of the initiation of a bursting under conditions of high excitability is given in Fig. 2c.

A clue to understanding the mode of operation of the trigger group came as a result of studying the response to natural stimuli that elicit swimming activity. Recordings were made from many neurons in the network, with as many as four electrodes recording simultaneously from different cells. Contact with one or a few tube feet of a starfish was followed by bursts of small excitatory postsynaptic potentials (EPSP's) in all cells recorded from. Surprisingly, some of these were very nearly synchronous in many of the cells (Fig. 2d). The synchrony is not due to electrical conduction since the magnitudes of the EPSP's were similar. It is more likely that inputs from the appropriate receptors arrive at many cells of the network simultaneously owing either to an extensive degree of divergence of sensory neurons before they terminate on the cells of the network or to the interposition of interneurons that provide for the divergence.

These synchronous small depolarizations, as well as weak currents applied by suction electrodes, are effective in giving rise to bursts, provided they occur in a sufficiently large group of neurons at the same time. Large depolarizations of single or small groups of neurons rarely lead to a synchronous burst. The distinction between the effectiveness of synchronous depolarizations in a large number of cells and the ineffectiveness of isolated large depolarizations in leading to bursts may well provide the neuronal mechanism for the trigger action. This type of operation combines aspects of the randomly connected neuron model of Beurle and the "multiple input, metastable feedback loop" of Bullock (*9*).

Occasionally, the animals do execute full swimming sequences in the apparent absence of any external stimulation. These are comparable to the familiar "vacuum activities" observed by ethologists (*1*). In *Tritonia*, they appear to arise as a result of cascading of spontaneous activity by local reexcitation and spreading over the network, at times when there is a high level of "background" activity.

The conclusions from the present evidence are that the function of initiating the swimming escape response resides with the pleural network, and that the basis of its operation is positive selection of inputs that affect many cells in the network simultaneously and rejection of those that excite only a few components.

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27 October 1969

Caribbean Cores P6304-8 and P6304-9: New Analysis of Absolute Chronology. A Reply

We are considerably annoyed with *Science* for having published a comment (*1*) critical of our work without informing us of its acceptance and giving us the customary option to reply in the same issue. In this comment, Broecker and Ku report their Th^{230}/Pa^{231} results on the same or adjacent samples from the Miami cores P6304-8 and P6304-9 which we had previously analyzed (*2*). Of the four samples tested, agreement between Miami and Lamont-Doherty was found for two, disagreement for the other two (Table 1 in *1*). Where disagreement exists, Broecker and Ku claim that their results are right and ours are wrong. We believe exactly the opposite and for very good reasons: (i) Our results match exactly the C^{14} time scale over the common range, while theirs do not; and (ii) our results are internally consistent in every case while theirs are not. Thus, not only do Broecker and Ku obtain ages approximately 30,000 years too old for the top of the cores, which are demonstrably modern by both C^{14} (*2*) and micropaleontological analysis at the subspecific level (*3*), but they also find a Th^{230}/Pa^{231} value of 29 for one core level and a value of 40 for a stratigraphically identical level in the other core, while we obtained values of 29 for both cores (Table 1 in *1*).

Our extraction technique (*4*) is directed toward removing from the sedi-

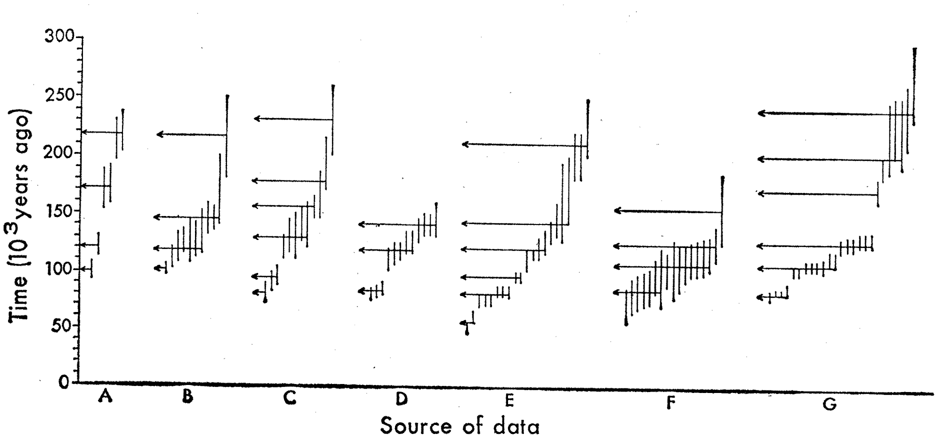

Fig. 1. Absolute ages of high sea levels during the past 300,000 years. Vertical lines are absolute ages with their published errors (from *9–15*) (see Table 1). Horizontal arrows represent best fits (chronological means).

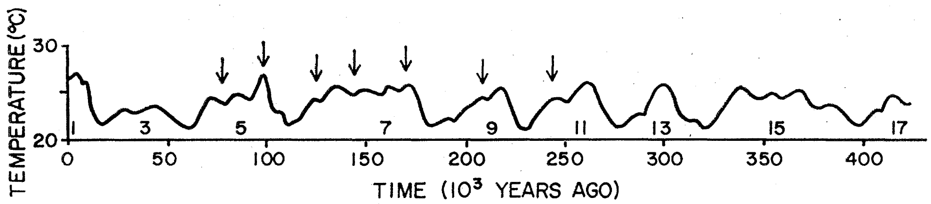

Fig. 2. The chronological relation between the generalized paleotemperature curve (from *8*) and high sea levels (from Table 1, column H).

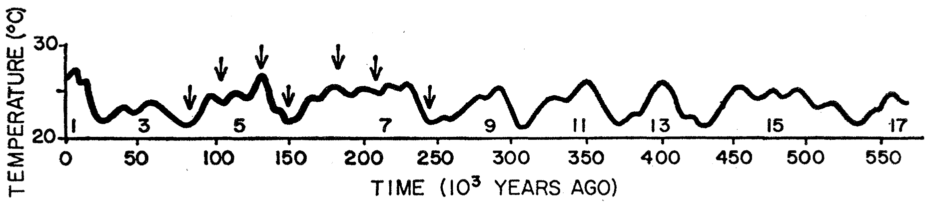

Fig. 3. The chronological relation between high sea levels and the generalized paleotemperature curve based on the time scale advocated by Broecker and Ku (*1*).

Table 1. Ages (10^3 years ago) of high sea levels reported by different authors (see Fig. 1). (A) Blanchard (*9*); (B) Osmond *et al.* (*10*); (C) Broecker and Thurber (*11*); (D) Stearns and Thurber (*12*); (E) Stearns and Thurber (*13*); (F) Szabo and Rosholt (*14*); (G) Mesolella *et al.* (*15*); (H) averages. The ages of the two earliest levels are very uncertain. Dashes indicate no data.

A	B	C	D	E	F	G	H
–	–	230	–	–	–	240	*235*
218	215	–	–	210	–	200	*211*
172	–	177	–	–	–	170	*173*
–	145	155	140	143	154	–	*147*
122	118	128	118	120	124	125	*122*
100	101	92	–	95	105	105	*100*
–	–	80	82	80	82	80	*81*

ment the uranium and daughter products scavenged from the ocean water by settling particles. We avoid extraction of the hard fraction embedded in the lattice of mineral particles derived from land, which usually are tens to hundreds of millions years old and only introduce noise. Hence, our reported concentrations of U, Th^{230}, and Pa^{231} are necessarily lower. The correction proposed by Broecker and Ku leads to negative Pa^{231} concentrations (Table 2 in *1*); this is a physical impossibility and, therefore, their proposed correction is rejected.

Not only do we realize that many cores give a Th^{230}/Pa^{231} ratio at the top greater than the theoretical 10.8 (*5*), but also we do expect this to be the case for the vast majority of the cores because only a minute portion of the deep-sea cores thus far collected by the various oceanographic institutions are stratigraphically continuous and undisturbed. Cores failing to yield the modern Th^{230}/Pa^{231}, such as the Swedish core 280 (*5*) and the Lamont core V12-122 (*6*), evidently contain varying amounts of reworked Th^{230} and are not suitable for absolute dating. Manganese nodules with Th^{230}/Pa^{231} ranging from 2 to 10 are generally believed to remove Pa from seawater preferentially and have no bearing on the present geochronological discussion.

The age of 313,000 years for the U-V boundary, which we obtained by extrapolating our own ages, is identical, as we pointed out (*2*), with the age of 320,000 years obtained by Ku and Broecker themselves (*6*) using the Th^{230} method. Furthermore, Ku and Broecker (*6*), using this method, obtained ages of 128,000 years for the boundary between stages 8 and 7; of 107,000 years for that between stages 6 and 5; and of 75,000 years for that between stages 5 and 4. As they showed (figure 2 in *6*), these ages are in exact agreement with our previously published Th^{230}/Pa^{231} time scale.

Having subsequently obtained, for corals from raised terraces in Barbados, ages which they thought were in disagreement with their own dating of core V12-122, they proceeded to reevaluate their core dates. Using arguments based on rates of sedimentation, they concluded that their previously published Th^{230} time scale was actually in error and should be stretched by 25 percent (*7*). In the process they also stretch our Th^{230}/Pa^{231} time scale, which we resent very much. Our data on numerous cores show that (i) the last interglacial ranged from 100,000 to 65,000 years ago; (ii) the previous one ranged from 175,000 to 120,000 years ago; and (iii) a full glaciation, 20,000 years long, took place between the two (ages read from figure 6 in *8* and figure 1 in *2*).

An analysis (Fig. 1) of the 104 published ages (70 by Lamont workers) for high sea level carbonates from various parts of the world, obtained by uranium decay series methods (*9–15*), leads to the values shown in Table 1. The averages (Table 1, column H) are in exact agreement with our time scale; when plotted on our paleotemperature curve (Fig. 2) high sea levels fall in every case within interglacial ages. If the "stretched" time scale proposed by Broecker and Ku were adopted, the relation between temperature and high sea levels would become random, with three of the seven high sea levels falling within glacial ages (Fig. 3).

We conclude that Broecker and Ku's suggestion cannot be accepted. More importantly, the high sea level ages set our time scale so strictly that even a small lengthening or shortening becomes impossible.

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