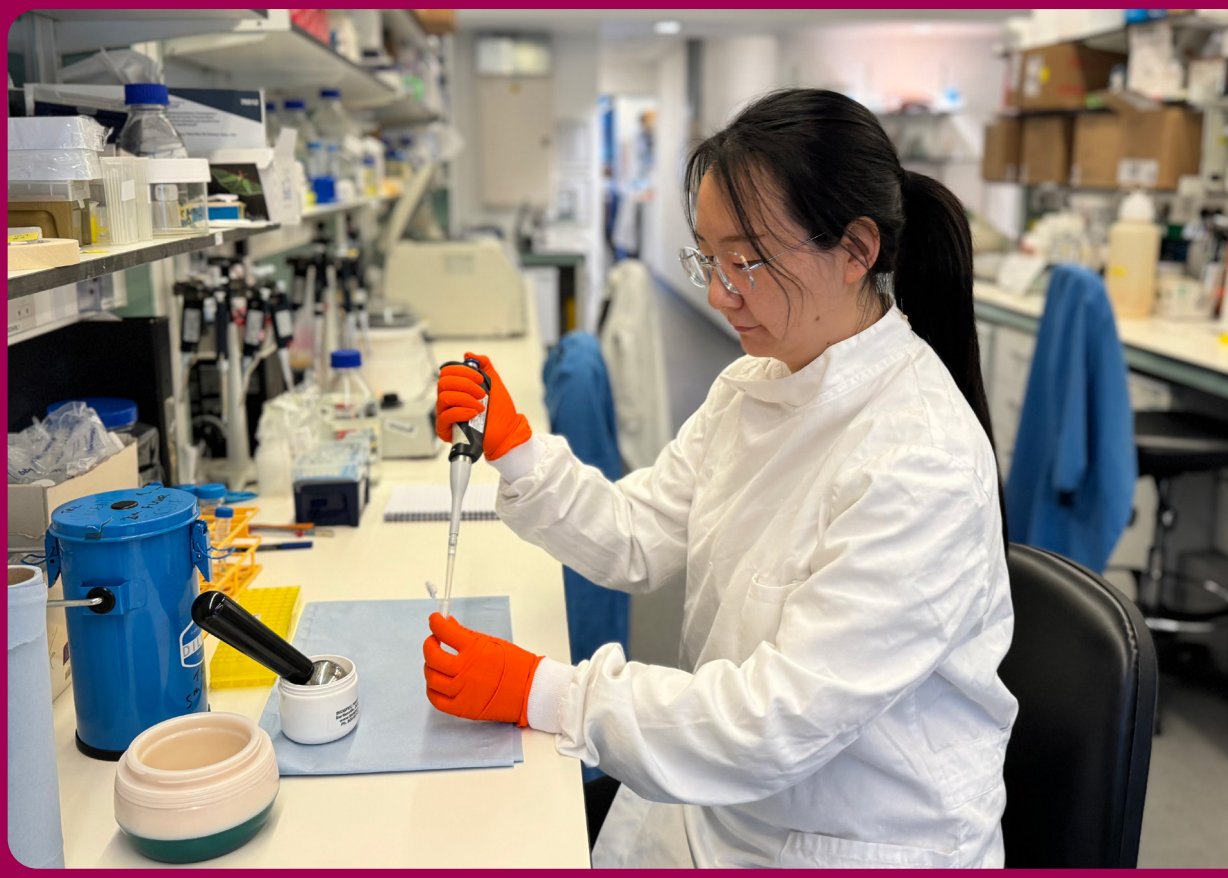
Arthritis UK

Centre for Osteoarthritis Pathogenesis

Impact Report



What causes osteoarthritis?

In 2013, we knew that osteoarthritis was a complex whole-joint disease driven by many different factors. However, the underlying pathways that drive and regulate this condition weren't well understood. This left a big and troublesome gap. In order to develop new and more effective treatments, it is essential to understand fully the basic processes involved in osteoarthritis, and identify how and why this condition develops and progresses.

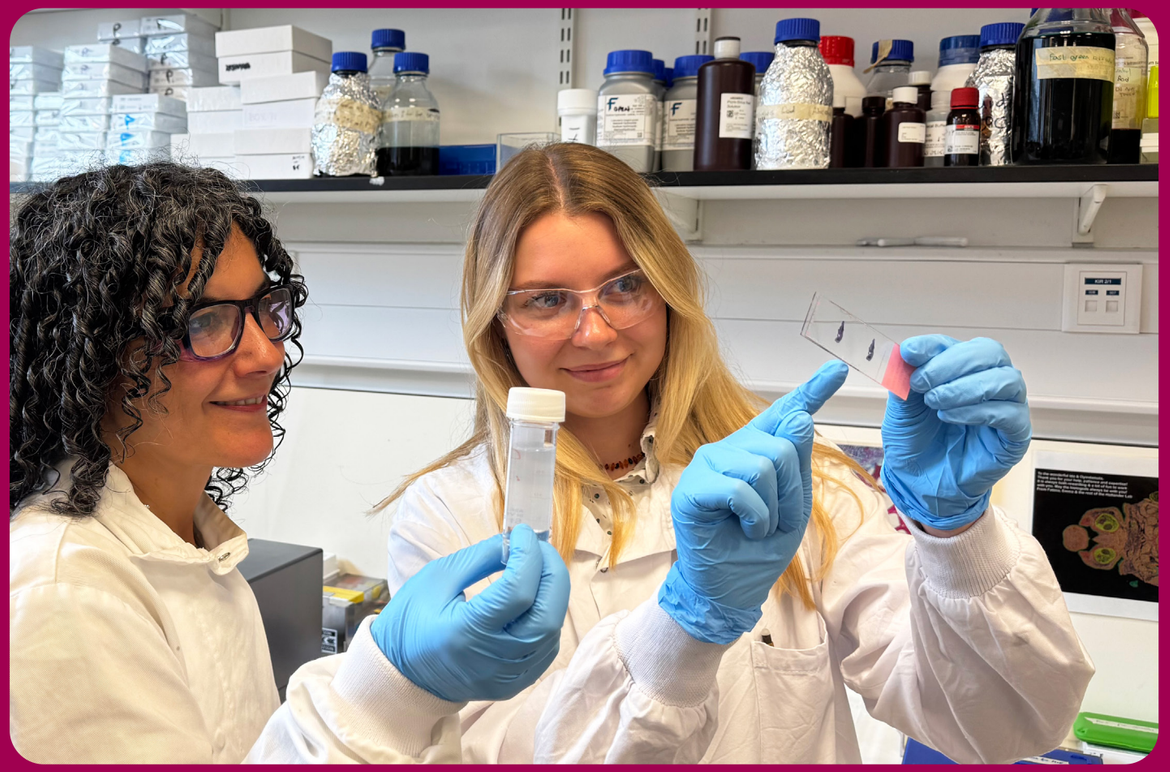
At that time, osteoarthritis research had largely been limited to investigating the processes occurring in late-stage disease. Dedicated research was needed to improve our understanding of why osteoarthritis starts and develops in the first place – a scientific term called pathogenesis.

Enter the Centre

In 2013, the Kennedy Institute of Rheumatology moved from Imperial College London to the University of Oxford, to lead and launch the Centre. Since then, Imperial College London, Queen Mary University of London, Sheffield University, King's College London, Southampton University, the University of Glasgow, the University of Edinburgh and the University of East Anglia have joined. The Centre aims to understand why osteoarthritis and associated pain develops, identify novel 'markers' which indicate disease risk, and develop new therapies for people with osteoarthritis.

Under the leadership of Professor Tonia Vincent, the Centre has received £4.5 million of infrastructure funding from Arthritis UK. This has supported network creation, capacity building, the tackling of scientific questions, the obtaining of additional funding, and the integration of patient and public involvement.

Arthritis UK | Centre for Osteoarthritis Pathogenesis

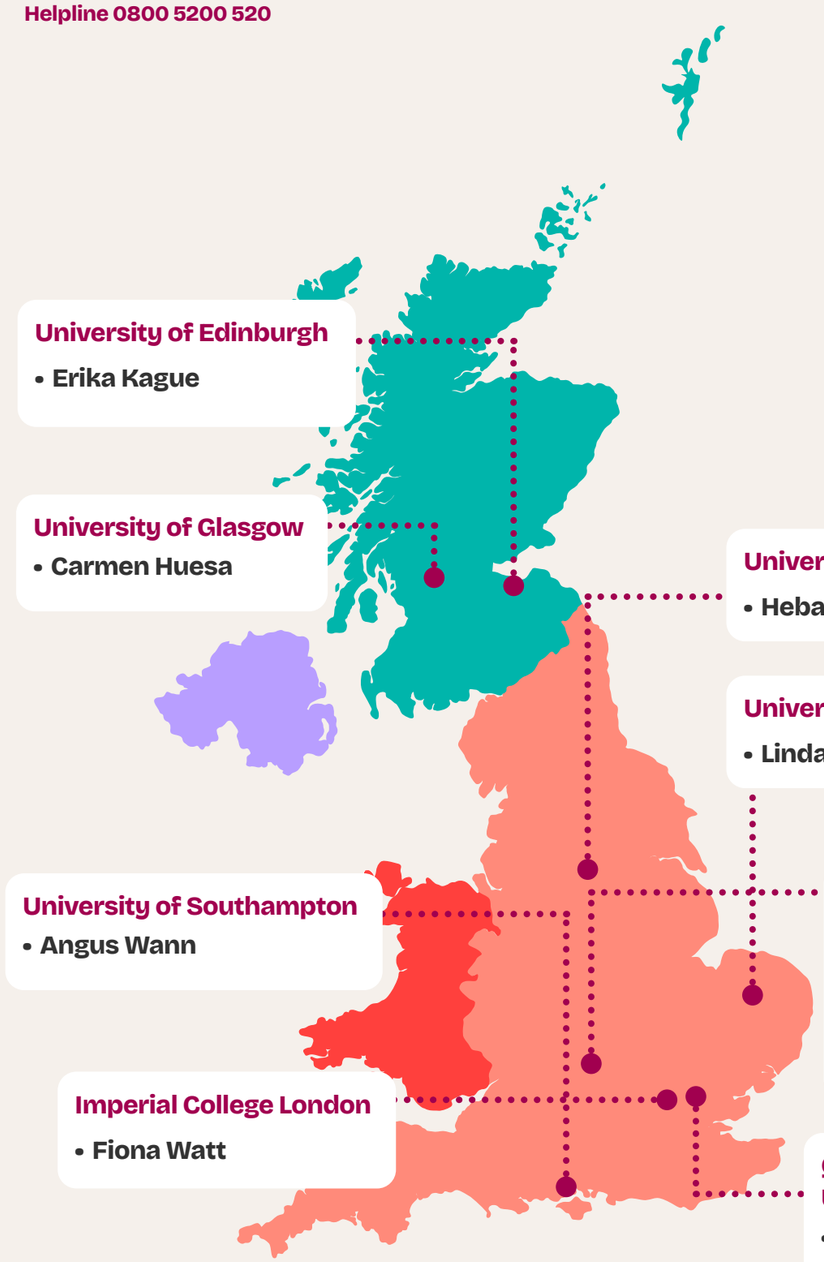


I have been immensely privileged to lead the Centre for Osteoarthritis Pathogenesis. Its inception in 2013 conveniently coincided with the Kennedy Institute of Rheumatology's move from London to Oxford and enabled us to find strong osteoarthritis collaborations within the Oxford ecosystem. Many of these were with the Botnar Institute for Musculoskeletal Sciences in which were embedded a number of bone and cartilage biologists and academic surgeons who have become essential partners in developing many of the more translational ambitions of the Centre. From the start we were keen to set up a translational pipeline – a roadmap that would enable us to take relatively early discoveries and test them through a series of steps to demonstrate their relevance to human disease and potential as drug targets. This has been a very successful approach and has resulted in new patents for novel osteoarthritis treatments as well as delivering early clinical studies in humans using repurposed drugs.

We started this Centre with an almost completely blank canvas as so little was known about the disease. It is fair to say that over the past ten years the landscape has changed substantially and we have a much clearer idea about what the disease is, why it starts and how to intervene. It has ended up being a very exciting journey!

One of the major successes of the Centre has been seeing junior members of the team grow and develop. This has included post-doctoral scientists developing into independent group leaders and junior group leaders going on to substantive senior positions at other universities. This has enabled us to move from being primarily Oxford University-based to becoming a multi-institutional Centre. This is reflected in our regular online Centre meetings that involve researchers across eight Institutions, enabling them to share data and discuss relevant new publications every week. Our Centre remains a vibrant, supportive environment to foster careers and is moving ever closer to new treatments for individuals with osteoarthritis.

Professor Tonia Vincent
Centre Director



The Arthritis UK Centre for Osteoarthritis Pathogenesis is:

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Finding new targets and treatments Page 10

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Thinking big and collaborating wide Page 16

04

Building capacity for the future Page 22

Our research impact areas

- New knowledge
- Influence on policy and practice
- New networks
- Leveraged funding
- Increased capacity to conduct research
- Patient and public involvement
- New intellectual property, products and services

£4.5m of Arthritis UK funding has led to:

More than **450** publications cited more than 25,000 times.

More than **£50m** in leveraged funding.

More than **140** staff and students trained and supported.

01

Understanding the root causes of osteoarthritis

Why is this important to people with arthritis?

To tackle a disease, it is important to understand first its inner workings. To do this, the Centre is investigating what a healthy joint looks like and what happens deep inside the joint when it develops painful osteoarthritis. From this, the Centre is helping to unlock the origins of osteoarthritis and dispel myths about the disease.

Helpline 0800 5200 520

01 **Myth:** Osteoarthritis is a passive process where our joint surfaces wear down.

Centre research shows that osteoarthritis is an active, biologically driven disease. It is better to think of osteoarthritis as a disease which causes the body's normal joint repair systems to be chronically switched on.

02 **Myth:** Cartilage can't repair itself and this explains why it breaks down as we age.

Centre research has discovered that cartilage can repair itself throughout our lives. It even happens in people with advanced osteoarthritis. The Centre has uncovered how cartilage can do this and has developed a novel approach, using the protein Agrin, that can promote joint repair.

03 **Myth:** Exercise wears down joints and worsens osteoarthritis.

Centre research supports the fact that keeping active helps maintain cartilage health as we get older – use it or lose it!

04 **Myth:** Osteoarthritis only affects older people.

Centre research is unravelling the molecules that drive osteoarthritis after severe joint injury, which explains why young people can get osteoarthritis.

The origins of osteoarthritis

Before the Centre started, we knew from studies in large populations of individuals with osteoarthritis that the most important risk factor for disease was mechanical stress, particularly evident in older people.

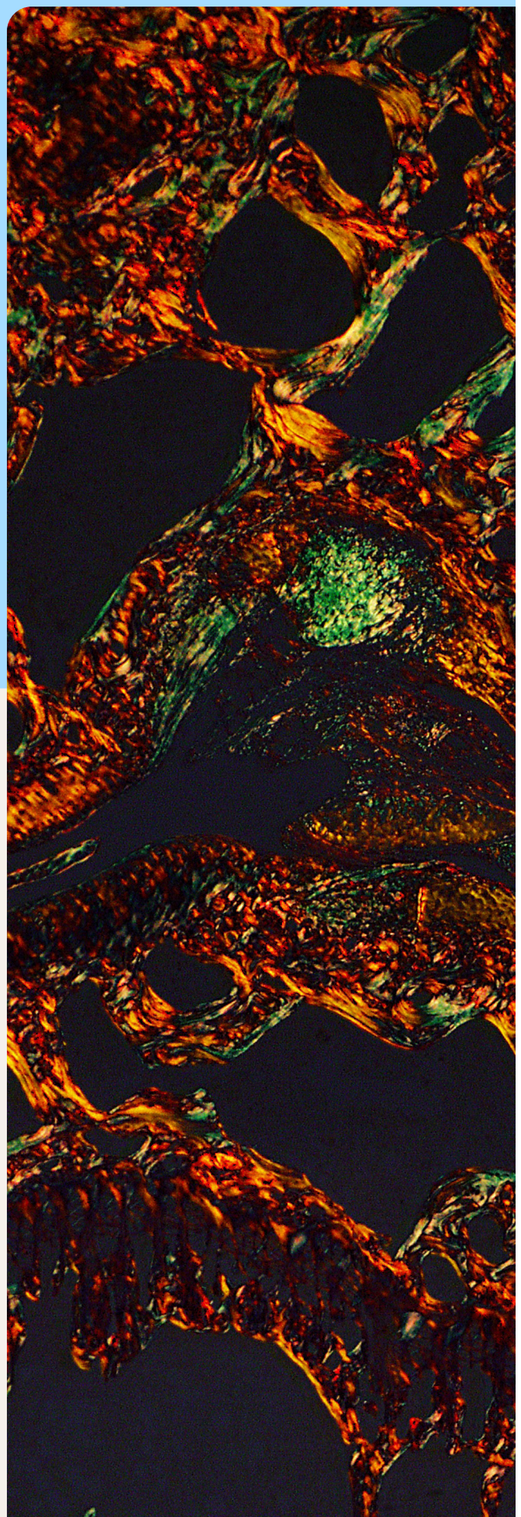
We also knew that osteoarthritis affects the joint in many ways, including cartilage breaking down, extra bone growth and low-grade inflammation. The Centre has tried to unravel the mechanisms that drive these responses and examined the link to symptoms such as pain. Their work has evolved substantially over ten years of funding.

New knowledge

- Centre researchers now better understand how key enzymes that break down cartilage, such as ADAMT4/5, are controlled. Pathways and molecules including JNK-2 and LRP-1 are involved.
- Centre research has shown that inflammation in osteoarthritis is very different to that seen in rheumatoid arthritis. Centre researchers termed this inflammation 'mechanoflammation' as it is activated directly by cartilage mechanical injury.
- Several mechanisms by which cartilage responds to mechanical injury have been found by the Centre - mechanisms that could be exploited to repair cartilage!
- Centre researchers have identified key pain-driving molecules that are made by damaged cartilage - these could present a target for therapeutics in the future.

02

Finding new targets and treatments



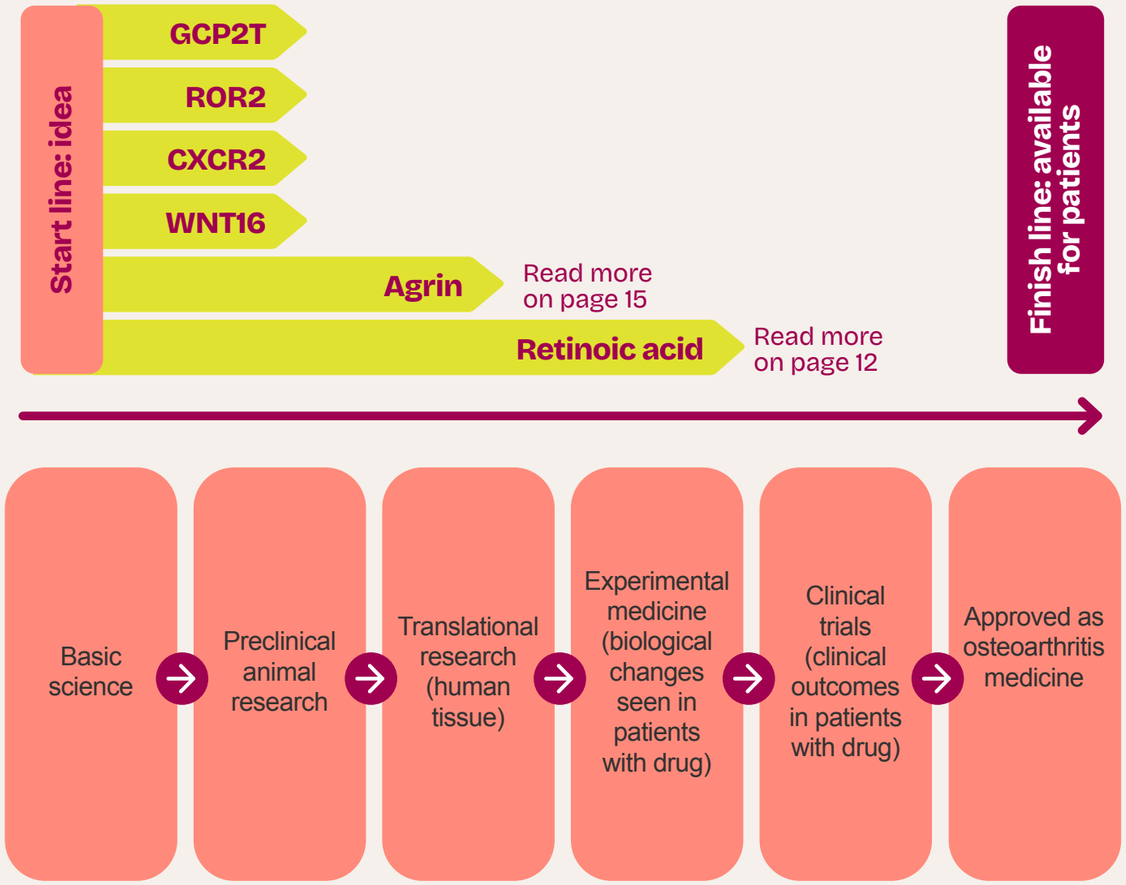
Why is this important to people with arthritis?

Treatments for osteoarthritis are desperately needed – existing therapies only partially reduce symptoms and no cure exists yet. However, there have been many challenges.

One of these is that osteoarthritis can take a long time to progress and is variable between individuals, making clinical trials (which are essential for licensing new therapies) difficult. Another more important reason is a lack of knowing which approach is best to target this disease. The Centre is leading research to unpick this disease and bring new osteoarthritis medicines closer to those affected, by finding new targets and treatments.

Potential new targeting molecules

Since 2013, Centre researchers have found several promising new targets that restore cartilage health while also easing symptoms. These are at different stages of development.



Small but mighty

GCP2T, ROR2, CXCR2 and WNT16 are all molecules early in the clinical development process that could help our cartilage stay healthy.

Hand osteoarthritis targets

New knowledge

Retinoic acid, a derivative of vitamin A, suppresses injury-induced inflammation in cartilage. Boosting natural levels of retinoic acid using the drug talarozole can suppress osteoarthritis in disease models. This target is now being explored as a new potential treatment for people with hand osteoarthritis in a study called RAMBOH-1 led by Centre Director Professor Tonia Vincent and researcher Professor Dominic Furniss.

Consistent support by Arthritis UK for the Centre has allowed the development of this trial over the course of a decade. It is only by such long-term investments that true advances are made in biomedical science. We are excitedly anticipating the results of the study and have other candidates in the pipeline. With continuing support from Arthritis UK and its generous donors, we hope that the next decade will finally see the introduction of disease-modifying treatments for the millions of patients who suffer from osteoarthritis.

Professor Dominic Furniss

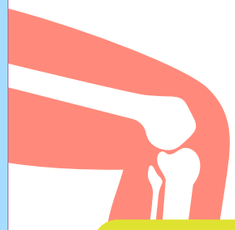
Patient and public Involvement

In another study called HOPE-e, people with lived experience of osteoarthritis were involved and helped manage a study to see whether hand osteoarthritis pain could be managed using hormone replacement therapy (HRT). Together, they found that running a clinical trial involving a form of HRT is feasible and acceptable for people with hand osteoarthritis. This is important given that osteoarthritis symptoms can start or worsen around the time of menopause starts or when HRT stops.

Leveraged funding

On the back of this, £2.26 million of funding from the National Institute for Health and Care Research (NIHR) has been awarded for a clinical trial using HRT in hand osteoarthritis led by Dr Fiona Watt.

Knee osteoarthritis targets



New knowledge

Centre researchers discovered that small package-like bubbles called extracellular vesicles can deliver repair molecules into cartilage. This is important because cartilage has a dense structure and lacks blood vessels, making it difficult for most molecules to get inside it. From this, a powerful new technology is being developed, enabling extracellular vesicles to be filled with osteoarthritis treatments and delivered through a single injection.

Intellectual property

Many patents for this delivery system have been granted. Plus, a spinout company of Queen Mary University of London (called ReFleks Ltd) was co-founded by Centre Investigators Professor Francesco Dell'Accio and Dr Suzanne Eldridge. Protecting and commercialising these discoveries in this way is crucial to leverage funding from pharmaceutical companies to turn them into potential medicines.

ReFleks

Ways clinicians can support patients with hand osteoarthritis without medicines

One article from the Centre highlights practical strategies that clinicians can use to support people with hand osteoarthritis without medicines.

These include (but are not limited to):

01 **Make a clear diagnosis**

02 **Give positive messages about what to expect from osteoarthritis**

03 **Explain that osteoarthritis is mechanically driven by an active process**

04 **Advise hand exercises**

Find support here for hand and wrist osteoarthritis

Stefan's story

"I'm an Emeritus Professor and surgeon scientist based at Lund University in Sweden. I've been involved with the Centre since it first started as a member of their academic advisory group."

Why was the Centre for Osteoarthritis Pathogenesis needed?

"Before the Centre, despite lots of research in this space, we did not understand enough about the mechanisms of the development of osteoarthritis. Consequently, we had no treatments to slow or stop the disease, and we still don't. In my view, Arthritis UK was very wise in announcing these big grants to make investigators work together with a shared focus and pot of money. This has had a real benefit to the field of osteoarthritis research in the UK.

Osteoarthritis is a very complex disease with a varied presentation. As with other complex diseases, you can't answer central questions from small, isolated studies and samples. Instead, you need large biobanks of samples connected with a rich clinical history. It takes many groups to bring enough samples and information together to form a biobank from which you can answer the most important questions. That's what the Centre grant enabled these researchers to do."

What has Stefan found in collaboration with the Centre?

"People with osteoarthritis can have a very different experience despite having the same diagnosis. It presents itself very differently. What we now know from Centre research like STEpUP OA is that the central mechanisms driving the origin of the disease are common to most patients with osteoarthritis, while the individual characteristics of each patient, such as their gender and weight or joint injury status, influence their unique response to those central common mechanisms. Knowing this allows us to focus future research on the important things and not do things that lead us in the wrong direction."

Where does Stefan think the osteoarthritis field needs to travel in the next 20 years?

"I have almost 50 years of perspective on osteoarthritis research and it is proving to be a very tough nut to crack. I am now much more optimistic than I have been in a very long time because we're realising the visions of large groups of researchers creating large samples and data banks to address this very complex disease in a much better way than we've been able to before, using state-of-the-art technology. Our increased understanding of molecular mechanisms, novel agents and drugs that are now appearing is making me hopeful, as is our evolving way to test new drugs using sophisticated types of clinical trials.

If you're involved in osteoarthritis research you need passion, patience, and perseverance. Because things don't happen quickly in this disease or in research. Researchers need these qualities but just as importantly, so do funders. They need to have the passion for the disease they're focusing on, which they obviously do, but they also need to have the patience and perseverance by providing long-term support."

Sue's story

"I'm a Senior Lecturer at Queen Mary University of London, where my research focuses on developing regenerative treatments for osteoarthritis. When the Centre was first established in 2012, I was a second-year PhD student. Now, I'm an independent researcher leading my own team."

What has Sue found through the Centre?

"Working with Professor Francesco Dell'Accio, we identified Agrin as a key regulator of joint regeneration. We discovered that Agrin activates resident stem cells within the joint and promotes the formation of new cartilage, effectively switching on repair pathways that are normally lost during osteoarthritis.

Over the years, supported by Arthritis UK funding, we have built a substantial body of evidence showing that Agrin can repair cartilage, improve joint structure and reduce pain in preclinical models. What makes this particularly exciting is that Agrin targets the underlying biology of tissue repair rather than simply managing symptoms."

How has being a part of the Centre helped Sue?

"The Centre has had a profound impact on my development as a scientist, leader and translational researcher. Professionally, it provided the environment in which I was able to grow from a PhD student into an independent investigator. Through the Centre and the support of my Arthritis UK Career Development Fellowship, I was able to establish my own research group, develop my leadership skills and pursue ambitious translational research that ultimately led to the creation of a spinout company called ReFleks. We have a final version of the Agrin product suitable for human use but to advance the therapy towards patients we first need to raise millions of pounds investment for safety and toxicity tests.

The Centre has also demonstrated the value of working closely with patients. One individual who has had a particularly important influence on my work is Sue Woollacott. She has been involved with the Centre for many years."

What has made the Centre successful?

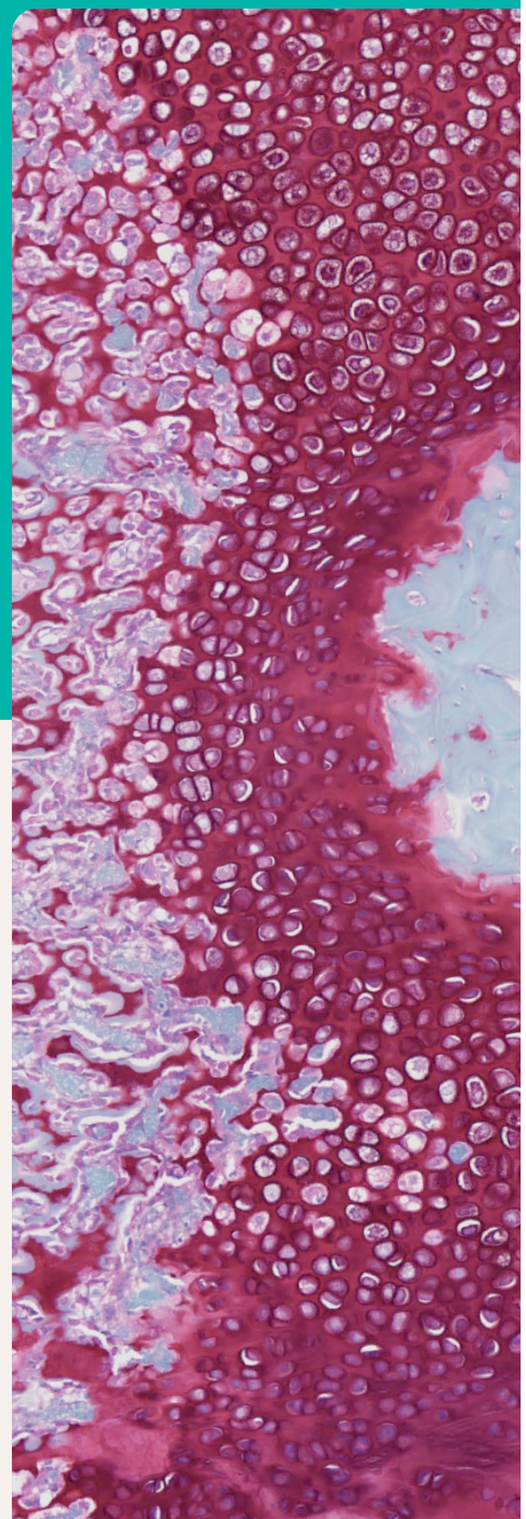
"The Centre's success cannot be measured solely by publications, grants or discoveries. Its real legacy is the generation of researchers it has helped develop, the patients it has empowered to contribute to research, and the collaborative culture it has created."

03

Thinking big and collaborating wide

Why is this important to people with arthritis?

Tackling big, ambitious research questions that can help people with osteoarthritis live their lives more fully requires lots of high-quality research and strong interdisciplinary collaboration. These efforts depend on funding and connections. Centre infrastructure has provided the environment and status to help leverage millions and form global connections, opening new opportunities to better understand and treat osteoarthritis in the future.



Is osteoarthritis one disease or several?

STEpUP OA

Osteoarthritis can present itself differently in different cases, and the impact it has on an individual is unique, leading researchers to ask: is osteoarthritis one disease or several?

STEpUP OA
Synovial fluid To define molecular Endotypes by Unbiased Proteomics in Osteoarthritis

Within one month of this discovery, the view count of this paper ranked in the top **3%** of all research published during the same time.

New knowledge

Centre research funded by the Kennedy Trust for Rheumatology Research and Arthritis UK showed that osteoarthritis is one variable disease with a common core biology, rather than multiple conditions. This was shown through STEpUP OA, the largest study of its kind to analyse over 7,000 proteins within joint fluid from over 1,300 individuals with knee osteoarthritis. By mapping the biology of osteoarthritis at this level of detail, Centre researchers can now look for new possible therapeutic approaches within these results.

New collaboration

Led by Centre Director Professor Tonia Vincent, STEpUP OA brings together academic colleagues from Canada, Sweden and the Netherlands with industry partners, UCB, Novartis, Pfizer, Galapagos, Fidia, Nordic Bioscience, GSK and Biosplice. STEpUP OA was the first time that a comprehensive analysis of protein in the joint fluid had been performed at scale, made possible by strong interdisciplinary connections within the project.

Leveraged funding

Over £2.2 million of support was received from industry and charity partners for STEpUP OA. £770k has since been awarded by Arthritis UK to Dr Fiona Watt to lead a new study called STEP FORWARD, to deepen understanding of knee osteoarthritis in its earlier stages so that we can predict who is at greater risk of disease progression over time. Currently, we don't have a way to test or predict this.

Why do some people develop osteoarthritis after joint injury and not others?

Genetics of Osteoarthritis Consortium

Many, but not all, individuals with a traumatic injury go on to develop osteoarthritis in the affected joint. However, we currently cannot identify which individuals with prior knee injury will go on to develop osteoarthritis, which individuals won't, and which could benefit from early targeted treatment.

New collaboration

Centre researcher Dr Fiona Watt leads the international Post-Traumatic OA (GO-PTOA) working group within the Genetics of Osteoarthritis Consortium to explore how our genetics can contribute to osteoarthritis risk following traumatic injury.

New knowledge

In an earlier, UK Biobank research study supported by Arthritis UK and funded by her UKRI fellowship, Dr Fiona Watt and collaborators at the Kennedy found that older age at the time of injury and being female both increase the chances of developing post-traumatic knee osteoarthritis. The highest risk occurring within the first five years after the injury. Knowing this means it may be possible to predict individuals with the highest risk of post-traumatic osteoarthritis in the future, opening up opportunities to treat them early or to halt (or even prevent) the condition's progression.

New knowledge

Dr Fiona Watt in collaboration with several other researchers supported by Arthritis UK, led a study to decide how PTOA clinical trials should be run, informed by people with lived experience.

Where does osteoarthritis pain come from?

Pain is a major, sometimes debilitating symptom of osteoarthritis that can greatly affect a person's ability to live a full life. What drives it inside the joint?

New knowledge

Injured cartilage cells make pain-causing molecules in osteoarthritis – the main one is called nerve growth factor (NGF). Centre researchers with collaborators at Oxford University showed that NGF can be blocked by a vaccine to relieve pain in preclinical disease models. Centre researchers have also helped show that one mechanism driving osteoarthritis pain involves the joint rewiring, with new blood vessels and pain nerves growing in new places that make it more sensitive to pain.

Leveraged funding

The Centre has defined big questions to better understand osteoarthritis, drawing in several millions of pounds for other studies.

Musculoskeletal Cluster within the UK Human Functional Genomics Initiative

- Can understanding how our genes influence osteoarthritis help reveal why some of the same genes also contribute to other conditions such as frozen shoulder, carpal tunnel syndrome and Dupuytren's disease?

PROBE

- What are the most meaningful measures of patient benefit that should be prioritised in osteoarthritis studies?

PROBE
PATIENT RELEVANT OSTEOARTHRITIS ENDPOINTS USING BIG DATA EVALUATION

Fiona's story

"I'm a clinical academic rheumatologist based in the Department of Immunology and Inflammation at Imperial College London and have been a member of the Centre since its inception in 2013."

What areas of research does Fiona focus on?

"I focus on translational research in osteoarthritis with a particular emphasis on predicting worsening osteoarthritis in high-risk groups, by working with human samples and cohorts of people. I also lead early-stage clinical trials with an aim to develop new osteoarthritis drug treatments.

This area of research is hugely important given that, despite osteoarthritis being the most common form of arthritis we don't have any specialist drugs that target its symptoms or slow down the disease."

What has Fiona found through the Centre so far and what has this led to?

"I've worked on many studies working with human participants, their samples and associated clinical data, rather than preclinical models. KICK, HOPE-e and STEpUP OA are just three examples and none of them would have been possible without Centre support. The number of people downloading our STEpUP OA paper is extraordinary, it's receiving huge interest.

My work leading the KICK study led to me receiving a UK Research and Innovation fellowship, without which I probably wouldn't have been able to receive a permanent research position (tenure). And the HOPE-e study, enriched by the Centre's patient registry OARVIL, helped us win other awards from the Pain Relief Foundation and NIHR, plus Arthritis UK for the SOLVE Osteoarthritis Consortium."

What is Fiona working on now?

"I'm continuing research on post-traumatic osteoarthritis because it is an early window into what is going on in osteoarthritis, giving us a unique opportunity to better understand its beginnings. Currently, I'm leading the STEP FORWARD study funded by Arthritis UK, building on from STEpUP OA to answer questions we have around stratification (the potential for subgrouping to assist in developing tests and treatments) in joint injury and menopause.

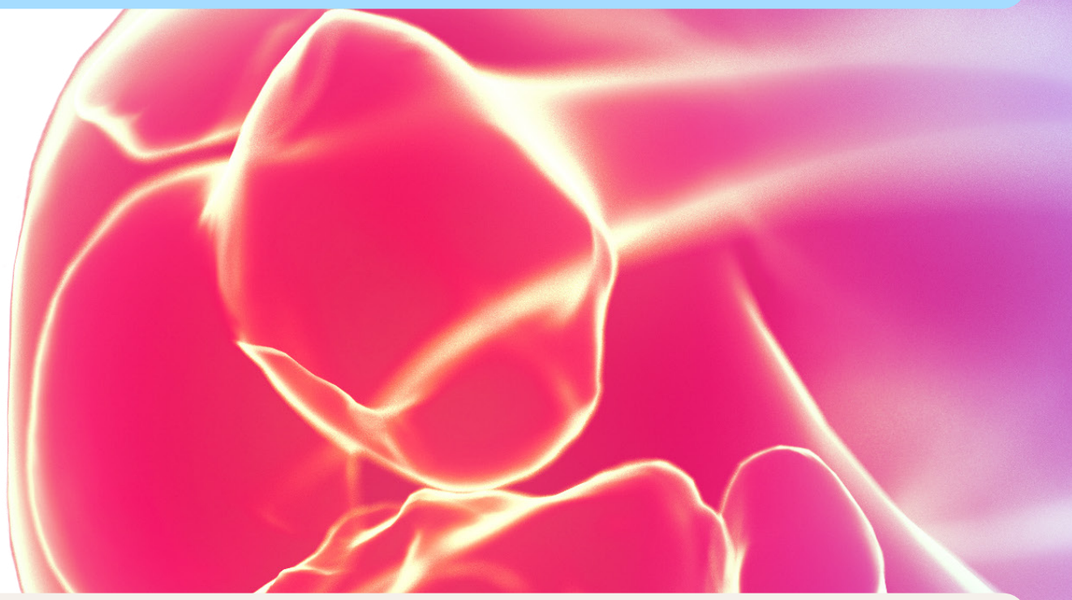
Also, I lead a working group in an international consortium called the Genetics of Osteoarthritis. From this work, we now know that there are many similarities in the genetic architecture between osteoarthritis and post-traumatic osteoarthritis, including a genetic susceptibility to injuring your joints in the first place."

Helpline 0800 5200 520

In Fiona's view, what makes the Centre successful?

"The Centre is greater than the sum of its parts. It has given me colleagues and friends, underpinning my existence and drive as a researcher. Key to the Centre's success has been Professor Tonia Vincent's strong leadership as Director. Keeping us on course, her stewardship has enabled us to try new things with a compass underneath us.

Before the Centre, the Kennedy Trust for Rheumatology Research was leading high-quality but mainly fundamental research in osteoarthritis. Now, we are able to do much more translational and clinical research – there aren't many places in the world that do what the Centre does, or do it as well."



"I've been involved with the Centre as a patient participant, and on their Advisory Group, for over a decade... From this, I have been given opportunities like talking on the radio and co-authoring research papers....There are so many knowledgeable, determined and successful researchers at the Centre.

Especially the women, Tonia, Sue and Fiona to name a few, who are helping to empower the next generation of female research leaders. Not only are they excellent at research but they have the ability to make patients feel important and valued."

Sue Woollacott
Centre patient participant

04

Building capacity for the future

Why is this important to people with arthritis?

Future breakthroughs rely on the next generation of research leaders and the resources available to them. Centre infrastructure has enabled many investigators to advance their careers, establish new osteoarthritis research groups, win awards, and sustain long-term studies that produce invaluable samples – fuelling even more discoveries.

Helpline 0800 5200 520

Capacity building

Nine former junior investigators from the Centre have moved into permanent (tenured) positions across England and continue osteoarthritis-related research, including:

- Dr Fiona Watt (Imperial College London)
- Dr Linda Troeberg (University of East Anglia)
- Dr Heba Ismail (University of Sheffield)
- Dr Paul Potter (Oxford Brookes University)
- Dr Angus Wann (University of Southampton)
- Dr Giovanna Nalesso (University of Surrey)
- Dr Suzanne Eldridge (Queen Mary University of London)
- Dr Anne Sophie Thorup (Novartis)
- Dr Bethan Thomas (UCB)

Being part of the Centre since its establishment in 2011, first as a postdoctoral fellow and later as a Principal Investigator, has been deeply rewarding. Its support fostered my independence, enabled collaborations, helped me secure fellowship funding, and establish my research group in Sheffield, focusing on identifying therapeutic targets for osteoarthritis.

Dr Heba Ismail
Associate Professor in Chronic Disease Biology, University of Sheffield

I joined the Centre in 2018, during which time I've progressed from research technician to defending my doctoral thesis. The experimental osteoarthritis models developed within the centre, alongside the excellent facilities at the Kennedy Institute, provided a strong platform for me to advance my research career and PhD project.

Dr Vicky Batchelor
Postdoctoral Research Scientist, University of Oxford

Research resources

Capacity building

The Centre has supported a number of osteoarthritis and joint injury cohorts, including **Knee Injury Cohort at the Kennedy (KICK).**

KICK is led by Dr Fiona Watt, working with Mr Andy Williams. KICK captured samples, clinical data and patient symptom information from 150 adults with a recent knee injury, to understand more about the links between joint injury and the development of osteoarthritis. This inspired the establishment of the **Oxford Knee Injury Cohort (OxKIC).**

OxKIC gathers detailed clinical, imaging and molecular data, alongside biological samples, from young individuals following acute knee trauma, most commonly sustained during sport. The cohort provides a unique resource to study the early biological mechanisms linking knee injury to the development of osteoarthritis.

Dr Stefan Kluzek
OxKIC Investigator

Meniscal Tear and Osteoarthritis Risk cohort (MenTOR) captures clinical and molecular data and samples from patients with a chronic meniscal tear, many of whom have early-stage osteoarthritis, where no damage can be seen in x-rays but other tests show early disease.

STEpUP OA examines clinical, demographic and molecular data using joint fluid from over 1,300 individuals. Through new collaborations this cohort continues to grow with paired measurements of blood proteins, genetics, and specific osteoarthritis biomarkers.

These cohorts are gifts that keep on giving because the data can be used again and again to investigate new research questions. For example, new data from groups of people from the MenTOR and STEpUP OA studies are now being investigated in the STEP FORWARD study.

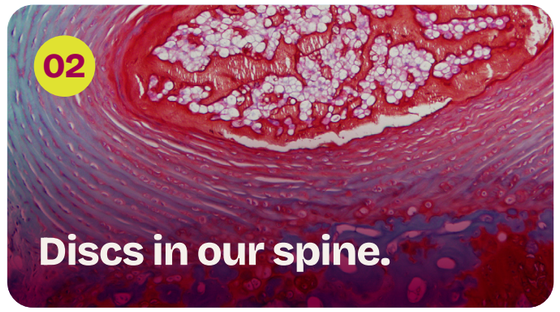
Patient and public involvement

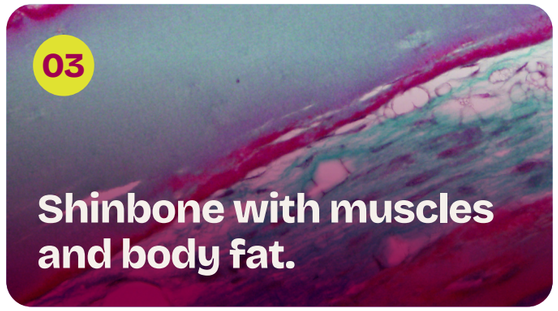
Centre funding supported the establishment of OARVIL in 2017, a registry of people with lived experience of osteoarthritis. OARVIL members have been involved in many Centre activities such as the annual Research Showcases and the BioArt Day, where art and science were combined to communicate research.

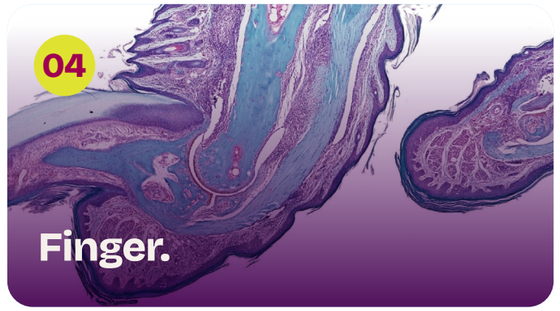
Capacity building

The expertise of Centre members has made them the go-to people for training new research talent and steering the direction of future research to ensure osteoarthritis remains a priority. For example, many are involved in:

- Funding panels – Centre members are regularly asked because of their expertise to sit on prestigious grant assessment panels to help ensure the best research gets funded in the future.
- Defining national priorities – Centre members are a key part of NIHR, the NHS research engine involved in helping to define the research questions that are most important to patients with osteoarthritis.
- Influencing osteoarthritis research worldwide – Centre members are spearheading large international efforts to understand disease.
- Training the next generation of researchers - the Centre hosts many students and post-doctoral scientists for training and exchanges.







Histology images above courtesy of Dr Ida Parisi with her team Oyindamola Ajisegiri and Ugne Radziukaite.

Glossary

Autoimmune
Conditions where the immune system, which normally protects the body from infections and diseases, mistakenly targets and attacks healthy tissues.

Biobank
Collection of biological samples like blood, tissue or DNA that are stored for research purposes.

Biomarker
Measurable sign of a condition or disease.

Cartilage
Smooth cushioning substance covering the ends of bones.

Clinical trial
Type of research study involving humans.

Enzyme
Protein that helps specific chemical reactions happen faster.

Extracellular vesicle
Bubble-like delivery packages (released by cells) that carry important materials, enabling cells to communicate with one another.

Pathogenesis
How a disease starts and develops.

Pathway
A chain of processes that lead to a specific product or change.

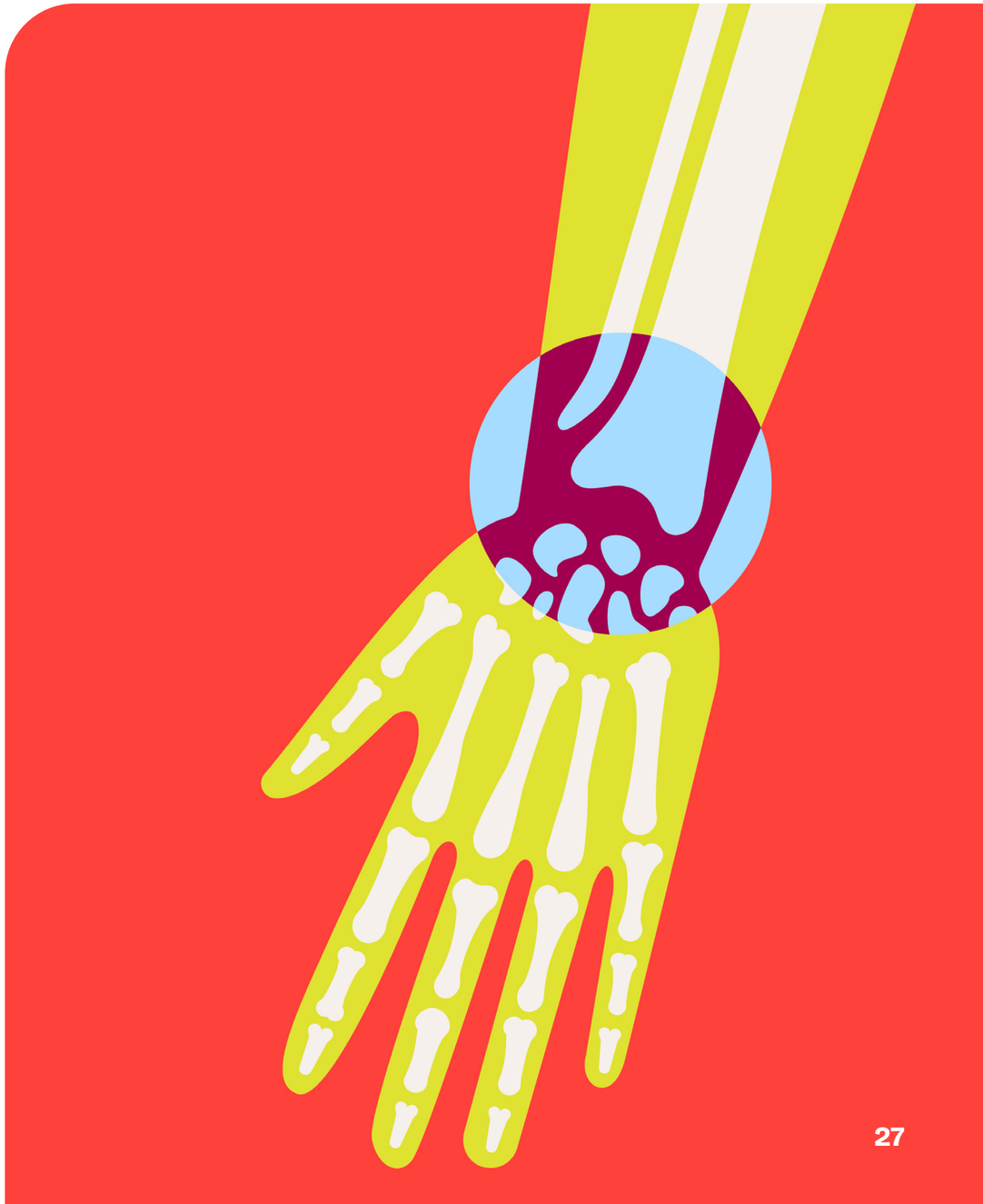
Post-traumatic osteoarthritis (PTOA)
Joint damage that happens after an injury, which leads to osteoarthritis.

Preclinical
Early-stage research, often in a lab or on animals, that happens before tests happen in people.

Helpline 0800 5200 520

Target
A specific molecule that a drug interacts with to produce a desired therapeutic effect.

Tenure
Permanent job in academia that provides long-term job security.



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