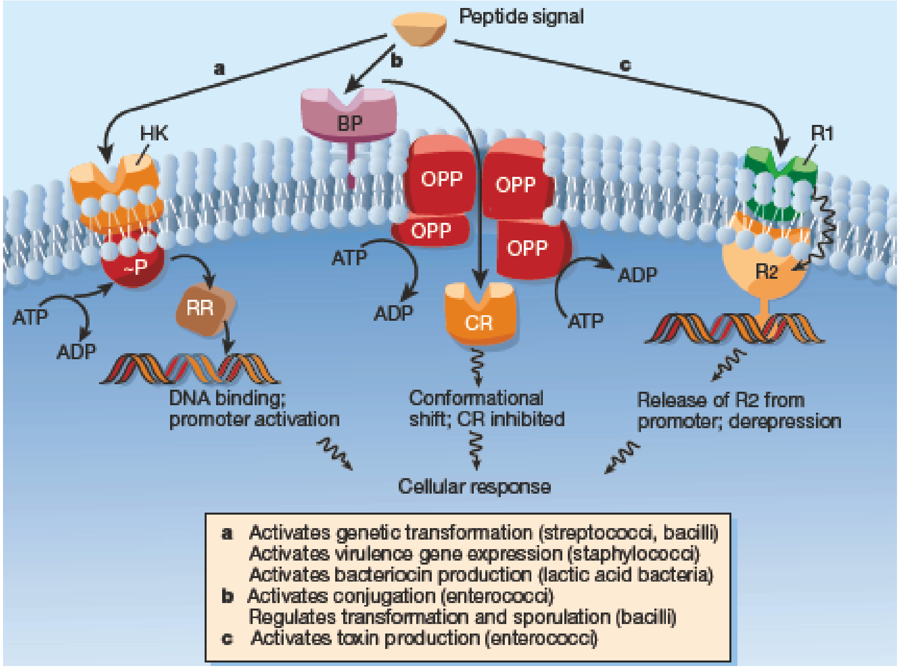

Figure 1 **Three mechanisms of cell–cell communication between bacteria. The signalling molecules are peptides, 5–25 amino acids in length, but are different for each pathway. a, A two-component signal-transduction system, in which binding of the peptide to a histidine kinase (HK) receptor on the cell membrane results in autophosphorylation (~P) of the kinase. The phosphate is transferred to a response regulator (RR), which can then bind to target DNA and activate a gene promoter and transcription. b, A binding protein (BP) on the cell membrane takes the peptide signal from the environment and uses an oligopeptide permease (OPP) to import the peptide into the cell. Peptide binding to a cytoplasmic receptor (CR) causes a conformational shift and inhibits receptor function (some CRs negatively regulate transcription; others act as phosphatases, with phosphorylated regulatory proteins as substrates). c, The pathway described by Haas *et al.*[1]. In the absence of the peptide signal (in this case, the LS component of the secreted cytolysin toxin), two proteins, R1 and R2, appear to act in concert to repress the cytolysin biosynthetic genes. Peptide-signal binding to R1 is predicted to disrupt the repressive R1–R2 conformation and result in increased gene transcription. Squiggly arrows indicate the effects of interactions; other arrows indicate direct molecular interactions. Bacterial activities controlled by each pathway are listed in the box.**

not been demonstrated directly, but they are consistent with the data and can be tested experimentally.

These results will affect our view of cell–cell communication in bacteria, and how we deal with the *Enterococcus* as an opportunistic pathogen. Clearly, peptide-mediated cell–cell signalling in bacteria can occur by any of at least three distinct mechanisms (Fig. 1). A search of the nearly completed *E. faecalis* genome sequence[13] suggests that there may be a dozen or more two-component signal-transduction systems, some of which could mediate cell–cell communication. In other words, in *E. faecalis* alone, many additional processes could be regulated in this fashion.

The new results[1] could also help in developing drugs to combat enterococcal infections. In some infections, production of cytolysin or other virulence factors (regulated, perhaps, by similar mechanisms) may be required to cause disease but may not be necessary for the organism's survival and growth in its normal habitat, the intestine. A drug that targeted the signal pathway to block virulence could prevent or cure infection. But because the bacteria would not be directly killed, the drug would not exert a strong selective pressure for development of drug resistance — one of the banes of modern medicine. ■

Gary M. Dunny is in the Department of Microbiology, University of Minnesota Medical School, 428 Delaware Street, SE, Minneapolis, Minnesota 55455-0312, USA.
e-mail: gary-d@biosci.cbs.umn.edu

1. Haas, W., Shepard, B. D. & Gilmore, M. S. *Nature* 415, 84–87 (2002).
2. Dunny, G. M. & Winans, S. C. *Cell–Cell Signaling in Bacteria* (Am. Soc. Microbiol., Washington, DC, 1999).
3. Fuqua, W. C., Winans, S. C. & Greenberg, E. P. *J. Bacteriol.* 176, 269–275 (1994).
4. Dunny, G. M. & Leonard, B. A. B. *Annu. Rev. Microbiol.* 51, 527–564 (1997).
5. Hoch, J. A. & Silhavy, T. J. (eds) *Two-Component Signal Transduction* (Am. Soc. Microbiol., Washington, DC, 1995).
6. Ike, Y., Clewell, D. B., Segarra, R. A. & Gilmore, M. S. *J. Bacteriol.* 172, 155–163 (1990).
7. Gilmore, M. S., Segarra, R. A. & Booth, M. C. *Infect. Immunol.* 58, 3914–3923 (1990).
8. Segarra, R. A., Booth, M. C., Morales, D. A., Huycke, M. M. & Gilmore, M. S. *Infect. Immunol.* 59, 1239–1246 (1991).
9. Clewell, D. B. *et al. J. Bacteriol.* 152, 1220–1230 (1982).
10. Gilmore, M. S. *et al. J. Bacteriol.* 176, 7335–7344 (1994).
11. Huycke, M. M. & Gilmore, M. S. *Plasmid* 34, 152–156 (1995).
12. Coque, T. M., Patterson, J. E., Steckelberg, J. M. & Murray, B. E. *J. Infect. Dis.* 171, 1223–1229 (1995).
13. http://www.tigr.org

Daedalus

Atmospheric charge

Lightning, says Daedalus, is universal. Not only are there about a thousand thunderstorms going on around the Earth at any one time, but lightning has been observed in the atmospheres of other planets, with different chemistry from that of Earth. The complex organic molecules built up by earthly lightning, precursors of life itself, should therefore exist on other planets. They may have given life a start there too.

Daedalus can think of two bases for lightning. First, phase changes, like that of water going to ice, must extrude charge. No solution or melt can have the same electron affinity as the solid, so a solidifying droplet must push charge ahead of the solid front. Second, any charged gas must expand, by self-repulsion. A big enough voltage (150 megavolts for air) would give a vacuum; smaller charges, of just a few megavolts, would merely provide strong lift. So solidification of any sort, coupled with charge sharing to an atmosphere, must give rise to convection. Couple this with a feedback mechanism, such as the return of charge in falling raindrops that partly freeze, and you soon build up enough charge separation for lightning.

To test these ideas, DREADCO physicists are building a large-scale lightning machine. They are starting with a hollow cooling tower. At the top, water will be sprayed down it from perforated pipes. It will lose heat and should partly freeze. The charge thus generated will be expelled into the remaining liquid. This should pass on charge to the surrounding air, which will expand and rise in its turn. At the top of the tower, copper electrodes will capture charge from the rising air and return it to the falling drops. In this way the tower will build a charge separation. It may also be done with brine. Brine is a conductor, but its freezing expels solid, insulating salt. Again, the physicists will look for the accumulation of charge. Any surplus high-voltage electricity from the tower will be bled from its top for use.

Sadly, Daedalus's tower may not generate much power. Even a full-scale thunderstorm only creates some 20 gigawatts. But he hopes to identify the aeroelectric processes that are important in lightning, on Earth or on other planets. The expansion of charged gas, and its resulting speed of uplift, are well worth knowing; so is the feedback of charge by falling drops. Both may help us to understand the biochemistry of other planets.

David Jones