CURIOSITY-DRIVEN RESEARCH

CANCER TREATMENT

- Cancer is responsible for a quarter of all deaths annually in the UK
- Modern physics research is a key component of the medical care given to people with cancer
- Modern treatments have been developed from studying stars and subatomic particles

What is it?

More people die from cancer in the UK than from any other disease. It is the major killer of both men and women in the UK and one in three people will be diagnosed with a form of cancer in their lifetime. Since 1950 the number of deaths from such things as heart disease and strokes has declined steeply, whereas the number of people killed by cancer has remained approximately the same. The number of people contracting cancer increases each year, though advances in treatment have meant that mortality rates are now falling. Modern physics research is a key component of the medical care given to people with cancer. Enabling early diagnoses and quick, effective and often painless treatment, progress in medical physics is aiding this reduction of mortality rates for many different kinds of cancer.

A large number of the recent advances in medical physics come not from the field itself but from such distant fields as astronomy and high-energy particle physics. Basic research in these subjects has yielded medical imaging techniques such as positron emission tomography (PET), which is able to follow specific chemicals around the body, to monitor blood flow and to see how effective drugs are. PET and another imaging technique, computerised tomography (CT), rely on extremely sensitive detectors originally designed for looking at stars to create images.

Astrophysics research has also resulted in methods of non-invasive cancer detection, such as selected ion flow tube mass spectrometry (SIFT). Originally designed for use in understanding gases in space, SIFT can detect and diagnose certain types of cancer by a simple breath test, avoiding the need for invasive examinations. Techniques devised to control experiments at particle accelerators have produced technology to direct beams of high-energy particles and radiation accurately. These can be used to target and destroy tumours, avoiding damaging the surrounding tissues and making the treatments much less arduous for patients.

Techniques for imaging tumours use the same principles and technology as those for imaging stars, and many modern cancer treatments have their origins in physics laboratories. From initial detection and diagnosis to treatment and recovery, basic research in physics is the driving force behind modern cancer care.

The science

Modern methods of detecting, imaging and treating tumours inside the human body exploit a knowledge of atoms and radiation acquired from studies of stars and subatomic particles. Imaging techniques such as PET rely on the principle that, when matter and antimatter meet, they will annihilate each other with the emission of energy. Injecting cancer patients with drugs attached to compounds that will emit antimatter allows scientists to follow their progress around the body by following the energy trail, thus seeing how effective the treatment is. By a similar mechanism the technique is able to monitor blood flow around the body, finding regions where blood flow is unusually high – regions that could be home to tumours.

CT scanning, invented by Sir Godfrey Hounsfield at EMI Laboratories, UK, is an advanced technique using X-rays. X-ray images are taken sequentially from different directions and these are then combined using computers to produce three-dimensional images. This method of combining multiple images has resulted in CT scans being much more sensitive and able to detect more kinds of tissue than conventional X-ray techniques can.

Radiation experiments have shown that some radioactive particles, once emitted from source, will all travel a well defined distance before stopping and releasing energy. Knowing the distance that these particles will travel through the human body, radiographers can target cancerous growths inside the body, tuning the particles to deposit all of their energy at that site while causing minimal damage to healthy tissue.

New techniques for detecting specific types of cancer include SIFT. Developed at the University of Birmingham to analyse the results of astrophysics experiments, this method was designed to detect extremely low concentrations of gases. It is now being applied to the study of the subtle changes in the chemical composition of the breath of patients with certain kinds of cancer.

Combining technologies such as PET and radiotherapy, to find tumours and then target and destroy them, has been a major advance in cancer treatment, proving extremely effective at killing cancerous cells while causing minimum discomfort to patients.

Cancer-treatment timeline

1961	The first treatment of cancer patients with beams of subatomic particles
1963	Allan Cormack of South Africa devises a method for computerised tomography scanning
1969	Godfrey Hounsfield creates the CT scanner at EMI Laboratories, UK
1973	The first PET image is taken by Michael Phelps and Edward Hoffman
1974	The first commercial PET machine is built
1975	CT scanners are introduced in hospitals
1980	The first clinically useful magnetic resonance imaging image is taken
1990	A national breast cancer screening campaign is started in the UK
1995	Cancer Research UK develops CHART, a technique for giving radiotherapy in many small doses
2002	The mortality rate of breast cancer is down by 15% on 1994 levels
Today	Scientists are working on non-invasive cancer tests, such as the breath test, SIFT

Radiation in medicine

Radiation therapy is used to treat many different kinds of cancer and is often used after surgery to ensure that the cancer does not return. It is also used as a primary method of stopping the growth of cancer in regions where surgery is too dangerous. High-energy radiation, produced by small, hospital-based, radiation sources, can prevent cancerous cells from dividing and multiplying, thereby halting the growth of tumours and, ultimately, killing them.

Radiation can also damage healthy cells. To try to minimise this, techniques are used to plan a course of treatment that minimises exposure. Initially an image of the patient is produced, often using a CT scanner. Using this three-dimensional map, computers can locate the tumour and devise a course of treatment that will move the radiation source around the patient, continuously targeting the tumour but not giving the healthy tissue too high a dose. Following treatment a further CT scan may be taken to monitor progress.

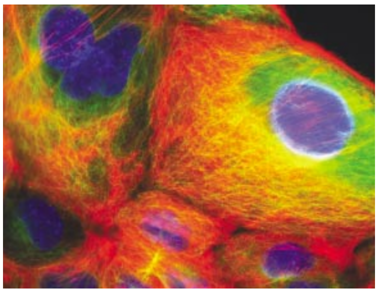
Cancer statistics

Cancer is the single biggest killer in the UK today, responsible for the deaths of more than 150 000 people every year. More than a quarter of all deaths from all causes in the UK are due to cancer. More than 0.25 million people are diagnosed with cancer every year; one in three people will be diagnosed in their lifetime. There are more than 200 different kinds of cancer affecting all parts of the body and all can be fatal if left untreated.

As detection rates and treatment programmes improve and the understanding of what causes cancer increases, mortality rates fall. In the 10 years after 1994, cancer mortality rates dropped by 10% and they continue to decrease, even as the total number of cases continues to increase.

Breast cancer is the most common form of cancer found in the UK. It is also the cancer responsible for the most deaths. One in nine women will contract it at some point in their lifetime. A nationwide breast cancer screening campaign was launched by the NHS in 1990. The procedure involves taking high-resolution X-ray images and closely examining them for abnormalities. If anomalies are found, the patient is given more X-rays and often PET scans and MRI scans, and examined with ultrasound.

Targeted radiation therapy is often used after surgery to kill off any remaining cancerous cells and to prevent regrowth of tumours. Since 1992, mortality rates from breast cancer are estimated to have dropped by 15%. Scientists at QinetiQ working on image-processing techniques to identify military targets have developed an automated method for checking the initial X-rays for signs of abnormalities, speeding up the process and making it more reliable.



Polarised light micrograph of cancerous liver cells.