1.2. The invisible giant: a future enabled by nanotechnology

So what could a nano-enabled future look like? Feynman was right in his prediction that the room-sized computers of the 1950s would be miniaturised to a single, hand-held device, but could he have had an inkling of the transformation that smart devices from mobile phones to tablet computers have wrought on modern life? Ultimately, every industry that involves manufactured items will be impacted by nanotechnology. As Aidan Quinn, who heads the nanotechnology group at the Tyndall National Institute, University College Cork says: "Nanotechnology will play a key role in developing cheaper or better performing electronic devices, sensors and solar cells than those available now."

Let us take a brief trip through a typical day sometime in the future to get a snapshot of just some of the ways in which nanotechnology may be able to impact on our lives.

One of the spheres where nanotechnology is likely to have a significant impact is in better targeted, more effective and personalised healthcare. So how are you feeling today? In the future, this might be a question that can be answered with a simple blood or breath test able to track blood sugar levels for diabetics or detect the first signs of a host of common cancers. Smart sensing devices will relay test results automatically to medical practitioners, or specialists, prompting further action or consultation where necessary. Treatment could be targeted to individual requirements, thanks to cheaper and more accurate DNA sequencing using nanopore-based devices. Those treatments will also have far fewer side effects because nanoscale drug delivery systems take medication direct to diseased or damaged tissue. As well as more effective chemotherapies for cancer with less severe systemic side effects, these advances will also enable controlled delivery of insulin without injections and improved treatments for dementia.

Meanwhile, physical injuries will be treatable with a new generation of MRSA-resistant, anti-bacterial bandages ensuring quicker healing. More major injuries, to the spine for example, will now be more treatable with new approaches that encourage the body's own repair mechanisms to grow replacement tissue. Artificial bone, skin, or even cardiac tissue might also be grown to order to facilitate recovery from damage or disease or restore lost sight and hearing.

Even the clothes we wear may have become smarter and better thanks to nanotechnology. Embedded sensors could monitor vital signs, while built-in energy harvesters could power personal electronic devices. New flame retardant materials, meanwhile, promise improved protection for emergency services or military personnel operating in extreme conditions and self-cleaning, water-resistant materials could mean better raincoats or anti-stain clothing for all consumers.

Nanotechnology could find its way into every corner of our homes, too. The plethora of plastic items used on a daily basis could in the future be made from plant-derived raw materials instead of petrochemicals thanks to a new generation of nanocatalysts facilitating more efficient and sustainable industrial processes. Food packaging could feature RFID (radio frequency identification) tags indicating the freshness and safety of food. And even the water we drink may have been filtered through a new generation of nanoscale membranes to remove chemical residues, bacteria, pathogens and other impurities.

Turn on the light and that could also be thanks to nanotechnology. The electricity powering the highly efficient LED (light-emitting diode) lamps now standard in our homes is likely to have come from photovoltaic tiles or panels on the roof or from a larger solar array further afield relayed along a new generation high-capacity, low-loss cables made from carbon nanotubes. Distributed local energy sources will be supplemented by on- and offshore wind farms featuring a new generation of highly efficient, long-lasting turbine blades relying on nanomaterial coatings for their high performance.

Homes, offices and public buildings will offer a comfortable environment year-round with much lower running costs thanks to highly insulating nanomaterials, thermochromic windows, or even energy-generating façades. Every watt of power that comes into a building will be monitored by networks of smart sensors transmitting information wirelessly to energy management systems ensuring that it is used efficiently with little or no wastage.

Some of that on-site generated energy might also be powering hybrid or all-electric cars, featuring a new generation of nanomaterial-based long-range, compact lithium-ion batteries. Or perhaps, further into the future, a hydrogen economy will have been established where cars run, much as they did once on gasoline, on ultraclean hydrogen fuel. Nanoporous materials will provide on-board hydrogen storage, while nanocomposite materials will make cars lighter and more economical to run. Nanoadditives to paints and windows will ensure scratch-, UV- and dirt-resistance, while nanoparticle-based lubricants keep the engine running smoothly.

Thanks to nanotechnology, of course, computers will now deliver more computing power but require less energy. Integrating new nanomaterials and nanoprocesses, like the self-assembly of cheaply-produced chemically synthesized building blocks, with existing silicon-based systems will bring new functionality at lower costs. Super flexible screens for displays or e-readers will be printed cheaply and easily using organic materials. And we may even be moving into an era of quantum computing.

Meanwhile, traditional heavy industries will have been transformed, replaced by new nano-enabled processes that use less energy, consume fewer raw materials, are easier on the environment and create products that can be more readily recycled. As well as transforming sectors like papermaking or composites, a new sector producing nanomaterials in novel, perhaps bio-inspired, ways will have been established.

While nanotechnology promises less pollution and lower emissions, it will also enable a new generation of ultrasensitive sensing devices to monitor what pollutants are there. The sensing capabilities of nano-based techniques will also have a central role in defence and security technologies, in the detection of pathogen or chemical contamination, authentication to tackle counterfeiting, crime prevention and forensics.

But as with any novel technology, the public will want to be reassured and informed of the safety of new products, while workers producing these items require safe working conditions. These issues are being addressed, with nanotechnology standing as an example of one of the first emergent technologies to attempt to enshrine consideration of health, safety and environmental impacts from the very beginning.

Is there any aspect of modern existence that nanotechnology will not touch? But that all-pervasiveness will not appear intrusive. Nanotechnology promises to transform current technologies invisibly, making them smarter, more efficient and less costly to the environment.