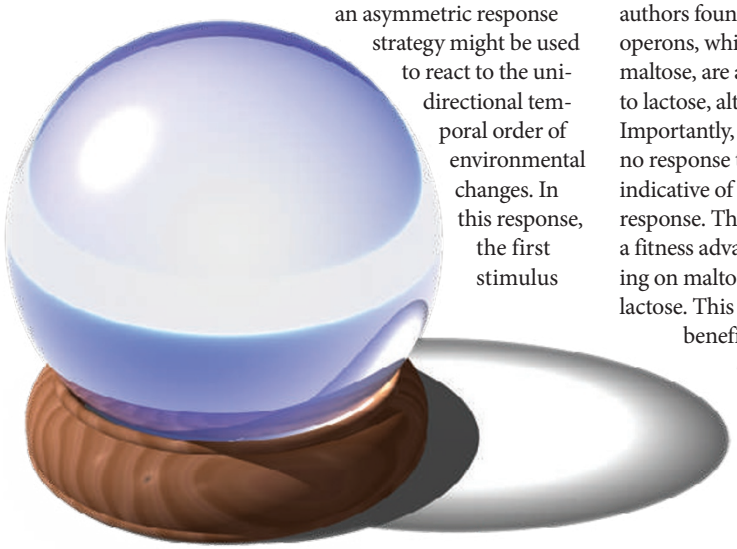
MICROBIAL GENETICS

Predicting the future

Faced with constantly changing environmental stimuli and stresses, microorganisms have evolved complex mechanisms to respond to altering conditions. The simplest strategy adopted is a direct one: monitor the environment for changes and then respond. In predictable, yet still changing environments, the anticipation of a changing condition based on a preceding signal may provide an adaptive evolutionary advantage.



Mitchell *et al.* reasoned that an asymmetric response strategy might be used to react to the unidirectional temporal order of environmental changes. In this response, the first stimulus (S1) would activate not only its designated response (R1), but also the response to the second stimulus (R2), whereas the second stimulus (S2) would activate only R2. To test this *in vivo*, the authors looked at the response of *Escherichia coli* to the metabolic environment encountered in the intestine. During passage along the digestive tract, bacteria are first exposed to lactose, followed by exposure to maltose further down the tract. The authors found that *E. coli* maltose operons, which are induced by maltose, are also induced by exposure to lactose, although to a lesser extent. Importantly, lactose operons showed no response to maltose, which is indicative of a unidirectional adaptive response. The authors also observed a fitness advantage when cells growing on maltose were pre-exposed to lactose. This kind of preparation only benefits an organism if the change in environmental conditions is actually encountered. Accordingly, when *E. coli* cells were grown for 500 generations on high levels of lactose with no exposure to maltose, the adaptive response was lost and no activation of maltose operons was observed in response to lactose.

Similar observations were seen in experiments with *Saccharomyces cerevisiae*, which encounters potentially fatal levels of oxygen radicals during the fermentation process, after switching from fermentation to oxidative respiration. The authors found that exposure to heat shock stress, which occurs during fermentation, led to cross-protection against oxidative stress. Using microarrays the authors were able to identify candidate genes that may be responsible for this trait.

These data show that the anticipation of environmental stimuli is an adaptive trait that has evolved at the cellular level in both prokaryotic and eukaryotic microorganisms.

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ORIGINAL RESEARCH PAPER Mitchell, A. *et al.* Adaptive prediction of environmental changes by microorganisms. *Nature* 17 Jun 2009 (doi: 10.1038/nature08112)