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"Cancer and Cures: How 250 Years of History Can Be Used In The Coming Times".

The theme for the science week talks this year is 'innovating for the future'.

It had taken me a bit of time to think of what to present to all of you and then I realised, "funding for cancer research always pops up on the telly, but what is our money actually doing?" We all know what cancer is, and we know that our scientists have worked, are working, and will continue to work on a cure for it. And we may have all heard of the various treatments provided for cancer patients, but do we know exactly what scientists want, and can, achieve? In this talk, I aim to tell you about what we already have in terms of combating cancer, and what we will have in several years' time.

Firstly, what is cancer?

Cancer, according to the NHS, "is a condition where cells in a specific part of the body grow and reproduce uncontrollably. The cancerous cells can invade and destroy surrounding healthy tissue, including organs." There are more than 200 types of cancer and in the UK, the 4 main types are: breast cancer, lung cancer, prostate cancer and bowel cancer. 1 in 2 people will have some form of cancer in their lifetime.

There are several causes of cancer.

Smoking is the largest cause of cancer in the world. It is also the biggest preventable cause of cancer in the UK and it causes at least 15 different types of cancer. Research has shown that for every 15 cigarettes smoked, there is a DNA change which would cause a cell in the body to become cancerous.
Another cause of cancer is obesity. It is the second largest cause of cancer in the UK; more than 1 in 20 cancer cases are caused by obesity. Being obese doesn't guarantee that you will develop cancer but it does increase your risk of getting the disease.
Skin cancer's main cause is too much exposure to ultraviolet radiation.
1 in 20 cancers could be prevented with a healthier diet. Your risk of cancer could also be reduced by keeping active.
Alcohol causes 7 types of cancer and it is more dangerous to drink and smoke than to do either one because alcohol makes it easier for the mouth and throat to absorb damaging chemicals such as tobacco.
Infections such as HPV can increase your risk of cancer.
Air pollution and radon gas are other causes of cancer.
Therapies such as HRT (hormone replacement therapy) can increase your risk of breast, ovarian and endometrial (womb) cancers, but the increase is small.
Certain jobs can also increase your risk of cancer depending on what you are exposed to. Being exposed to asbestos, diesel engine exhaust, silica, pesticides and herbicides and UV radiation increases your risk of developing the disease.
Another cause for cancer is certain inherited genes. These genes could be faulty. All cancers develop because one or more genes have mutated.

There are several treatments that are currently used to treat cancer patients.

When diagnosed with cancer, the first resort is to opt for surgery. In the surgery, the surgeons remove the tumour, they remove the whole tumour if the cancer is contained in one area. Surgery is also used to debulk a tumour. Removing part of the tumour can help other treatments work better. The risks of surgery are pain and infection.

Radiation therapy uses high doses of radiation to kill cancer cells and shrink tumours. It does this by damaging their DNA. Cells that have been damaged beyond repair stop dividing or die. It is not a single session treatment, it happens over a series of days or weeks. There are several side effects depending on the area that is treated.

The next treatment is one that is often spoken about, and that is chemotherapy. It is often used when cancer has spread and it is therefore harder for a surgery to completely remove the tumour. It uses drugs to kill the cancer cells. It can be used to cure cancer, lessen the chance it will return or stop or slow its growth. It can, like other treatments, also be used to shrink tumours that are causing pain. It can be taken orally, through an IV, an injection, intrathecal (in the spaces between the layers of tissue that cover the brain and the spinal cord), intraperitoneal (peritoneal cavity: intestines, stomach, liver), intra-arterial (the artery that leads to the cancer), or topical (in a cream).

The next few treatments are immunotherapy (helping the immune system fight cancer), targeted therapy (targets proteins that control how cancer cells grow, divide and spread, researches design treatments that can target these proteins), hormone therapy (slows or stops the growth of cancer that uses hormones to grow), precision medicine and biomarker testing (looking for genes, proteins or other substances that can provide information about cancer).

These are some of the main treatments used for treating cancer, but what does the future hold? What advances are scientists making? Most of the treatments being created are ones that have already been introduced to a few patients. Constant improvement and trialing is key to finding out the solution.

The first treatment is precision medicine. Precision medicine opposes the idea that there should be one drug for all those suffering with cancer. Instead, it focuses on tailoring medicine to subgroups of patients. Currently, you can recieve a range of therapies from the previous ones mentioned depending on the type of cancer you have, its size, and if it is contained in one area or if it has spread. Precision medicine analyses the genetic changes in your tumour, enabling doctors to give you the best treatment/combination of treatments possible. Precision medicine is currently available, but not for everyone. Looking into the future, researchers hope to discover as many of the genetic changes that can cause cancer to grow, develop and spread. They do this by giving you a biopsy, where the doctor removes a sample of your cancer and sends it to a special lab where a DNA sequencer starts looking for these genetic changes. Once they find these genetic changes, the next step is to develop drugs to target these changes and then clinically trial them. We are yet to discover precision medicine's full potential, but from the results that we have already seen, we are certain that we are making headway.

If there is one type of therapy that has a large range of options for the future, it is immunotherapy. Immunotherapy is treatment that helps your immune system fight cancer. It is a type of biological therapy, a biological therapy being a treatment that uses substances

made from living organisms to treat cancer. The immune system, when carrying out its normal function, detects and destroys abnormal cells and prevents the growth of many cancers. Even though the immune system acts to prevent cancer, cancer cells still find a way to dodge destruction. Some ways they do this are: having genetic changes that make them less visible to the immune system; having proteins on their surface that 'turn off' immune cells; changing the normal cells around the tumour so they interfere with the immune system's response.

The first innovation being made, although it has already been put into practice, is the idea of checkpoint inhibitors. Immune checkpoints are already part of the normal immune system. They prevent an immune response for being so strong that it destroys healthy cells in the body. They engage when T cells (proteins on the surface of the immune cells) recognise and bind to partner proteins on other cells, in our case, tumour cells. These proteins are called immune checkpoint proteins. When the checkpoint binds to its partner, they send an 'off' signal to the T cells, preventing the immune system from destroying the cancer. What checkpoint inhibitors do is that they block the checkpoint proteins from binding to their partner proteins. This prevents the 'off' signal from being sent, allowing the T cells to kill the cancer cells. 2 drugs that have been developed are nivolumab and ipilimumab. They have made significant progress in destroying cases of highly advanced melanoma and lung and kidney cancer. As great as the innovation is, it does have some flaws. There are several side effects. These side effects can vary based on how healthy you are before the treatment, your type of cancer, how advanced it is, the type of checkpoint inhibitor you are receiving and the dose. Some common side effects include rashes, diarrhea and fatigue. Inflammation is a much rarer side effect, but depending on where the inflammation is located, serious conditions can develop. For example, diabetes occurs from pancreas inflammation. Another downfall is that it is not available for everyone, but with large donations to several research groups, scientists are optimistic that they will soon be able to change that.

The next innovation on my list is T-cell therapy. T-cell therapy is a type of immunotherapy that makes your own immune cells better able to attack cancer. There are two subcategories under T-cell therapy: tumour infiltrating-lymphocytes therapy (TIL therapy) or CAR T-cell therapy. They both involve collecting your own immune cells, growing large numbers of them in a lab and then administering them to you by injecting them into your vein. This process of growing the treatments usually takes around 2-8 weeks. In this waiting time, you will usually receive other treatments that will help get rid of other immune cells. You do this because the therapy is most effective when there are less immune cells.

TIL therapy uses T-cells, specifically tumour infiltrating-lymphocytes, that are found in your tumour. These lymphocytes are then tested to find out which ones best recognise your tumour cells. They then treat the lymphocytes to make them grow in large numbers quickly.

CAR T-cell is very similar to TIL therapy. The difference is that your T-cells are changed to make the protein CAR (chimeric antigen receptor) before they grow them and give them back to you. CARs allow T-cells to attach to specific proteins on the surface of the cancer cells, improving their ability to attack the cancer cells. There is a serious side effect to CAR T-cell therapy which is cytokine release syndrome. This can cause fever, nausea, headache, rash, rapid heartbeat, low blood pressure and trouble breathing. In most cases, patients only get it mildly but it can be life-threatening

The penultimate innovation that I have in store for you today is epigenetic therapy. Epigenetic therapy is pretty much the opposite of what we currently have. Most of our current treatments focus on destroying cancer cells, epigenetic therapy focuses on transforming them instead. Epigenetics is how genes can switch 'on' and 'off' depending on outside influences, that is the easiest way to explain it. Research into this field is constantly changing scientists' understanding of not only cancer, but many other diseases. It has also led to drugs that are currently being clinically tested. Scientists hope that they will soon be able to put forward these drugs to hospitals and clinics.

And finally, vaccines. Will there ever be a vaccine for cancer? When I first looked into this question, I was hoping to find some sort of prevention vaccine, like the AstraZeneca or Faiser vaccine against Covid, and there was some result, but not the one I had hoped for. Seeing as some cancers can come from the HPV infection, taking the HPV prevention vaccine can also act as a slight protectant against cancer. But, I did discover that vaccines for cancer are being created as treatments. Cancer vaccines are a type of immunotherapy. They work by strengthening the body's natural defenses against the cancer. The idea is that cancer cells contain these substances called tumour-associated antigens. These antigens are not present in normal cells, and when they are, they are present at low levels. The treatment vaccine should be able to help the immune system recognise these antigens and destroy the cancer cells that contain them.

The treatment vaccines can be made in three ways:

1. From your own tumour cells; the vaccine will then be tailored to you, causing your immune response to work against features unique to your cancer.
2. From tumour-associated antigens; these are found in many people with a specific type of cancer therefore the vaccine could work for a group of people.
3. From your own dendritic cells (a type of immune cells that help identify and attack abnormal cells); these vaccines would stimulate your immune system to respond to an antigen on tumour cells.

There are five main types of vaccines that are currently being developed and trialed internationally:

1. Antigen vaccines; the one talked about above
2. Whole cell vaccines; it uses whole cancer cells instead of just an antigen
3. Dendritic cell vaccines; also mentioned above
4. DNA vaccines; made from bits of DNA from cancer cells
5. Anti Idiotype vaccines; makes antibodies against cancer cells

Vaccines still need to be tested so we have not, like the other treatments, realised their full potential.
With so many options to look forward to, we can see a brighter future ahead of us. That is my talk done, so finally any questions and thank you for listening.

- Further reading and for extra information:
    - https://www.cancerresearchuk.org/about-cancer/causes-of-cancer/smoking-and-cancer/how-does-smoking-cause-cancer#tobacco10

- https://www.nhs.uk/conditions/cancer/#:~:text=Cancer%20is%20a%20condition%20where,process%20is%20known%20as%20metastasis.
- https://www.cancerresearchuk.org/about-cancer/causes-of-cancer/obesity-weight-and-cancer
- https://www.cancerresearchuk.org/about-cancer/causes-of-cancer/sun-uv-and-cancer
- https://www.cancerresearchuk.org/about-cancer/causes-of-cancer/diet-and-cancer
- https://www.cancerresearchuk.org/about-cancer/causes-of-cancer/alcohol-and-cancer
- https://www.cancerresearchuk.org/about-cancer/causes-of-cancer/infections-eg-hpv-and-cancer
- https://www.cancerresearchuk.org/about-cancer/causes-of-cancer/air-pollution-radon-gas-and-cancer
- https://www.cancerresearchuk.org/about-cancer/causes-of-cancer/hormones-and-cancer
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- https://www.cancerresearchuk.org/about-cancer/causes-of-cancer/inherited-cancer-genes-and-increased-cancer-risk
- https://www.cancerresearchuk.org/about-cancer/causes-of-cancer/age-and-cancer
- https://www.cancer.gov/about-cancer/treatment/types
- https://www.mskcc.org/news/future-five-reasons-optimism
- https://www.cancerresearchuk.org/about-cancer/cancer-in-general/treatment/immunotherapy/types/vaccines-to-treat-cancer