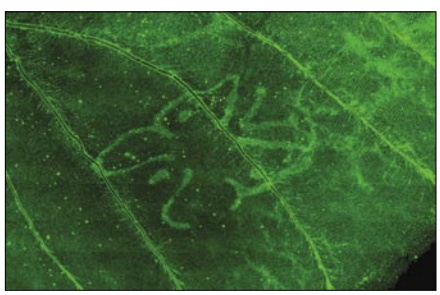
Evolution-on-a-Chip

Lab-on-a-chip technology is becoming increasingly commonplace in biological research. The discipline of evolutionary ecology would not seem at first glance a strong candidate to take advantage of these microscale-fabricated devices, but this thinking may soon change. Traditional studies of evolutionary ecology using bacteria have been performed on bacteria grown in reactors called chemostats. Chemostats are not heterogeneous environments and lack spatial structure, limiting the experiments a biologist can perform. To remedy this situation, Keymer et al. set out to fabricate microscale devices to study how bacteria adapt to different regions on a heterogeneous landscape. The fabricated "landscape" consists of a linear array of 85 square wells, 100 μm square by 30 μm deep in size, called microhabitat patches (MHPs) etched into silicon wafers and all connected by channels 5 μm wide and 50 μm long, allowing for migration of bacteria between MHPs. Nutrients were supplied to MHPs by 200-nm channels—too narrow for bacteria to pass through. By changing the number of etched nutrient channels going to specific MHPs they were able to change the landscape conditions, making some MHPs more nutrient rich than others. The results they obtained demonstrate the ability to use these devices to understand evolutionary processes at both a local (a single MHP) and global (the entire array of MHPs) level. Keymer et al. found that in a "flat" landscape, where all 85 MHPs had equal numbers of nutrient channels, local MHPs showed fluctuations in population size while over the entire array a metapopulation emerged that demonstrated a more constant growth rate. In more complex experiments where different numbers of nutrient channels were connected to MHPs, bacteria were able to colonize the entire landscape. Interestingly, this colonization process could be divided into distinct epochs based on bacterial expansions over time into all areas of the landscape, even adaptation to the nutrient limited MHPs. This current work demonstrates the utility of microscale-fabricated devices for studying evolutionary ecology and suggests in the future people might be describing "environments-on-a-chip." *–NB*

-Keymer et al. 2006. Bacterial metapopulations in nanofabricated landscapes. Proceedings of the National Academy of Sciences of the USA 103:17290-17295.

Laser Sharp Gene Expression

The ability to control gene expression in a specific tissue or cell type allows researchers to better understand gene function in vivo. Turning on the expression of a transgene can be done using genetic systems, such as yeast GAL4/UAS, or simply using a heat-shock promoter. The GAL4/UAS system requires the GAL4 transcription factor to be under the control of a regulatory region to permit tissue specific expression, while induction of heat-shock promoter driven transgenes often leads to a global expression pattern. An obvious drawback of the GAL4/UAS system is the need for a specific regulatory region that may not be available for all tissues or organisms of interest, while the drawback of heat-shock driven expression is lack of specificity in the expression pattern. Studies have shown single cell expression from a heat-shock promoter driven transgene can be



induced using either heated needles or lasers. Ramos et al. are now moving one step further, showing that laser-induced gene expression can occur over a much larger population of specific cells. In studies using the butterfly (*Bicyclus anynana*) wing as a model system, transgenic butterflies harboring a GFP transgene fused to the *Drosophila hsp70* promoter were subjected to a variety of laser pulses; microslits were placed over the laser beam, allowing different patterns of light to be focused on the areas of interest. Laser light focused in a single line pattern on the wing resulted in green fluorescence in a subset of cells in the treated area in more than 75% of individuals. Ramos et al. went on to show that even more complex GFP expression patterns could be obtained by creating microstencils to cover the laser beam, demonstrating the potential of this technique to reproduce the more complicated gene expression patterns often observed during development. This work improves on methods to induce gene expression in large numbers of specific cells, expanding the repertoire of techniques available for gene function analysis. *–NB*

- Ramos et al. 2006. Temporal and spatial control of transgene expression using laser induction of the hsp70 promoter. BMC Developmental Biology 6:55.