An optimist's guide to radioactivity: using medical imaging to develop and improve new treatments.

At 01:23 on the morning of 26th April 1986, one of the reactors at the Vladimir Ilyich Lenin Nuclear Power Plant in Ukraine exploded. In the moments that followed trillions of radioactive atoms were unleashed into the atmosphere. Two days later, fallout from the explosion would be detected, in the form of the radioactive atom iodine-131, at a power station in Sweden, and shortly afterwards the full scale of the disaster would be revealed worldwide.

You will of course recognise the power plant's unofficial name: Chernobyl. It is hard to know how many lives were lost because of the eponymous catastrophe, but estimates range from several thousands up to 200,000. The story of Chernobyl is a cautionary tale known by most and is synonymous worldwide with both man-made disaster and the dangers of radioactive materials. But, when we call something radioactive, what do we actually mean?

Radioactivity refers to the release of energy from unstable atoms. Atoms are made up of electrons, neutrons and protons. A radioactive atom (or radioisotope) has too many neutrons or protons, and so is heavy and 'uncomfortable'. To overcome this, the radioactive atom sheds its extra weight by releasing the excess sub-atomic particles and emitting energy in the process. It's analogous to a wet (and grumpy) dog, dripping with water. It will shake its fur to get rid of the water, spraying it everywhere to make itself happy again. However, unlike Winston ruining the walls and carpet, not all radioactivity is bad.

Consider the radioisotope iodine-131. Whilst its presence shocked Swedish scientists in 1986, today it is used all over the UK to treat patients with thyroid cancer. After it's administration, the isotope naturally homes in on a patient's thyroid, and the energy iodine-131 releases is enough to damage and kill the cancerous cells in that area.

Another example of how radiation is used to help people with diseases is the use of radioactive sugar by doctors to detect tumours in patients. Every cell in your body needs sugar for energy. But tumours are made up of much more active cells, so require more sugar. If you inject a patient who has a suspected cancer with radioisotope-doped sugar, then you can keep an eye out for it using a medical scanner. These scanners are capable of detecting and visualising the energy emitted by the radioactive sugar. Because cancers are more active, they will take up more of the radioisotope and will light up like a Christmas tree in the image.

In my research I use this principle – of using radioisotopes to image inside of the body – to help develop and test new medicines for treating diseases. In particular, I am using tiny, spherical materials known as nanoparticles. These nanoparticles contain chemotherapy or anti-inflammatory drugs within them, which reduces the nasty side effects of these drugs. Additionally, incorporating these drugs into nanoparticles means they travel differently inside the body. The shape and size of nanoparticles allows them to selectively accumulate at tumours or sites of inflammation. This means you can get more targeted delivery of your drug.

However, these nanoparticles are far from perfect: inject them into a patient you can't know for sure that they'll go where they're needed and treat the disease site. This results in patients potentially being given ineffective treatment; wasting precious time and money, which could have been spent treating the patient more effectively.

This is where my work comes in. I take certain radioisotopes and incorporate them into these nanoparticles – without changing the structure of the particles – and make them radioactive. I do this with lots of different nanoparticles designed to treat various diseases including: cancer, arthritis and heart disease. The radioactive tag I place on the particles means they are now visible with medical imaging equipment – the same doctors use for detecting radioactive sugar. So, when I inject these radioactive nanoparticles into a living subject and then take a scan of their bodies, I can see whether or not the nanoparticles are making their way to the target area.

This information is invaluable for scientists and companies who are designing new nanoparticles, as they can use our technique to know early on in development if their new drug is effective or not. Furthermore, my colleagues and I hope that eventually we will use this method to directly help patients by tracking nanoparticles inside their bodies using medical imaging. Therefore, predicting if they will benefit from treatment with those certain nanoparticles or not.

As Chernobyl tragically showed, radioactivity can undeniably be dangerous. But when used in the correct way, it is a powerful tool for treating and detecting disease, whilst aiding the creation of new and improved disease treatments.