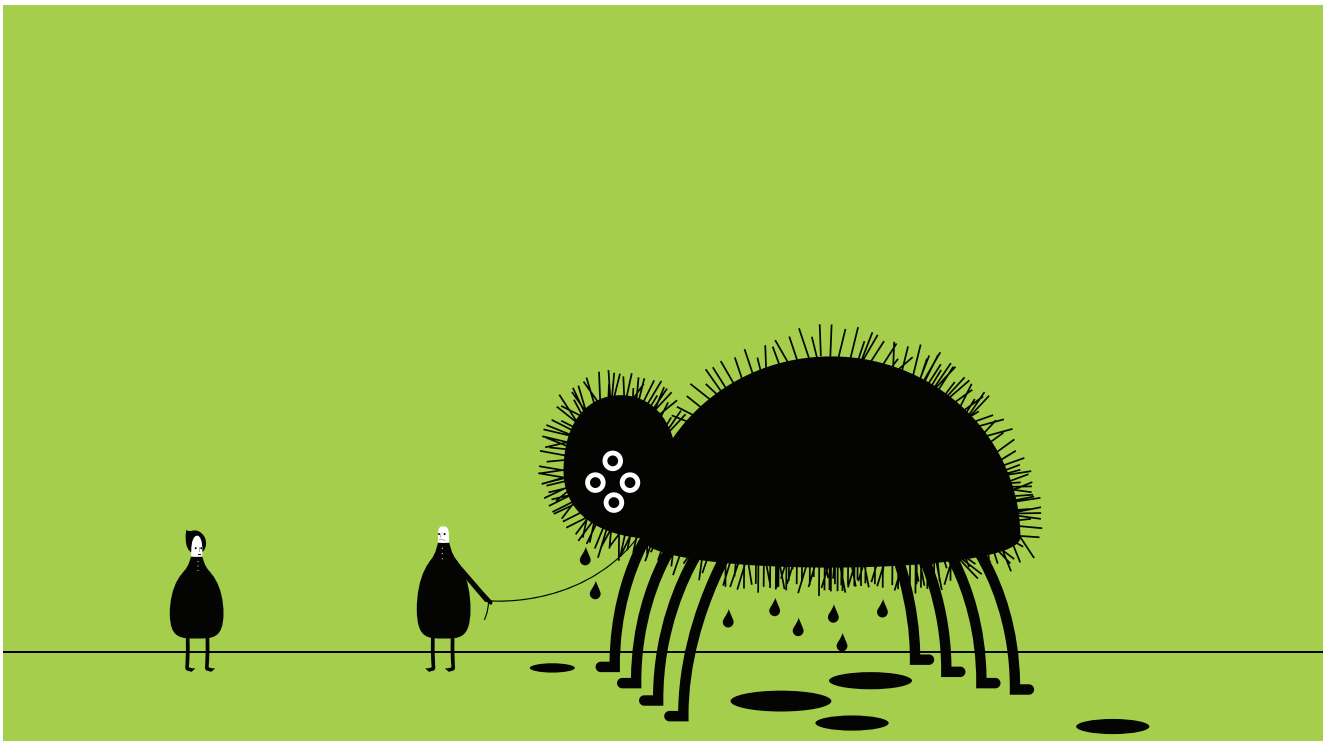
From wonder drugs to superbugs

Once the ultimate magic bullet,
antibiotics are now fuelling the rise of drug-resistant bacteria

BONNIE SCHIEDEL ILLUSTRATIONS BY SIMON OXLEY



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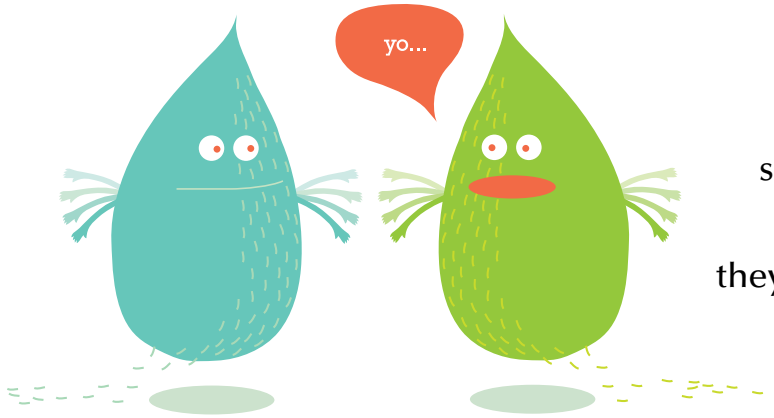

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Modern medicine doesn't have too many miracle pills, but for many years, antibiotics seemed to deserve that description. Only 60 years ago, common ailments such as bladder infections, strep throat and sinusitis just had to be endured, and more serious illnesses such as pneumonia and meningitis — or even an infected cut that led to bacteremia (blood poisoning) — were sometimes fatal. All that changed with the advent of sulpha drugs in the 1930s, penicillin in the 1940s and other antibiotics that soon followed.

But bug-fighting antibiotics are double-edged swords: over time, certain micro-organisms that cause infections can become resistant to one or more antibiotics, rendering the drugs useless and potentially allowing fierce bugs such as vancomycin-resistant enterococci (VRE) to emerge. In their antibiotic-sensitive form, these bacteria are found normally in the intestinal track, but if they acquire vancomycin resistance and this drug is used, the antibiotic kills off all susceptible organisms and leaves VRE bacteria free to grow unchecked in an open field with no competition. Antibiotic-resistant bugs are on the rise, and this is a serious problem.

Think an antibiotic-resistant infection couldn't happen to you? Think again. Many Canadians are misinformed. According to a 2006 survey by the National Information Program on Antibiotics, 63% of Canadians believed that by rarely using antibiotics, or by using them only as prescribed, they could avoid getting antibiotic-resistant infections. But it's the actual bacteria, not one's immune system, that become resistant to medications. "More and more, we're seeing people who've never really taken antibiotics being exposed to resistant bacteria," says Dr. Edith Blondel-Hill, a Kelowna, B.C., physician who specializes in microbiology and infectious diseases and is medical director of the community education program, Do Bugs Need Drugs? "It's a problem that applies to everyone."

Becoming resistant

Bacteria are tough —they've been around for four billion years. Some varieties can thrive at the bottom of the ocean or at temperatures higher than 100°C, and they're incredibly adaptable. "These micro-organisms have been making antibiotics for their own use for millennia, presumably to protect themselves, or to have some advantage when they're clinging to a bit of tree root or whatever," notes biochemist Dr. Gerard Wright, director of the Michael G. DeGroote Institute for Infectious Disease Research at McMaster University in Hamilton, Ont.

"Furthermore, bacteria are remarkably adaptable and able to swap genetic information, including antibiotic-resistance genes," says Wright. "Couple this with an astounding ability to multiply — they can double their numbers in as little as 20 minutes — and you get perfect-storm conditions for the spread of resistance."

Bacteria can become resistant in many different ways. "They can produce proteins that sit in the cell membranes and act like pumps to funnel the antibiotics from inside the cell to outside. They can chemically inactivate the antibiotic using proteins or enzymes. Or they can simply spontaneously mutate and evade." Their capacity to outsmart antibiotics is impressive.

Another piece of the puzzle is that antibiotics are just being used too often — and inappropriately. "Antibiotics used to be thought of as very innocuous drugs with no long-term problems, so why not give them freely to patients?" says Blondel-Hill. "Then we figured out that the more antibiotics we give, the more resistance there is out there."

In agreement is Dr. Yvonne Shevchuk, a pharmacy professor at the University of Saskatchewan in Saskatoon, who sits on the Canadian Committee on Antibiotic Resistance. "One of the biggest misconceptions the public has is that all infections need treatment with antibiotics. But antibiotics don't work on viral infections such as colds, influenza and many sore throats."

So how is it that patients are getting unneeded antibiotics? One reason is that it can be hard to tell if a respiratory infection is caused by a virus or a bacterium. "As well, some viral infections predispose you to a bacterial infection a week or two later," says Blondel-Hill. "So there was a line of thinking awhile back that if you gave antibiotics during the primary viral infection, you would prevent the secondary bacterial infection. But we now know that's not the case."

Furthermore, doctors are often pressured by patients to prescribe antibiotics. "The daycare won't take your child back until he's been on antibiotics for 48 hours, or the patient has been in the waiting room for a long time and doesn't want to have 'wasted' her visit," says Blondel-Hill. Moreover, it can take a fair amount of time to convince someone that he doesn't need an antibiotic and to clarify the difference between a bacterial and a viral infection, to explain that the viral infection he has now may or may not result in a bacterial infection later. But it doesn't take long to write a prescription, and in the current health-care setting, most doctors are still paid according to the number of patients they see.

Antibiotics still have an honoured place in treating infections. But here's the bottom line: antibiotics are powerful, and we need to use their power wisely.

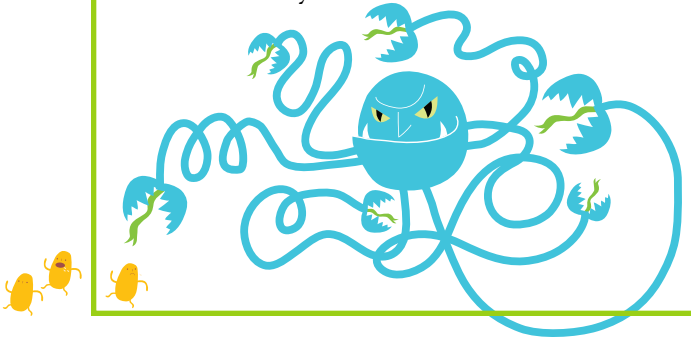
Know your meds

THE BASICS OF ANTIBIOTICS Antibiotics are derived from many sources. Some are made synthetically and some are processed from natural products such as bacteria and fungi. Most antimicrobials are taken in oral form but some are given intravenously or intramuscularly. Several come in topical creams or drops for the skin, eyes and ears. Also available are bandages and dressings treated with antibiotics.

Broad-spectrum antibiotic target multiple families of bacteria, while their narrow-spectrum counterparts target fewer types.

"Using the right antibiotic is important," says University of Saskatchewan pharmacy professor Dr. Yvonne Shevchuk. "Different types of antibiotics affect specific bacteria, so you can't just use something that worked for your neighbour."
Be sure to ask your doctor or pharmacist detailed questions about your antibiotic prescription.

- How many times a day do you take it?
- With or without food?
- For how many days?
- When can you expect results?
- What are the common side effects?
- What should you do about them?



Preventing resistance

THE HANDS HAVE IT! Health-care professionals advocate frequent handwashing throughout the day. This helps to avoid getting sick in the first place, thereby keeping the number of antibiotic prescriptions down. Here's your hand hygiene refresher course. Wet your hands with warm water. Apply soap and rub your hands together, including between the fingers, for at least 20 seconds. Rinse your hands for 10 seconds and dry well.

SAY NO TO ANTIBACTERIAL SOAP Once it goes down the drain, its components can stay around in soil and water for months. This causes environmental bacteria to adapt and become resistant to it, and then perhaps transfer that resistance to some of the bad bugs that cause disease in humans. (Alcohol-based sanitizing gels are fine because they kill bugs on the spot.)

WASH PLEASE If you're in a hospital or other health-care setting, politely remind those who will be examining you to wash their hands first.

DO YOU REALLY NEED AN ANTIBIOTIC?
If your doctor prescribes an antibiotic, ask which bacterial infection it's for. One of the most common reasons adults get antibiotics is for bronchitis, when, in fact, almost all cases of bronchitis are due to viruses.

If you and your doctor are satisfied that an antibiotic is appropriate, take the medication at the prescribed dose until it's finished (unless you're experiencing severe side effects). Otherwise, you'll kill off some but not all of the bacteria, thereby making the hearty survivors that remain behind more likely to find ways to become resistant to that antibiotic.

Antibiotic sampler

Antibiotics are used variously to fight infections of the brain, blood, eyes, ears, mouth, spinal cord, bones, cartilage, joints, skin, soft tissues, breasts, nails, abdomen, and the digestive, urinary and reproductive tracts. If one antibiotic proves ineffective, your doctor may prescribe another one from a different class. Currently, there are about a dozen different classes of antibiotics. These fight micro-organisms by destroying their cell walls and interfering with crucial cell processes. Here's a sampler.

CELL-WALL-DESTROYING AGENTS

Block the synthesis (formation) of the cell wall that protects bacteria from osmotic shock, stress caused by sudden changes in the solutions surrounding them.

ANTIBIOTIC	EXAMPLES
Penicillins	Amoxicillin, ampicillin, cloxacillin, methicillin *(members of the most widely used family of antibiotics, the beta-lactams)*
Cephalosporins	Cephalexin, cefprozil, cefixime, cefaclor, ceftriaxone
Glycopeptides	Vancomycin, teicoplanin

INHIBITORS OF PROTEIN PRODUCTION

Prevent the synthesis of proteins required for cell growth and reproduction.

ANTIBIOTIC	EXAMPLES
Aminoglycosides	Gentamicin, tobramycin, streptomycin
Macrolides	Erythromycin, azithromycin, clarithromycin
Tetracyclines	Tetracycline, minocycline, doxycycline
Oxazolidinones	Linezolid

INHIBITORS OF DNA/RNA SYNTHESIS AND REPLICATION

Inhibit cell division and gene transcription.

ANTIBIOTIC	EXAMPLES
Fluoroquinolones	Ciprofloxacin, gemifloxacin, levofloxacin and moxifloxacin
Sulfonamides	sulfamethoxazole, sulfanilamide
Rifamycins	rifampicin

SIMON OXLEY/ISTOCKPHOTO

Think an antibiotic-resistant infection couldn't happen to you? Think again

Outmanoeuvring microbes

New individual antibiotics and whole new classes of antibiotics are being developed to combat highly dangerous resistant infections such as methicillin-resistant *Staphylococcus aureus* (MRSA) — which, by the way, is now showing up in the community-based population in evermore virulent forms, not just in immunocompromised patients in health-care settings such as hospitals and nursing homes.

Scientists are also finding promise in surprising places. For example, at the 2008 meeting of the American Chemical Society, Louisiana researchers were excited about the resistance-busting properties of alligator blood. "We know how prevalent drug resistance is and that it's inevitable," says McMaster University biochemist Dr. Gerard Wright. The big challenge is finding ways to reduce the odds that it will develop. "One way is to screen large collections of compounds and look for things that augment the activity of antibiotics. We've got a bunch of stuff in the pipeline that looks really positive."

Learn more

www.dobugsneeddrugs.org Information for parents, teachers, kids, daycare centres and assisted-living facilities

www.ccar-ccra.com The Canadian Committee on Antibiotic Resistance

http://can-r.ca The Canadian Antimicrobial Resistance Alliance

www.foodsafetynetwork.ca Click on General Public, then on Fact Sheets to get information on agriculture and antibiotics.