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Comment on "Population genomics of early events in the ecological differentiation of bacteria"

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Comment on "Population Genomics of Early Events in the Ecological Differentiation of Bacteria" by Shapiro et al.
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Shapiro et al. (*1*) have shown that ecologically distinct, closely related populations of marine *Vibrio* can be nearly identical in a single gene while they are much more divergent elsewhere in the genome. They conclude that single-gene sweeps, not genomic sweeps, are responsible for regions of high identity in *Vibrio* genomes. They thus claim evidence against periodic selection, where selection favoring an adaptive mutation purges variation genome-wide (*2*), owing to extremely low recombination rates (*3*). However, periodic selection theory applies only to the diversity within a single, ecologically homogeneous population (ecotype) (*2, 4*), while the single-gene sweeps observed involve transfer of an adaptive gene across ecotypes; these sweeps are therefore outside of periodic selection theory.

Instead, single-gene sweeps across ecotypes are predicted by the widely accepted model of speciation by horizontal genetic transfer (HGT) (*5-7*). Here a niche-specifying gene from one (donor) ecotype transfers on a small segment to a recipient organism in another pre-existing ecotype; the recipient cell thereby founds a new ecotype. Only one HGT event is needed to homogenize the donor and new ecotypes at the niche-specifying gene while they maintain pre-existing divergence elsewhere in the genome (Fig. 1).

A related explanation for single-gene sweeps is that a generally-adaptive gene may transfer across ecotypes and without creating new ecotypes, the transferred gene confers benefit to each recipient ecotype (*2, 4*) (Fig. 2). Receipt of the adaptive mutation in a given ecotype then causes a periodic selection event within the ecotype. The populations thereby become identical for the transferred sequence but retain their pre-existing divergence everywhere else on the genome. We conclude that Shapiro's results do not contradict either empirical estimates of low recombination rates in bacteria or periodic selection theory. Two models of inter-ecotype transfer of adaptive genes explain the single-gene sweeps observed, and are consistent with periodic selection occurring within ecotypes.

References

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Fig. 1. Speciation by Horizontal Genetic Transfer. Niche-specifying genes transferred between ecotypes can stimulate ecotype formation events, resulting in homogenization of a single gene across some ecotypes. (A) Two ecotypes have distinct ecologies, owing to expression of their unique sets of niche-specifying genes. The genome of an individual is indicated by a circle, and the niche-specifying genes are indicated by the symbols along the genome. The color of the box indicates the ecotype; the color(s) of a genome indicates the origin(s) of its genes. (B) One niche-specifying gene (square) is transferred only once on a small DNA segment (blue line) from a member of Ecotype 1 to a member of Ecotype 2. (C) The recipient of the gene, formerly in Ecotype 2, now has a unique set of niche-specifying genes. As it begins to express the received gene, it consequently changes its ecology (enters the green box). This is the founding of a new ecotype that is distinct both genetically and ecologically from Ecotype 1 and Ecotype 2. The new ecotype is identical for the transferred gene with Ecotype 1 but is elsewhere divergent from that ecotype.

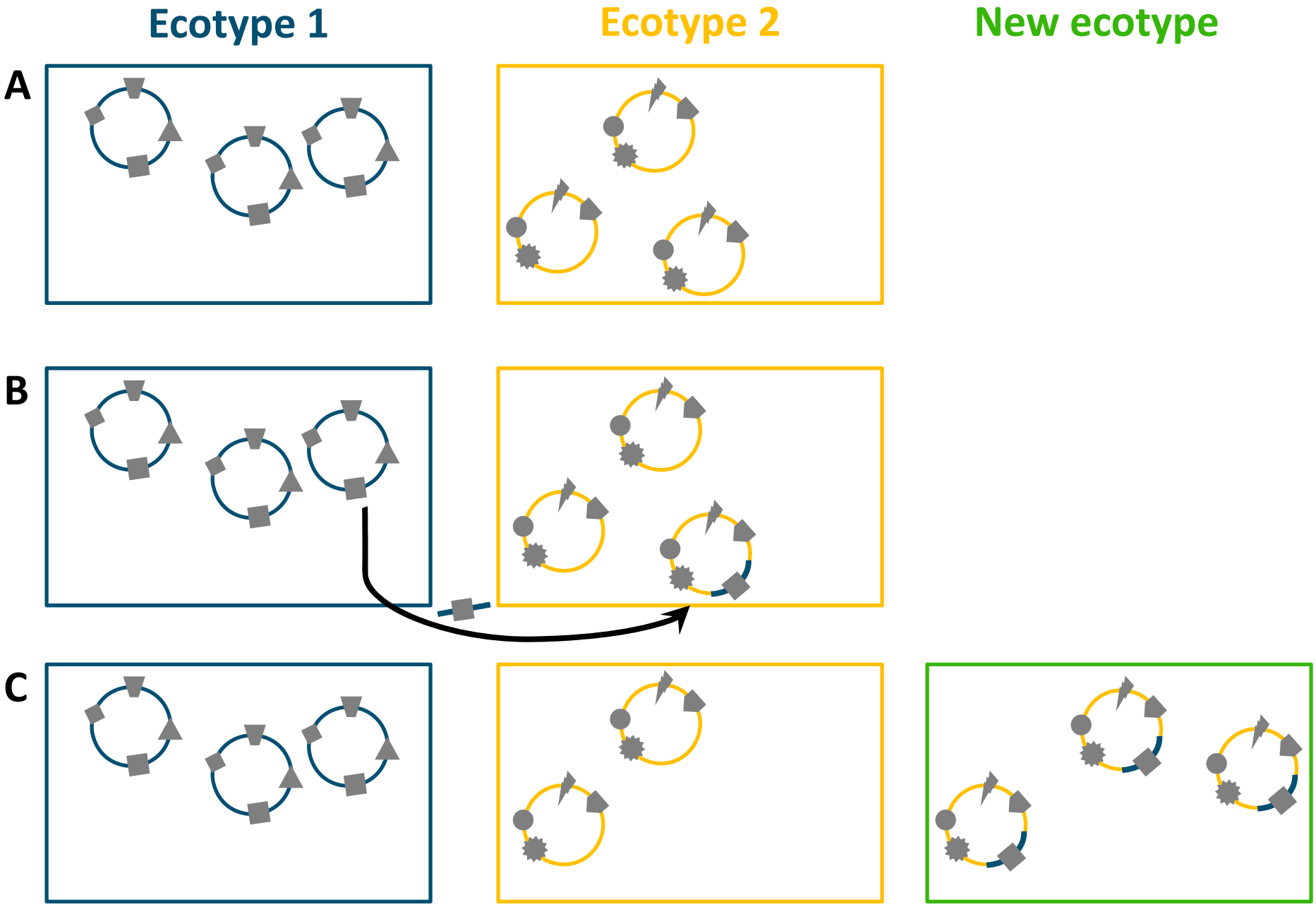
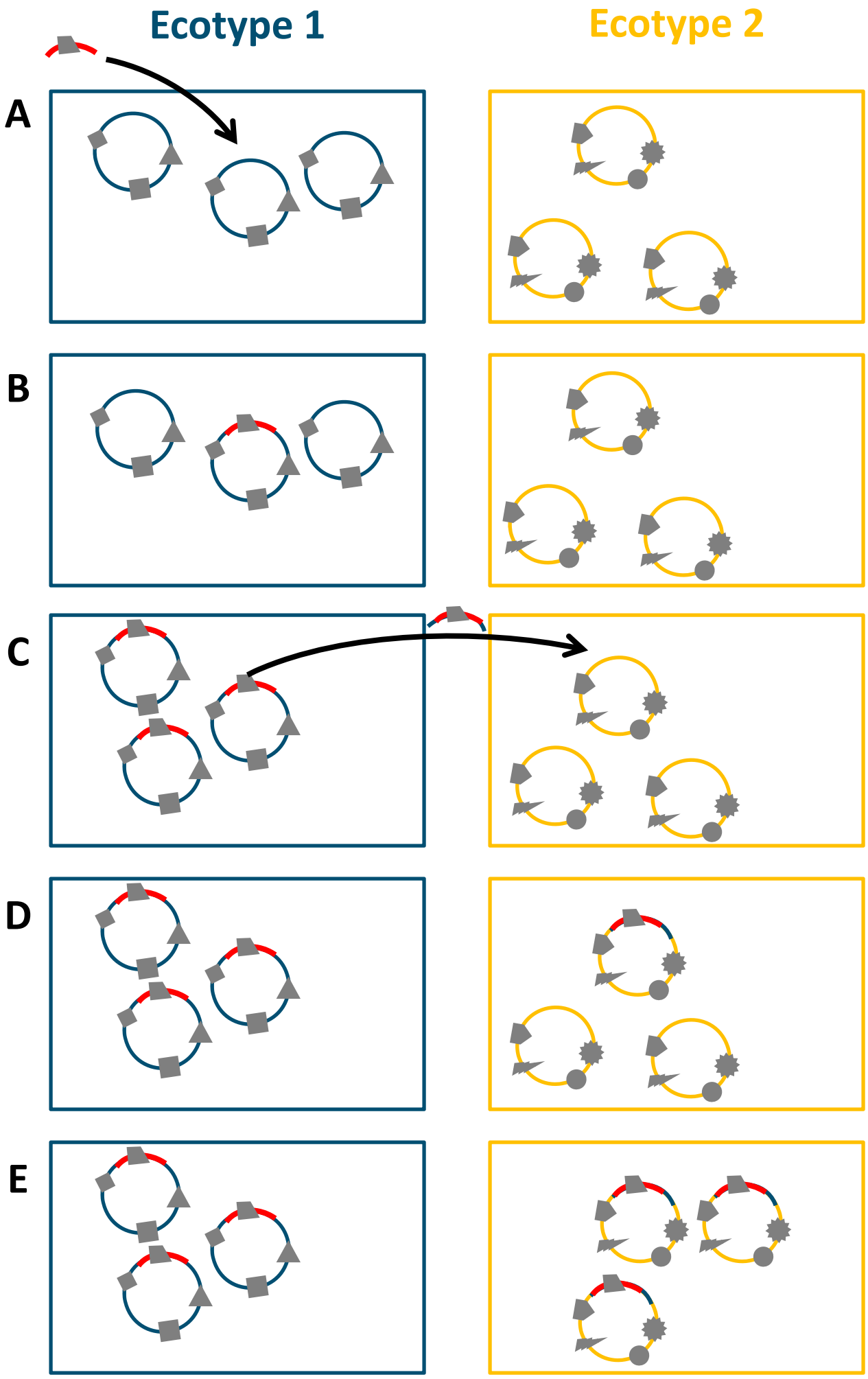

Ecotype 1
Ecotype 2
New ecotype
A
B
C

Fig. 2. The Act Globally Adapt Locally model. Niche-transcending adaptations acquired from individuals of other ecotypes can cause periodic selection events in (and limited to) the recipient ecotype, resulting in a single gene being homogenized across ecotypes. The format of the figure follows that of Supp. Fig. 1. (A) A single individual in Ecotype 1 receives a niche-transcending adaptation (trapezoid) on a small segment of DNA (red arc) from an individual outside of Ecotype 1. (B) The recipient individual becomes more competitive than the other members of Ecotype 1 while its set of favored resources and conditions remains unchanged. (C) Owing to periodic selection within Ecotype 1, all members of Ecotype 1 are descendants of the individual that received the niche-transcending gene. The gene is then transferred on a small DNA segment (with ends that may differ from the piece originally transferred in panel A) to an individual in Ecotype 2. (D) The recipient member of Ecotype 2 becomes more competitive than the other members of Ecotype 2 while its ecology remains unchanged and distinct from that of Ecotype 1. (E) Owing to periodic selection within Ecotype 2, all members of Ecotype 2 are descendants of the individual that received the niche-transcending gene. A genomic survey of Ecotype 1 and Ecotype 2 would show that they are homogenized at the niche-transcending gene, yet divergent at all other loci. Adapted from (*2*).


Ecotype 1
Ecotype 2
A
B
C
D
E