Speech script by Sir John Kingman, Chair, UK Research and Innovation

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Venki, thank you very much.

The context for all UKRI's work is framed by the Government's clear and ambitious aim to raise the overall R&D intensity of the UK economy to 2.4% of GDP, compared to 1.7% now.

This is rightly a very demanding number. If it can be realised, it will mark a very major change in the nature, and indeed prosperity, of the UK economy, making the most of the extraordinary scientific strengths the UK already enjoys.

The evidence of the huge contribution R&D can make to productivity and growth is overwhelmingly strong.

This is presumably why, alongside the Government's, the Opposition has also proposed its own R&D target.

So we have a welcome blast of political consistency: consensus across the political spectrum around the critical importance of what we are all trying to achieve.

For UKRI, there is no more important question – and responsibility – for us to address than: how we can help make this happen?

I am not going to attempt a holistic answer to that question here this afternoon. It obviously has many facets. Public funding for scientific research is undoubtedly key. But our target is of course both a public and private sector target, and indeed more R&D in the UK is done in the private than in the public sector. So we also have to have a clear view about how best to optimise the environment for private sector research. This will necessarily take us into all sorts of wider policy areas – as well as public funding - including the tax framework, the health of the venture capital and patient capital ecology, regulation and so forth.

UKRI is, as you would expect, in the process of undertaking a series of in-depth seminars to deepen our thinking and share insights on all these topics.

But this afternoon I want to home in and focus on one particular, hugely important, aspect of the overall challenge.

In fact, very unusually, I want to put aside completely all the money issues this afternoon.

I want to talk instead – as you have in this conference over the last two days – about people.

My point is that people are at least as important for UKRI's strategy, and for the 2.4% target, as money.

If we want to transform the R&D intensity of the UK economy, we don't just need the right amounts of money to be spent in the right way. We could have all the money in the world, but we also need people – outstanding people - to do the R&D.

And the arithmetic is no less demanding when it comes to people, than in relation to money.

If we want R&D spending as a % of GDP to rise by 50% or so to meet 2.4%, we will also need 50% or so more researchers.

So we need very seriously to ask ourselves: where are all these very skilled people going to come from?

That is my question today.

We start, of course, with at least one very precious national asset, which is the presence in this country of a disproportionate share of the world's greatest teaching universities.

But their graduates, especially STEM graduates, are in intense demand. Most graduates, understandably, do not have either the aptitude or the inclination to pursue careers in scientific research and development, and go off into all sorts of sectors of the economy where, at any rate on the evidence of the persistent graduate wage premia in these subjects, employers put their skills to excellent use.

That's fine. If we care – as we should - about the overall economy, it is both inevitable and good that this will happen.

But it follows that we what we actually need to do, both for the sake of the economy and for the sake of British science, is enlarge the overall size of the pool of talented and qualified people in STEM.

There are only two ways this can happen.

The first is to bring in more talent from abroad. This international flow is extremely important, if inevitably challenging in the context of the Government's clear commitment to reduce net migration.

The second is to educate more talent at home. This means thinking through how we can, realistically, expand the pipeline of high-quality people studying STEM subjects, in the UK, at every level.

I should say that there is also a whole different set of issues around researchers in the arts, humanities and social sciences, for instance in relation to serious shortages in modern languages. These too are critically important to UKRI. However, particularly in the context of the 2.4% challenge, I do want to home in today on what it will take to make a step change specifically in our STEM workforce.

Let me start with international migration.

Most scientists believe rightly, and passionately, that great science is inherently international.

The movement of researchers across countries increases productivity, drives collaborations and problem-solving, and the openness of UK research to global talent over many decades has undoubtedly been critical to its success.

As the Royal Society has often said, Science is Global. [1]

This does however create an unavoidable tension, at a time when the British Government has an objective to reduce net migration to the UK to the tens of thousands. And on top of that, at a time when there are all the complex challenges of Brexit to navigate, as well.

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[1] https://royalsociety.org/topics-policy/publications/2016/european-academies-statement-science-is-global/

The Government is clearly very alive to these tensions and has taken important steps to ensure that the migration regime recognises the importance of research and innovation.

I know that Brexit has unavoidably created a great deal of uncertainty for scientists in the UK, and those that might be planning to come here.

Our participation in Horizon 2020 and its predecessors has clearly helped the UK to attract and retain excellent people. It is not just about the funding provided through these programmes, as important as this is. Just as critical is the opportunity these programmes provide to collaborate effectively with other excellent scientists, in Europe and beyond.

I welcome the government's clear intention to forge a deep science partnership with the EU. Moreover, from the outset, the Prime Minister has stressed the value of bringing highly skilled researchers to the UK from across the world. In 2016 she said:
"We're ambitious for Britain to become the global go-to place for scientists, innovators and tech investors."[2]

A message she repeated earlier this year when committing to negotiate for the UK fully to associate with the excellence-based European science and innovation programmes.

At Jodrell Bank she reasserted the point, saying:
"The UK will always be open to the brightest and the best researchers to come and make their valued contribution. And today over half of the UK's resident researcher population were born overseas. When we leave the European Union, I will ensure that does not change."

Yesterday's budget announcement of £100m for international fellowships is a further sign of the Government's commitment to continuing to recruit top researchers to the UK.

Indeed, as yet, despite fears to the contrary, the UK has not seen a fall-off in international student numbers, with 442 thousand students in 2016/17[3] - a record number - maintaining the UK as the second most popular destination for international students behind the US[4], although our market share of international students is declining due to slower growth – 2% in the last five years – compared to over 20% growth in our competitors. Those completing PhDs remain exempt from the Tier 2 Cap.

The Government last year announced over £100 million to attract highly skilled researchers to the UK through the Ernest Rutherford Fund. And for EU citizens, including nearly 50,000 working in our universities[5], the Government's message is clear: even in a no deal Brexit your rights will be protected.

However, it is clearly essential that the post-Brexit immigration system has the flexibility and nimbleness to support the necessary growth of the research workforce, and encourages talented international researchers to choose the UK, as will the free flow of individuals to collaborate, attend meetings and conferences and so forth.

The nature of our visa system can create difficulties for the recruitment of researchers. Between December 2017 and July 2018, over 8000 Tier 2 visa applications in STEM and medical professions were refused because of the cap[6]. And with demand outstripping

[2] CBI conference 2016
[3] HESA
[4] MAC 2018
[5] HESA: academic and non-academic
[6] Data released by the Home Office

supply, the effective salary requirements were frequently well above the minimum of £30,000 – up to twice as high, affecting all applicants, bar those working in PhD level roles, or on the Shortage Occupation List.

It is therefore very positive that since the removal of doctors and nurses from the cap in July, the cap has not yet been exceeded. Although a temporary measure, the Home Secretary has signalled he has no intention of reversing this change. Wider rules changes made this year are also welcome, including a UKRI scheme in July for researchers under Tier 5, and a doubling of the number of Exceptional Talent places to 2000 visas per year.

However, the Tier 2 minimum salary level of £30,000 means that many technical roles, including many specialist ones, cannot be filled through this route.[7]

We also need a student visa system that doesn't put barriers up to international students who wish to enter the UK's R&D workforce. The Migration Advisory Committee's recommendation to offer PhD students an automatic year's leave to remain after completion of studies is therefore very welcome. We need to do more to support international students who want to remain in the UK to work.

The size of visa and resettlement costs can also be challenging - not only for researchers and their families to move and settle in the UK, but also to prospective employers. It can particularly impact on small, high growth innovative businesses because they do not have the money, time or experience needed to navigate the visa system.

All in all, this means the Government has some extremely difficult balances to strike.

UKRI does not of course have any direct role in these decisions.

But I am very clear, as is Mark Walport and the UKRI board, that we nevertheless have an essential responsibility to use whatever influence we may have, to do all we can to ensure that the interests of research and innovation carry as much weight as possible.

Paul Nurse's report, which led directly to the creation of UKRI, envisaged UKRI not just as a funding body but also, as it were, the conscience and advocate of the research and innovation agenda, and everything that matters to it. We embrace that responsibility.

This means, I hope it goes without saying, we will do everything possible to seek arrangements which introduce as few barriers as possible to a vibrant, open and world-class research and innovation scene in Britain.

Equally, if we go back to the overarching challenge with which I began, we must be clear-sighted. The reality is that, if we need to increase the number of active researchers in the UK by the order of something like 50%, we would be deluding ourselves if we imagined for a moment that this could - or should - somehow be achieved entirely through bringing in all that talent from abroad.

This means we are going to need to grow more of our own. A lot more. At least 50% more.

So, how?

I want to start by paying tribute to our hosts, the Royal Society, and their hugely powerful and compelling Vision for Science and Mathematics Education from 2014.

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[7] Russell Group publication on international technicians

I also want to tell you that UKRI is putting its money where its mouth is. At “our end” of the talent pipeline, as it were, UKRI spends about £600m every year on PhDs, fellowships and other skills interventions. Additional money from the National Productivity Investment Fund has allowed us to kick-start the process of broadening the pipeline and providing support for the next generation of research and innovation talent in the UK.

We have committed to create over 1,000 new PhD places, including a new wave of centres of doctoral training focused on artificial intelligence.

And the extra funding has allowed UKRI to launch the new Future Leaders Fellowship, which will support the growth of a cadre of over 500 world-leading researchers and innovators, not only in our universities but also, uniquely, in business too.

We can and we will do more to grow the number of research leaders and PhD graduates that drive our knowledge economy. However, we are at the very end of, and dependent on, a “talent pipeline” through the UK’s education system

The concept was, I think, first mapped out and analysed in a seminal report by the late Sir Gareth Roberts, commissioned by the Treasury in the 1990s.

It remains true today, as Gareth pointed out then, that we will not have more postgraduates in STEM unless there are more high-quality undergraduates studying STEM. And we will not have more undergraduates studying STEM unless we have more high-quality school students studying STEM at A level. And - particularly since we persist in running in the world’s most uniquely specialised post-16 school system – children need previously to have been taught science and maths well enough, and inspiringly enough, to GCSE level to want to go on to take STEM subjects at A level.

This is the talent pipeline.

Now of course, there is not actually a single pipeline. Researchers can move between sectors, they can return from career breaks and so on. Moreover, whilst PhDs are particularly important for academic research, many researchers in industry do not have PhDs. There are major issues too concerning the supply of technicians who may not require undergraduate degrees; they are essential to achieving the R&D target, yet there are serious concerns over their supply. The rapid growth in data science and AI requires us to train large numbers of data analysts and engineers. And, of course, educational and training routes into technical roles are diverse, from apprenticeships to PhDs.

So there is, perhaps, more like a network of pipelines.

Roberts also called, quite rightly, to improve participation from groups currently underrepresented in science and engineering, particularly women and certain ethnic minority groups.

Here, there are some positive signs of change. For instance, girls represented 48% of total STEM entries at GCSE in 2017 – a 4% increase year-on-year – and more girls have A-Levels in Physics, Maths, Further Maths, Chemistry and Computing than ever before.

In Higher Education, half of all STEM undergraduates are female and for postgraduate study women now make up the majority of enrolments in STEM subjects.

But whilst two thirds of male STEM graduates go on to work in STEM roles, only half of female STEM graduates do. In UKRI’s own research portfolio in some disciplines women make up fewer than 20% of grant holders. And on the Innovate UK side, just 16% of applications were led by women in 2016/17. Women make up less than 15% of the STEM workforce in the UK.

To put the point starkly: if we could find a way to close this gender gap, that might in fact be the single biggest thing that anyone could do to transform UK R&D.

Now I also realise that over the past two days you have been discussing in depth what the future research culture and system should look like.

These questions are critically important to UKRI. I have already talked about our duty to be an advocate. As a major funder and employer of circa. 7,000 people, UKRI must take the lead in modelling equality, diversity and inclusion (EDI) in our own actions and in promoting equality, diversity and inclusion in the research and innovation landscape, nationally and internationally.

Last month we appointed a new External Advisory Group for equality, diversity and inclusion. The group, led by my brilliant colleague, the ESRC's Executive Chair Jennifer Rubin, will work to help us develop an ambitious EDI strategy, with a firm commitment to improving outcomes with evidenced interventions and programmes, and to build the evidence base where it is weak.

Mark Walport has already spoken to you today, too, about bullying and harassment. I want firmly to echo what he said. The UKRI Board is very clear that these behaviours are completely unacceptable. Where UKRI is an employer we have a duty to prevent these incidents, and to take appropriate action. And as the largest funder in the UK research and innovation landscape, even where we are not the employer, we will not shy away from ensuring, including through our terms and conditions of funding, that the right values are set.

We want to develop our approach to bullying and harassment in academia in dialogue with partners, so that together we can stamp out these behaviours and ensure a supportive environment for research to flourish at all levels. Being on the front foot in tackling issues such as quality, diversity and inclusion, and bullying and harassment is vital to founding a strong relationship and building trust between the research and innovation community and the public.

But let me take you back to my analogy of the pipeline, or pipeline network.

And let's apply to this metaphor a very stylised, illustrative thought experiment.

If we want 50% more researchers, technicians and so on to pop out of the various ends of the pipes, we are very likely to need a set of pipes each of which is broadly 50% fatter than it currently is.

That is a very considerable ask. Let me give you a broad sense of what it would mean, in terms of scale.

There are currently around 290,000 researchers in the UK, the bulk in STEM. 50% more researchers would mean around 150,000 more.

Over 200,000 undergraduates start studies in STEM subjects a year. So we would need perhaps 100,000 or so more each year.

And since maths and science subjects are typically prerequisites for studying the relevant courses at degree level, we would need many more A level students in these subjects. For maths and further maths A-Level, for example, a 50% increase would mean around 50,000 extra entries a year.

What this implies for teacher numbers, even in the very crude world of my thought experiment, is a little more difficult to say, since it depends on all sorts of factors including class sizes and so on.

To teach 50% more A level students might be possible with fewer than 50% more teachers. But then again, given that such a high proportion of STEM teachers in state schools currently lack the necessary relevant qualifications, which is to say that we are already coming from rather a long way behind, it might be unwise to plan on that basis.

In which case we would be talking about needing a little under 20,000 extra active A-Level STEM teachers.

Now I make no great claims for this very basic set of highly illustrative numbers. In particular, if we could shift the propensity for individuals at each stage in the pipeline to move on to the next, which clearly we should aim to do, that would slightly reduce to numbers we need.

Nevertheless, the big picture is clear and unavoidable. Achieving 2.4% will require a very major shift at all stages of the skills pipeline. And the biggest single challenge by far is by definition at the beginning of the pipeline – in schools.

Now it is also of course worth saying that in practice, if we could ever realise anything like such a transformation, the benefits would be felt very much more widely than research.

In practice, the great majority of any additional STEM A-Level students and undergraduates will not end up working as researchers. Most will choose to put their skills to use in other parts of the economy.

But this too would be a thoroughly good thing. We know that studying STEM attracts high wage premia and is strongly associated with economic productivity.

In fact I would go so far as to say that there is probably nothing more significant that any Government could do for productivity and growth than to seek to attempt something like the kind of transformation of the STEM pipeline, particularly in schools, that I have just described.

We should note that some real progress has been made in recent years.

- The UK already spends a higher proportion[8] of the total curriculum time on STEM for 12-14 year olds than the OECD average, and recent years have seen an increase in the proportion of pupils taking 2 or more STEM-facilitating subjects[9].
- More students are also taking triple science[10].
- From 2010 to 2018, we have seen an increase of 25.9% more women entering STEM A levels in England;
- Take-up of computer science A level increased by 25% (to 9447 students) from 2017-18
- Maths is now the most popular A level, taken by 26.9% of students taking academic qualifications.
- DfE is investing an additional £406 million in education and skills, including boosting spending on maths, digital, and technical education to help increase the supply of STEM skills.

[8] OECD – 37% vs 28% OECD average
[9] 29% in 2011 to 32% in 2016
[10] DfE stats - 17% to 24% from 2009 to 2017

But we also need to remind ourselves of quite how far we have to go. For a good stocktake, I commend an excellent recent paper by the Education Policy Institute:

- Only 50% of physics teachers in the UK, and 46% of maths teachers, currently have a relevant degree.
- Even at key stage 4, 46% of maths teachers and a third of physics teachers do not have either a maths or a science degree.
- At key stage 4, only 34% of maths teachers and 45% of chemistry teachers in deprived schools outside London have a relevant degree. For physics, the figure is just 17%.
- Teacher training targets (themselves set at very low levels) in maths, physics and chemistry are persistently missed.
- Exit rates from STEM teaching are also alarmingly high – only 50% of physics and maths teachers are still in teaching in English state schools, 5 years after starting training.

Now we know that many factors affect the flow of talent in and out of STEM teaching[11]. Workload and working conditions, progression opportunities, professional recognition and autonomy, and access to continued professional development are all critical.

But I am afraid we need also to confront some stark economic realities, again highlighted in the EPI paper. These relate to teachers' pay.

First of all, teacher pay in practice varies little by subject taught. This means that schools are either choosing not to, or cannot afford to, make use of the considerable pay flexibility they theoretically enjoy to fill their gaps with qualified teachers.

Second, salary relativities between teaching and other occupations are much larger in STEM than in other subjects. Average salary levels for maths graduates in their late 20s in teaching are about £4,000 a year below what maths graduates in other sectors are paid – whereas graduates in English, history and (interestingly) biology actually earn £4,000-£5,000 a year <u>more</u> in teaching than in other sectors.

So what we see are big gaps in STEM teaching – where teaching pays much less than elsewhere.

And we see far fewer gaps in other subjects – where teaching can pay a lot <u>more</u> than elsewhere.

As an economist might say, go, figure.

It appears, in short, that a very large number of schools are in practice – whether for financial or cultural reasons – deploying an unqualified, or at any rate underqualified, teacher in STEM, or simply tolerating a vacancy, than paying what is necessary to fill that gap with a properly qualified teacher.

It seems to me very hard to envisage a true step-change in the quality and quantity of UK STEM teaching which does not grasp this nettle.

On this subject, there is very interesting recent work by the Gatsby Foundation looking at the potential effects of even a very small, 5%, salary supplement, paid directly to schools, for qualified science and maths teachers – along the lines of policies pursued notably successfully in a number of US states. This appears to show that the benefits of such an intervention would be material - and also that the costs would be surprisingly manageable.

[11] https://assets.publishing.service.gov.uk/government/uploads/system/uploads/attachment_data/file/686947/Factors_affecting_teacher_retention_-_qualitative_investigation.pdf

Now, to be fair, the Government has not been asleep on this job. In fact it has taken some pretty substantial steps:

- The Government is planning to make one-off payments of £5,000 (or £7,500 in some areas) to maths (but only maths) teachers who remain in teaching three and five years after qualifying
- From September 2018, DfE will be offering reimbursement of the student loan repayments that biology, chemistry, computer science, language and physics teachers have made, targeted in 25 local authorities (though in practice the raising of the student loan repayment threshold will rather limit the impact of this approach for most early career teachers.)
- And yesterday's budget announced a further £10m for a regional trial to test how to improve retention of early career maths and physics teachers.

These initiatives are greatly to be welcomed, and I do wholeheartedly welcome them.

But we also need to hold them up and ask whether they yet match up against the sheer scale of the challenges we face - and the opportunity we have - as a nation, and ask whether we do not need to go significantly further?

In particular, why not simply bite the bullet and just find an effective mechanism to ensure that qualified STEM teachers are paid more, to reflect the straightforward reality that they are scarcer and in more demand than teachers in other subjects?

The Government wants the UK to be what it should be, a major scientific nation.

If that is our aim, I suggest a "modest proposal": that it is not an unreasonable starting-point that <u>all</u> children in Britain's state schools should have the opportunity to be taught STEM subjects by qualified teachers, such that significantly more of them might realistically go on to study STEM later on, to huge benefit to themselves, to society and the economy – and in the case of at least some of them, also to British science.

That is, and I'm sorry to end on this challenging note, a very long way from where we currently are.

We could and must do better.

Thank you very much.