can this new, expanded timespan show an ancestor-descendant relationship to be chronologically untenable in western Europe? We believe that the western European dates may provide the best evidence for a region where there was a transition to modern populations with significant local genetic input from Neanderthals, in that there is now more than enough time for the process of

evolution due to natural selection to proceed at a reasonable rate. For instance, the rates of change between Neanderthals and early ‘modern’ Europeans for a truly diagnostic feature such as anterior tooth size are small relative to other recent evolutionary changes. These rates are one-half those between early and late Upper Palaeolithic samples and one-tenth the rate of change between Europeans of the Mesolithic and Neolithic who are only 3,500 years apart (D.W.F., manuscript in preparation).

There is also no evidence that indicates a “gradual displacement [of Neanderthals] to more marginal and less favorable environments, where their dwindling numbers would have suffered greater attrition from the vagaries of fluctuating climates and food supplies as well as disease”¹. Earlier, from the same evidence Stringer argued just the opposite², that Neanderthals persisted into the Upper Palaeolithic “. . . not just in backward or isolated areas either. Saint-Césaire is, in fact, situated in a region densely occupied during the Middle and Upper Palaeolithic.” The marginalization interpretation would not seem to apply to the Neanderthals of western Europe, any more that it applies to the Neanderthals of western Asia, where Neanderthals and their so-called ‘modern’ contemporaries lived for a period estimated to be as long as 60,000 years, manufacturing identical industries and using the same technology to do so, applying their tools in similar ways (the microwear is identical), burying their dead with the same customs, hunting the same game species and butchering them the same way. Here, these two supposed human species are known to coexist with archaeologically indistinguishable adaptations for a very long time and there is no evidence of banging or whimpering. There simply are no data to support the assertion of a cultural, biological or ecological marginalization of Neanderthals.

Stringer and Grün suppose that Neanderthals may have been a different species, but then they assert that the species “were probably sufficiently closely related to allow hybridization”, saying that “mitochondrial DNA studies have been used to suggest that there is no trace of a genetic input from Neanderthal females in recent European samples”. (We know of no discovery of Neanderthal mitochondrial DNA.) To make sense of these contradictory claims one would have to assume that this new understanding of species is not based on reproductive isolation, and that the “hybridization” was between Neanderthal men and the women of the “anatomically modern” humans who (presumably) replaced them.

Stringer and Grün assert that "the simplistic equation of hominids and technologies in Europe has thus been abandoned". Yet they also state that the contemporaneity of 'modern' humans and Neanderthals is "established" by the earlier Aurignacian of western Europe, which is said to be "firmly associated with modern humans". But what new evidence supports such a "firm association"? Earlier, on the basis of the same data set, Stringer³ asserted just the opposite: "apart from the Saint-Césaire skeleton . . . we know nothing of the population of the beginning of the French Upper Palaeolithic, particularly those of the early Aurignacian". This contradiction remains unresolved. Moreover, in central Europe the earlier Aurignacian is associated with some fragmentary but diagnostic specimens that have several unique elements of Neanderthal morphology and no unique "modern" European features⁴. This is relevant to the question of who manufactured the earliest Aurignacian because the earliest 'modern' central European remains, such as Mladeč and Vogelherd, do not derive from the earliest Aurignacian levels. This does not prove that the earlier Aurignacian is associated with Neanderthals, but it surely suggests the need for more caution than expressed by Stringer and Grün. There is no evidence that indicates a "gradual displacement [of Neanderthals] to more marginal and less favourable environments, where their dwindling numbers would have suffered greater attrition from the vagaries of fluctuating climates and food supplies as well as disease"¹.

The replacement of Neanderthals by 'modern' populations in western Europe is treated as a fact. It is not. Rather than demonstrating the coexistence between Neanderthals and 'modern' humans, the new date reinforces the notion that in western Europe, as in central Europe, the actual Neanderthal remains always precede definitive remains of 'modern' populations. In the west these two now appear separated by a greater timespan. As far as central and western Europe are concerned, the new data provide more than sufficient reason to retract the declaration that "models centred on a direct ancestor-descendant relationship between Neanderthals and modern *Homo sapiens* must surely now be discarded"⁵.

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STRINGER REPLIES — The points raised by Wolpoff and Frayer make me wonder

whether we have made any progress since our last exchange with Wolpoff about the significance of Saint-Césaire, more than 10 years ago⁶.

The morphology of the Saint-Césaire fossil and of other actual or claimed late Neanderthals does not provide overall support for a model of local evolutionary continuity in Europe. Although it is true that in certain selected respects, such as nasal breadth and dental size, these specimens show a closer approach to later humans than do actual or presumed earlier Neanderthals, most features show stasis. In fact, for features related to midfacial projection (one of the best established Neanderthal apomorphies) Saint-Césaire deviates in the direction away from early modern European values.

Regarding Aurignacian hominids, Wolpoff and Frayer misquote the comment "firmly associated with modern humans", which referred to the industries which replaced the Châtelperronian and Szeletian, not the early Aurignacian, which is contemporaneous. It is surprising that the authors do not seem to be aware of a recent review listing possible and more definite hominids from the French Aurignacian (including Cro-Magnon), concluding that none shows significant Neanderthal features⁷. Regarding Vindija, I can only echo the words of Allsworth-Jones who stated "there are no convincing grounds for associating Neanderthal remains with the Aurignacian at Vindija"⁸. If, despite this, the presence of a bone point (a later Aurignacian artefact) is used to date these Neanderthal-like hominids, it would certainly seem to establish their broad contemporaneity with anatomically modern hominids such as those from Velika Pečina, Mladeč and Vogelherd⁹.

A further misunderstanding lies in the continuing confusion of different species concepts. As I have pointed out elsewhere^{10,11}, the morphological and phylogenetic species concepts I use do not depend on the presence or absence of hybridization and anyway, many closely related 'biological species' today are capable of hybridization. A demonstration that hybridization occurred between Neanderthals and early modern humans would not be proof that they were conspecific.

Wolpoff and Frayer answer our speculations about European events with far

more speculation about western Asia. If they are not willing to recognize a coexistence of Neanderthals and modern humans in Europe, it is difficult to see how they can be so sure of a coexistence (let alone one of 60,000 years) of the two types in western Asia from much less precise dating evidence.

Wolpoff and Frayer cite my 1988 News and Views piece on the thermoluminescence dating of the Qafzeh early modern *Homo sapiens* fossils in the Levant⁵. The estimated age of this material, since supported by other data¹², was more than 50,000 years greater than the date now obtained for Saint-Césaire. If this material does indeed indicate such an early appearance of the modern human morphology, the quote seems even more appropriate now than in 1988.

Beyond these arguments about interpreting the fossil and archaeological records, there is the matter of interpreting the dating evidence. There is complete statistical overlap between the thermoluminescence date for Sainte-Césaire and radiocarbon dates for other Châtelperronian sites, and for numerous Aurignacian sites¹³. Another important issue was touched on by Mercier *et al.*¹⁴. This concerns the growing possibility, based on ice-core data and uranium series and thermoluminescence comparisons with ¹⁴C, that radiocarbon dates in the period around 30,000 radiocarbon years are significantly underestimating true ages. If this is confirmed by further work, it would not affect the established contemporaneity of the Châtelperronian and Aurignacian, but would provide even stronger evidence for a coexistence of late Neanderthals and early modern humans in Europe.

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Scientific Correspondence

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