senseable city lab:.::

It is part of our cultural mythology that if you think hard enough about something, you will figure it out – the light bulb popping on in your mind. But history shows that technological change is not characterised by great inventive leaps – it is almost always incremental and builds on a previous technology.

Thomas Edison didn't invent the light bulb, he merely produced a better filament, and even then he only discovered that filament after trying thousands. James Watt didn't invent the steam engine – he improved Newcomen's. Henry Ford didn't invent the assembly line and Steve Jobs didn't invent the mouse and its "point-and-click" OS: he copied (some say "stole") them from the Xerox Corporation.

This is the dark secret of our creativity – we copy ideas, tinker or play with them, and sometimes combine them with other ideas to make new things. Sammy's hafted knife is a wooden club and a blade. But this means that our creativity does not require any real individual creativity at all. Our ideas could even be no better than random and still: if just one person accidentally stumbles on to a good one (as Edison did), others can copy it.

Now, it might seem remarkable but this simple mechanism of copying and incremental progress is the same one that evolution by natural selection has blindly used for billions of years to create organisms like you and me.

Biological organisms copy their genes when they reproduce, sometimes these genes mutate and occasionally new combinations combine to make a new species. Genetic mutation is random, but by accident some mutated genes improve on the old and natural selection ensures they survive and spread.

We can blame evolution for making us little more than the glorified karaoke singers we are. Or as Voltaire put it: "originality is nothing but judicious imitation".

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Smart toilets and sewer sensors are coming

Advances in genomics are moving the bioengineering laboratory into the city sewers. In 2014, our wastewater systems will become smart, with automated sampling and lab-on-a-chip biosensors enabling the real-time prediction of viral outbreaks, making connections between environmental factors and public health, and answering fundamental questions about the nature of cities. This digital nervous system for the sewers will be a scaled-up version of the human enteric nervous system – a major component of our nervous system, which carries information between gut and brain.

Compared to about ten trillion human cells, there are about 90 trillion cells in our body that are not actually "us"; and the majority reside in the gut. The Human Microbiome Project's researchers (see p59 of *The* WIRED *World in 2013*) showed these microbes collectively contain well over 100 times more genes than our own genome, and these contribute significantly to our health and well-being. In the gastrointestinal tract, for example, bacteria can provide essential nutrients and help us digest foods that we otherwise could not absorb. But they can also metabolise drugs we take, lowering their efficacy or even creating toxic byproducts. Microbiome function is believed to be so essential and pervasive that many have recently referred to it as "the invisible organ".

Advances in DNA-sequencing tech make it possible to characterise the human microbiome, and soon we will be monitoring it daily, looking out for warnings of illness. At MIT's SENSEeable City Lab, we are working towards the concept of the smart toilet. This would recognise its user and carry out biomarker and microbiota analysis. The Japanese bathroom maker Toto has already developed an early version of a toilet that can carry out (simpler) urine analysis, and advances in lab-on-a-chip tech promise to broaden the spectrum of at-home molecular analysis in the near future. The key challenges to a comprehensive scan remain the size, cost and complexity of the technology needed to move sequencing and bioassays out of the lab.

Individual sensors such as these are more than a year off, but similar sensing can be done sooner at city scale. A vast reservoir of valuable information on human health and behaviour lives in our sewage, but the majority of this resource remains untapped by current research and available technologies. This is the goal of a smart sewage system called Underworlds, developed at MIT by the SENSEable City Lab and the Alm Lab. Examining aggregated wastewater across several cities, in 2014 the project will establish the techniques and technologies required to deploy a near-real-time network of biosensors, automata and purpose-built labs. The team is prototyping all components of the future smart grid, from the physical infrastructure required across a city, through the biological assays and downstream analytics and visualisation tools to make the most out of the collected data.

Underworlds promises to decode the biological signature of cities, providing information that can extend the boundaries of epidemiological science and understanding, enable real-time public-health strategies and inform policy makers and researchers with an open, cross-disciplinary data platform for studying urban health. Extending the digital nervous system of our environments to the depths of the urban underworld will tell the connected story of the world living inside us and the world we live in.

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ILLUSTRATION: JOHN-PATRICK THOMAS