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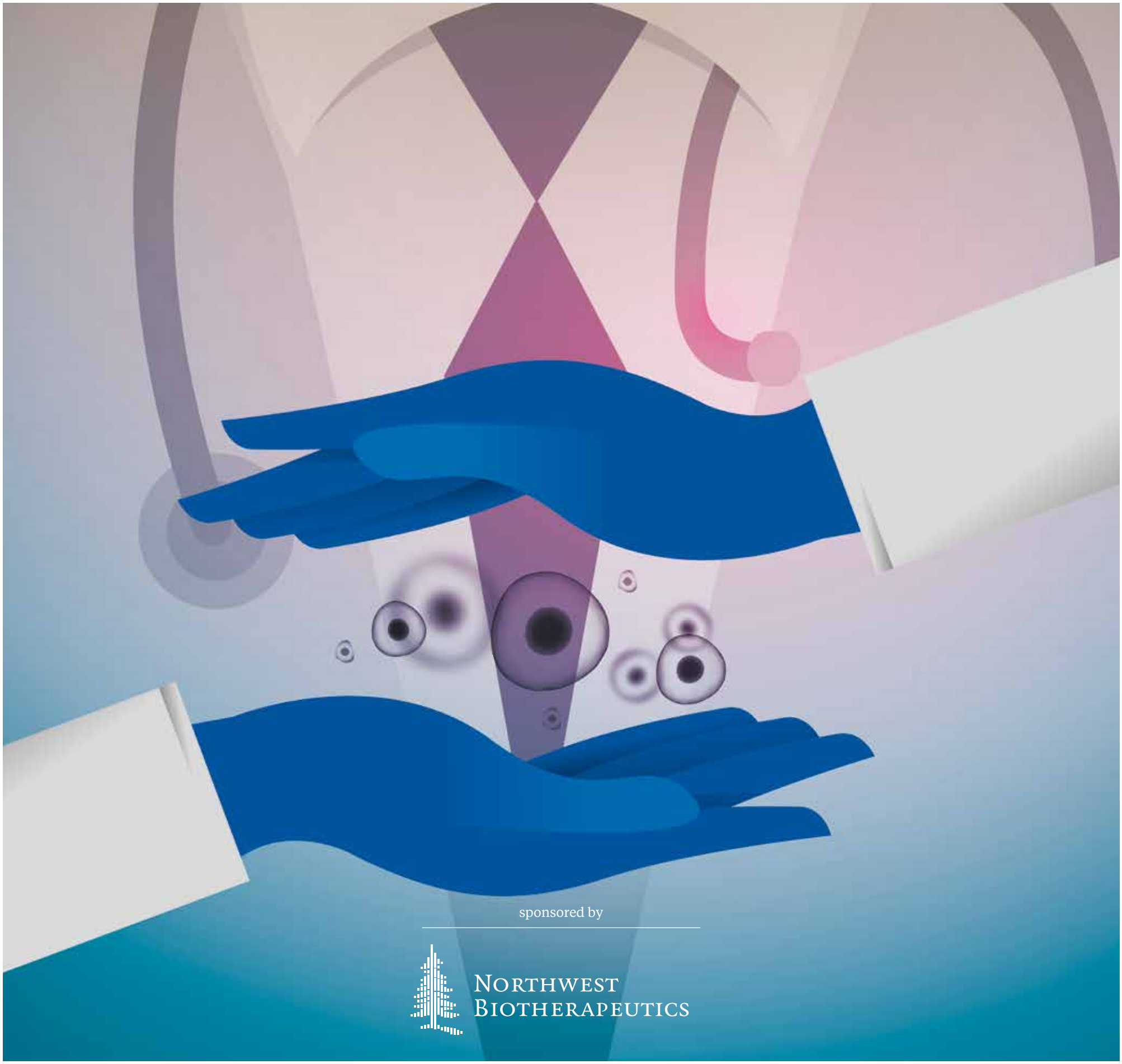
CANCER TREATMENTS



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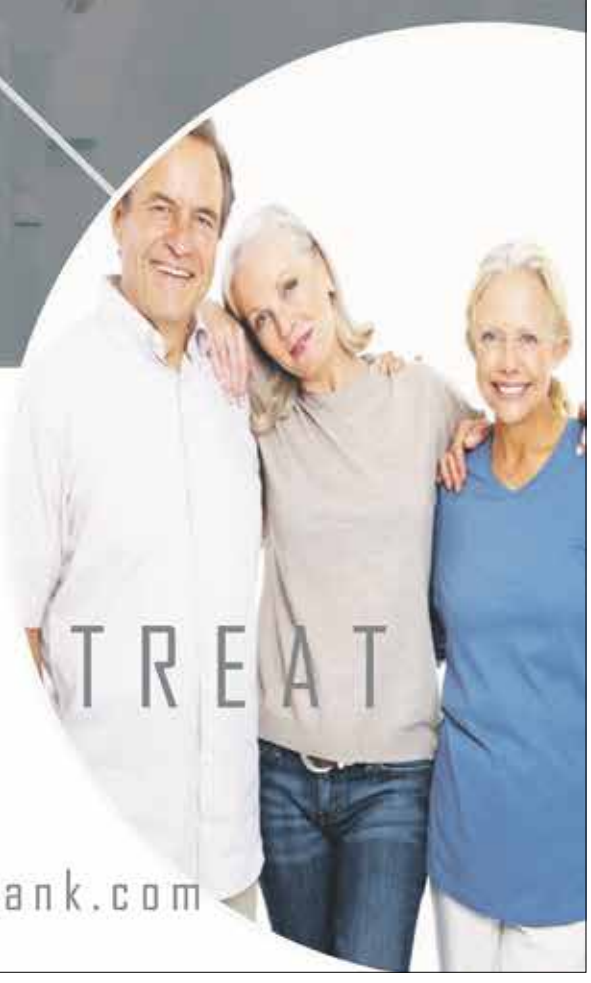

TREAT

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Conquering cancer is a race still to be won

The race to cure cancer is proving to be a marathon as doctors strive to develop new treatments and the UK struggles to improve early diagnosis

◆ OVERVIEW

● DANNY BUCKLAND

Cancer was first recorded at the dawn of history and humanity has been suffering in a half-light of understanding for most of that time. Medical interventions have developed gradually as the disease was able to elude efforts to tame its malignant complexity.

The odds of surviving had the statistical skew that would scare even the most desperate of gamblers and it seemed the more we learnt, the more labyrinthine the foe became.

The burden is immense – 8.2 million people die worldwide annually from cancer according to World Health Organization figures – and its impact is personal and economic.

But a century of pioneering research has redressed the balance so that cancer's innate ability to cloak itself and thwart therapies is not so effective; the game of medical hide and seek is being won by man.

Our ability to interrogate the core of a cancer, to strip back its disguises, has opened up a brighter world where talk of a cancer-free future is bold yet justified.

Survival rates have improved dramatically with patients able to live longer and with more fulfilling lives. Scientists can now engineer tailored treatments that outgun earlier blunderbuss techniques with short-lived action and debilitating side effects.

Cancer survival rates in the UK have doubled over the last 40 years with 50 per cent of adults diagnosed in 2010-11 expected to live ten years or longer.

"It is clear that we have made very good progress over the last 20 years and the exciting thing is that the pace is picking up as we know more about the molecular origins of cancer and how the body's own immune system can react to it," says Professor Peter Johnson, chief clinician for the charity Cancer Research UK.

"The numbers of people getting some types of cancer are falling thanks to reductions in smoking rates, although our ageing population means that overall numbers are increasing. People will unfortunately always get cancer, but our ability to diagnose, treat and help them to live with it or provide a cure is improving all the time."

But advancements in healthcare design, government support and public health awareness are also key components in the fight against cancer.

"It is important to take a whole-system approach," says Professor Johnson, who is also director of the Southampton Cancer Research UK Centre. "We are interested in the range of things we can do to prevent deaths from cancer. This includes reduction of alcohol and tobacco consumption, fighting obesity, better routes to diagnosis so we cut down the number of people presenting with cancer which has gone beyond the point of cure – something we do less well than some other countries – conventional therapies, such as surgery, chemotherapy and radiotherapy, and on to the new treatments.

> **Our ability to interrogate the core of a cancer has opened up a brighter world where talk of a cancer-free future is bold yet justified**

"It is like the successful British Cycling mantra of optimising everything that can be optimised."

The biggest buzz is the promise of immunotherapy – an approach that restores and steels the body's immune system to fight off cancer naturally. In laboratories around the globe, the painstaking work of decoding cancer structures is paying dividends as scientists zero in on trigger points to switch off its defences.

Cancer Research UK, which benefits from £500 million of annual public donations, is a world leader clocking up 55,000 research hours each week in its labs, but Professor Johnson sees collaboration as the accelerator pedal in the race to beat cancer.

"We work very closely with partners in biotechnology and the pharma industry, and there is no doubt that we depend on each other," he says. "The industry depends on the scientific research that Cancer Research UK funds to generate new ideas and targets for treatment, and our academic investigators depend on our partners in industry to develop treatments as quickly as possible.

"Successive governments have also played their part over the last 15 years by supporting science and technology and university and NHS research."

In addition, the pharmaceutical industry has been pivotal with members of the Association of British Pharmaceutical Industry (ABPI) spending more than £3 million daily on cancer treatment research in the UK.

It believes that innovative medicines will get to patients quicker if clinical trials and the regulatory framework are redesigned to support early drug development.

"As new medicines become increasingly personalised, the research needed to bring these to patients becomes increasingly complex. Further collaboration between industry, research charities, academia and the NHS will be important to identify new targets," says Dr Virginia Acha, ABPI research medical and innovation executive director.

"These medicines require molecular tests to identify patients who will respond to treatment. The development and delivery of these medicines raise logistical challenges for the NHS, industry and research organisations, including co-ordination of centralised databases, lab and diagnostic services."

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Tailor-made treatments offer new hope

Personalised cancer medicine, based on identifying biomarkers to target treatment, is an attractive aim which promises new hope for patients

◆ **PERSONALISED TREATMENT**

● **NIGEL HAWKES**

A tumour is not one thing, but many. We know this because drugs that work for some patients don't work for others and drugs that work for a while often stop working later. So cancer not only presents a lot of different targets, but targets that can evolve to escape attack.

The promise of personalised cancer medicine is to tailor treatments to the particular target each case presents. This can work better than the broad-brush approach, but only if there are reliable ways of identifying what is particular to each case and medicines adapted to that particularity. Enthusiasts for this approach claim it will transform cancer medicine to everybody's benefit.

According to Oxford University's Professor Tim Maughan, launching a new £5-million initiative to improve bowel cancer treatment: "We'll identify ways to tailor treatment and ensure patients receive the drugs and other therapies that will benefit them the most, and make a significant difference to their chances of beating this common disease."

How do we know this can work? The breast cancer drug Herceptin is one of the best examples. It improves survival in breast cancer, but only in women whose tumours overexpress a protein that encourages cell proliferation – true of about 30 per cent of patients. So

> **The search is now on for biomarkers in every type of cancer that can act as signposts for therapy – and the belief is that thousands exist**

Herceptin is limited to those women who test positive for the HER-receptor.

The HER-receptor is playing the role of a biomarker, useful to clinicians in deciding the best therapy. Some biomarkers relate to the patient's genes, such as the breast cancer genes BRCA1 and BRCA2, which can be useful in assessing an individual's risk of the disease. Others relate to the genes of the tumour itself.

The search is now on for biomarkers in every type of cancer that can act as signposts for therapy – and the belief is that thousands exist. In 2012 an international team profiled the genes in cell lines taken from tumours and examined any links they could find to drug sensitivity or resistance. They found hundreds.

"We studied how genetic changes in a panel of more than 600 cancer cell lines effects responses to 130 anti-cancer drugs, making it the largest study of this type to date," said Dr Matthew Garnett of the Sanger Institute in Cambridge when the study was published in *Nature*. "Our key focus is to find how to use cancer therapeutics in the most effective way by correctly targeting patients who are most likely to respond to a specific therapy."

The difficulty may be in seeing the wood for the trees. Methods for reading the entire gene sequences of tumours are now becoming affordable, but what they show is daunting. In 2012 a team from Cancer Research UK's London laboratory sequenced the DNA from a few kidney tumours and found only a third of the mutations were shared by the whole mass of the tumour. Mutations at one end of the tumour were different from those at the other; secondary tumours that had spread elsewhere were different again. The complexity seemed insurmountable.

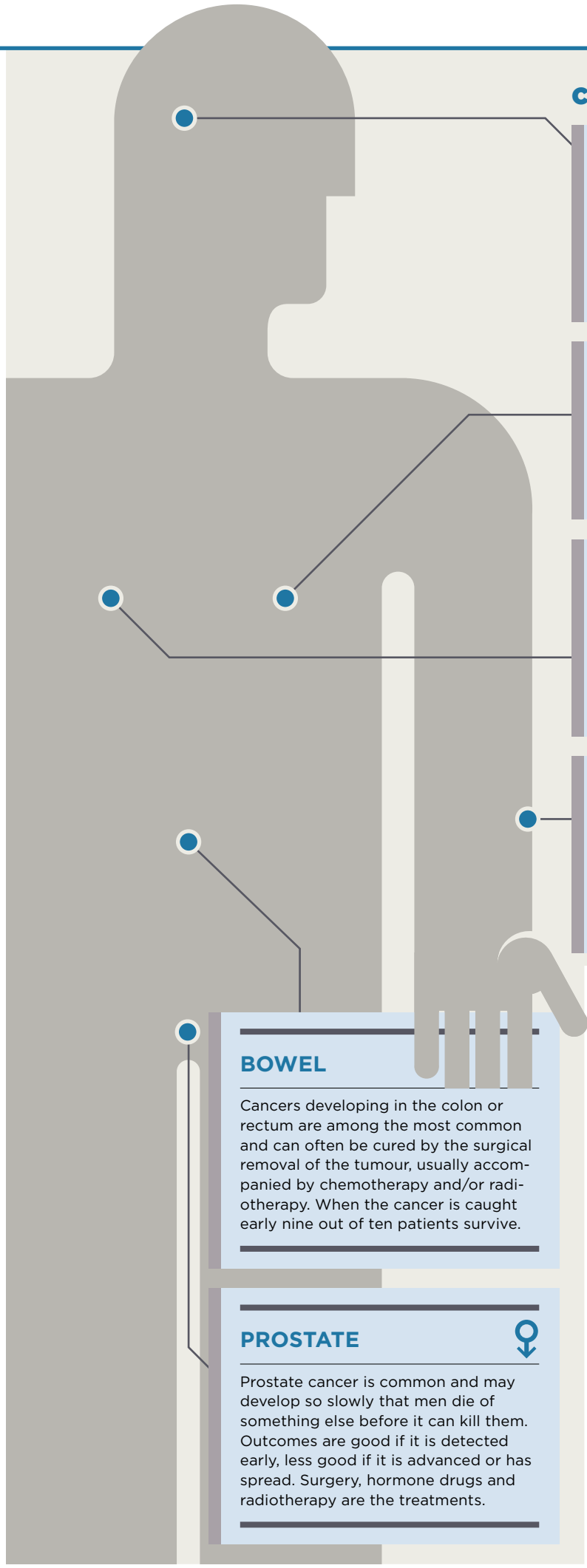
"I'm still quite depressed about it, if I'm honest," team leader Charles Swanton told *Nature*. "And if we had higher-resolution assays, the complexity would be far worse."

Critics such as Dr Stuart Hogarth of King's College London say that biomarkers have been overhyped and too many are being generated with too little consistency in the way they are tested and validated.

Writing in the journal *Molecular Oncology*, American cancer specialists Lynn Henry and Daniel Hayes suggest he may have a point. "In spite of three decades of research and thousands of reports of circulating biomarkers, very few tumour markers have established clinical utility," they say.

But one that has is a mutation called KRAS used in assessing whether patients with colorectal cancer will respond to treatment with Avastin.

New drugs require exhaustive and expensive trials, but many biomarkers have been generated by less exacting approaches, often using the patients who happened to present themselves. So while personalised cancer medicine is an attractive aim, rigour will be needed to ensure that its promise is not dissipated in a blizzard of biomarkers that signify little.



CANCER TYPES

BRAIN

Tumours that originate in the brain are uncommon – about 12 in 100,000 people develop them every year. A brain tumour is more likely to be a secondary cancer spreading from elsewhere in the body. Outcomes vary according to the precise type of tumour.

BREAST

One in nine women will develop breast cancer at some point in their lives. Regular screening can help detect the cancer early, when treatment is very effective – deaths are now at their lowest for 40 years.

LUNG

Lung cancer is often detected late and hard to treat effectively. Primary lung cancers are mostly the result of smoking, but the lung is also a common site for the spread of cancers for other parts of the body. For cancers detected early, surgery can be curative.

MELANOMA

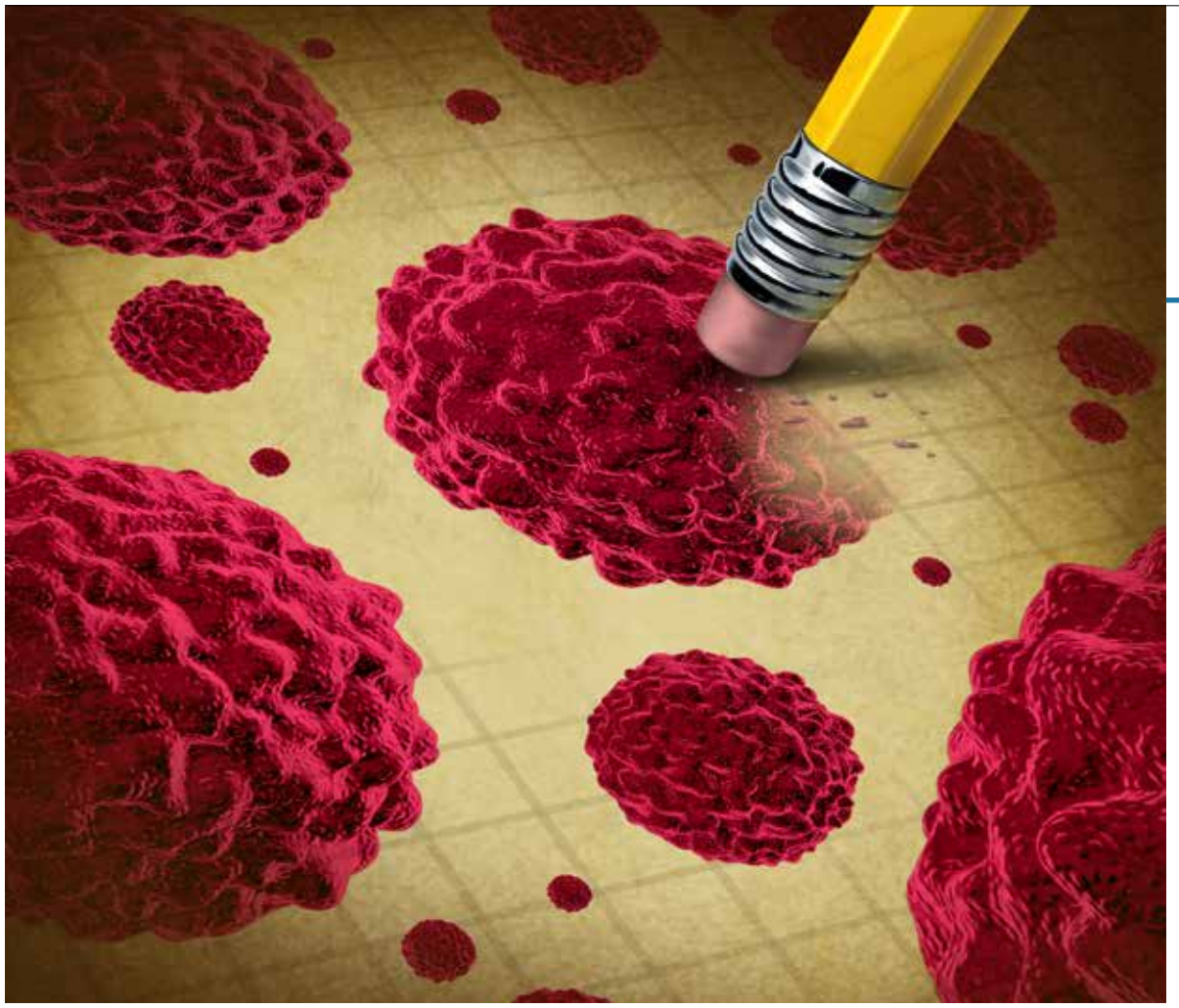
Melanoma is the least common form of skin cancer, but by far the most serious. It can spread from the skin to other parts of the body, commonly the lungs, liver, bones, abdomen and brain. Increasing exposure to the sun is blamed. Outcomes are good when diagnosed early.

BOWEL

Cancers developing in the colon or rectum are among the most common and can often be cured by the surgical removal of the tumour, usually accompanied by chemotherapy and/or radiotherapy. When the cancer is caught early nine out of ten patients survive.

PROSTATE

Prostate cancer is common and may develop so slowly that men die of something else before it can kill them. Outcomes are good if it is detected early, less good if it is advanced or has spread. Surgery, hormone drugs and radiotherapy are the treatments.



Helping cancer patients to heal themselves

Immunotherapy is a new class of cancer treatments which has the medical world fizzing with excitement and hope that cancer can be transformed from a death sentence to a chronic condition

◆ IMMUNOTHERAPY

● DANNY BUCKLAND

The big players in pharmaceuticals, along with niche biotechnology companies, are forging ahead with new drugs that will help patients to heal themselves.

The leap forward has come from scientists unpicking the seams of the molecular cloaks cancers use to evade the body's immune system and mutate. They cunningly employ receptors on their cell surface to demilitarise the defensive white blood cells, or T cells, which patrol our body checking for invaders such as a virus or tumour.

The T cells should attack but become neutered and leave the tumour free to wreak havoc.

Immunotherapy has been a concept for more than a century, but the challenge has been to understand how cancer switches off the T cells and then to discover effective therapies to reboot the immune system into tumour-kill mode.

Drugs known as checkpoint inhibitors are being developed to make tumours visible to the T cells, and other research is advanced in techniques of removing the cells, engineering them to recognise cancers and then infusing them back into a patient where they proliferate and combat the disease.

Spectacular results have already been achieved in early trials and immunotherapy drugs to treat melanoma, a severe skin cancer, have been approved and are giving thousands of patients a longer life.

Northwest Biotherapeutics is conducting groundbreaking clinical trials to weaponise the body's powerful dendritic cells, and there is hope that 50 per cent of all cancers will benefit from immunotherapy as we grow to understand more about the complex interplay between cancer cells and the body's immune system

> We are in an exciting time because we have the technology to understand the entire genome of a tumour

"Cancer immunotherapy has waxed and waned over 150 years, but has made a dramatic comeback during the last five to ten years with a number of drugs being approved," says Robin Jones, consultant medical oncologist at London's Royal Marsden Hospital, who specialises is soft tissue and bone sarcoma. "In some cancers, there have been dramatic improvements with patients, who would have faced an immediate death sentence, now living with it for long periods of time. It almost turns cancer into a chronic disease.

"One of the beauties of immunotherapy is that it seems to work well in complex tumours with high mutational load. Using the body's own system to fight the cancer appears to be more effective and produces more durable benefit than introducing a conventional drug, which artificially blocks one or more pathways that the tumour can easily circumvent.

"I am very excited by some of the work we are doing to improve things for our patients – many of whom are young and have particularly aggressive disease – making their lives and their families' lives better. The prospects are exciting, but we need more clinical trials and greater collaboration, particularly with the rarer cancers."

Professor Robert Watkins, director of medical oncology at Manchester University, has just launched the ATTACK trial of 72 stomach cancer and melanoma patients across Europe to determine the efficacy of gene-modified T cells.

His adoptive cell therapy system harvests and genetically arms a patient's T cells with special receptors on their surface, called chimeric antigen receptors (CARs), which are designed to unmask tell-tale proteins on tumour cells when they are returned to the patient via an intravenous drip.

"There has already been great success in melanoma, so the challenge now is to show you can control tumours for a long period in a good number of patients," says Dr Jones.

The potency of CAR T cells is revolutionary. "These are powerful therapies with enormous impact," says Stan Riddell, of the US Fred Hutchinson Cancer Research Center in Seattle. "Patients with acute lymphoblastic leukaemia, who have failed everything, are being put into remission with a single infusion of a very small dose of these CAR T cells."

Laboratories are building up libraries of "off-the-shelf" receptors which can be positioned in T cells to help them lock on to a range of tumour targets. But Dr Riddell also believes immunotherapy will need to be paired with conventional therapies to get the best results.

"We are in an exciting time because we have the technology to understand the entire genome of a tumour," he says. "We can sequence it and understand what genes are being expressed. In some ways it is a golden age of opportunity, but I don't think it is a golden age for patients just yet as a lot of work still needs to be done to translate the potential into therapies. But there is great excitement because we are starting to see what is possible."

Dr Sergio Quezada, of University College London, is researching how to outwit cancer mutations. "There is much work to do, but the landscape will change," he concludes. "There is a lot of hope that there will be cancers, which will be easier to target, resulting in better treatments and survival rates."

'LIVING DRUG' THERAPY

One of the most exciting developments in immunotherapy is adoptive cell therapy or ACT, a process whereby T cells or T lymphocytes – a type of white blood cell essential for human immunity – are revitalised in a laboratory and then returned to the patient where they proliferate and overwhelm cancers.

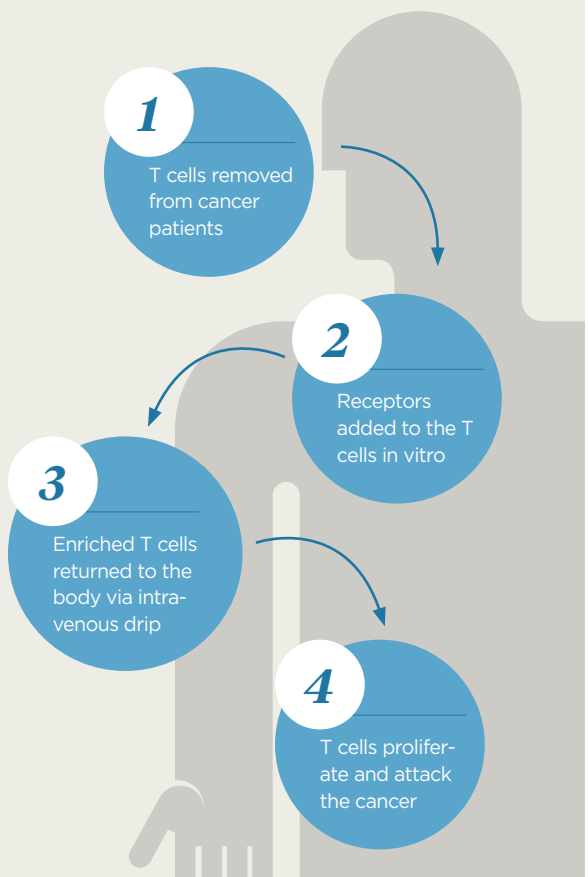
Doctors take a tissue sample from around the cancer site where there has been anti-tumour activity and separate out the T cells, which are then cultured and engineered to respond to tumour receptors.

They are delivered back into the patient via intravenous drip and can now infiltrate tumours in large numbers and destroy them.

It has been described as giving a patient a "living drug" and, although only administered in small clinical trials, several have entered remission or become cancer free.

In an early-stage clinical trial at the Children's Hospital of Philadelphia, 89 per cent of acute lymphoblastic leukaemia patients not responding to conventional therapies went into complete remission after receiving T cells redesigned to recognise and target the cancer's specific protein.

It was granted breakthrough status by the US Food and Drug Administration in 2012.



Long road on the journey to find a cure for all cancers

The history of cancer reveals a slow and painful progression towards modern treatments which at last seem to be gathering momentum

◆ **HISTORY**

● **NIGEL HAWKES**

Cancer is as old as mankind – older even, since dinosaurs endured it. Where there is life there is the chance that the machinery running the cells will go wrong, leading to uncontrolled growths which the ancients recognised and named.

Greek physician Hippocrates compared the finger-like projections from a tumour to a crab – an odd image, since few tumours actually resemble crabs, but it stuck. The Roman physician Celsus, active in the first century BC, coined the word cancer from the Latin word for crab.

> Apothecaries stocked up on boar's tooth, fox lungs, tincture of lead, ground white coral and other equally unlikely remedies

Early treatments for cancer were either fanciful or too awful to contemplate. Apothecaries stocked up on boar's tooth, fox lungs, tincture of lead, ground white coral and other equally unlikely remedies, while barber-surgeons occasionally undertook mastectomies without anaesthetic in insanitary conditions.

In the 18th century, the Scot John Hunter, one of the founders of modern surgery, declared that if a tumour had not invaded nearby tissue and was moveable, "there is no impropriety in removing it".

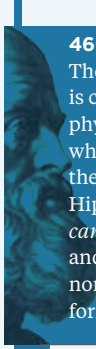
The discovery of general anaesthesia in the middle of the 19th century set off a golden age of surgical innovation. The American surgeon William Halsted pioneered radical cancer operations, attempting to outpace tumour growth by more and more extreme removal of tissue, in the belief – only partly true – that recurrence meant that some of the tumour had been left behind. He proved that surgeons could remove cancers, but whether patients were thereby cured was less clear. Some were, most were not.

The fashion for radical surgery left many patients disfigured, but it also left a legacy. One of Halsted's students at Johns Hopkins Hospital in Baltimore, Hugh Young, was directed by him to focus on urological cancers. Young protested he knew nothing of urological surgery. "I know you don't know anything, but we believe you can learn," replied Halst-

Countdown of cancer pioneers

3000-28 BC

3000 BC
The earliest known description of cancer is in an ancient Egyptian textbook on trauma. Known as the *Edwin Smith Papyrus*, it describes eight cases of tumours or ulcers of the breast that were removed by cauterisation with a tool called the fire drill. The document says of the disease: "There is no treatment"



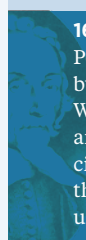
460-370 BC
The origin of the word cancer is credited to the Greek physician Hippocrates, who is considered to be the Father of Medicine. Hippocrates used the terms *carcinos* (Greek for crab) and *carcinoma* to describe non-ulcer forming and ulcer-forming tumours

50-28 BC
Roman physician Celsus translates the Greek term into cancer, the Latin word for crab

130-200 AD

130-200 AD
Greek physician Galen uses the word *oncos* (swelling) to describe tumours. Although the crab analogy of Hippocrates and Celsus is still used to describe malignant tumours, Galen's term is now used as a part of the name for cancer specialists – oncologists

1600s



1628
Post-mortem examinations by English physician William Harvey lead to an understanding of the circulation of blood through the heart and body that had until then been a mystery

1665
Robert Hooke publishes *Micrographia*, which presents several accounts of observations through the use of the microscope

1676
Anton van Leeuwenhoek, a Dutch trader, scientist and pioneer of microscopy, observes water and was surprised to see tiny organisms – the first bacteria observed by man

1700s

1713
Italian doctor Bernardino Ramazzini reports the virtual absence of cervical cancer and relatively high incidence of breast cancer in nuns, and wondered if this was in some way related to their celibate lifestyle. This was an important step towards understanding the role played by hormones, such as hormonal changes in pregnancy, sexually transmitted infections and cancer risk

1761
John Hill, a London physician, records an early observation linking tobacco, specifically snuff, and cancer in his analysis *Cautions Against the Immoderate Use of Snuff*

1775
Percival Pott of Saint Bartholomew's Hospital in London describes an occupational cancer in chimney sweeps, cancer of the scrotum, caused by soot collecting in the skin folds. Many more studies subsequently identify a number of occupational carcinogenic exposures and lead to public health measures to reduce cancer risk at work

1800s

1838
German pathologist Johannes Müller demonstrates that cancer is made up of cells and not lymph, but he believes cancer cells did not come from normal cells. Müller proposes that cancer cells developed from budding elements or blastema between normal tissues

1855
Rudolph Virchow, a student of Johannes Müller, coins his now famous aphorism *omnis cellula e cellula* (every cell stems from another cell). With this approach, Virchow launches the field of cellular pathology

1860
German surgeon Karl Thiersch shows that cancers metastasise through the spread of malignant cells and not through some unidentified fluid

1880s
William Halsted develops radical mastectomy for breast cancer in New York

1896
Emil Grubbe uses X-rays to treat breast cancer in Chicago

1900

1902
The Imperial
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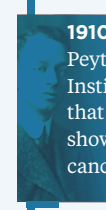

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ed haughtily before stalking off. Young learnt well, developing radical prostatectomy, the removal of the prostate gland which cured many men with prostate cancer and continues to do so more than a century later.

Surgery remains a mainstay of the treatment of solid cancers, but until it was joined by drugs and radiation – the modern troika that propels cancer care – its impact was limited. Radiation came first, pioneered in 1896 by a medical student, Emil Grubbe, barely a year after Wilhelm Röntgen discovered X-rays. Grubbe and his successors found that X-rays and other forms of radiation could indeed kill tumours. They did not fully understand why, but we now know that the treatment worked by breaking the DNA that is found in every cell and controls the process of cell division. Radiation kills healthy cells as well as cancer cells, but cancer cells are easier to kill because they are dividing faster.

Not for the first or last time, hubris crept in. Siddbartha Mukherjee, a cancer doctor and author of *The Emperor of All Maladies*, a prize-winning history of cancer, quotes a Chicago physician as saying of radiation therapy in the early-1900s: "I believe this treatment is an absolute cure for all forms of cancer. I do not know what its limitations are."

Not so fast. Radiation could not deal with tumours that had spread, and it caused collateral damage, in many cases provoking fresh cancers. Grubbe himself died riddled with cancers caused by his experiments, but he must have been a tough character, since he survived to the age of 85. As Mukherjee writes: "Radiation was a powerful invisible knife – but still a knife. And a knife, no matter how deft and penetrating, could only reach so far in the battle against cancer."

Anti-cancer drugs made their entrance in the 1940s. In a grim paradox, the first was nitrogen mustard, a poison gas used to slaughter soldiers in the trenches of the First World War. Soldiers who survived exposure to it suffered the destruction of their lymphocytes – white blood cells – and needed regular blood transfusions. This selective action against a particular type of cell suggested that nitrogen mustard might be used to treat lymphoma, a tumour of the lymph system. It worked and nitrogen mustard, rechristened mustine, became the first licensed chemotherapy agent.

Other drugs appeared in rapid succession, some triggered by biological insight, others by pure guesswork. One of the most striking of the former was aminopterin. Sidney Farber at Boston Children's Hospital, aware of work by British haematologist Lucy Wills, who had shown that some forms of anaemia could be cured by Marmite, a condiment rich in folic acid, decided to treat his childhood leukaemia patients with folic acid. Not only did it not work, it made things worse, hastening the children's deaths.

> **Targeted therapies substitute subtle intervention for brute force, aiming to disable or block processes that enable cancer cells to grow, divide and spread**

Undaunted, he decided to try antifolates, drugs that block rather than encourage the growth of white blood cells. To his delight aminopterin, a drug synthesised by chemists at Lederle Laboratories, caused near-miraculous remissions of leukaemia in some patients. Alas, the disease soon returned. But Farber's brave trial, ridiculed by colleagues, was the first step in treating childhood leukaemia, whose ultimate success remains perhaps the greatest triumph ever achieved by chemotherapy.

That came from a combination of drugs administered together, which is now typical of the chemotherapeutic regimens for most cancers. The treatments were tough, the doubters many. "It took plain old courage to be a chemotherapist in the 1960s and certainly the courage of the conviction that cancer would eventually succumb to drugs," says Vincent DeVita, who was instrumental in developing a combination of drugs that raised the survival rate for Hodgkin's disease from zero to over 70 per cent. It took huge resilience from the patients, too.

The virtue of chemotherapy is that it can, in principle, seek out cancer cells wherever in the body they are, even if they have spread. The first cancer to be cured was choriocarcinoma, a rare cancer of the placenta, using methotrexate which is still a useful drug 60 years later.

But the biggest improvements in outcomes came from combining surgery with drugs – adjuvant therapy. Radiation may also be used in a triple-pronged attack designed to wrestle the cancer into submission. The gains are usually incremental rather than spectacular, but they add up.

Modern chemotherapy no longer relies exclusively on drugs that are in essence poisons. Targeted therapies have been developed that substitute subtle intervention for brute force, aiming to disable or block processes that enable cancer cells to grow, divide and spread. These include trastuzumab (Herceptin) for breast cancer, imatinib (Glivec) for chronic myeloid leukaemia, and certuximab (Erbitux) for colorectal, lung, and head and neck cancers.

Better targeting was made possible by a discovery at Cambridge in 1975, when César Milstein and Georges Köhler found how to make antibodies, in pure lines and in any amounts. Antibodies form a key part of the immune system, homing in on specific targets in the body (usually germs), so these man-made antibodies could be used as satnavs homing in on tumours. They can work in various ways, by blocking growth signals, carrying radioactive particles or chemotherapy drugs to the target, or by blocking the growth of blood vessels that tumours need to survive.

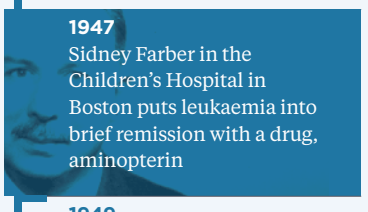
While new therapies are welcome, no single treatment is ever going to "cure" cancer. Progress is stepwise, sometimes appearing frustratingly slow – but progress it is.

1920-1960

1920s
The British Empire Cancer Campaign is set up, focusing on testing new treatments in patients

1926
Janet Lane-Claypon publishes a groundbreaking comparative study of 500 breast cancer cases and 500 control patients of the same background and lifestyle for the British Ministry of Health

1939
Gordon Ide at Rochester University, New York, suggests tumours might generate a substance that encouraged the growth of blood vessels to sustain them



1947
Sidney Farber in the Children's Hospital in Boston puts leukaemia into brief remission with a drug, aminopterin

1949
The US Food and Drug Administration approves the first chemotherapy drug, based on a poison gas from the First World War

1956
Metastatic cancer is cured for the first time when methotrexate is used to treat a rare tumour called choriocarcinoma

1960-1980

1965
Vincent DeVita and colleagues at the US National Cancer Institute in Washington show combination therapy can cure advanced Hodgkin's lymphoma

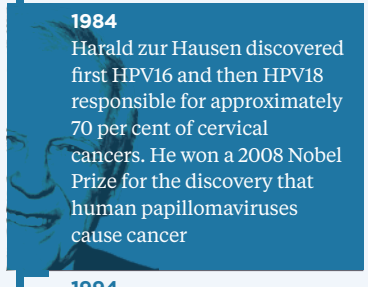
1971
Godfrey Hounsfield, working for EMI at Hayes, Middlesex, invents the CT scanner which improves imaging for both surgery and radiation treatment

1975
César Milstein and Georges Köhler at Cambridge invent monoclonal antibodies

1975
Larry Einhorn of Indiana University shows combination therapy can cure 70 per cent of advanced testicular cancer cases

1980-2000

1981
Trials organised by Bernard Fisher, a Pennsylvania surgeon, show that removing just the tumour and not the whole breast works equally well for early breast cancer



1984
Harald zur Hausen discovered first HPV16 and then HPV18 responsible for approximately 70 per cent of cervical cancers. He won a 2008 Nobel Prize for the discovery that human papillomaviruses cause cancer

1994
The first inherited breast cancer gene, BRCA1, is found

1997
Rituximab, the first drug based on a monoclonal antibody, is licensed

1998
Herceptin, a monoclonal antibody drug aimed at hormone-sensitive breast cancer, is licensed

2000-2010

2001
Imatinib (Glivec) a drug that interrupts tumour signalling pathways is licensed for chronic myeloid leukaemia and also found to be effective against gastrointestinal stromal tumours

2002
The Cancer Research Campaign merges with the Imperial Cancer Research Fund to become Cancer Research UK

2004
Avastin, the first drug to inhibit blood vessel formation by tumours, is licensed

2006
Vaccine against human papilloma virus, the cause of ovarian cancer, is licensed

2010-2014

2010
A new bowel cancer screening technique, known as a bowel scope, which could save thousands of lives is rolled out

2011
Scientists make progress in deciphering the molecular signature of prostate cancer and find a new accelerator gene that drives the growth of breast cancer

2012
Cancer Research UK scientists discover that breast cancer is in fact ten separate diseases

2013
Research reveals 80 new genetic variations that increase the risk of breast, ovarian and prostate cancers

2014
UK death rates for breast, bowel, lung and prostate cancer combined are down by almost a third in 20 years. And the World Health Organization's International Agency for Research on Cancer has now identified more than 100 chemical, physical and biological carcinogens

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- Among different patients with the same cancer
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- In a single tumour, in a single patient, as it progresses

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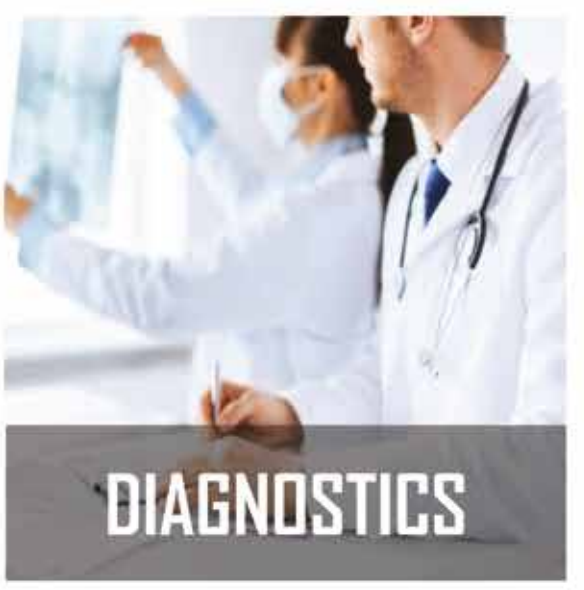
- Drug sensitivity testing
- Tumour grafting for personalised mice for personalised research
- Diagnostics

TESTING



DIAGNOSTICS

TREATMENT OPTIONS

Greater awareness of risk factors and earlier diagnosis can cut UK cancer toll

A healthy lifestyle, increased awareness, and more widespread vaccination and screening have great potential to reduce the risk and rate of cancer

◆ PREVENTION

● LORENA TONARELLI

Estimates suggest about 80 per cent of cancers are caused by environmental factors, as opposed to endogenous agents, such as genetic mutations, oxidative stress and inflammation. The most common of these factors are smoking, alcohol, obesity, inactivity, ultraviolet radiation, air pollutants, food carcinogens and chemicals, including asbestos and benzene.

Exposure may occur through lifestyle, diet and occupation, and contributes to more than 200 types of malignancies, such as lung, breast, colon and blood cancers. Environmental factors also include infectious agents, such as human papillomavirus and the bacterium helicobacter pylori, which cause cervical and stomach cancer, respectively.

Currently more than 331,000 cancer cases are diagnosed in the UK each year – 50,000 more than a decade ago. And the situation is set to get worse.

Tom Stansfeld, health information officer at Cancer Research UK, explains: "Cancer risk increases with age – and the UK population is ageing. This means that half of Britons will develop cancer in their lifetime. We need to plan ahead to make sure the NHS is fit to cope. With health services already overstretched and people living longer, it's clear prevention is going to be vital to tackle cancer head on."

The good news is environmental risks are modifiable. Research in the *British Medical Journal* shows, for example, that stopping smoking before middle age lowers the risk of lung cancer by about 90 per cent.

"Smoking remains the largest preventable cause of cancer, responsible in the UK for more than one in four cancer deaths and nearly a fifth of all cancer cases," says Mr Stansfeld. "We've seen the number of smokers fall in the past few decades. This has, and will continue to have, an effect on preventing over 14 different cancer types."

For lung cancer, specifically, National Cancer Intelligence Network data shows male mortality has nearly halved – from 85 per 100,000 in 1990 to 46 per 100,000 in 2011 – thanks to widespread smoking cessation.

Unfortunately, factors such as obesity and alcohol are driving up the number of other cancer types. Mr Stansfeld adds: "In the UK, two thirds of adults are overweight or obese and the amount of alcohol drunk per person has nearly doubled in the last 50 years. So there is scope for improvement across these areas, while the work on smoking continues.

"Evidence shows that more than four in ten cancer cases could be prevented by eating healthily and in moderation, exercising more, avoiding alcohol and enjoying the sun safely. This isn't a guarantee against cancer, but it can stack the odds in your favour."

> "With health services already overstretched and people living longer, it's clear prevention is going to be vital to tackle cancer head on

The same is true for vaccination against malignancies caused by infectious agents. Vaccines enable the immune system to recognise and fight these agents, lowering cancer risk.

Farzin Farzaneh, professor of molecular medicine at King's College London, explains: "Vaccination against hepatitis B and human papillomavirus infections have already led to reductions in liver and cervical cancer, respectively. There have also been major breakthroughs in vaccination against non-infection-related malignancies such as breast, prostate and brain cancer. This is currently used in clinical trials to stop the disease from returning following treatment, but it could eventually help prevent cancer in the first place."

Aspirin, too, has protective properties against certain cancers, particularly of the colon, Professor Jack Cuzick, head of the Centre for Cancer Prevention at Queen Mary University of London, points out.

In a recent review, he concluded that taking aspirin for ten years, starting between ages 50 and 65, reduces by up to 9 per cent the number of cancer events over a 15-year period. "Aspirin use, together with a healthy diet and exercise, may thus be the most important preventive measure after not smoking," says Professor Cuzick.

Early diagnosis also plays a pivotal role in cancer prevention, in terms of reducing mortality. Landmark research by the London School of Hygiene & Tropical Medicine, and subsequent analyses, estimates that up to 11,000 UK cancer deaths could be prevented each year, and that these events are largely related to late diagnosis.

Lack of awareness of cancer symptoms is a contributing factor. A 2012 Cancer Research UK and Tesco report found that more than 75 per cent of 2,090 people surveyed did not list pain, cough and bowel problems as potential cancer symptoms.

40%

of cancer cases could be prevented through lifestyle changes

Source: Cancer Research UK

11,000

cancer deaths could be avoided each year with early diagnosis

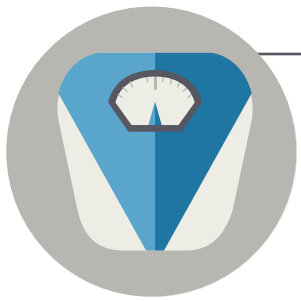
Source: *British Journal of Cancer*/Abdel-Rahman

And that is where screening comes in. Screening is available in the UK for breast, cervical and colorectal cancer. It is not completely accurate and may result in overdiagnosis – the detection and treatment of tumours that would never have caused problems. But the benefits clearly outweigh the harm.

A review, led by Professor Sir Michael Marmot of University College London, concluded that breast cancer screening with X-ray mammography, for instance, saves 1,300 lives annually in the UK and only about one in four women diagnosed with cancer through screening are overdiagnosed.

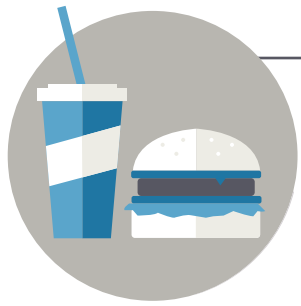
According to Professor John Field, director of research at the University of Liverpool Cancer Research Centre, a similar programme is needed for lung malignancies, the most common cause of UK cancer mortality. He notes that 75 per cent of lung cancer patients are diagnosed too late, resulting in more than 35,000 deaths annually. US data shows screening smokers with low-dose computed tomography could reduce this toll by 20 per cent.

CANCER RISK FACTORS



WEIGHT

Overweight and obesity cause ten types of cancer, including breast, bowel and pancreatic, which are thought to be responsible for more than 5 per cent of all cancers in the UK.



DIET

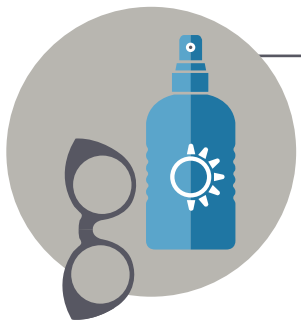
Diets rich in fat and processed meat, and poor in fruit and vegetables, cause nearly 10 per cent of cancer cases; salty diets account for about 25 per cent of stomach cancer cases.

SMOKING

Smoking accounts for 80 per cent of UK cases of lung cancer, nearly 20 per cent of all cancer cases and more than 25 per cent of all cancer deaths; it kills more than 35,000 people annually.

ALCOHOL

About 12,800 UK cancer cases annually are linked to alcohol, including 3,200 cases of breast cancer, the most common malignancy; overall, alcohol can cause seven types of cancer.

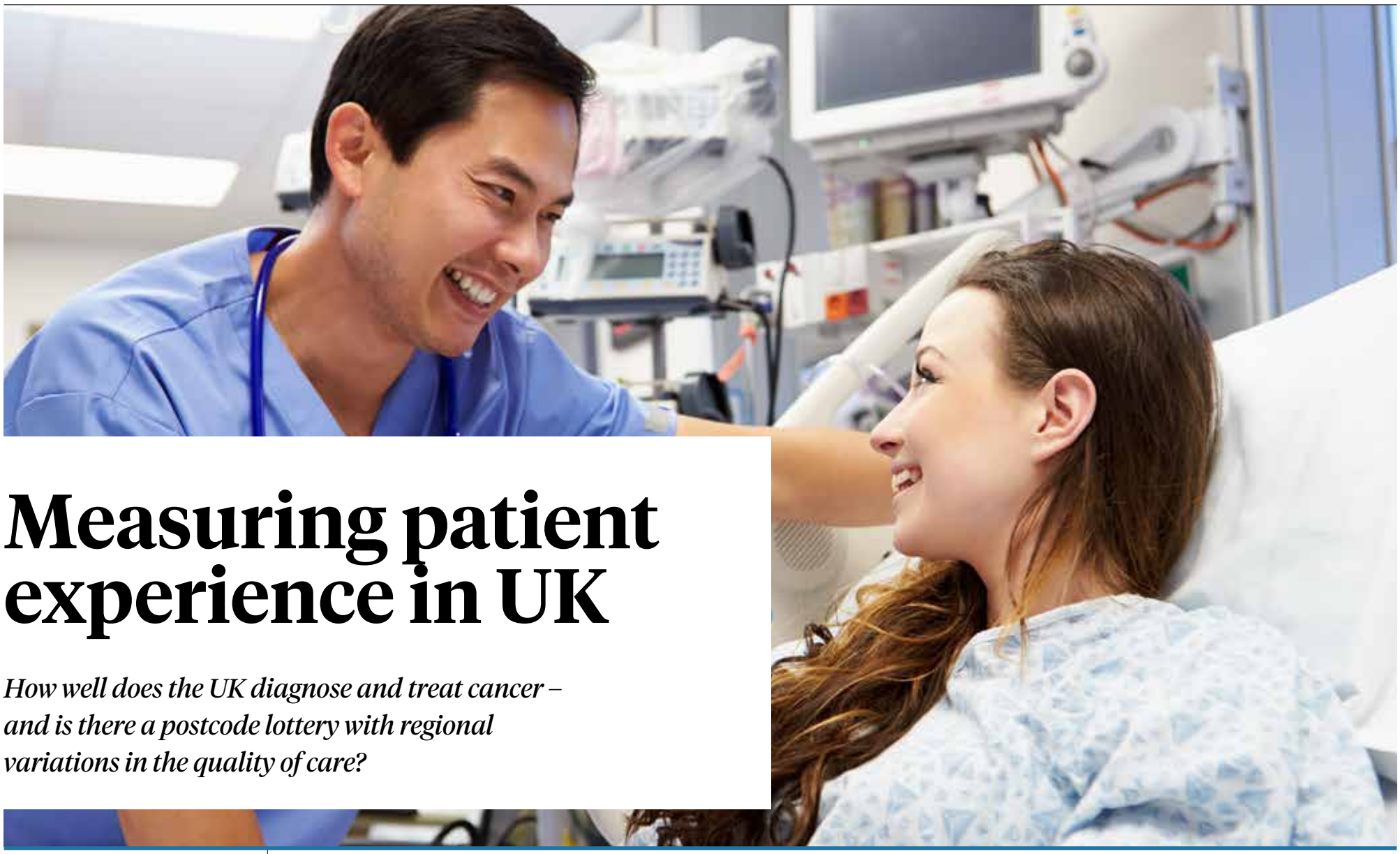


UV EXPOSURE

Too much exposure to ultraviolet (UV) radiation from the sun or sunbeds accounts for 86 per cent of skin cancer cases in the UK every year; sunburn triples the risk for this cancer.

INACTIVITY

Being physically inactive increases the risk of breast, bowel and womb cancer; some 3,400 cases of cancer are believed to be related to exercising less than 150 minutes a week.



Measuring patient experience in UK

How well does the UK diagnose and treat cancer – and is there a postcode lottery with regional variations in the quality of care?

◆ **PATIENT EXPERIENCE**

● **LORENA TONARELLI**

The management of cancer has come a long way in the past few decades and this has significantly changed the outlook for patients. In the 1970s, most people with the disease would die within a few years. Today, cancer is less of a death sentence and more a chronic illness. Many people are living longer after the diagnosis and, although some cannot be cured, they can be treated successfully. As a result, the patient journey through the disease has become more complex and varied.

Surgery remains the main treatment for most solid tumours. Patients may also be offered radiotherapy or chemotherapy, either after surgery to consolidate treatment or before surgery to reduce the size of tumours that would otherwise be too large to be operable. Additionally, other options have become available, thanks to the massive strides forward made in cancer treatment, largely as a result of the development of targeted treatments such as immunotherapy.

Keyoumars Ashkan, professor of neurosurgery and lead for neuro-oncology at King's College Hospital, London, says: "There have been significant advancements in cancer treatments and outcomes in the past decade. Life expectancy for breast cancer, for example, has increased substantially. And we are beginning to see improvement in survival also in some of the most malignant tumours known to man, such as brain cancers.

"The problem with conventional treatments is that we try to fit the patient to the therapy. But there is no one-size-fits-all approach when it comes to cancer. Immunotherapy, on the other hand, utilises the patient's own immune system to fight the illness. As such, it can deliver personalised treatment that fits to the patient, increasing significantly the chances of success."

Monoclonal antibodies, such as the breast cancer drug Herceptin (trastuzumab), which can selectively delay or even stop the growth of tumoural cells, while leaving healthy tissues intact, are a typical example of targeted immunotherapy.

Another important area is genetic testing, says Lester Barr, a consultant surgeon at University Hospital of South Manchester NHS Foundation Trust and chairman of the breast cancer charity Genesis. "Testing for the breast cancer gene mutations BRCA1 and BRCA2 allows women to take steps, such as preventative mastectomy or regular check-ups, to protect themselves against the disease. Not only has this made a huge difference for women at risk of inherited forms of breast cancer, in the future genetic testing will allow to predict the disease across the whole population."

> **A further 5,000 lives could be saved each year if England matched the average European survival rate**

The above advancements and many others have been pivotal in reducing cancer mortality in the UK. The latest figures show that twice as many people survive cancer now compared with 40 years ago. However, they also show that a further 5,000 lives could be saved each year if England matched the average European survival rate. While this might suggest that cancer treatment is better in other countries, experts point out that, in fact, the single most important factor for England's lower survival rate is late diagnosis.

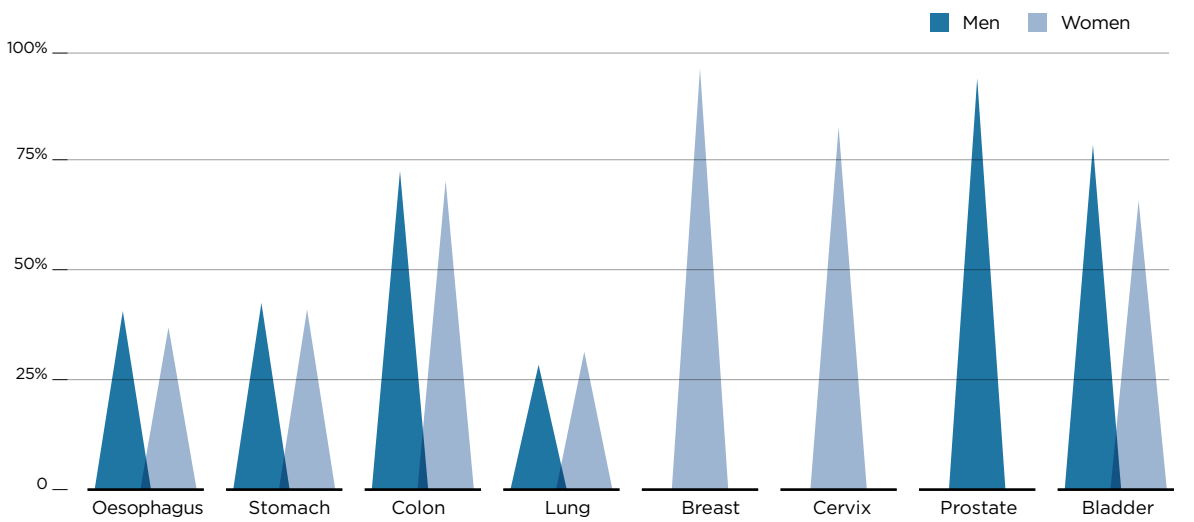
"This occurs for several reasons," explains Professor Jane Maher, a consultant clinical oncologist at the Middlesex Mount Vernon Cancer Centre and Macmillan Cancer Support's chief medical officer. "People are often unaware of, or don't report, what could be warning signs of cancer. The elderly and people from poor economic backgrounds are more likely to be diagnosed following admission to A&E, when they are in the advanced stages of the disease. Furthermore, certain cancers are difficult to diagnose because they present with nonspecific symptoms. And, lastly, access to diagnostic tests, such as CT scans, varies across the country. It's easy to get tested in some areas, but not in others."

Despite this, the increase in cancer survival, although suboptimal, has been paralleled by a steady improvement in patient satisfaction with the care received.

"We know from the national C*ancer Patient Experience Survey 2014*, conducted by Quality Health, that access to clinical nurse specialists, who are largely provided by charities and other organisations, has been key to such improvements as they have given good-quality information and support," says Professor Maher. "The clinical nurse specialist provides a great deal of emotional help. Additionally, patients may benefit from counselling and peer support."

PATTERNS OF CANCER SURVIVAL IN ENGLAND

ADULTS DIAGNOSED 2004-08 AND FOLLOWED UP TO 2013



Among the 25 area teams in England, the largest annual change from 2004 to 2008 in one-year survival was for oesophageal cancer (increasing 5.5% per year) for both men in Durham, Darlington and Tees and for women in North Yorkshire and Humber

Wide geographic differences in survival were observed; the range in one-year survival between the 25 area teams was greater than 10% for cancers of the oesophagus and stomach in men, and for cancers of the oesophagus, stomach, colon and bladder in women

Source: Office for National Statistics, April 2015

‘SUPPORT IS OUT THERE’

Esther Jury, a 43-year-old mum of two and garden designer from Norwich, went to her GP last year. She had persistent abdominal pain and a swollen stomach, and thought that these might be due to her recent pregnancy. Instead, they were symptoms of ovarian cancer.

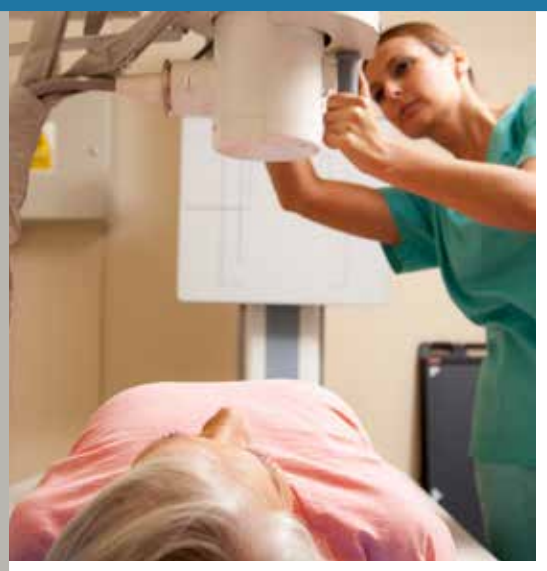
This form of cancer is the fifth most common in women, after breast, bowel, lung and womb cancer. It affects more than 7,000 women annually in the UK, according to the ovarian cancer support charity Ovacome. It usually manifests with bloating, difficulty eating and persistent abdominal pain.

“I was very lucky to have an excellent GP, who took my concerns seriously, and referred me immediately to Norfolk and Norwich University Hospital, so that I could undergo tests and have surgery to remove a suspected mass in my ovaries,” says Mrs Jury.

“Not knowing what was wrong with me was really difficult, so in a way the diagnosis came as a big relief. I was diagnosed very quickly and this allowed me to make timely important decisions about treatment. I had my womb, appendix and lymph nodes removed, as a preventative measure. Surgery was followed by six months of chemotherapy. The thought of having chemotherapy was scary but, in the end, it was not as bad as I thought. I didn’t lose my hair and never had vomiting because the nurse was very good at dosing the drug.

“It was really helpful to meet other women of my age, who are in my same situation, through charity and other groups. I think it’s important to spread the message that it’s not all doom and gloom. There are many choices for patients in terms of treatment. And there is excellent support out there. A diagnosis of cancer is not the end – life does go on.”

ACTING QUICKLY MAY SAVE YOUR LIFE



When Nevo Burrell discovered a lump in her breast, one evening two years ago, she knew that time was of the essence. She took no chance and went to see her doctor the following day. This may well have saved her life.

Within four weeks, the lump in her right breast was removed. And, after four weeks of radiotherapy, the 47 year old from London was given the all clear.

“The fact that I knew about breast cancer and its symptoms – I had discussed this with my GP months earlier – helped me stay calm when I found the lump,” says Mrs Burrell. Incidentally, a few weeks earlier I had read in a newspaper article that, thanks to significant advancements in cancer research and treatment, many cases of breast cancer can now be treated successfully. So, I felt somehow reassured about what was lying ahead.

“During radiotherapy, I found it extremely useful to speak with other people. I also became interested in complementary therapy for cancer and, as a result, I took up yoga and zumba dance, among other things.

“Quite unexpectedly, the big challenge came when I finished my treatment. In the weeks before, I had been cared for by a very supportive team of nurses and doctors. As I stopped seeing them, I felt like I was suddenly on my own. So I joined the support group at Macmillan and that was helpful.

“It’s crucial to be able to talk about your illness with others. It helps you realise that you are not alone. Surround yourself with positive people. Don’t be afraid to share your feelings with family and friends. And, last but not least, take good care of yourself. Cancer can take a physical toll on patients. Looking good helps you feel better.”

Areas of greatest improvement, compared to the first survey in 2010, include patients feeling more satisfied with the range of treatment options they are being offered, and feeling treated with respect and dignity by staff. Overall, 89 per cent of patients rate their cancer care as “excellent or very good”.

“However, there are significant variations among hospitals across the UK,” adds Professor Maher. “Patient experience is particularly poor in London, for example. Furthermore, there have not been improvements in terms of communication among the many care teams that look after each individual patient. And ineffective communication increases the risk of patients falling through the gaps. So, it is really important to remember that, although working with systems and organisations is vital, ultimately people need to work with people.”

Cancer treatment is mostly funded by the NHS. A 2011 BUPA report puts the overall annual cost for cancer care across NHS, private and voluntary sectors at £9.4 billion. This figure is forecast to increase to £15.3 billion by 2021.

Alongside conventional treatment, cancer patients may choose to receive, under medical supervision, complementary therapies, such as massage, yoga or aromatherapy. There is evidence that these may help improve life quality and overall wellbeing by reducing anxiety, pain and tiredness. Some people may opt for alternative therapies, including certain diets or nutritional supplements, instead of conventional treatment. But there is no research or clinical evidence supporting their efficacy and safety.

According to the charity Macmillan Cancer Support, there are currently two million people living with, or beyond, cancer in the UK. By 2030, this figure is expected to double.

Although cancer management and patient experience have improved in recent years, there is still a long way to go to further improve survival through timely diagnoses, and to ensure that all patients across the country receive the highest standard of care and support, at all times.

Hear the call to join forces in the fight to beat toughest cancers still taking lives

Scientists, researchers and clinicians are being urged to put aside fierce competition and protectionism to join forces in the fight against cancer

◆ **TRIALS AND COLLABORATIONS**

● **VICTORIA FLETCHER**

Over the last 15 years, scientific and technological breakthroughs have changed the face of cancer research.

The mapping of the human genome, improvements in both computer power and data analysis, and breakthroughs in understanding the immune system have made it possible for scientists to take great strides forward.

But over this period, it has also become clear that collaboration is needed between academics, hospitals, charities and the pharmaceutical industry if the pace of discovery is to continue.

With everything moving at such a pace, patients' groups and charities have also begun to ask the question, if we truly want to beat cancer, why isn't all this research data shared freely?

For academics in the UK, collaborating is key to the war on cancer. At University College London Cancer Institute (at UCLH), Professor Charles Swanton is leading a groundbreaking project mapping the genetic changes that occur during the lung cancer disease course – a disease that has traditionally seen little improvement in survival rates.

The TracerX trial is enrolling 850 patients in ten centres around the UK, regularly collecting biopsies that will provide new insights into the course of the disease – and common targets for treatment.

"We are absorbed by the idea of collaboration because one lab together with my clinic at UCLH keeps me very busy, and there is a lot of expertise we are not set up for and a lot we cannot do to interrogate cancer genomes exhaustively," says Professor Swanton. "We need expertise from across the UK and so have ten hospitals recruiting patients and many senior UK research scientists helping.

"This study is sequencing spatially and temporally separated lung cancer genomes changing constantly in the same patient and it's a huge undertaking when scaled to 850 patients. But we need these sorts of big studies to get to grips with how and why lung cancer is incurable."

Professor Swanton and his collaborators will be analysing on average up to 12 trillion letters of DNA in each patient, across 850 patients over nine years. Although analysing the genomes of cancer patients is getting faster, it remains an expensive and time-consuming business because essential elements still have to be done by scientists rather than computers. Even computational technology is struggling to keep up with the data explosion from cancer studies at a price that is affordable.

But it is not only scientists who are collaborating with one another; industry has also begun to see the benefits of greater collaboration to speed up research.

Angela Kukula, director of enterprise at the Institute of Cancer Research, says: "In recent years the pharmaceutical industry has contracted and consolidated, and their research and development departments are often smaller. So nowadays we see independent researchers funded by charity doing the early, innovative, blue-sky work and, once something looks promising, we partner back with pharmaceutical firms for the next stage."

> **Collaboration is needed between academics, hospitals, charities and the pharmaceutical industry if the pace of discovery is to continue**

Dr Kukula says that this approach has benefits for patients as it means the drugs that are developed are not "me too" drugs similar to ones already on the market, but are often targeting rare and under-represented forms of disease.

Robin Jones, a sarcoma oncologist at London's Royal Marsden Hospital, has been working on some of these trials looking into immunotherapy for sarcoma. This disease is complex and hard to treat, and patients currently have few treatment options. He says this type of research, in this case involving a biotechnology firm working with scientists, can produce important results.

"Immunotherapy is a big player in the cancer field now," says Dr Jones. "As a sarcoma oncologist, it can be difficult when you see patients who should have more treatment options and better survival rates. But some of the immunotherapy treatments that are currently in trials look promising and there is very exciting work in hand."

There are other forms of collaboration too, involving big data. Researchers and industry are finally starting to see the benefits of sharing information about the trials they work on.

In addition, there is a push to put more raw data – or anonymised health information about patients in a trial – on to websites for researchers to mine, as long as patient confidentiality is retained.

Last year, a number of projects for sharing this sort of big data were announced by pharmaceutical firms. One of these, the Project Data Sphere, involves AstraZeneca, Bayer, Celgene, Janssen, Pfizer, Sanofi and Memorial Kettering Sloan Cancer Centre all agreeing to share the raw data from cancer trials.

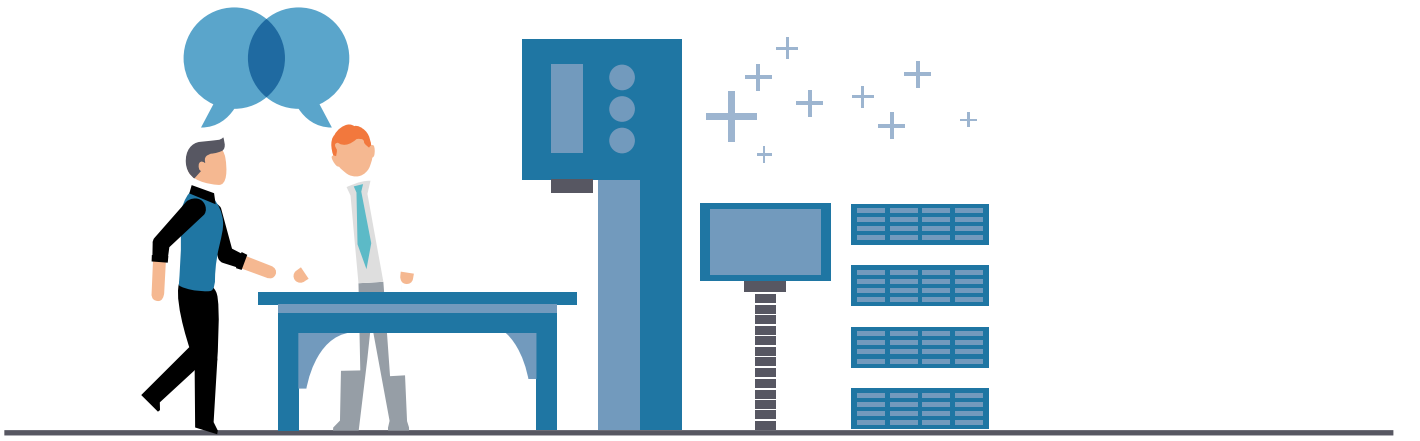
In Europe, the hotly anticipated European Clinical Trial Regulation will also require all types of trial, including those on cancer, to be publicly registered and for their results to be published. The largest registration site in the world is currently ClinicalTrials.gov.

European campaigners want this to go even further and have set up the All Trials campaign. This calls for both the pharma industry and researchers to publish previous trial results, a sentiment that was recently backed by the World Health Organization.

So far, GSK has agreed to do this for all trials dating back to 2000. Step by step, other pharmaceutical firms and some researchers are signing up to the initiative, but campaigners say more still needs to be done to improve the sharing of clinical trial information.

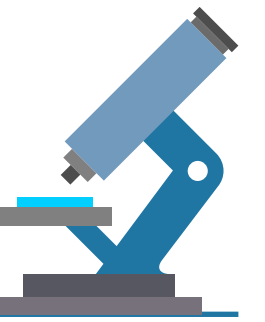
The future of cancer research will not only be affected by the sharing of past

Scientists prepare samples for a DNA sequencing machine



On the brink of a major cancer breakthrough?

Such is the challenge posed by the threat of cancer to take away life, few could claim victory, but outcomes have improved dramatically and a milestone breakthrough may be within reach



◆ **FUTURE SUCCESS**

● **VICTORIA FLETCHER**

For generations, cancer was known as the "Big C", a disease so frightening and deadly that sufferers could barely utter its name. But scientists believe the next generation of patients may start to have a very different experience of cancer.

Peter Johnson, chief clinician at Cancer Research UK, says: "In some cases, cancer will become a chronic disease rather than a killer. This is already happening in diseases such as breast cancer and with the new molecular therapies. But at the same time we are looking for treatments to cure patients completely."

New treatments and better survival rates for some cancers have already started to shift patient behaviour, Professor Johnson says.

"Patients used to think nothing could be done and so were reluctant to see a doctor quickly. But the message is starting to get through that getting diagnosed early will make a big difference to the chance of surviving cancer and we are seeing a change in attitude, with more people coming to the doctor sooner.

"A lot more still has to be done to encourage patients to get diagnosed sooner, but these sorts of shifts could have an important impact in the years to come."

In future, the conversations between patient and doctor could change dramatically. At diagnosis, for example, patients will be given far more detail about their tumour based on molecular analysis carried out during an initial biopsy or blood test. Clinicians should be able to tell patients far more about how their cancer will behave and the types of treatments that will help.

"The process of diagnosis is going to be more sophisticated and also the types of treatment," Professor Johnson says. "Keyhole surgery using robots will be far more common and this will minimise trauma to the patient, helping them to recover more quickly.

"Radiotherapy will be more finely targeted to cause less damage to surrounding tissues, while proton beam therapy is another approach to treating cancers in difficult areas such as the brain. In addition to this, we are already using more targeted treatments and antibody treatments, with very exciting results from immunotherapy for melanoma and lung cancer."

In an era of NHS cutbacks, important questions remain. For example, will health systems be able to afford the cost of the genetic tests and the new drugs that patients need? Or could the imminent arrival of new treatments be delayed by lengthy negotiations between industry and government over price?

Few health economists, think-tanks or charities seem ready to broach this controversial subject. Professor Johnson points out: "I think it's important to recognise that cancer drugs are a small proportion of the total NHS budget."

But away from the detail of who will pay for what, the new era of cancer treatments is getting tantalisingly close. Each month, clinical trial data is published revealing impressive, often extraordinary results, although important data showing whether these patients actually live longer is yet to come.

However, this has not stopped new drugs, known as immunotherapy checkpoint inhibitors, made my firms such as Bristol-Myers Squibb and Merck, from electrifying science journals and financial markets.

Tumour shrinkage in melanoma patients in a recent trial, prompted Dr Stephen Hodi, associate professor of medicine at the Dana-Farber Cancer Institute, to describe them as "simply unprecedented", while another doctor said one patient's dissolving tumour was "one of the most astonishing responses ever seen".

Work using T cells from a patient's own body to attack cancerous cells has also shown encouraging results in the treatment of leukemia, with some dying patients apparently cured using the approach.

In addition, scientists are excited by work using a patient's own dendritic cells to create a vaccine, which can help to provoke the immune system to fight and kill cancer cells.

Almost all the pharmaceutical giants, including Novartis, Roche, Merck and AstraZeneca, are racing to get immunotherapies on to the market with trials focusing on various forms of cancer.

> **People are too scared to say we're on the verge of beating some cancers, but what's coming around the corner is truly exciting**

But recent results suggest the most promise will come not from using one drug, but from combining many types of immunotherapies including cancer vaccines. Knowing which combination to use and when could still take a long time for researchers and industry to unravel. And collaboration will again be needed provide the results that clinicians and patients need.

Navid Malik, an industry analyst and non-executive director of vaccine pioneers Northwest Biotherapeutics, says it's not just pharmaceutical firms that hold the key to cancer breakthroughs.

"Clinical trials have changed in recent years and are shorter and more focused these days," he says. "This means that smaller biotechnology firms have the power to research and trial new cancer therapies too. This is the renaissance period for biotechs. Why do they need to work with pharmaceutical firms if they can get to market this fast?

"Up until recently, you could count innovation in cancer drugs on one hand but now, with immunotherapy and cancer vaccines showing impressive results in shorter trials, this is all changing.

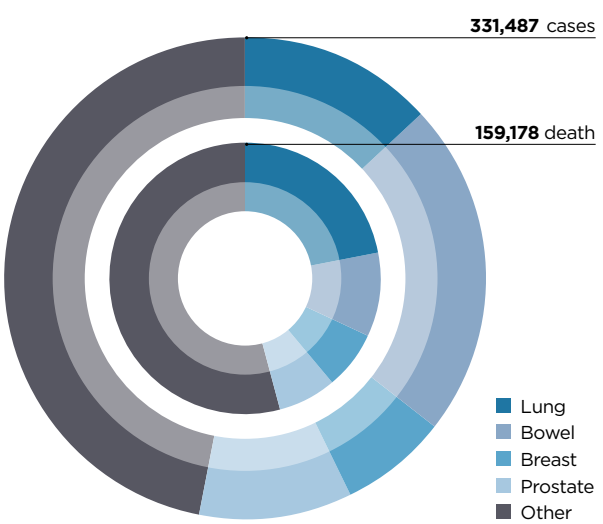
"People are too scared to say we're on the verge of beating some cancers, but what's coming around the corner is truly exciting."

trial data, but also by the way in which future trials are carried out. The advent of genomics, personalised medicine and immunotherapy has meant that clinical trials are now smaller and faster than ever.

As scientists pinpoint the molecular changes that fuel cancer growth they can hand-pick the drugs to interrupt the disease. It means patients can be matched with the best medicine for them from the outset or benefit from drugs made using their cells, including cancer vaccines.

Dr Navid Malik, an industry analyst and non-executive director at Northwest Biotherapeutics, which is working on new cancer vaccines, says: "In the United States last year, the Food and Drug Administration approved 41 new drugs, nine of which were 'breakthrough therapies' and two were approved based only on phase I trials. Things are now happening very fast in cancer research and it's an incredibly exciting time for researchers, industry and for patients."

CANCER IN THE UK



Source: Cancer Research UK, 2015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