



The monthly rate of the opening dates of wars at latitudes 30–60° N (a) and 30–60° S (●) are correlated with the duration of the daily photoperiod. Data for the photoperiod duration at latitude 45° N (a) and 45° S (c) (---) are taken from ref. 4. The correlation between the monthly rate of wars in (a), and the duration of the daily photoperiod were found to be highly statistically significant. Spearman's rank coefficients 0.834, $P < 0.001$ and 0.86, $P < 0.001$, respectively. A phase-shift of one month in advance in the photoperiod rhythm resulted in improved correlations: Spearman's rank coefficients 0.991, $P < 0.001$ and 0.986, $P < 0.001$, respectively, the correlation between the monthly rate of wars in (c) and the duration of the daily photoperiod was found to be highly statistically significant. Spearman's rank coefficient 0.912, $P < 0.001$. A phase-shift of one month in advance in the photoperiod rhythm did not result in improved correlation. Opening dates of wars around the line of Equator (latitudes 30° N–30° S (b) show a constant monthly rate throughout the year.

in affective aggressiveness which results in the correlation described here. Could the photoperiod environmental cue be one of the factors which call the "lust for hatred and destruction"³ into play?

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Release factors and genetic code

SIR — Meyer *et al.* reported¹ that UGA was a code for the amino acid cysteine in the ciliate *Euplotes octacarinatus*, in addition to the 'universal' cysteine codons UGU and UGC. UAA was its stop codon, and codon UAG was not found^{1,2}. Meyer *et al.* suggested that the "role of the classic termination codons had not yet been established when the ciliates started to diverge from other eukaryotes". We have already proposed³ a different explanation: divergent codes in ciliates, such as *Tetrahymena*, "may be formed by capture of stop codons". Similarly, Miceli *et al.*², referring to *Euplotes*, suggested that "the eccentric genetic code of some ciliates is a derived and not a primitive character".

Release factors in eukaryotes normally recognize stop codons UAA, UGA and UAG. In *Euplotes*, these factors appear to be specific for UAA^{1,2,4}, and, if so, codons UGA and UAG would become untranslatable nonsense codons which disappear from coding sequences⁵. We suggest that UGA reappeared as a cysteine codon when G in cysteine anticodon GCA became modified, perhaps to I (inosine) so as to pair with U, C and A in the third positions of codons, UGU, UGC and UGA. Similar modifications of G in anticodons, to pair with U, C and A, have been proposed for anticodons GUU (asparagine) and GAU (isoleucine) in echinoderm mitochondria⁶, and for anticodon GUA (tyrosine) (in addition to anticodons GUU and GAU) in planarian mitochondria (Y. B. *et al.*, manuscript submitted).

In *Tetrahymena*, release factors became specific for UGA (rather than UAA) so that UAA and UAG became untranslatable and disappeared. These codons would have been captured by glutamine³ when two additional glutamine anticodons were formed by mutation of anticodon UmUG to UmUA in a duplicate of glutamine transfer RNA, followed by mutation of a duplicate of codon UmUA to CUA⁷. UAA and UAG were translated as glutamine in *Tetrahymena* and the ciliates *Oxytricha*, *Paramecium* and *Stylonichia* when they reappeared, by mutations of some CAA and CAG glutamine codons³. An alga, *Acetabularia*, presumably followed the same course of events⁸.

Planarian mitochondria evidently use UAG as the only stop codon. UGA encodes tryptophan and UAA (in addition to UAU and UAC) for tyrosine. One release factor, RF2, which recognizes stop codons UGA and UAA in prokaryotes, has not been detected in rat mitochondria⁹. Presumably it has been deleted, because it would read UGA as

stop¹⁰. Another release factor, RF1, which normally recognizes stop codons UAA and UAG, has apparently become specific for UAG in planarian mitochondria, making UAA untranslatable so that it disappeared. UAA was captured by tyrosine when anticodon GUA became modified, presumably to IUA, and UAA reappeared from mutations of tyrosine codons UAU and UAC (Y.B. *et al.*, manuscript submitted; see ref. 10). This change seems analogous to the one with UGA in *Euplotes*.

The capture of UGA by cysteine in *Euplotes* probably occurred after the divergence of *Euplotes*¹¹ as a recent event in ciliate phylogeny. The changes we have suggested accord with the codon capture theory for non-disruptive change in the genetic code⁵.

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Ice age carbon

SIR — Two recent attempts have been made to understand past changes in the global carbon cycle by estimating changes in carbon storage during the ice age. One was based on a climate-biosphere model¹, the other on palaeoecological inferences². Changes in carbon storage are thought to be related to carbon dioxide levels during the last glacial maximum, 18,000 years before present (BP). The two approaches give very different estimates for change in terrestrial carbon storage: ± 50 giga-tonnes (10^9 g) for the former¹ and about 1,350 Gt for the latter². But the marine record supports neither conclusion.

Marine $\delta^{13}\text{C}$ data can be used to constrain terrestrial-based estimates of carbon variations, as some of the marine changes in the glacial–interglacial reservoir reflect effects due to the transfer of