Talk is cheap in the city

Henry L. Bertoni

Telecommunications companies have paid a heavy price for their share of the radio spectrum. So they have been quick to exploit 'multiple antennas' that can increase transmission rates in urban areas.

Because we love to talk, and because modern microchips have brought down the cost, cellular (mobile) phones have become a ubiquitous feature of Western society since their introduction in the early 1980s. This demand has made the wireless-communications industry a leading part of the high-tech economy. But growth depends on attracting new subscribers, and the market is already reaching saturation in some areas — Finland leads the world in this respect, with 71 cellphones per 100 people. So, in order to keep growing, the industry must find new applications for the public to buy into.

The wireless industry sees data services, particularly e-mail and Internet links, as the solution. Unfortunately, compared with wired networks, wireless connections generally suffer from a low rate of data transmission, which results in unacceptable delays when downloading a typical web page. Three solutions to this problem have been proposed, and in this issue M. R. Andrews, P. P. Mitra and R. deCarvalho describe how they are working towards the most ambitious of the three (*Nature* **409,** 316–318; 2001).

One solution developed by a consortium of large companies is to slim down the content of data-rich web pages so they work with the low data rates of cellular networks and the small screens of palm-sized devices. This approach is embodied by the wireless application protocol (WAP), which incorporates a lightweight version of the mark-up language used to format documents on the web.

A second solution limits the length of the radio transmission to short distances, over which relatively high data rates are possible. Wireless versions of local-area networks (LANs) take this approach, but require that the wireless device is within a few tens of metres from a connection to a wired network. So public areas must be dotted with these wired access points, or the user will be restricted to a small area, thereby losing all the benefits of a portable technology.

The most ambitious approach, and the one that will benefit from the ideas of Andrews and colleagues, seeks to increase the data transmission rate of the radio channel, even for the much longer distances covered by cellphones.

Radio signals from a base station or wired access point are often scattered by objects such as buildings (Fig. 1a). This scattering provides multiple paths between the base station and the wireless device, and allows them to communicate even when they are not in sight of each other. When cellular networks were first introduced, this multipath scattering gave rise to destructive interference, echoing and other problems that limited signal quality. Various approaches were taken to overcome these problems, one of which is to use multiple antennas to take advantage of the multiple communication channels created by scattering.

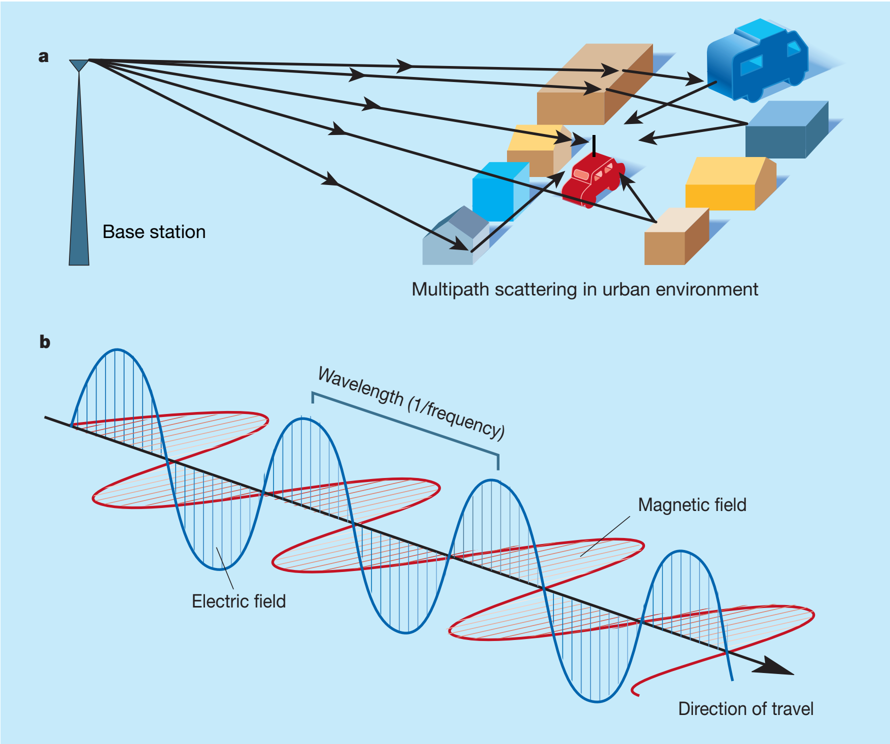

Figure 1 **The smart approach to improving wireless communications.** a, **In an urban environment, the radio signals transmitted by a base station are scattered along several paths. These slightly different signals can be picked up by multiple antennas on wireless devices, resulting in greater signal reliability.** b, **Radio waves are just like any other electromagnetic wave: in free space, the electric and magnetic fields are perpendicular to each other and perpendicular to the direction of propagation — they are said to be linearly polarized. On page 316 of this issue, Andrews *et al.* show that the different polarization states created by scattering radio waves can be detected by a type of multiple antenna that is more compact than existing systems. This feature promises greater wireless capacity for small mobile devices in urban areas.**

In view of the difficulties caused by multipath scattering for ordinary cellular networks, it came as a surprise when communications engineers suggested that multiple antennas could be used to increase the rate of data transmission in a scattering environment, such as a dense urban area. By using a group of *N* antennas for transmission and *N* for reception, and with a signal-processing system in the receiver, they were able to transmit data at *N* times the rate that could be achieved using single-transmit and single-receive antennas. This improvement is made possible by the unique 'echo signature' of each of the transmitting antennas, which is detected by the signal-processing system. Such gains are not possible when the antennas are in a non-scattering environment, because *N* independent signals have to be transmitted in order to take advantage of the increased capacity.

The type of multiplicative scaling offered by multiple antennas has already had a big impact on the wireless industry, in which much smaller gains can generate excitement. But there is one disadvantage with this approach. As originally conceived, the multiple antennas within a group have to be

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separated by a small distance, which could be as small as half the radio wavelength if they are located at the receiver, or several wavelengths if they are at the base station. Depending on the frequency band used by the wireless network, the wavelength is about one-third or one-sixth of a metre. As a result, the use of multiple antennas is restricted to base stations, because they cannot be placed far enough apart in palm-sized devices.

This is where Andrews and colleagues come in. They show that it is not necessary for the antennas to be physically separated to obtain an increase in the rate of data transmission. Instead, the antennas can be located at the same point as long as they receive signals with different polarization states. In an electromagnetic wave, such as a light beam or radio signal, the vibrating electric and magnetic fields that make up the wave can point in different directions, known as polarization states. In free space, there are only two polarization states because the electric and magnetic field must be perpendicular to one another and to the wave's direction of propagation (Fig. 1b).

In a scattering environment, however, extra polarization states are created in all three directions in space at the receiver. Andrews and colleagues exploit this fact to triple the data rate in a simple system by using a group of three perpendicular electric-dipole antennas, all located at the same point. Each electric-dipole antenna transmits or receives a component of the electric-field polarization in three dimensions. What is more, the authors show from theoretical simulations that they could increase the data rate sixfold ($N=6$) by using three magnetic-dipole antennas at the same location. For this to work, the three magnetic-field components must be uncorrelated with each other and with the three components of the electric field, in order for there to be six independent information channels. This is a surprising finding because in free space the magnetic field can always be predicted if the electric field is known.

In their elegant experiment, Andrews and colleagues have unequivocally demonstrated that electric-dipole antennas increase data rates by accessing different polarization states. But when developing mobile devices it is likely that designers will use other types of antennas, such as patch antennas, that can more easily be integrated into the case of the terminal. Nonetheless, the knowledge that multiple antennas located at the same place can increase data capacity sixfold will encourage engineers to be more aggressive when developing integrated antennas for wireless services requiring high rates of data transfer. ■

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Diabetes

The missing link with obesity?

Jeffrey S. Flier

The molecular mechanisms underlying the link between obesity and diabetes have been elusive. A new protein, christened 'resistin', can now be added to the panoply of factors that may be involved.

Type II diabetes is the most common form of diabetes in the Western world, and is strongly linked to obesity — over 80% of sufferers are obese. The molecular basis for this link has remained a mystery. On page 307 of this issue[1], however, Steppan and colleagues describe how they have identified a new hormone, which they have named 'resistin', that is produced by fat cells. Their results indicate that resistin may form at least part of the missing link between obesity and diabetes.

In patients with type II diabetes, insulin is less able to promote the uptake of glucose into muscle and fat, and to inhibit the production of glucose by the liver. Several molecular mechanisms are known by which this state — insulin resistance — comes about, but the full picture is not yet available[2].

Obesity is characterized by the increased storage of triglycerides (fat molecules) in adipose tissue and causes insulin resistance. But how does this increased energy storage in fat cells (adipocytes) promote insulin resistance in muscles, the liver and elsewhere in the body? For many years, it looked as if free fatty acids would provide the link. These products of triglyceride metabolism are the main form in which energy is transferred from stores in adipose tissue to other sites in the body for metabolic use. After all, levels of free fatty acids in the bloodstream are higher in obese than in non-obese people, and free fatty acids can induce insulin resistance in tissues other than adipose tissue[3]. However, as well as having a role in energy storage, adipocytes also secrete numerous peptides that might lead to insulin resistance or other complications of obesity (Fig. 1).

Two such peptides are the cytokine tumour-necrosis factor-α (TNF-α) and the hormone leptin. Although better known for its roles in inflammation and immunity, TNF-α is expressed in normal adipocytes, is overexpressed in adipocytes from obese people, and can cause insulin resistance through effects on insulin-mediated cellular signalling pathways[4]. TNF-α is almost certainly involved in insulin resistance *in vivo*.

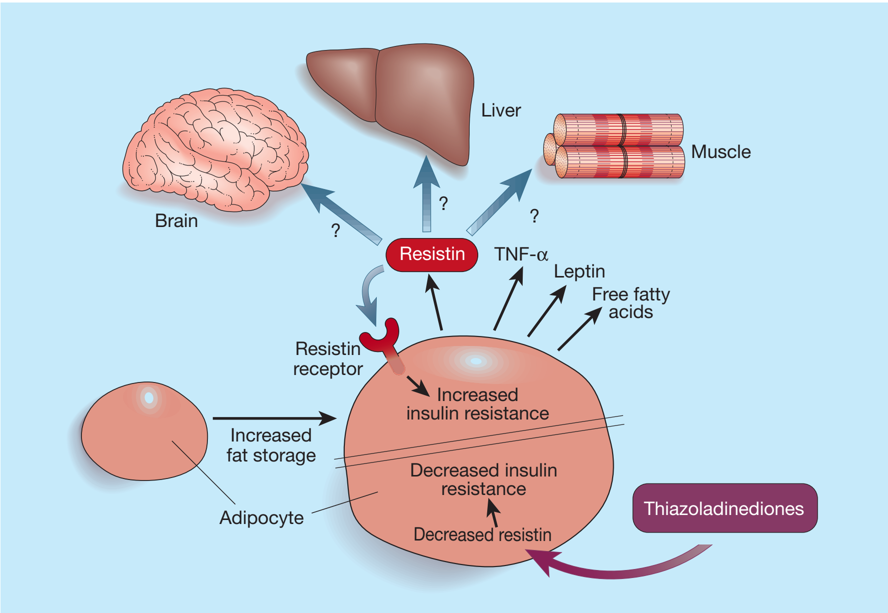

Figure 1 **Obesity causes certain tissues in the body (such as muscle and liver) to be less sensitive to insulin. Such insulin resistance is one of the main features of type II diabetes. From left, as fat cells (adipocytes) store more fat molecules and enlarge, they release several products that can modify the body's sensitivity to insulin. Free fatty acids and tumour necrosis factor-α (TNF-α) cause insulin resistance, and leptin, which regulates energy balance, probably causes insulin sensitivity. Steppan *et al.*[1] have identified a new protein, resistin, that is secreted by adipocytes. Resistin causes insulin resistance through its effects on adipocytes and perhaps other tissues. Thiazoladinedione drugs reduce insulin resistance and are used to treat type II diabetes. These drugs suppress the expression of resistin by adipocytes, and their antidiabetes effects may, at least in part, be achieved through this mechanism.**

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