Research 24

Danish Cancer Society

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Contents

The image shows cancerous tissue from the stomach photographed under a microscope. The tissue has been stained with luminescent dyes highlighting different structures within the cell: Blue marks the cell nuclei. Purple stains the entire cell nucleus, except for the nucleoli, which appear as black holes inside the cell. Nucleoli are structures where the cells' protein factories — ribosomes — are produced. Turquoise marks pan-cytokeratin, a protein researchers use to distinguish cancer cells from normal surface cells. Yellow is a marker for damage or stress in the nucleolus that affects how ribosome production takes place. Photo: Kezia Oxe, DCI

The Danish Cancer Society supports research

The Danish Cancer Society pursues a three-track strategy for supporting research: Independent research, strategic research and the Danish Cancer Institute (DCI). This annual impact report comprises research supported through all three tracks. The Danish Cancer Society awards research funding through independent committees composed of both experts and patient representatives. Researchers at DCI apply for funding on equal terms with external researchers.

Danish Cancer Institute

Independent research

Strategic research

Danish Cancer Society Research

Over the past five years, the Danish Cancer Society has supported research with an average annual amount of DKK 422 million. Research is one of the Society's main objectives, and thanks to contributions from people across Denmark, we support a wide range of research projects throughout the country every year. In this report, you can read about some of the projects and results made possible by this funding in 2024.

In 2024, there was a great deal of drilling, hammering and rebuilding in the Danish Cancer Institute's laboratories in Copenhagen. The renovations were necessary to make room for four new research groups relocating to the Danish Cancer Society from the University of Copenhagen. These groups include some of the world's leading researchers in their fields, with expertise in some of the most fundamental parts of the body's cells.

The Danish Cancer Institute (DCI) is now embarking on several exciting initiatives, including a new basic research centre focusing on so-called epigenetics. When we say that cancer often arises from an interaction between our genes and environment, the influence of the environment takes place through epigenetic changes. Epigenetics refers to processes that help regulate our genes and how they function in the body, and epigenetic changes play a role in conditions such as cancer and ageing.

Another initiative is the development of a new infrastructure – a specialised expertise that will be built up within the DCI but made available to researchers across the country, benefiting multiple research environments in Denmark. This infrastructure is based on a completely new technology that makes it possible to cut into the cell's DNA and use advanced microscopy to immediately observe how this affects the cell. Both the new researchers and the new laboratories are an important addition to the Danish Cancer Society, and we are delighted to be able to strengthen cancer research in this way. In the coming years, this will undoubtedly lead to many important results that can help develop better treatments and services for cancer patients.

There is also a great deal of important research taking place in other parts of the country, which the Danish Cancer Society continues to support. This year, researchers at Herlev and Gentofte Hospital will launch the world's first clinical trial combining T-cell therapy with the highly advanced genetic scissors CRISPR. The aim is to make T-cell therapy effective for more patients. The trial will initially involve ten terminally ill patients with melanoma.

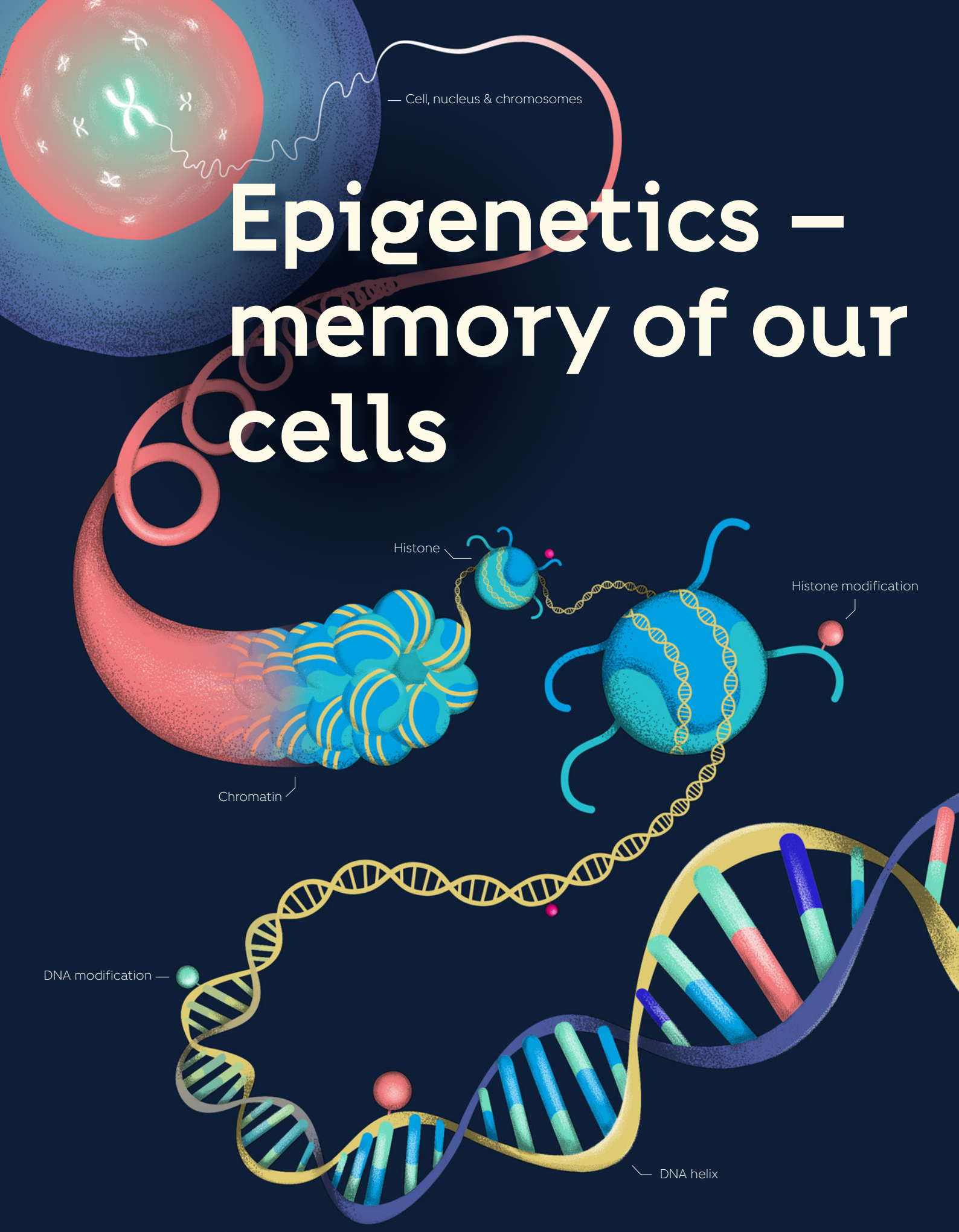
At the other end of the patient journey, there is post-cancer follow-up. In 2024, Aarhus University Hospital introduced a new follow-up programme for rectal cancer patients. As more and more people survive cancer, there is also a growing need to focus on the late effects of treatment to ensure that survivors can live well after cancer. Patients will still receive CT scans at scheduled intervals, but regular check-ups with physical examinations have been replaced by a digital follow-up programme training patients to recognise both late effects and signs of relapse. It is an important step towards a new type of follow-up after cancer.

These are just a few examples of the exciting research that the Danish Cancer Society helps make possible. None of this would be possible without the generous donations the Danish Cancer Society receives from people across Denmark every year - thank you.

We hope you enjoy your reading.

Mads Melbye
Research Director

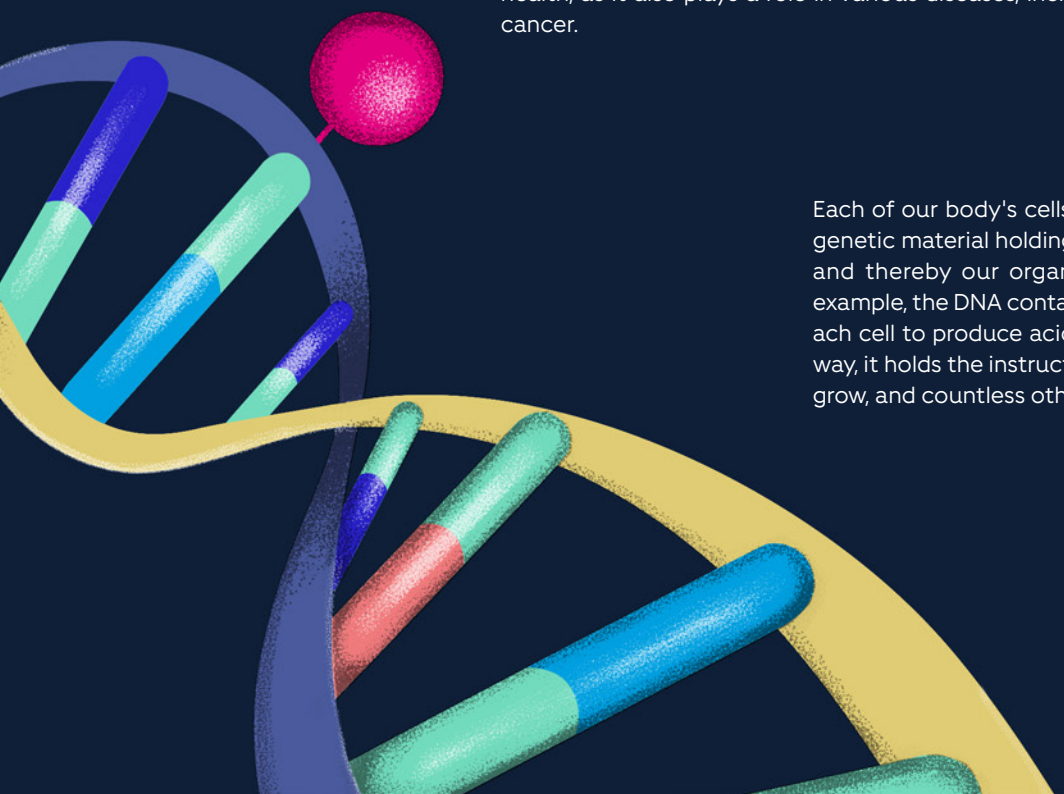
Jesper Fisker
Managing Director



Epigenetics – memory of our cells

The cells of our body contain our genetic material: DNA. DNA can be compared to a cookbook for our body – containing instructions for everything from our eye colour to many aspects of our health and disease.
In recent years, researchers have increasingly focused on epigenetics – the science of how cells develop and retain their specialised properties. Epigenetic researchers study 'epigenetic information', which refers to how our genetic material, DNA, is organised within the cell nucleus. This organisation has a major impact on which genes a cell is able to use. In the following pages, you can explore what epigenetics is all about.

Our bodies are made up of millions of cells that look different and serve different functions. Throughout life, these cells can continue to change. Chemicals, stress, diet and many other factors influence our cells — and in some cases, can even alter them. Differences in cell identity are driven by so-called epigenetic processes. These processes regulate how our DNA is folded within cells and determine which parts of the genetic information are accessible and read. Understanding epigenetic regulation is crucial for our health, as it also plays a role in various diseases, including cancer.



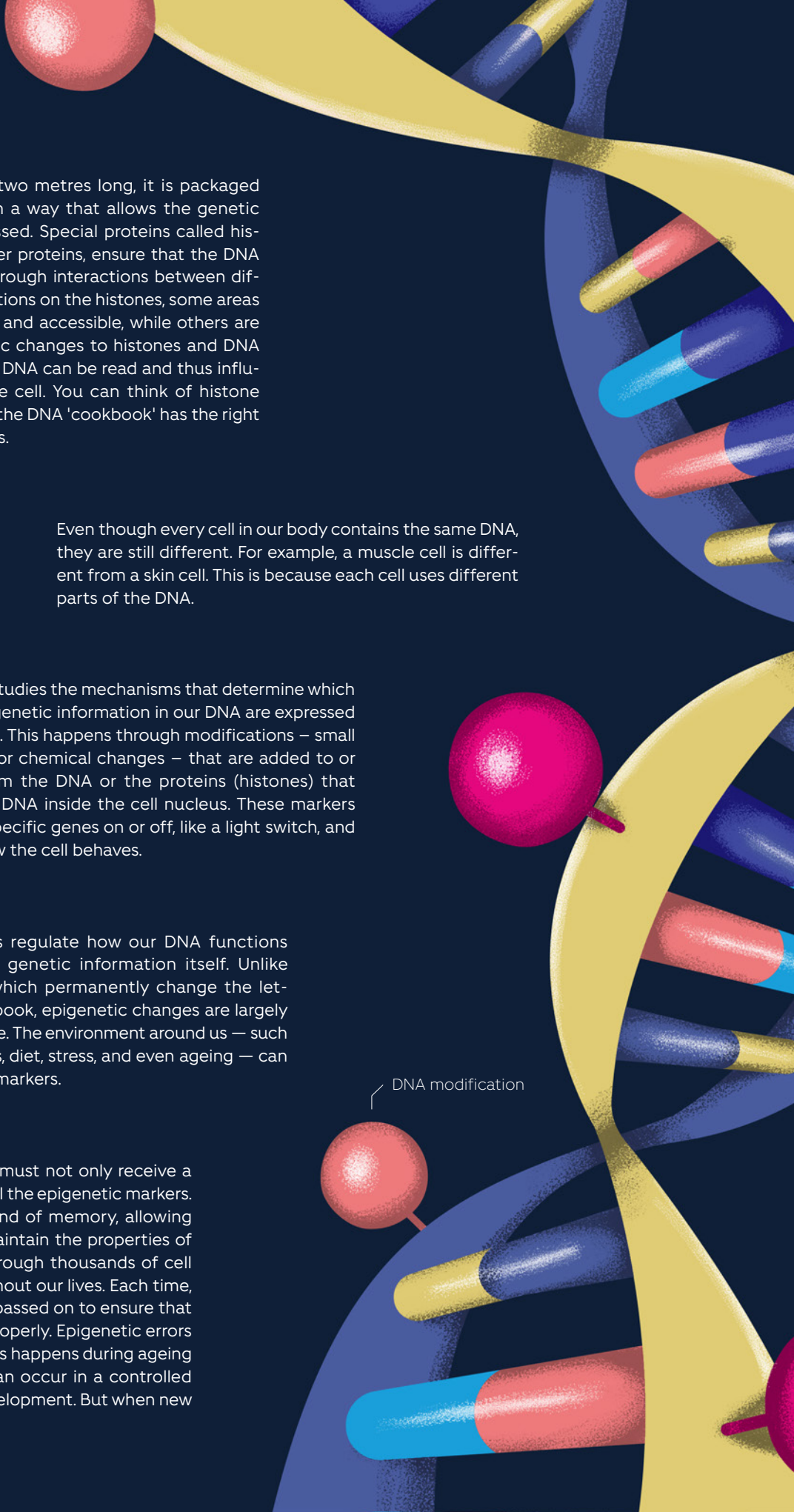
Each of our body's cells contain a copy of our DNA – the genetic material holding the instructions for how our cells, and thereby our organs and entire body, function. For example, the DNA contains the recipe that enables a stomach cell to produce acid to break down food. In the same way, it holds the instructions for our eye colour, how tall we grow, and countless other functions of the body.

Although DNA is about two metres long, it is packaged inside the cell nucleus in a way that allows the genetic information to be expressed. Special proteins called histones, together with other proteins, ensure that the DNA is packaged correctly. Through interactions between different chemical modifications on the histones, some areas of the DNA remain open and accessible, while others are tightly packed. Epigenetic changes to histones and DNA affect which parts of the DNA can be read and thus influence the function of the cell. You can think of histone markers as ensuring that the DNA 'cookbook' has the right recipes on the right pages.

Even though every cell in our body contains the same DNA, they are still different. For example, a muscle cell is different from a skin cell. This is because each cell uses different parts of the DNA.

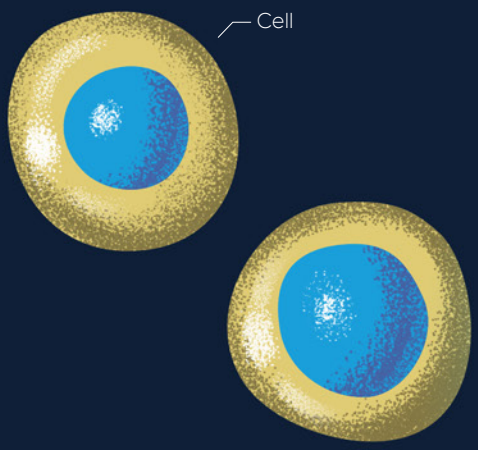
Epigenetics studies the mechanisms that determine which parts of the genetic information in our DNA are expressed in a given cell. This happens through modifications – small 'bookmarks' or chemical changes – that are added to or removed from the DNA or the proteins (histones) that package the DNA inside the cell nucleus. These markers can switch specific genes on or off, like a light switch, and influence how the cell behaves.

Epigenetic processes regulate how our DNA functions without altering the genetic information itself. Unlike genetic mutations, which permanently change the letters in the DNA cookbook, epigenetic changes are largely dynamic and reversible. The environment around us — such as smoking, chemicals, diet, stress, and even ageing — can influence epigenetic markers.

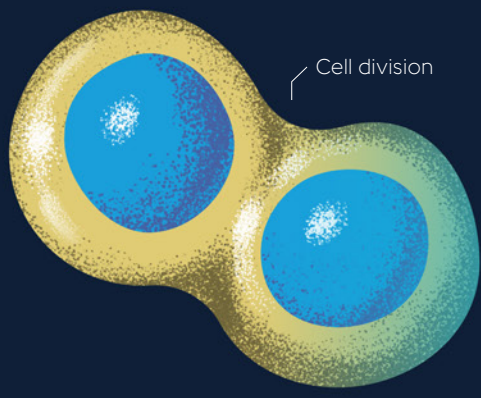


When a cell divides, the new cell must not only receive a copy of the DNA, but also inherit all the epigenetic markers. In this way, they function as a kind of memory, allowing the new cell to remember and maintain the properties of the original cell. This happens through thousands of cell divisions in billions of cells throughout our lives. Each time, the epigenetic memory must be passed on to ensure that the body continues to function properly. Epigenetic errors can cause cells to lose functions, as happens during ageing – or to acquire new ones. This can occur in a controlled way during the body's natural development. But when new

properties are introduced in an uncontrolled way, it can lead to diseases such as cancer.



Epigenetic processes already play an important role during the body's development. All the body's cells originate from a single fertilised egg that divides and gives rise to specialised cells. During this process, many epigenetic changes take place that are essential for the body to develop and function normally.



Understanding epigenetic regulation has important implications for health and disease, including cancer. For example, epigenetic changes in specific cancer-related genes can cause them to lose their ability to protect cells from cancer. Other genes that control cell growth may become overactive, causing cells to divide uncontrollably. Once cancer has developed, cancer cells can exploit epigenetic mechanisms to gain characteristics that help them grow more aggressively or become resistant to treatment.

Researchers are interested in epigenetics because it may offer new insights into what goes wrong in cancer cells — and could lead to the development of new, targeted treatments.

Some types of chemotherapy kill cancer cells by interfering with the copying of DNA. However, it is still unknown how chemotherapy affects the copying of epigenetic memory in the cells that survive. Researchers believe this may influence the risk of developing late effects.
Studies have shown that some cancer patients age more rapidly after undergoing chemotherapy. This may be linked to the way chemotherapy affects epigenetic markers in cells.

In 2024, researchers received a grant to establish a new epigenetics research centre at the Danish Cancer Institute. The centre will focus on understanding how the dynamic epigenetic processes occurring during cell division ensure that cells retain information and a lifelong memory. *Read more on page 21.*

02

Danish Cancer Institute

The Danish Cancer Institute (DCI) is the Danish Cancer Society's own research centre. In 2024, DCI reinforced its leading role in cancer research through a number of significant achievements. At the same time, a strong foundation was laid for future research.

DCI is one of Europe's largest cancer research centres with around 250 researchers representing some 30 nationalities. Its research spans from basic research in biology and epidemiology to computational and translational research that quickly brings scientific advances to patients. DCI has also established a patient and relatives panel to help ensure that the patient perspective is included in new projects. In 2024, DCI published 327 scientific articles that contributed new knowledge and advanced cancer research across a range of fields. One study documented that six HPV types, including the main cancer-causing forms, HPV16 and 18, have now been eradicated among young men in Denmark. The results demonstrate the effectiveness of the HPV vaccine and show that the overall burden of the virus in society is decreasing, which could help prevent many cancers in the future.

DCI's research has also gained visibility among the general public. For example, researchers have shown that high-dose hormonal IUDs increase the risk of breast cancer. The results also highlighted that hormones from IUDs affect the whole body, not just locally. Taken together, this knowledge is crucial for conversations between women and their doctors about contraceptive choices. The research attracted significant national and international media attention and also brought focus to issues of gender equality and the need for alternative forms of contraception — especially for men. In another example, DCI researchers helped shed light on ultra-processed foods and the health risks they pose, such as obesity and diabetes.

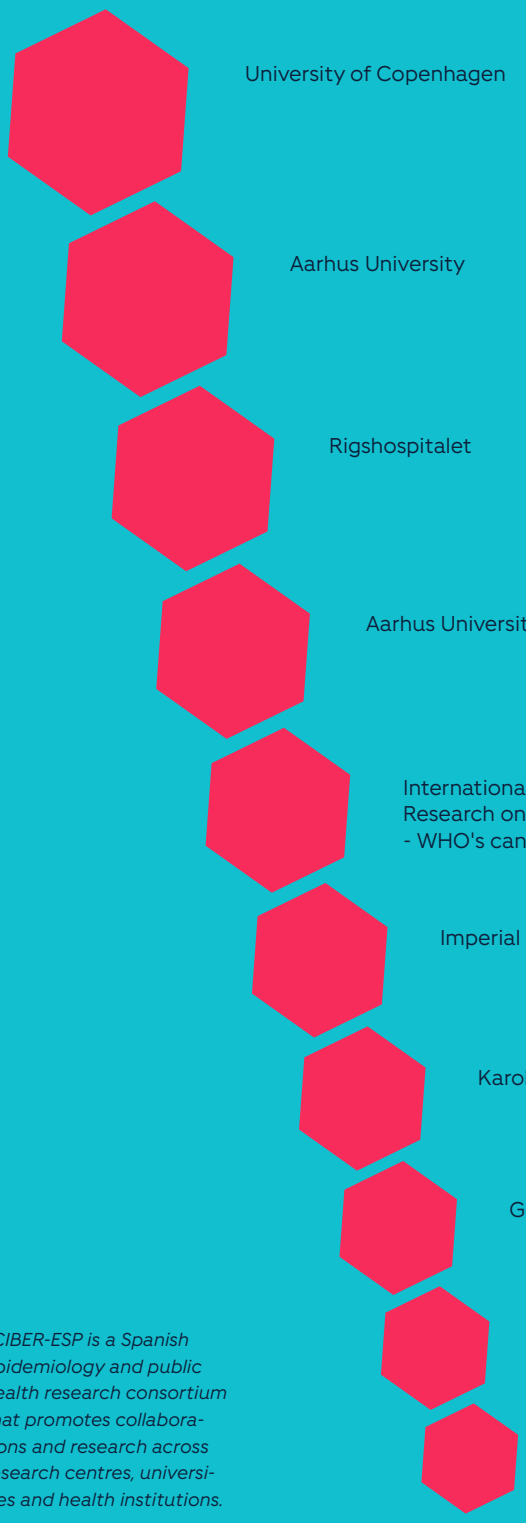
These are just some examples of DCI's research strengths. DCI is home to researchers who are at the forefront of their field and who contribute research and knowledge of significant societal relevance.

In 2024, the foundation was also laid for two major new initiatives: An infrastructure that will give all researchers in Denmark access to a new technology combining CRISPR genetic scissors and advanced microscopy, and a basic research centre for epigenetics. These initiatives will help the Danish Cancer Institute maintain its international leadership in cancer research in the years to come.

2020 - 2024

Partners

Collaboration at national and international level is crucial for the research conducted at the Danish Cancer Institute. The figure shows the research institutions that have published most joint research publications with DCI in the period 2020-2024.



**CIBER-ESP is a Spanish epidemiology and public health research consortium that promotes collaborations and research across research centres, universities and health institutions.*

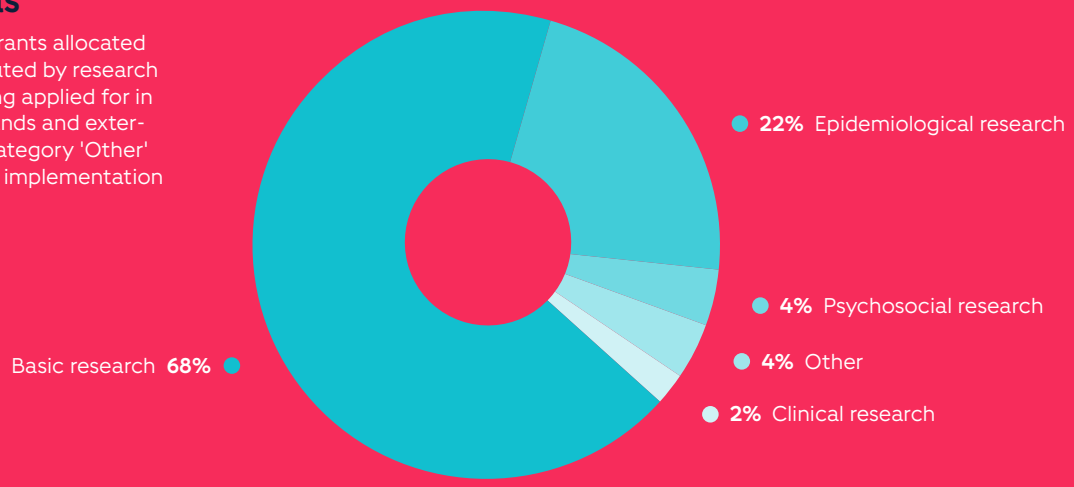
Finances

The aggregate financial statements for the Danish Cancer Institute show expenses of DKK 209.7 million in 2024, of which basic funding from the Danish Cancer Society amounted to DKK 79.4 million for payroll and operating expenses and DKK 45.4 million for fundamental costs. During 2024, researchers at DCI also received research grant pledges totalling DKK 114.7 million from a large number of foundations. The money will be used to fund research projects in the coming years.

Learn more about the finances and see financial statements for the Danish Cancer Society as a whole on the Society's website: www.cancer.dk.

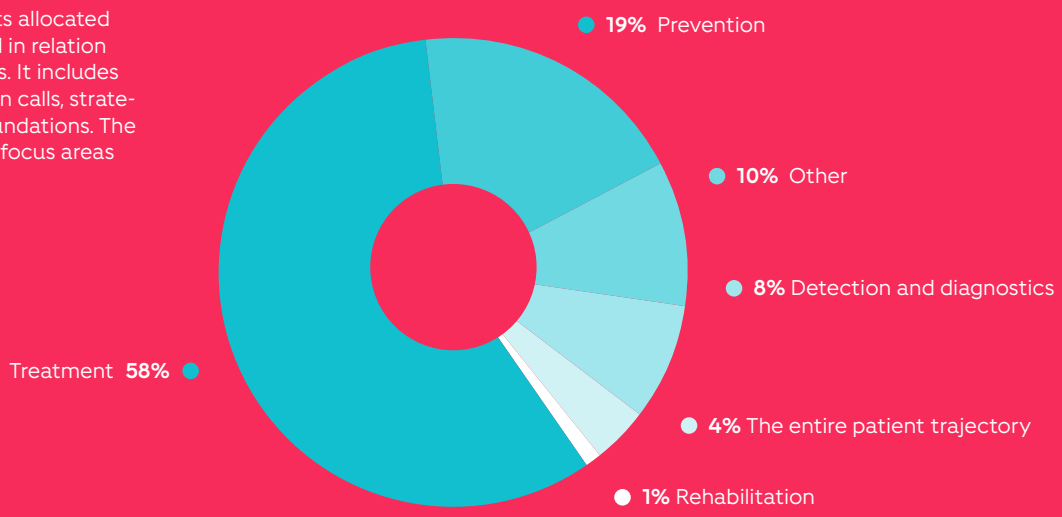
Research areas

The chart shows the grants allocated to DCI in 2024, distributed by research area. It includes funding applied for in open calls, strategic funds and external foundations. The category 'Other' includes areas such as implementation research.



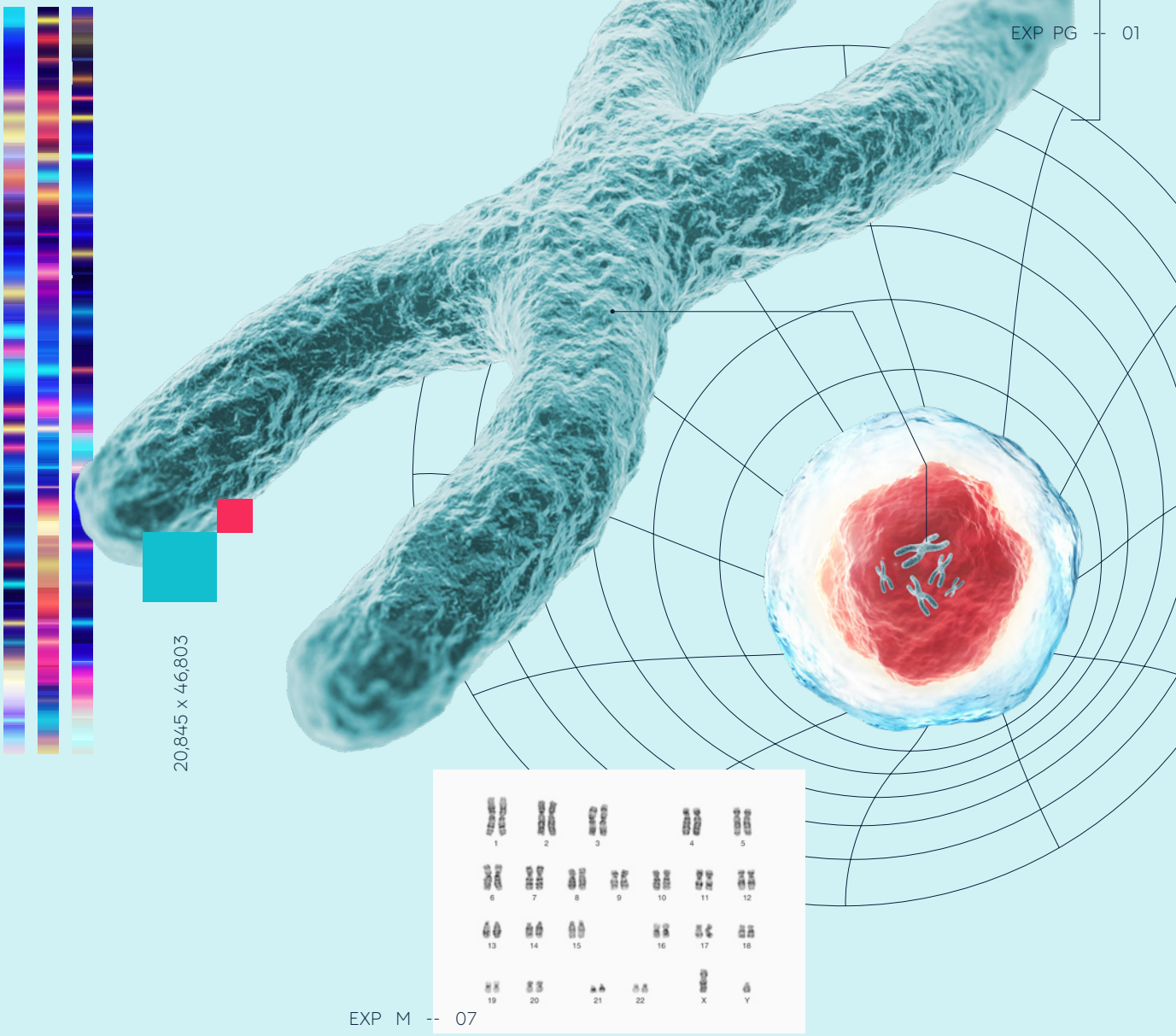
Patient trajectory focus

The chart shows the grants allocated to DCI in 2024, distributed in relation to patient trajectory focus. It includes funding applied for in open calls, strategic funds and external foundations. The category 'Other' includes focus areas such as late effects.



RESULT FROM 2024

New knowledge about lung cancer



Scientists have identified a gene that plays a particularly important role in non-small cell lung cancer. This discovery provides new insights into the genetic changes that contribute to this specific form of lung cancer, which is a life-threatening disease affecting both men and women.

An international team of researchers, including members of the Genome Integrity research group, has studied chromosomal changes in non-small cell lung cancer. This type of cancer is characterised by highly unstable chromosomes that frequently undergo changes. This instability increases the risk of the disease recurring, and the research shows that one gene in particular plays a key role in the development of unstable chromosomes in non-small cell lung cancer cells. It is the FAT1 gene that determines both whether changes occur in the chromosomes and whether the cells can repair these changes before they develop into cancer.

These new insights give researchers a much better understanding of the mechanisms leading to non-small cell lung cancer. At the same time, they open up the possibility of investigating whether analysing FAT1 could be used in the treatment of non-small cell lung cancer — and perhaps even to predict how the disease will progress. The results were published in the renowned scientific journal Nature Cell Biology.

Important for the normal function of cells

Understanding errors in chromosomes and our DNA repair systems is crucial to understanding how cancers such as non-small cell lung cancer develop. In this new study, researchers have used advanced genetic methods to map – as precisely as possible – what goes wrong and how. The conclusion is that if the FAT1 gene is missing from cells, it not only increases chromosomal instability but also impairs the DNA repair system. By removing the FAT1 gene in cells in the lab, researchers were able to observe the changes caused in the cells. The results showed a wide range of negative consequences. Without the FAT1 gene, the risk of errors in the chromosomes and during cell division increases. The cell nucleus becomes deformed, the number of chromosomes (the entire genome) can double, and the cells enter a constant state of stress, which raises the risk of further DNA damage.

– Taken together, our results show that if non-small cell lung cancer cells lose FAT1, it increases their risk of chromosomal errors and of disrupting the cells' DNA repair system. In other words, the FAT1 gene acts as a tumour suppressor, meaning that the normal function of FAT1 is to help prevent non-small cell lung cancer from occurring, says Professor Jiri Bartek, Head of Genome Integrity, who took part in the research.

Overall, the loss of FAT1 dramatically enhances chromosomal instability. This increases the likelihood that the cancer will progress more rapidly and become resistant to existing treatments.

Understanding DNA repair mechanisms may help pave the way for better treatments

The DNA repair system studied by the researchers is the so-called HR system. Previous research from the Danish Cancer Institute has shown that knowledge of the HR system may also be used to improve treatment for patients with stomach and oesophageal cancer. Read more on page 20.

Dictionary

Chromosomes: Found in the nucleus of cells and contain our genetic material (DNA).
Chromosomal changes: Can give cells new properties. This can be beneficial for evolution, as it allows the body to develop. But it can also pose a risk, because certain properties in our genetic material should never change.
Cancer and chromosomes: Cancer cells often have unstable chromosomes with many changes that contribute to the development of the disease.
Repair system: Cells have mechanisms that detect and repair DNA damage.
Tumour suppressors: Genes coding for products that help prevent or slow down the development of cancer. Tumour suppressors are missing in some cancer tumours.
Risk of cancer: If the repair system fails, the risk of life-threatening DNA changes increases significantly.

The results are published here: Lu WT. et al.: TRACERx analysis identifies a role for FAT1 in regulating chromosomal instability and whole-genome doubling via Hippo signalling. Nat Cell Biol. 2024, Dec 30. DOI: 10.1038/s41556-024-01558-w.

RESULT FROM 2024

Rare genetic disease provides new insights into cancer

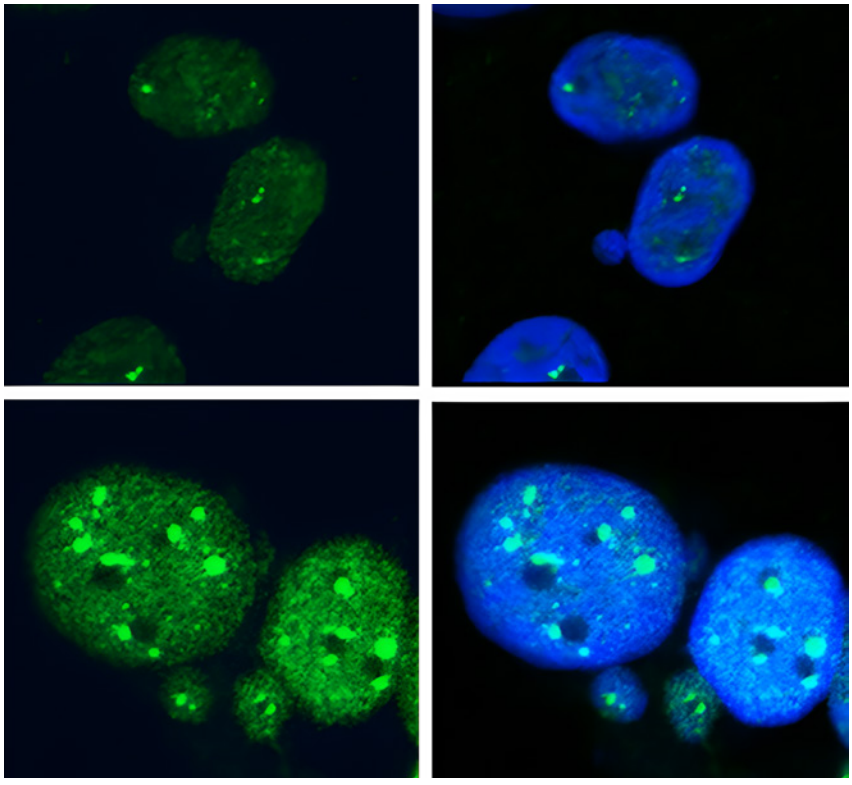
Dorthe Helena Payne-Larsen

By studying the inherited disease Bloom Syndrome, researchers have shown how errors in protein can lead to genetic chaos.

The Nucleolar Stress and Disease research group has used the rare genetic disorder Bloom Syndrome as a model system to investigate how genetic changes that can lead to cancer arise. Bloom Syndrome is characterised by patients having multiple life-threatening genetic defects.

In the new study, researchers examined ribosomal DNA (rDNA), which plays a key role in the cell's ability to produce proteins. Errors in rDNA can affect the entire genome and increase the risk of cancer. The research focused on how mutations in rDNA arise.

The results indicate that two proteins in particular, Rad51 and BLM, play a key role. In normal cells, these two proteins work together to ensure that errors in rDNA are repaired correctly.



Stained cancer cells photographed under a microscope. The top horizontal row shows normal cancer cells, while the bottom row shows cells missing the BLM protein. The cells' DNA is stained blue, and rDNA appears as light green. The images show that in cells without BLM, torn fragments of rDNA (bright green) are found in so-called micro-nuclei (small blue areas), which are small structures that contain DNA lost from the cell nucleus. Photo: Nature Communications.

DKK

The Danish Cancer Society supports research

The project 'Novel treatment approaches and molecular mechanisms for Bloom Syndrome' received DKK 2,630,000 from Knæk Cancer in 2021.
The project 'Mechanisms and cancer relevance of genome instability in repetitive DNA sequences' received DKK 1,800,000 from the Danish Cancer Society Scientific Committee in 2017.
The project 'Mechanisms and cancer relevance of genome instability in repetitive DNA sequences' received DKK 2,100,000 from the Danish Cancer Society Scientific Committee in 2017.

BLM acts as an outpost, preparing the rDNA for repair. Only once BLM has completed its task can Rad51 begin the repair process. And when the repair is complete, BLM is responsible for ensuring that it is properly finalised. But in some cases, this process goes wrong:

– Our research shows that Rad51 can actually begin the repair process even when the BLM protein is missing. One of the most serious consequences of Rad51 starting the repair without BLM is that, without BLM to complete the process properly, the rDNA risks being torn apart. This can cause cells to lose large sections of rDNA, resulting in extensive genetic damage. The errors can also spread to other parts of the genome, creating genetic chaos with multiple errors throughout the genetic material, says group leader Dorthe Helena Payne-Larsen, who led the new study.

The research has provided new insights into how errors in rDNA can lead to genetic mutations in cancer. The researchers' next step is to uncover how and why Rad51 initiates uncontrolled DNA repair, and to find ways to prevent this faulty activation of the protein.

– We are also investigating whether this new knowledge can be used to develop more effective and less aggressive treatments for cancer in Bloom Syndrome patients. If successful, the results may also be relevant for other cancer patients in whom BLM mutations arise during cancer development, says Dorthe Helena Payne-Larsen.

The results are published here: Gál Z. et al.: Hyper-recombination in ribosomal DNA is driven by long-range resection-independent RAD51 accumulation. Nat Commun. 2024, Sep 6. DOI: 10.1038/s41467-024-52189-6.

NEW RESEARCHER ´24

He researches blood cancers

Consultant haematologist Carsten Utoft Niemann has joined the Danish Cancer Institute. The collaboration strengthens DCI's research into blood cancers, aiming for better treatments with fewer late effects.

For many years, Carsten Utoft Niemann's research has focused on how to select the best treatment for each individual patient with blood cancer. His work has led to better treatments, including methods now used to predict which patients are at increased risk of life-threatening infections. In his research, Carsten Utoft Niemann combines genetic analyses with data from laboratory studies and clinical trials. By analysing vast amounts of data, the goal is to find answers to how treatment can be offered that ensures the best possible survival with the fewest side effects and late effects.

Carsten Utoft Niemann is internationally recognised for his work, and as of 1 October, he joined DCI in a part-time position along with seven staff members.

This collaboration strengthens DCI's ambition to remain at the forefront of cutting-edge cancer research and to bring research knowledge into clinical practice as quickly as possible. Research Director Mads Melbye explains:

– Carsten Utoft Niemann's research into personalised blood cancer treatment is a great asset to our efforts to ensure world-class, patient-centric research. We are very much looking forward to the results this collaboration will bring, says Mads Melbye.

RESULT FROM 2024

Analysis may pave the way for better treatment of stomach and oesophageal cancer

Cancers of the stomach and oesophagus may be treatable with cancer drugs already used for other types of cancer. These drugs work because of an internal defect in the cells that prevents them from repairing a specific type of DNA damage.

Repairing DNA damage is vital for cells, as it can otherwise lead to cancer. But in some cells, the DNA repair system is defective, which increases the risk of cancer. In 2024, the Cancer and Medicine research group demonstrated that many cancer cells from the stomach and oesophagus have defects in the Homologous Recombination (HR) repair system. This leads to a unique pattern of genetic damage and, importantly, opens up the possibility of treating these cancer cells with existing drugs – either cisplatin or PARP inhibitors. Both drugs cause specific DNA damage that would normally be repaired by the HR system. When the HR system malfunctions, cancer cells are unable to repair the damage, and they die. The researchers studied cells in the lab and the results were promising. Postdoc Aurel Prosz, one of the lead authors of the new study, explains:

– We studied cancer cells that lacked the HR system and carried many of the errors that occur when the HR system fails. When we treated them with the drug, we observed that the more defects the cells had, the more effective the treatment was, he says.

The researchers hope that their findings will lead to clinical trials. This would involve examining patients with stomach or oesophageal cancer to determine whether their cancer cells lack the HR system before treating them with cisplatin or PARP inhibitors. In this way, researchers can study the potential connection between the HR system and the effectiveness of the treatment.

Brand new insights

The research also showed that defects in another repair system — the so-called Nucleotide Excision Repair (NER) system — make cancer cells sensitive to cisplatin or PARP inhibitors. This is the first time it has been demonstrated that cancer cells from the stomach and oesophagus can have defects in this system.

– We estimate that around 10-15% of patients with stomach or oesophageal cancer may benefit from cisplatin or PARP inhibitors because they have defects in either the HR or NER system, says Aurel Prosz.

The research also opens up the possibility that cisplatin and PARP inhibitors could eventually be offered as treatment for other cancers — such as breast, prostate or ovarian cancer — if analyses show defects in the HR system.

The results are published here:
Prosz A. et al.: Mutational signature-based identification of DNA repair deficient gastroesophageal adenocarcinomas for therapeutic targeting. NPJ Precis Oncol. 2024, Apr 8. DOI: 10.1038/s41698-024-00561-6.

The research was made possible through computer analysis of large amounts of data.

– Computers are an important part of cancer research today. The analyses that played a major role in our results would not have been possible 20 years ago. Back then, we simply didn't have the computing power we needed, says Aurel Prosz.

DKK

The Danish Cancer Society supports research

The project 'Improving survival in upper gastrointestinal cancer by targeting DNA repair deficiency specific therapeutic vulnerabilities' received DKK 2,625,000 from the Danish Cancer Society Scientific Committee – Biology & Clinic in 2022.
The project 'Reducing lung cancer mortality by early disease detection using methylated DNA patterns and DNA fragmentation profiles of plasma samples' received DKK 1,750,000 from Knæk Cancer in 2022.

NEW PROJECT FROM 2024

Basic research centre to provide insights into cellular memory

At a brand-new research centre, experts from DCI will focus on epigenetics in the coming years. The work is supported with DKK 67 million from the Danish National Research Foundation and led by top international researchers in the field.

Our genetic material — DNA — holds the blueprint for how our cells function, and cells use different parts of the DNA depending on their specific role. This is where epigenetics comes in. This process plays an important role in regulating our genes and can determine which genes are read by switching specific genes on and off. Professor Anja Groth, one of the world's leading researchers in epigenetics, is heading the new Center for Epigenetic Cell Memory.

The work will be carried out in close collaboration with colleagues Professor Niels Mailand, Associate Professor Nils Krietenstein and Professor Jakob Nilsson. Together, they will investigate what happens to epigenetic information during cell division, and how cells manage to retain this information even after millions of divisions. Errors in epigenetic processes can lead to cancer, and the researchers aim to explore whether, for example, DNA damage or chemotherapy can interfere with the transmission of epigenetic information and thereby affect healthy cells. These insights may inform the development of new cancer treatments and contribute to healthy ageing by deepening our understanding of how cells maintain their function throughout life.

Read more about epigenetics on page 6.

RESULT FROM 2024

Live healthier at midlife and prevent cancer

Does changing your lifestyle in middle age really make a difference? Yes, says researchers.

Our lifestyle affects our risk of developing cancer. But is it really worth giving up cigarettes and alcohol, and focusing on healthier eating and more exercise when you're in your 50s? According to a large European study of more than 500,000 people, researchers from the Danish Cancer Institute have shown that the answer is yes.

– Our results show that you can reduce your cancer risk by changing your lifestyle, even if you are a little older, says group leader Anja Olsen from the Diet, Cancer and Health research group, who contributed to the new study.

In short, the study shows that participants who moved from being among the least healthy to among the healthiest reduced their risk of cancer. Conversely, those who went from living a healthy lifestyle to an unhealthy one increased their risk. The greatest benefit was seen in quitting smoking, but all healthy lifestyle changes had a positive effect and helped reduce cancer risk. Previous research has shown that up to 40% of all cancer cases worldwide could be prevented if everyone followed the recommendations on smoking, alcohol, BMI, physical activity and healthy eating.

The results are published here:

Botteri E. et al.: Lifestyle changes in middle age and risk of cancer: evidence from the European Prospective Investigation into Cancer and Nutrition. Eur. J Epidemiol. 2024, Feb. DOI: 10.1007/s10654-023-01059-4. Epub 2024 Jan 5.

NEW PROJECT FROM 2024

A revolution in Danish cancer research is taking shape: Infrastructure for cutting-edge gene technology opens in Copenhagen

EXP GENTQ -- 01

The combination of CRISPR and microscopy is creating entirely new possibilities. It can be used to study how fundamental processes in cells are altered in various diseases, which can give researchers new insights into a range of diseases, including cancer, according to Professor Jakob Nilsson.

Jakob Nilsson

Researchers will establish a laboratory to house a technology combining genetic engineering and microscopy. Researchers from across Denmark can have access to the new technology, which will create a strong infrastructure for the Danish research community.

As one of the newest technologies in cell research, it combines two powerful techniques. One is the CRISPR genetic scissors (which you can read more about on page 28) and the other is a high-tech microscope able to look deep inside cells. Although these two techniques are often used separately, a new method has been developed that combines them. This allows researchers to make genetic changes to a cell's DNA and immediately observe how it affects the cell's function. This technology is still available in only a few places worldwide, but in 2024, researchers were given the opportunity to establish a laboratory to house it at the Danish Cancer Institute. This has been made possible by a grant of DKK 14.5 million from the Novo Nordisk Foundation. The laboratory will be open to researchers across Denmark. It will be possible to either get assistance with experiments using the technique or visit the lab to conduct experiments independently.

This new facility will place Denmark at the forefront of advanced cancer research, says Professor Jakob Nilsson, who heads the laboratory.

– I see great potential for this technology to pave the way for entirely new research across a wide range of fields. It takes highly specialised knowledge and equipment to use this technology, and by bringing both the equipment and expertise together in one place, we can ensure the method is used optimally while also promoting knowledge sharing and further development, explains Jakob Nilsson. He continues:

– DCI already has state-of-the-art microscopy facilities and strong expertise in genetic research, so it makes perfect sense to locate the new laboratory here, he says.

Putting Denmark on the world map

The new laboratory focuses on making this advanced technology accessible to researchers by providing technical support, advice and access to the necessary equipment.

– We help researchers plan their experiments and offer guidance throughout the entire process, from carrying out experiments and analysing the results. It's a highly complex technology that requires expertise to use effectively, says Jakob Nilsson.

The grant from the Novo Nordisk Foundation runs for six years, giving the researchers the opportunity to stay at the forefront of technological development. The ambition is to continuously develop the expertise as new technological advances emerge.

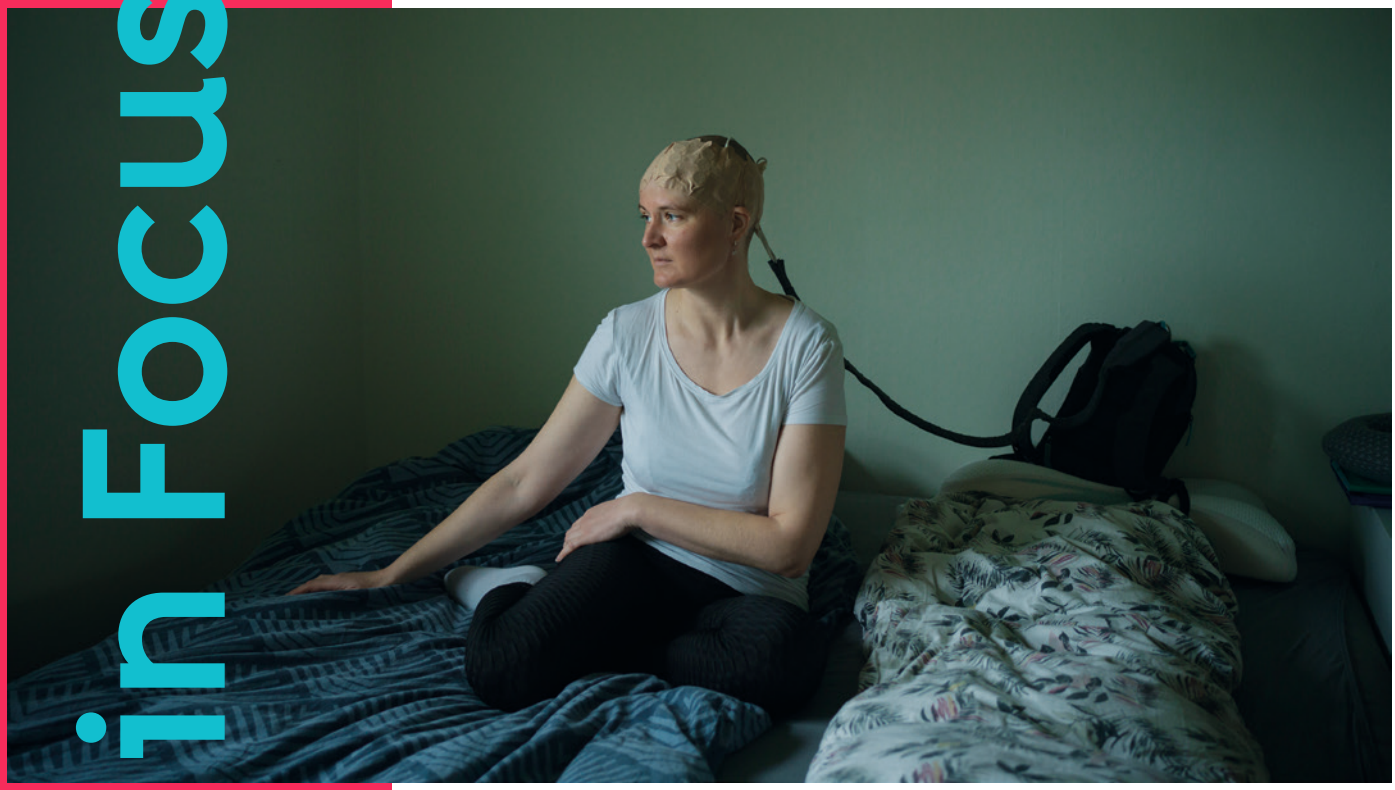
– I believe this new facility will help position Denmark as a leader in CRISPR gene editing and screening, says Jakob Nilsson.

The new laboratory is scheduled to be built in 2025.

Watch the video with Jakob

Scan QR codes right here

Research in Focus



In a previous study, researchers tested the use of electric fields to treat glioblastoma. Kate, pictured here, took part in the study.

Fighting brain cancer with electricity

In a newly launched project, the Membrane Integrity research group is growing glioblastoma brain cancer cells in a special laboratory device. The device emits an alternating current that creates an oscillating electric field across the cells — a method that has previously been shown to disrupt the cells' ability to divide. The electric field can also create holes in the cells' membranes, potentially making it easier for the cells to absorb drugs that can kill them. This is why the researchers are now exposing the cancer cells to both an electric field and drugs. The goal is to determine whether the combination works and to better understand the underlying mechanisms. In previous clinical trials patients with glioblastoma wore a cap powered by batteries to expose the brain tumour to electric fields, but the underlying cause of any effect is still unknown.

The Danish Cancer Society supports research

The project 'Targeting Membrane Repair in Glioblastoma Multiforme by Derivatives of Phenothiazines' received DKK 2,400,000 from Knæk Cancer in 2022.

Talking a lot on your mobile phone doesn't increase the risk of brain tumours

In an international study, researchers examined more than 250,000 mobile phone users to investigate whether frequent or long-term use increases the risk of developing brain tumours. The results show that by 2020, even the most active mobile phone users had no higher risk of developing brain tumours than those who used mobile phones less. This is explained by PhD Aslak Harbo Poulsen from the Work, Environment and Cancer research group, one of the researchers behind the study. The researchers will continue to follow the study participants.
– Some of the tumours we're studying are rare and can take many years to develop, and mobile phone technology is constantly evolving. That's why we will keep following the cohort to keep an eye on the cancer risk over time, says Aslak Harbo Poulsen.

The results are published here: *Feychting M. et al.: Mobile phone use and brain tumour risk – COSMOS, a prospective cohort study. Environment International. 2024, March. DOI: 10.1016/j.envint.2024.108552.*

International conference on late effects

In September, researchers gathered in Copenhagen to share the latest knowledge on late effects. Among the results presented was a study showing that quality of life declines for women with incurable breast cancer as the number of treatments increases. This holds true regardless of the type of treatment, even when women have received newer treatments with fewer side effects. This was the seventh time the conference was held, organised by the Danish Cancer Institute and the Danish Cancer Society's National Centre for Cancer Survivorship and General Late Effects (CASTLE).

Gathering of statisticians

In November, 115 statisticians from universities, hospitals and industry from all over Denmark convened at the Danish Statistical Society's conference, hosted at the Danish Cancer Institute. During the meeting, experts discussed a wide range of statistical methods, including modern techniques for analysing registry data and clinical trials, as well as the use of predictive models and artificial intelligence. This is the first time the Danish Cancer Institute has hosted the event, highlighting its strong expertise in applying statistical methods to cancer research.

Insights into long-term aspirin use

Aspirin has been in the spotlight for years because of its potential effects against cancer. However, uncertainty about aspirin's protective benefits against cancer, combined with the risk of serious side effects, has so far prevented experts from recommending daily aspirin use for cancer prevention in healthy individuals. A study from the Danish Cancer Institute and the Department of Clinical Epidemiology at Aarhus University Hospital supports maintaining this recommendation. The study analysed registry data on drug use and cancer incidence over a 20-year period in just over 1.9 million people in Denmark, 30% of whom had taken aspirin. The results showed that individuals who took aspirin daily for at least five years had a lower risk of several types of cancer. However, the study also found an increased risk of some cancers and no overall reduction in cancer risk among aspirin users. As a result, aspirin should not be used for general cancer prevention. Nonetheless, further research is needed to determine whether it may have preventive potential for specific groups and certain types of cancer.

The results are published here: Skriver C. et al.: Long-term aspirin use and cancer risk: a 20-year cohort study. Cancer Inst. 2024, Apr 5. DOI: 10.1093/jnci/djad231.

RESULT FROM 2024

Mothers' work may influence daughters' cancer risk

A mother's occupation can impact her daughter's likelihood of developing breast cancer. The correlation is particularly strong in one specific field. This was demonstrated by the Work, Environment and Cancer research group.

Women whose mothers worked in horticulture have a slightly increased risk of developing breast cancer later in life compared to those whose mothers did not work in horticulture. The cause remains unknown, but the researchers have a theory, explains working environment researcher Julie Elbæk Pedersen, who conducted the study together with senior researcher Johnni Hansen from the Work, Environment and Cancer research group.

– Previous research has shown a link between exposure to certain types of pesticides and an increased risk of breast cancer. The same has been observed in laboratory animals. Maybe that's the explanation here too, but we don't know for sure. Exposure to pesticides in greenhouses may be particularly risky because workers are in a smaller, enclosed space, leading to higher exposure compared to working outdoors, says Julie Elbæk Pedersen.

The risk of breast cancer among daughters of female horticultural workers is 33% higher. While this represents only a small increase in risk for individual women, the researchers emphasise that the findings are still significant:

– It would be relevant to investigate the cause of the increased cancer risk and whether these exposures are still present in horticulture. Breast cancer is the most common cancer among women, and while we know of several risk factors, it is still crucial to learn more so we can improve prevention in the future, says Julie Elbæk Pedersen.

The results are published here: Pedersen JE. og Hansen J.: Risk of breast cancer in daughters of agricultural workers in Denmark. Environ Res. 2024, Jan 1. DOI: 10.1016/j.envres.2023.117374.

RESULT FROM 2024

Firefighters face a higher risk of these cancers

In 2024, researchers from the Work, Environment and Cancer group also examined cancer risk in another profession: firefighting. The results showed an increased risk of bladder cancer, melanoma, prostate cancer and testicular cancer.

Firefighters are exposed to many hazardous elements in their work that may contribute to cancer. According to a 2024 study, firefighters in Denmark have an increased risk of several types of cancer. Among firefighters who have worked full-time in the profession for more than five years, the risk of melanoma is 37% higher. The risk of bladder, prostate and testicular cancer is also elevated, though to a lesser extent. The study, based on nearly 12,000 Danish firefighters diagnosed with cancer between 1968 and 2021, is one of the largest of its kind in the world.

The results are published here: Pedersen JE. et al.: Cancer incidence in a cohort of Danish firefighters: An extended long-term follow-up 1968–2021. Am J Ind Med. 2024, Sep. DOI: 10.1002/ajim.23635. Epub 2024 Jul 4.

NEW PROJECT FROM 2024

Researchers to investigate cancer cell membranes

Cancer cells are characterised by unrestrained proliferation, which is one of the reasons they require large amounts of energy. Researchers will now study specialised membranes inside cells that play a key role in supplying energy.

In a new project, researchers will examine the endoplasmic reticulum (ER) —a structure that occupies a large part of the cell's interior and is essential for both protein production and cellular metabolism, which generates energy for the cell. Cancer cells have an exceptionally high energy demand due to their rapid growth, which is one of the reasons researchers are launching a new project to better understand the ER.

– It is reasonable to assume that the ER plays a crucial role in cancer cells, as it supplies them with energy and serves as a production and distribution centre for proteins and fats within the cell. That's why we want to investigate ER in cancer cells—and, importantly, how these cells repair damage to this system. In the long term, this research may help identify new ways to target cancer cells by preventing repair mechanisms and, in turn, combating the disease, says group leader Jesper Nylandsted from the Membrane Integrity research group, who is leading the study.

The Danish Cancer Society supports research

The project 'Unraveling the Complexity of Endoplasmic Reticulum Membrane Repair Required for Cancer Cell Survival' received DKK 2,400,000 from the Danish Cancer Society Scientific Committee – Biology & Clinic in 2024.

NEW PROJECT FROM 2024

Can cancer cells die from stress?

Researchers are studying the molecular mechanisms behind cancer cells' stress defences while testing a potential new treatment in mice. If the results are promising, this research could pave the way for an entirely new approach to cancer treatment.

Cancer cells often experience high levels of stress, and now researchers – led by Professor Niels Mailand – are investigating whether blocking their ability to manage stress could cause them to die. Stress in cancer cells can arise from their uncontrolled growth, external factors such as chemotherapy or physical damage as they spread through tissue. This stress can damage DNA, among other things, and to survive, cells rely on stress response systems to repair the damage. One of the most important of these systems is the SUMO system, which is more active in cancer cells than in normal cells. Aggressive cancers are particularly dependent on this system, and by inhibiting the SUMO system, researchers hope to stress the cancer cells to the point of death. Researchers have shown that inhibitors of the SUMO system, currently showing promising potential in cancer treatment in clinical studies, are especially effective against cancer cells with genetic alterations in the p300 gene. Since p300 mutations are common in cancer cells, but rare in healthy cells, researchers see great potential for using SUMO inhibitors effectively while sparing healthy tissue.

The Danish Cancer Society supports research

The project 'Exploiting synthetic lethality with SUMO inhibitors in precision cancer therapy' received DKK 2,550,000 from the Danish Cancer Society Scientific Committee – Biology & Clinic in 2024

The genetic scissors

EXP CRISPR -- 01

EXP CRISPR – 03

CRISPR is an advanced method for modifying genes. It is used in a wide range of research projects. Here is an explanation of what it is.

CRISPR is a kind of 'scissors' that scientists can use to alter our genetic material. It can change, delete or insert new genes. For example, it can be used in experiments with mice or on cancer cells in the lab. If the researcher wants to remove a specific gene they can use CRISPR to see what effect it has on the cancer cell. Understanding the role of genes may lead to new and better treatments.

The CRISPR technique consists of two parts: The first part is Cas9, an enzyme that acts as the 'scissors'. The second part is guide RNA, a special molecule that acts as a signpost in the cell, ensuring that the modification is made in the right place. The guide RNA is a copy of the DNA sequence that researchers want to change. When a cell is supplied with guide RNA and the Cas9 cutting tool, the guide RNA directs Cas9 to the correct location in the cell, where it makes the cut. Cas9 and guide RNA can be purchased as ready-made products. However, researchers can also design their own RNA and produce the Cas9 cutting enzyme themselves.

The two scientists who discovered and developed the CRISPR technique were awarded the 2020 Nobel Prize in Chemistry. Today, it is a widely used tool in laboratories around the world.

NEW PhD & RESULT FROM 2024

New PhD focusing on cell metabolism

In 2024, Chiara Pecorari defended her PhD at the Danish Cancer Institute. Her research has provided new insights into a protein that affects the spread of cancer cells.

When Chiara Pecorari wrote her thesis in cell and molecular biology at the University of Rome, she quickly realised that her passion lay in cancer research. So when she was offered a position in the Redox Biology research group, she gladly accepted. In 2024, she defended her PhD thesis, where she focused on the protein AKR1A1. The protein helps regulate cellular metabolism, which in turn influences how cells obtain energy to grow and divide.

Cellular metabolism is of great interest to cancer researchers because it is one of the processes frequently altered in cancer. Just as humans derive energy from food, cancer cells rely on carbohydrates to fuel their uncontrolled growth and division. The AKR1A1 protein is part of normal metabolism and can regulate carbohydrate availability. However, cancer cells often lack AKR1A1. As a result, their metabolism is altered, enabling them to draw energy from alternative sources to sustain their growth and proliferation. Chiara Pecorari's research explores the changes that occur in cancer cells when they lose AKR1A1 and how this loss can lead to more efficient energy production in cancer cells.

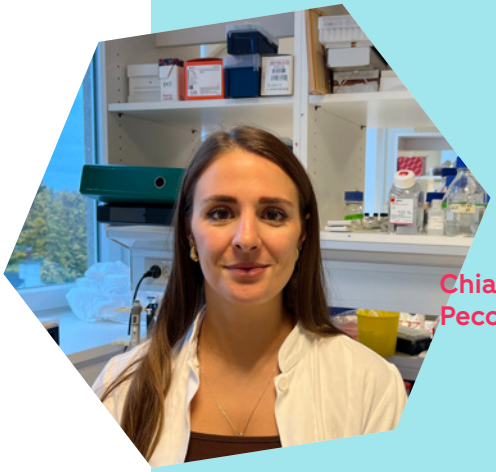
AKR1A1 plays a key role in the kidneys and liver, yet cancers that develop in these organs often lack this protein. Based on her findings, Chiara Pecorari is now testing a compound designed to counteract the metabolic effects of AKR1A1 loss in cancer cells. This could lay the foundation for a treatment using drugs to restore AKR1A1 function in cancer cells that have lost the protein. In her trials, Chiara Pecorari administers a combination of the AKR1A1 restorative treatment alongside chemotherapy.

– We are testing the treatment on cancer cells from kidney cancer patients, and preliminary results show that it is even more effective at killing cancer cells than chemotherapy alone. It's still in the laboratory stage, but it tells us we're on the right track, says Chiara Pecorari.

In the long term, she hopes that insights into AKR1A1 will also have implications for other diseases, such as diabetes and neurodegenerative disorders, where AKR1A1 is also altered.

Educating future researchers

A total of 13 PhD students graduated from DCI in 2024. Find a list of them all on www.cancer.dk/phd-defences-2024



Chiara Pecorari

In 2024, Chiara Pecorari defended her PhD at the Danish Cancer Institute. Originally from Italy, she works in the Redox Biology research group.

Meet Chiara Pecorari

29-year-old Chiara Pecorari is from Italy, from a town near Rome. She wrote her thesis at Tor Vergata University in Rome in the field of cell and molecular biology. Her supervisor was Giuseppe Filomeni, PhD, group leader in the Redox Biology research group at the Danish Cancer Institute.

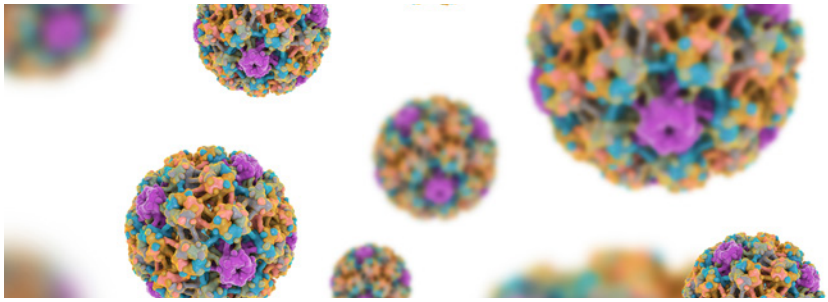
After her thesis, Giuseppe Filomeni offered her a position in Denmark, and in 2020, Chiara joined the Danish Cancer Institute. That same year, she began her PhD, and on 22 May 2024, she defended her thesis entitled 'Deciphering the role of AKR1A1 in renal and liver cancer progression'.

Chiara is currently employed in the Redox Biology research group as a postdoc.

RESULT FROM 2024

Susanne Krüger-Kjær

Danish study: Significant decrease in cancer-causing viruses



Professor Susanne Krüger Kjær led a study showing that young men tested negative for six types of HPV, including the two high-risk types, 16 and 18, which cause most HPV-related cancers.

HPV (Human Papilloma Virus) is responsible for several cancers in both men and women, including penile cancer, anal cancer and cervical cancer. In 2024, research showed that several types of the HPV virus have now been eradicated among young men in Denmark.

Vaccination against HPV was introduced in the Danish childhood vaccination programme for girls in 2009 and for boys from 2019. Previous research has shown that HPV infection is very common in both men and women. In 2024, the Virus, Lifestyle and Genes research group published a study examining how prevalent HPV infection is among young men in Denmark after approximately 10 years of HPV vaccination for women. The results were extremely positive:

– All men tested negative for six types of HPV, including the two high-risk types 16 and 18, which cause most HPV-related cancers. This is the first time we have demonstrated this in Danish men. It is really good news and confirms that we are on the right track in reducing the prevalence of the virus and, in turn, preventing hundreds of cancer cases, says Professor Susanne Krüger Kjær, who led the study. She is a research group leader at the Danish Cancer Institute and professor at Rigshospitalet.

Keep the momentum going

The men in the study were not vaccinated against HPV themselves, as the vaccine was only introduced later as an option in the boys' childhood vaccination programme. The few men who had purchased the vaccine privately were excluded from the study. Based on the new results, researchers conclude that the six HPV types not found in the men have disappeared due to herd protection. This means that, thanks to the vaccine, women no longer transmit the virus to men, who are now protected as a result.

– Through HPV vaccination, we are reducing the amount of virus in society. But this progress can be reversed if, for example, fewer people get vaccinated or if we only vaccinate one gender, says Susanne Krüger Kjær.

She therefore has a clear call to action:

– It's incredibly important that we maintain our efforts to reduce the virus burden in society. Our study shows that this is possible if we maintain high vaccine uptake among both girls and boys. This can prevent many cancer cases and save hundreds of lives, says Susanne Krüger Kjær.

The results are published here: Munk C. et al.: Prevalence of HPV and HPV type distribution in penile samples in young men in Danmark – results 10 years after implementation of a girls-only HPV vaccination program. J Infect Dis. 2024, Mar 12. DOI: 10.1093/infdis/jiae068. Online ahead of print.

Study results

The HPV types that the researchers could not detect among the young men were types 6, 11, 16, 18, 31 and 45, which are common in the general population. The study included men aged 18 to 19 undergoing conscription examination, representing a broad cross-section of young men in Denmark. Sample collection was led by senior researcher Christian Munk from the Virus, Lifestyle and Genes research group. A total of 280 men participated in the study, which was conducted in 2019-2020.

RESULT FROM 2024

Better understanding of the biology of childhood cancer

Breastfeeding reduces the risk of acute lymphoblastic leukaemia, the most common childhood cancer. The findings are a step towards understanding why children develop cancer.

Research from the Hematology research group supports the public health recommendations that mothers breastfeed their newborns. The researchers compared children who had been exclusively breastfed for different durations and found the lowest risk of leukaemia among those who were breastfed the longest. Few children develop leukaemia, regardless of how long they have been breastfed. However, according to the researchers, these findings represent a step towards a deeper understanding of the biology of childhood cancer. The results reinforce the overall benefits of breastfeeding and suggest that it may have a biological effect which reduces a child's risk of leukaemia. The researchers hope that future studies will provide greater insight into the mechanisms behind these findings.

The results are published here: Søegaard SH. et al.: Exclusive Breastfeeding Duration and Risk of Childhood Cancers. JAMA Netw Open. 2024, Mar 4. DOI:10.1001/jamanetworkopen.2024.3115

Dictionary

Exclusive breastfeeding means that the baby almost exclusively receives breast milk. Breastfeeding may be supplemented with water, and the baby receives formula at most once a week.

The Danish Cancer Society supports research

The project 'Epigenetic variation and acute lymphoblastic leukaemia in childhood' received DKK 1,600,000 from the Danish Cancer Society Scientific Committee in 2019.

RESULT FROM 2024

Good news about breast cancer treatment

Marie Lund

Medical doctor and researcher Marie Lund is one of the researchers behind the study, along with Professor Mads Melbye, Research Director at the Danish Cancer Society. The study shows that there is no link between treatment with the breast cancer drug aromatase inhibitors and an increased risk of blood clots in the brain or heart.

There has been concern that treatment with aromatase inhibitors, a common breast cancer drug, might increase the risk of blood clots in the brain or heart. However, the largest study in the field to date has found no such risk.

Aromatase inhibitors are currently used to treat breast cancer in postmenopausal women if the cancer depends on the hormone oestrogen to grow. The medicine has helped more of these women survive breast cancer compared to previous treatments.

Until now, it has been unclear whether aromatase inhibitors increase the risk of developing blood clots. However, a 2024 study based on data from nearly 33,000 Danish women with breast cancer does not support this concern. The 33,000 participants included both women treated with aromatase inhibitors and a control group of women not treated with aromatase inhibitors.

– As more cancer patients live longer with their disease, it becomes increasingly important to focus on the long-term effects of treatments. That's why the new finding is significant for both doctors and patients, says Marie Lund. She led the new study and is a consultant physician at Bispebjerg Hospital, a clinical associate professor at the University of Copenhagen and a researcher at Statens Serum Institut. Research Director Mads Melbye from the Danish Cancer Institute, the senior author of the study, adds:

– Our results do not support an increased incidence of blood clots in the brain or heart in any of the groups treated with aromatase inhibitors. This means that even for patients with a history of ischaemic heart disease, heart failure or stroke, there is no reason to opt out of treatment with aromatase inhibitors, he says.

Valuable registries

In the study, researchers used the Danish clinical database of women with breast cancer and linked it to data from the Danish National Patient Registry to determine whether these women later developed cardiovascular disease. The database was also linked to other registry-based information about the women to enable researchers to account for various factors that could influence the correlation being studied. This study is not a randomised trial, which is traditionally used to establish associations. However, in Denmark, aromatase inhibitors are prescribed according to national guidelines. Unlike traditional randomised trials, where patients are often followed for a limited period, this type of study is particularly useful for detecting side effects that may arise both during treatment and long after it has ended.

Valuable registries

The primary objective of the study was to determine whether patients developed heart attacks or strokes as a result of treatment. The researchers examined both women with a history of cardiovascular disease, including ischaemic heart disease, heart failure or stroke, and those with no prior history of these conditions. Ischaemic heart disease is a general term for heart conditions caused by narrowing of the blood vessels that supply the heart with blood and oxygen.

Source: *Marie Lund and the Danish Heart Foundation.*

Resultaterne er offentliggjort her:
Lund M. et al.: Ischemic cardiotoxicity of aromatase inhibitors in postmenopausal women with early breast cancer: An analysis of real-world data. The Lancet Oncology. 2024, Online 29 October.

RESULT FROM 2024

New insights into hormonal IUDs and cancer

Results from the Cancer and Medicine research group show that women who use high-dose hormonal IUDs have an increased risk of breast cancer. According to the researchers, this finding should impact how doctors counsel women on hormonal contraception.

If 10,000 women use a high-dose hormonal IUD for five years, there will be 14 more cases of breast cancer compared to a similar number of women who do not use the IUD. These findings come from a study from the Cancer and Medicine research group, published in the prestigious scientific journal JAMA. According to the researchers, these findings should lead to the recognition of breast cancer as a potential side effect of the highest-dose hormonal IUD and should be included in the counselling session about the pros and cons of hormonal IUDs:

– For some, IUDs may still be the best choice. But if you're in your 30s and 40s, when the risk of breast cancer is no longer minimal, it may be worth considering this information. There are alternatives, including lower-dose hormonal IUDs and hormone-free IUDs such as the copper IUD, says PhD and team leader Lina Mørch, who led the new study.

The study included all types of hormonal IUDs, but the majority were high-dose. There were too few low-dose IUDs to specifically assess their effect. However, researchers expect the risk associated with low-dose IUDs to be significantly lower than that of high-dose IUDs.

Hormones work beyond the local area

Opinions may vary on whether the increased cancer risk is significant, but Lina Mørch emphasises that recommendations for contraceptive pills have previously been changed based on evidence that certain types increase the risk of blood clots. The risk of blood clots was similar to the breast cancer risk now identified in this study, which is why the researchers believe the findings should be taken seriously. The study also reinforces that the assumption that hormones from IUDs act only locally in the abdomen and do not circulate to other parts of the body is incorrect. Previous research from Lina Mørch's research group has already documented that hormonal IUDs can increase the risk of depression.

More accurate than previous studies

The 2024 study is the most comprehensive study in the field to date, accounting for multiple factors that may influence breast cancer risk.

– This is the first study on the cancer risk of hormonal IUDs where we have thoroughly accounted for women's previous exposure to hormones. Even with this consideration, we still observe an increased risk of breast cancer, says Lina Mørch.

The study was also designed to closely mimic a clinical trial, with additional analyses accounting for lifestyle factors such as smoking habits and BMI, which can influence breast cancer risk.

The research also indicated a trend suggesting that the risk of breast cancer increases the longer women use hormonal IUDs. However, this finding was not statistically significant, primarily because only a small number of women in the study had used IUDs continuously for many years.

The results are published here:
Mørch LS. et al.: Breast cancer in users of Levonorgestrel-releasing intrauterine systems. JAMA. 2024, Nov 12. DOI: 10.1001/jama.2024.18575

RESULT FROM 2024

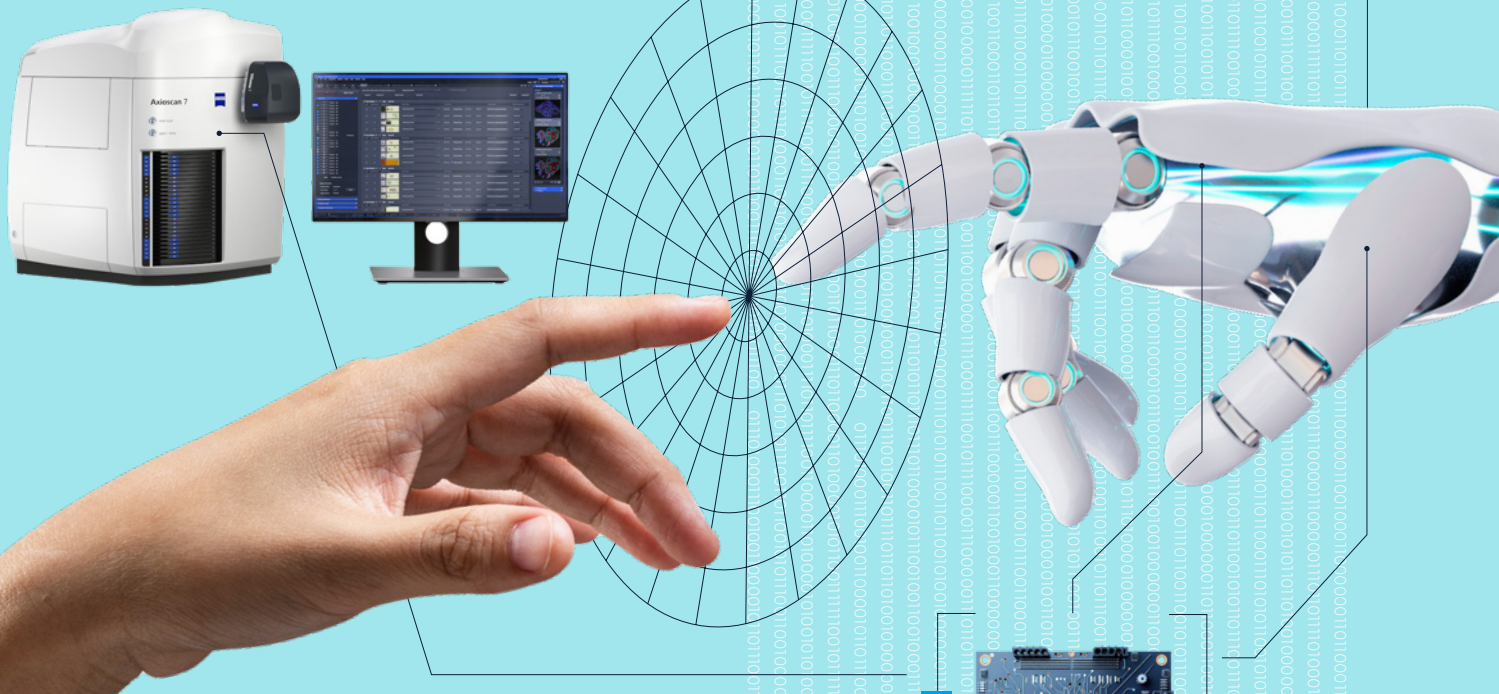
Research benefits neurological disorder

Research from the Danish Cancer Institute has contributed to the approval of a new drug for serious neurological disorders.

In September, the US Food and Drug Administration (FDA) approved Arimoclomol, the first drug approved for the treatment of Niemann-Pick type C disease, a severe neurological disorder in which patients typically have a life expectancy of only around 13 years. The effects of Arimoclomol are based on a discovery made in the lab by Professor Marja Jäättelä when she was a PhD student. Since then, Marja, who now leads the Cell Death and Metabolism research group, has continued to build on this discovery, which describes fundamental mechanisms relevant to multiple diseases, including cancer. The rights to Arimoclomol were later sold to an American company, which has now successfully obtained approval for its use in treatment.

EXP AI – 01

A new era for cancer research



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EXP AI – 02

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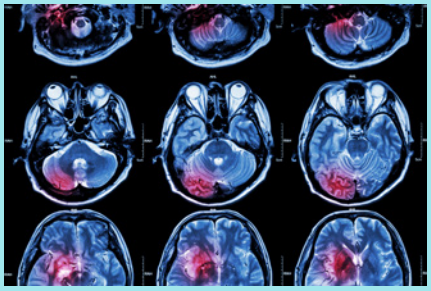
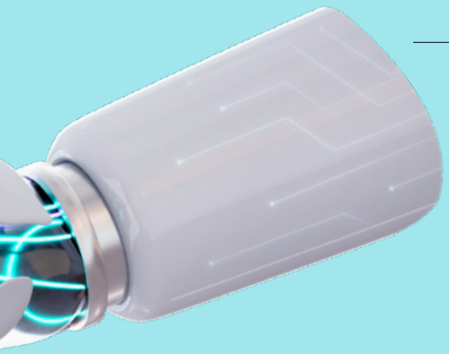


EXP AI – 03

Artificial intelligence has the potential to revolutionise cancer research. By leveraging advanced algorithms, scientists can analyse vast amounts of data faster and more accurately than ever before, unlocking new possibilities in diagnostics, treatment and drug discovery. This series of stories offers insight into how artificial intelligence is already being applied in cancer research and the future potential of this technology. From detecting early signs of cancer to developing personalised treatments, AI is set to play a pivotal role in the future of medical science.

This introduction was written by the artificial intelligence model ChatGPT4.



Better radiotherapy for breast cancer

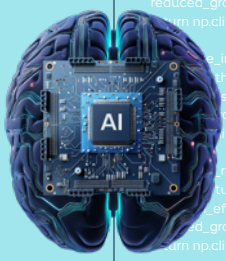
Artificial intelligence has shown great potential in analysing medical images and scans. Now, a major research project will explore whether AI can help identify the exact areas that need radiation after breast cancer surgery. Every year, approximately 3,500 women in Denmark receive radiotherapy as part of their breast cancer treatment. Once the tumour has been surgically removed, radiation is directed at the remaining breast, the chest wall, if the entire breast has been removed, or the lymph nodes in the armpit, if there is a risk that the cancer has spread. The radiotherapy aims to eliminate any remaining cancer cells while avoiding damage to healthy tissue. The preparation for radiotherapy currently involves a doctor marking the area to be radiated on a CT scan of each woman's anatomy. This new research project investigates whether AI can assist in this process. ensuring the best possible radiotherapy treatment for women while reducing doctors' workload. The project is led by hospital physicist and Professor Stine Sofia Korreman in collaboration with consultant physician and Professor Birgitte Vrou Offersen, both from Aarhus University Hospital.

Patients must be physically and mentally ready for surgery

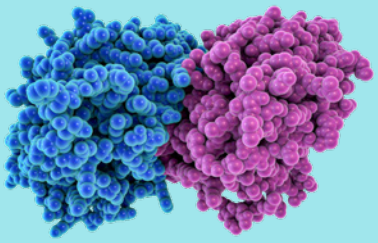
AID-SURG is the name of Zealand University Hospital's new approach to patients undergoing surgery for colon or colorectal cancer. By using artificial intelligence and health data, patients are categorised into four risk groups and offered tailored pathways leading up to surgery. The aim is to minimise the risk of complications by ensuring that patients are physically and mentally prepared before undergoing surgery. Before surgery, the computer is fed with information about the patient, such as age, gender, blood test and scan results and any specific risk factors. The computer will then categorise the patient according to their risk of dying within a year of surgery. This serves as an indicator of the patient's frailty and helps determine a pathway, such as physical training, to prepare the patient for surgery. The new approach to bowel cancer surgery is now being trialled at seven hospitals in Denmark, with support from Knæk Cancer. A key objective of the project is to determine whether AI or doctors are better at categorising patients into risk groups. The project is led by consultant physician and Professor Ismail Gögenur.

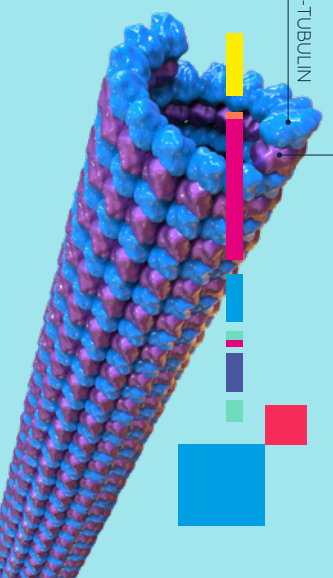
Algorithms to help detect lung cancer early

Lung cancer is a serious disease, and better methods are needed to detect it at an earlier stage. Researchers have developed an algorithm that can predict whether a patient has lung cancer based on blood tests, age and smoking status. The researchers trained the algorithm on data from patients who were examined for suspected lung cancer and then tested it on data from patients with COPD monitored at Vejle Hospital. They had found that 5% of these patients were actually diagnosed with lung cancer during the study period. Since COPD patients regularly visit the hospital for check-ups, researchers continued working on an algorithm specifically designed for this type of patient. Developing an effective lung cancer algorithm requires precise information about smoking status. To address this, researchers have also created an algorithm that automatically scans texts such as patient records and predicts whether patients are non-smokers, former smokers or active smokers. The project is led by Margrethe Bang Henriksen, PhD student at Vejle Hospital, and is supported by the Danish Research Center for Lung Cancer.



EXP AI – 04

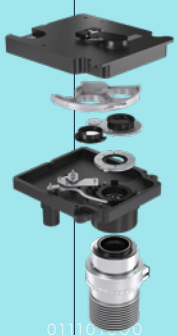


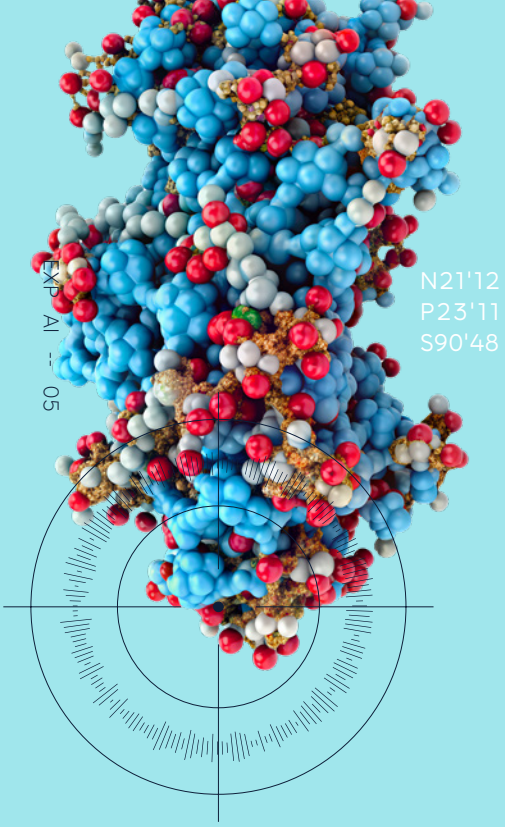


Ancient cell parts uncovered with artificial intelligence

Research from the Danish Cancer Institute demonstrates how artificial intelligence can reveal details about microtubules – tiny filaments inside cells that play an important role in cell division. Using AI, researchers mapped the proteins inside microtubules and discovered that their structure has remained nearly unchanged for millions of years – from algae to humans. This knowledge could pave the way for improved cancer treatments. Some chemotherapies, such as taxanes, inhibit cancer cell growth by targeting microtubules. However, they also affect healthy cells, potentially causing side effects. By leveraging AI, researchers can identify specific proteins in the microtubules of cancer cells and develop treatments that target them exclusively. Researchers hope this could be the first step towards chemotherapy with fewer side effects. The next step is to identify which microtubule proteins are best suited for targeting cancer cells and developing treatments.

The results are published here: *Andersen JS. et al.: Uncovering structural themes across cilia microtubule inner proteins with implications for human cilia function. Nat Commun. 2024, Mar 27. DOI: 10.1038/s41467-024-46737-3.*





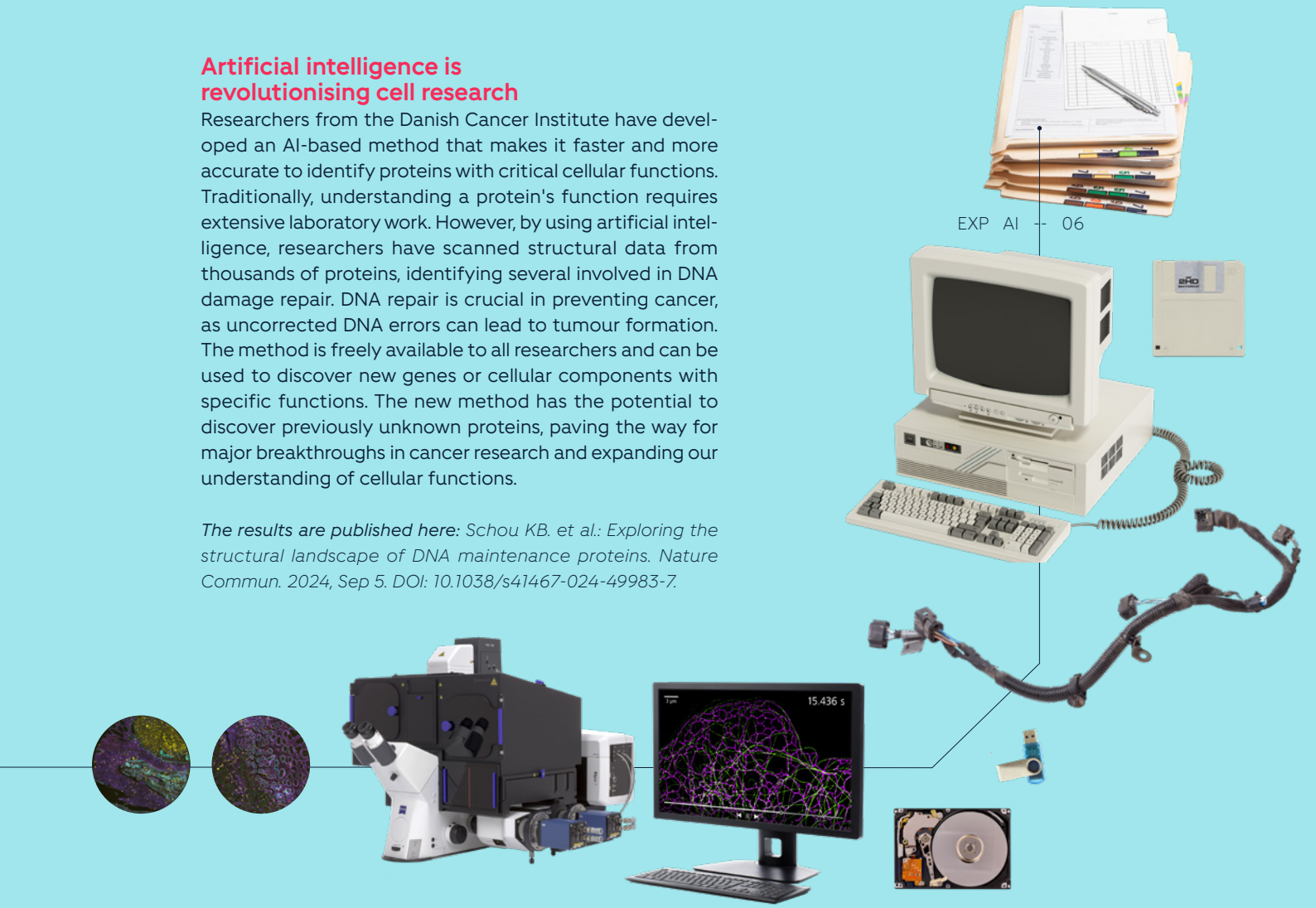
Designing novel medicines

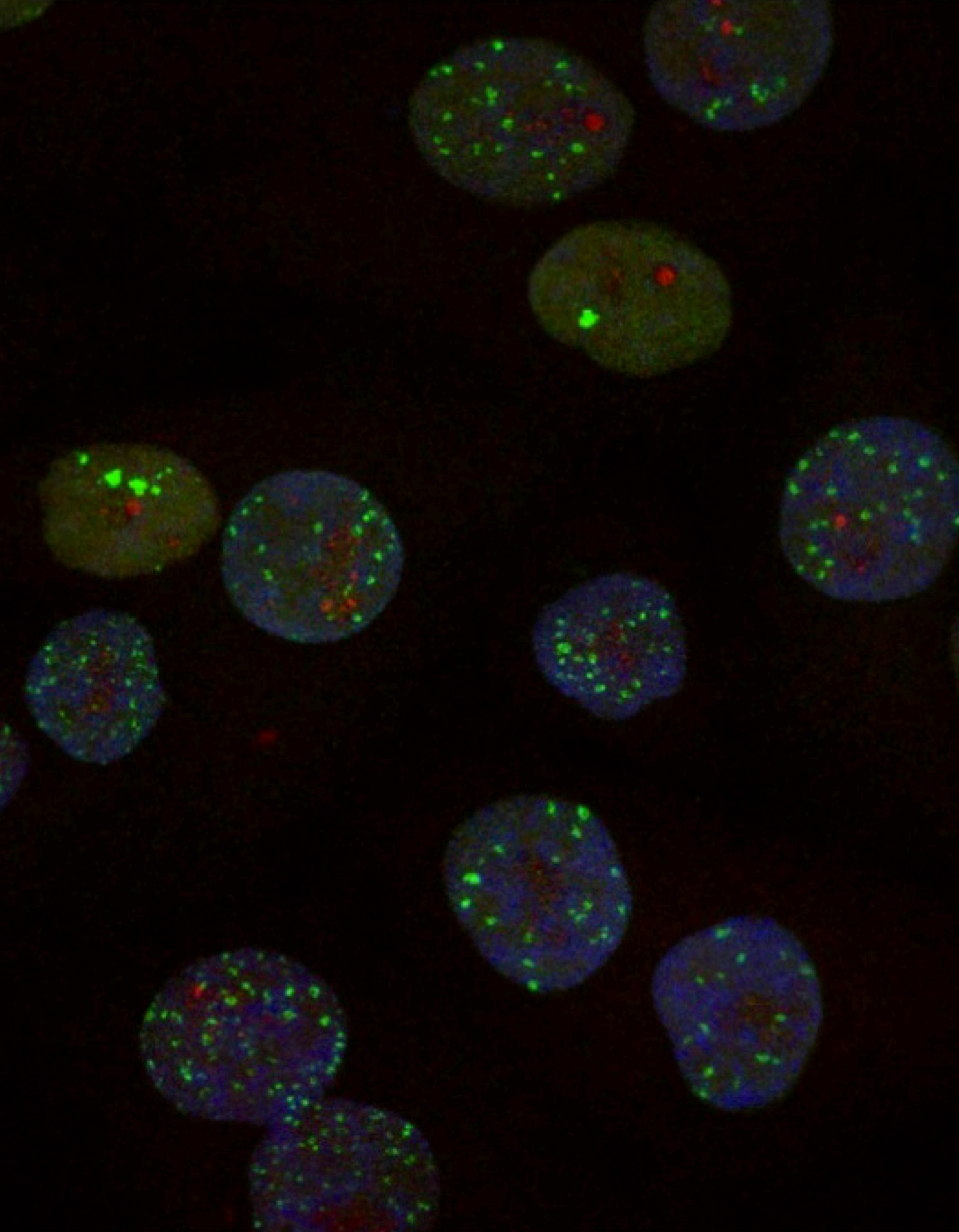
Researchers at the Danish Cancer Institute are focusing on a key protein that regulates cell metabolism, cell division and DNA repair. In 70% of all cancers, the protein is overexpressed and essential for survival. Now, researchers have identified a target within the protein that can be used to block its function in cancer cells. In collaboration with Canadian researchers, they are using artificial intelligence to design millions of virtual molecules with the chemical and physical properties needed to inhibit this specific protein. Next, the small molecules are analysed to identify those with the highest likelihood of being effective. Ultimately, the molecular specifications are sent to a pharmaceutical factory, where a drug is produced and tested on cancer cells in the laboratory. So far, the research has led scientists to focus on a couple of particularly promising molecules.

Artificial intelligence is revolutionising cell research

Researchers from the Danish Cancer Institute have developed an AI-based method that makes it faster and more accurate to identify proteins with critical cellular functions. Traditionally, understanding a protein's function requires extensive laboratory work. However, by using artificial intelligence, researchers have scanned structural data from thousands of proteins, identifying several involved in DNA damage repair. DNA repair is crucial in preventing cancer, as uncorrected DNA errors can lead to tumour formation. The method is freely available to all researchers and can be used to discover new genes or cellular components with specific functions. The new method has the potential to discover previously unknown proteins, paving the way for major breakthroughs in cancer research and expanding our understanding of cellular functions.

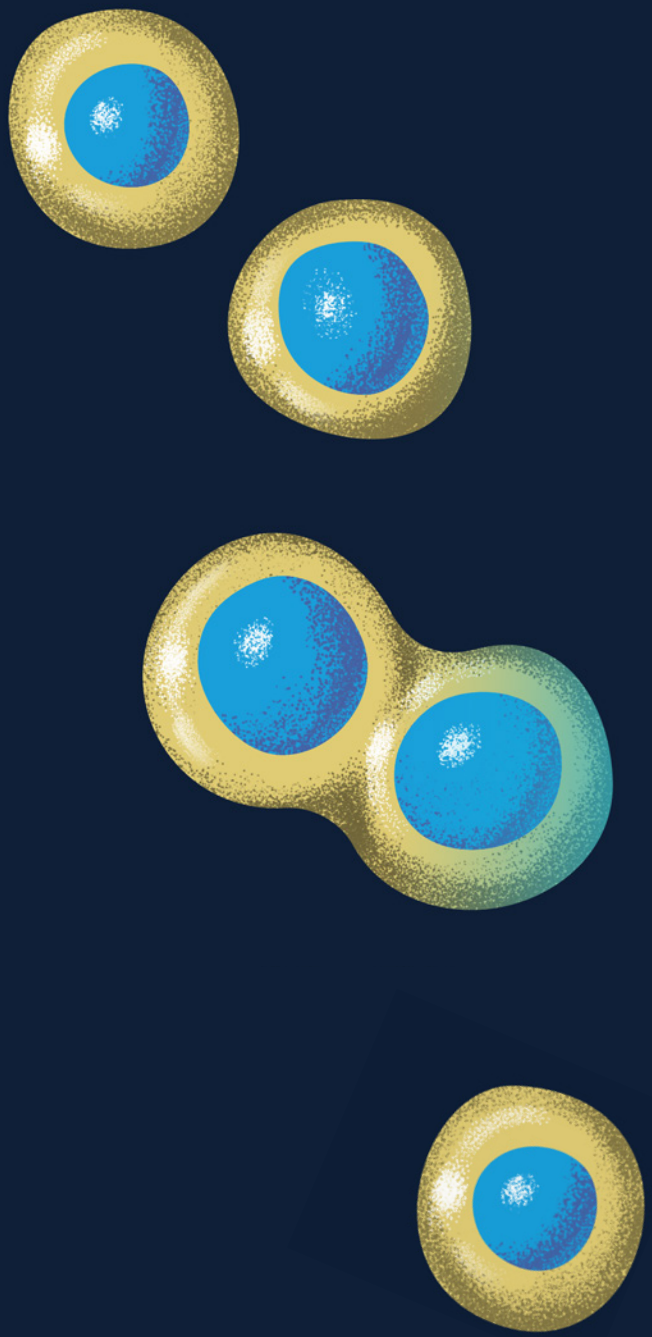
The results are published here: *Schou KB. et al.: Exploring the structural landscape of DNA maintenance proteins. Nature Commun. 2024, Sep 5. DOI: 10.1038/s41467-024-49983-7.*





In pursuit of a life without cancer

On behalf of the Danish Cancer Society, we thank everyone who has helped to make our research possible.



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