Teaching Guide for: Virus Adaptation to Environmental Change

Speaker: Paul Turner
Video link: https://youtu.be/xNCMgAgLoq4

Major topics

- Ecology
- Evolution
- Microbiology

Overview

Viruses have an incredible capacity to adapt to environmental challenges, but sometimes, the environment constrains viral adaptation. Turner's laboratory uses experimental evolution to study how viruses adapt to environmental changes (e.g. temperature changes), and the mechanisms by which viruses jump to novel host species. Turner's work suggests that viruses with greater capacities to block the innate immune systems of their hosts, also have a greater likelihood of emerging on new host species. Also, he describes how virus adaptation to environmental change may be constrained by trade-offs: viruses can evolve either greater reproduction or greater survival, but not both simultaneously.

Sub topic

- Trade-offs

Multiple-choice questions

(*students should start video at 27:34 - https://youtu.be/xNCMgAgLoq4?t=1654)

1. In Dr. Paul Turner's viral evolution experiments, he exposed the VSV virus to four different temperature treatments for 100 generations and then measured their fitness (replication ability) at both warm (37°C) and cool (29°C) conditions. Which treatment resulted in the highest fitness in both warm and cool conditions?

   a. Constant warm temperatures
   b. Constant cool temperatures
   c. **Alternating warm and cool temperatures**
   d. Random variation across a range of cool and warm temperatures
   e. All the treatments had nearly identical fitness

2. In the VSV experiment, which virus population had the same fitness as the ancestral population in both warm and cool environments?

   a. Constant warm temperatures
   b. Constant cool temperatures
   c. Alternating warm and cool temperatures
   d. **Random variation across a range of cool and warm temperatures**
   e. All the treatments had fitness similar to the ancestral population

3. In another experiment, Dr. Paul Turner studied the ability of the phi-6 virus to adapt to heat stress by exposing some viral lineages to heat shock (50°C) and then measuring the survival of control and heat-shock lineages to various temperatures. Did this experiment indicate that heat-shock improved the ability of viruses to withstand high temperatures?

a. No, control and heat-shock viruses had similar survival at all temperatures
b. No, heat-shock viruses showed lower survival at temperatures >44°C than control lineages
c. Yes, heat shock lineages showed >60% survival at all temperatures studied
d. **Yes, heat shock lineages survived significantly better than control lineages at temperatures >44°C, though even these viruses showed high mortality at >48°C**

4. In a continued study, Dr. Paul Turner identified an important trade-off for the heat-shock virus lineages. While these lineages were better able than control lineages to withstand high temperatures, they also exhibited _____________

a. Reduced survival at average temperatures
b. **Lower reproduction (replication) at average temperatures**
c. Reduced severity of infection in host cells
d. Lower resistance to antiviral medications

Relevant literature

Alto, B. W., Wasik, B. R., Morales, N. M., & Turner, P. E. (2013). Stochastic temperatures impede RNA virus adaptation. Evolution: International Journal of Organic Evolution, 67(4), 969-979.

McBride, R. C., Ogbunugafor, C. B., & Turner, P. E. (2008). Robustness promotes evolvability of thermotolerance in an RNA virus. *BMC evolutionary biology*, *8*(1), 1-14.

Dessau, M., Goldhill, D., McBride, R. L., Turner, P. E., & Modis, Y. (2012). Selective pressure causes an RNA virus to trade reproductive fitness for increased structural and thermal stability of a viral enzyme. *PLoS genetics*, *8*(11), e1003102.

De Paepe, M., & Taddei, F. (2006). Viruses' life history: towards a mechanistic basis of a trade-off between survival and reproduction among phages. *PLoS biology*, *4*(7), e193.

Related resources

This video is included in Session 10 of iBiology's Evolution Flipped Course, which has additional downloadable teaching guides and recommended videos. We encourage educators seeking more materials to visit the course page.

Acknowledgments

We thank Dr. Laci Gerhart-Barley for sharing her multiple-choice questions for this video. For more information on how to implement this video in your teaching through homework

assignments, check out Dr. Gehart Barley's [publication] and [webinar] with Dr. Brittany Anderton, Associate Director of iBiology.