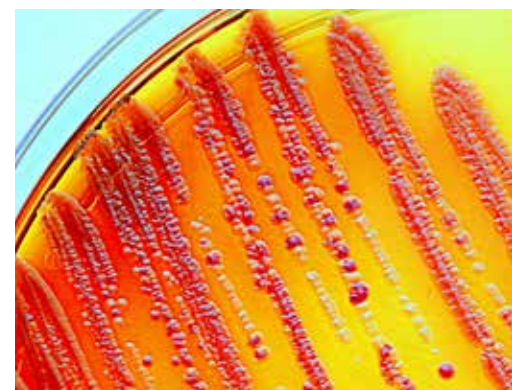
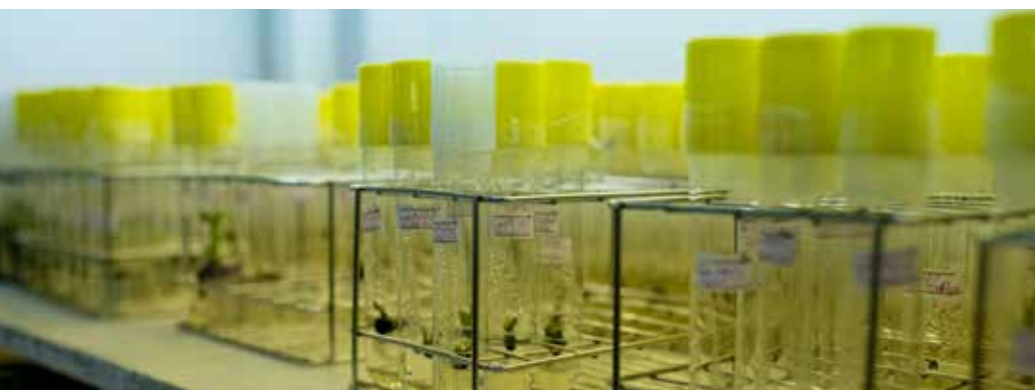
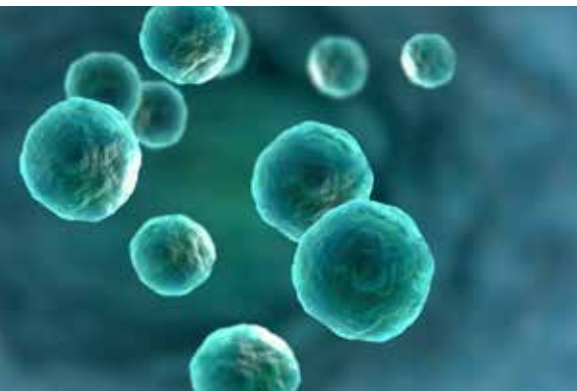


Bioscience facts and figures



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Foreword

Bioscience in the 21st Century has a vital role in driving opportunities for a more prosperous, sustainable and healthy society, in the UK and beyond.

Our generation is tasked with addressing sustainably three interconnected challenges: feeding a growing population whose diets are changing, with limited natural resources; reducing our reliance on fossil fuels; and ensuring our ageing population enjoys an improved health span to match increased longevity. BBSRC invests in world-class bioscience research, infrastructure, and people to ensure that the UK is best placed to find solutions to these major issues.

Cutting edge bioscience is at the heart of the bioeconomy. BBSRC's investments support creative frontier research that leads to breakthrough discoveries, development of innovative technologies to unlock new opportunities, and brings research discoveries and new capabilities together to tackle complex challenges faced by society. Finding solutions requires thinking across traditional disciplines and sector boundaries, so BBSRC works with a range of partners to support a pipeline of innovative and multidisciplinary research that impacts our lives.

Using credible, current, external figures, this act book has been compiled to set the scene in which bioscience operates, giving context to the challenges we face and highlighting the breadth and complexity of the research areas BBSRC supports. These facts are not exhaustive, but represent holistically the current landscape for BBSRC's interests and the growth of the bioeconomy.

BBSRC Investment

£332M – BBSRC research investment in 2015/16

£124.9M was invested in Agriculture and Food Security

£50.4M was invested in Industrial Biotechnology and Bioenergy (IBBE)

£56.8M was invested in Bioscience for Health

£136.3M was invested in World-Class Underpinning Bioscience

Values include shared capital and cross-cutting research

441 grants were awarded in 2015/16

£43M of funding was used to support **2000** PhD students

£74M invested in capital funding



The Bioeconomy

SECTOR FIGURES

€2.1 trillion – annual turnover for the European bioeconomy (EU-28; 2013)¹

18.3M – the number of people employed in the EU-28 bioeconomy (2013)¹

£220Bn – the total Gross Value Added (GVA) of the UK bioeconomy²,

of which:

£56Bn is the direct GVA of the bioeconomy (3.5 % of national GVA)²

£164Bn is the GVA from activities upstream and downstream of the bioeconomy²

5.2M – total number of jobs supported by the UK bioeconomy²

981,000 people are directly employed by the bioeconomy²

4.2M people are employed indirectly by the bioeconomy²

Frontier Bioscience

- **£738M**: UK investment made in early-stage life sciences in the first 6 months of 2014, making it the leading European destination for this kind of research.²
- The UK's field- eighted citation impact is strongest in biological, clinical and environmental sciences.²
- For every £1 spent by the UK on research, 50p is generated for the wider economy in **every subsequent year**.³
- **1st** – the UK's position among comparator countries for top-quality published research.⁴
- UK research receives **11%** of all citations for biological science publications.⁵

Innovation

- The UK is ranked second in the EU-28 and third in the world in the Global Innovation Index 2016.⁶
- The UK is the fourth-largest contributor to biotechnology research and development worldwide.²
- 4.9 % of UK interdisciplinary publications are collaborations with industry.⁷
- Interdisciplinary research papers are cited more often in patent applications.
- The UK held 3.13 % of the world's high-quality triadic patents filed in 2012, substantially higher than other larger countries. Triadic patents are those jointly filed at the European Patent Office, the United States Patent and Trademark Office, and the Japan Patent Office⁸
- 404 biotechnology patents were made by UK residents in 2011.⁸
- The UK ranks 7th worldwide for its share of total biotechnology patent applications.⁸

The Bioeconomy is defined as:

“All economic activity derived from bio-based products and processes which contribute to sustainable and resource-efficient solutions to the challenges we face in food, chemicals, materials, energy production, health and environmental protection.”

Bioscience Leadership Councils: Industrial Biotechnology Leadership Forum (IBLF), Agri-tech Leadership Council (ATLC), Synthetic Biology Leadership Council (SBLC). 2015.

UK BIOECONOMY
SUPPORTS
5.2 MILLION
JOBS ACROSS
THE UK



**GLOBAL
RANKING IN
BIOSCIENCE**

£220 BILLION GVA
VALUE OF UK BIOECONOMY

Agriculture and Food Security

SECTOR FIGURES

Food demand is projected to rise by at least **20%** globally in the next 15 years⁹

€165.7Bn – the GVA of agriculture in the EU-28 in 2014¹⁰

£107.6Bn – the GVA of the UK's broader Agri-Food sector (6.8 % of UK total) in 2015¹¹

£201Bn – consumer expenditure on food, drink and catering in 2015¹¹

£42.43 – the average spend on food and drink per person each week¹²

£8.7Bn – the GVA of UK farming in the year 2016-2017¹³

70% of the world's poor live in rural areas where agriculture is the primary industry¹⁴

793M people were undernourished worldwide in 2014-2016¹⁵

Economics

- The UK exported £20Bn of food, animal feed and drink in 2015.¹¹
- The UK imported £42.5Bn of food, animal feed and drink in 2015.¹¹
- The UK supplies 52 % of its own food; 29 % comes from EU countries.¹¹
- 3.9M people in the UK (13.5 % of the population) are employed in the broader Agri-Food sector (including fishing)¹¹
- In UK agriculture, forestry and fishing, 49 % of the workforce is seasonal.¹⁶
- 5 % of jobs in the agricultural sector are professional occupations such as veterinary surgeon, forestry and arboricultural consultant, biologist, agronomist and nutritionist.¹⁶

Natural Resources

- Globally, around 12 % of ice-free land is used for growing crops.¹⁷
- As of 2016, 17.4m hectares (71 %) of land in the UK were used for agriculture.¹³
- UK natural assets such as geology, soil and water were valued at £1.6 trillion in 2015 and are presently increasing in value.¹⁸
- Freshwater ecosystems comprise £39.5Bn of UK natural assets.¹⁹
- 65 % of global fresh water is in soil.¹⁷
- 10 % of the water used by the UK is consumed by agriculture.²⁰ 95,000 hectares of farmland are equipped for irrigation.²⁰
- The total store of organic carbon in soil is estimated to be 2300 gigatonnes.¹⁷
- Worldwide, 12M hectares of land are abandoned each year due to soil erosion arising from unsustainable farming practices.²¹

- It can take up to 1000 years to form one centimetre of soil.²²
- On average, earthworm presence in agroecosystems produces a 25 % increase in crop yield and a 23 % increase in above-ground biomass²³ in estimated 150 earthworms per metre squared of soil.²⁴

Cereal Crops

- In 2013 the FAO listed the global top five crops by production as sugar cane, maize, rice, wheat and potatoes.²⁰
- The world produced an estimated 2.61Bn tonnes of cereals in 2016, including 760.3M tonnes of wheat and 499.2M tonnes of rice.²⁵
- The UK's cereal exports are worth £2.1Bn annually.¹¹
- 392.5M tonnes of cereals were traded internationally in 2016-2017.²⁵
- The UK produced 16.6M tonnes of wheat, 7m tonnes of barley and 820,000 tonnes of oats in 2014.²⁶
- Over the past 30 years, more than 90 % of yield gains in the UK's major crops have been achieved through plant breeding innovation.²⁷

Horticulture including potatoes

- Global production of fruit and vegetables is 22 % short of the quantity needed to meet the world's nutritional requirements.²⁸
- The UK's single largest source of fruit and vegetable imports is Spain, with 20 % of fruit and 32 % of vegetables originating there in 2015.²⁹
- Poor weather in Spain in early 2017 decreased yields of vegetables commonly imported to the UK by 25 %, causing price increases of up to 40 %.³⁰
- Total exports of fruits and vegetables from the UK increased by 29 % between 2014 and 2015, to 287 thousand tonnes.²⁹

- The UK fruit and vegetables sector generated a GVA of £2.2Bn in 2015.¹¹
- UK household consumption of fruit has decreased by 11.4% since 2006.¹¹
- 104,411 tonnes of strawberries were grown in the UK in 2014.²⁶
- Extensions in the growing season, larger yields and an increased demand for soft fruit drove a 9.6% increase in UK fruit production in 2015, reaching £695 million in value.²⁹
- In 2016, the UK produced over 5 million tonnes of potatoes- a decrease of 5% since 2015, despite a larger area being planted.³¹
- The average net yield per hectare of potatoes in the UK is 45 tonnes.³¹
- The UK produced 94,857 tonnes of mushrooms and truffles in 2014.²⁶
- The UK produced 20% of its total supply of tomatoes in 2015, the highest proportion since 2002.²⁹

Livestock

- World annual meat production is projected to reach 376m tonnes by 2030.³²
- In 2013 there were 1.49Bn cattle, 1.17Bn sheep, 1.00Bn goats, and 977m pigs worldwide.²⁰
- 36% of meat consumed globally is pork (as of 2012).³³
- Global annual meat consumption is projected to reach 45.3kg per person in 2030, almost double the quantity consumed in 1966.³²
- In December 2016, the UK had 4.5 million pigs, 9.8 million cattle and 34 million sheep.³⁴
- In 2014 the UK produced 9546 tonnes of honey.³⁵
- UK households spent £2.18Bn on fresh and frozen beef in 2016-2017, up 0.6% on the previous year.³⁶
- In 2014, UK export of beef increased by 6%, with the top five export destinations being other EU member states.³⁷
- UK households spent £576.2M on fresh and frozen lamb in 2016-2017, a 12.5% fall from 2015.³⁶
- The UK is the largest producer of sheep meat in the EU, and has the largest flock in the EU, with over a quarter of the total EU flock (38). It exported almost 78,000 tonnes of sheep meat in 2016.³⁹

Dairy

- The UK is the third largest milk producer in Europe. Annual milk production in the UK was 14.5Bn litres in 2016, a 3.3% decrease from 2015, which saw the highest annual output since 1990.¹³

- Since 1975, the average milk yield per cow has increased by 93%.⁴⁰
- Milk accounted for 17.8% of total agricultural output in the UK in 2014, and was worth £4.6Bn in market prices.⁴⁰
- In March 2016 the price of milk at the farm gate fell to 22.4p per litre,⁴¹ the lowest since 2009.⁴⁰
- There are 1.9M dairy cows in the UK, and the average size of a UK dairy herd in 2015 was 142.⁴¹
- Mastitis affects around 30 cows in every hundred each year in the UK.⁴² It costs the UK dairy industry approximately £200m per year.⁴³
- In 2014, the UK produced 410,000 tonnes of cheese.³⁵

Poultry and Eggs

- World poultry production increased by 104.2% from 1990 to 2012.³³
- 79.9% of all meat consumed by people in the UK is poultry (33.1kg/person/year).⁴⁴
- The UK slaughtered 73.1M chickens and 1.9M turkeys in December 2015 to produce 130,500 tonnes of poultry meat.⁴⁵
- The UK imported £2Bn and exported £350M of fresh and frozen poultry in 2014.⁴⁴
- In 2016, the UK produced 10.4Bn eggs, but consumers bought 12.6Bn eggs.⁴⁶
- The UK's egg consumption is estimated to have grown by 2Bn eggs per year between 2004 and 2015.⁴⁷
- Free range egg sales made up 53% of the retail market in 2015, up from 32% in 2004.⁴⁸

Fisheries

- In the 1960s the average person consumed 9.9kg of fish each year; by 2012 consumption had grown to 19.2kg per person (worldwide).⁴⁹
- Worldwide capture production of fish has increased from 90.8m tonnes in 2007 to 91.3M tonnes in 2012.⁴⁹ The UK is the second largest producer of fish by volume in the EU-28.⁵⁰
- 12,000 fishermen work in the UK, landing 600-700,000 tonnes of fish each year.⁵¹
- 97% of UK households bought seafood in 2015-2016, spending £6.24Bn (a 1.3% increase on 2014-2015).⁵²
- Salmon, cod and tuna are the top three fish eaten in the UK by value and volume.⁵²

Aquaculture

- Global aquaculture production reached 97.2M tonnes in 2013.⁵³

Agriculture and Food Security

- The UK is the second largest aquacultural producer in the EU-28 by volume, but the largest by value, worth £958M in 2014 and almost doubling in value since 2000.⁵⁰
- In 2014, the UK aquaculture industry produced 193,000 tonnes of fish and 22,000 tonnes of shellfish.⁵⁴
- Salmon, mussels and trout make up 98 % of UK aquaculture.⁵⁰
- The overall estimated value of the UK shellfish industry in 2012 (£33.2M) represents a 74 % increase from 2011.⁵⁵
- Aquatic parasites are estimated to cause annual losses to the global aquaculture finfish industry between 1.05bn USD and 9.58bn USD.⁵⁶
- Shortages in fishmeal and fish oil, commonly used to feed carnivorous farmed fish like salmon, are driving research into the use of alternatives such as soybean products and vegetable oils.⁵⁷
- Farmed fish can be sterilised via triploid induction (inserting an extra set of chromosomes), which removes the risk of interbreeding with wild fish whilst boosting productivity and extending harvest windows.⁵⁷
- There is growing interest in vaccine development for farmed fish, with vaccines under development against sea lice and Infectious Pancreatic Necrosis.⁵⁷
- There was a 60 % increase in UK Pacific oyster production from 2011 to 2012.⁵⁵

Livestock Disease Prevention

- Mastitis, lameness and bovine viral diarrhoea are the top three causes of losses in the UK cattle industry, costing £273.6M per year.⁵⁸
- On average, UK dairy farmers spend £7,531 on antibiotics each year.⁵⁹
- Vaccination led to the global eradication of rinderpest, a disease of ruminants. Eradicating rinderpest saved African countries US\$1Bn annually.⁶⁰
- A herd breakdown due to bovine tuberculosis (bTB) infection costs the farmer £14,000 and the government £20,000 on average.⁶¹
- Over 9M TB tests were conducted on cattle in Great Britain in the year ending September 2015.⁶¹
- An outbreak of foot and mouth disease in 2001 cost the UK between £6Bn and £9Bn, with £91M paid in compensation to farmers.⁶²
- The BSE outbreak in the 1990s cost £4.2Bn to enact control policies and caused £1.15Bn in economic losses for the affected industries.⁶³
- Bluetongue virus (BTV) causes swelling, nasal discharges and other symptoms in ruminants.⁶⁴ The virulent strain BTV-8 reached Europe in 2006 and an outbreak occurred in the UK in 2007.⁶⁵ Isolation of farms to prevent a wider UK outbreak averted losses of £485M and 10,000 jobs.⁶⁶

Crop Protection

- The global annual cost of losses due to plant diseases is US\$220Bn.⁶⁷
- Globally, it is estimated that weeds cause comparable crop losses to those caused by insect pests and crop diseases combined.⁶⁸
- UK crop protection averts losses of £4Bn.⁶⁸
- The total cost of bringing a crop protection product to market is US\$260M.⁶⁹
- In 2014, the UK's national agrochemical market was worth almost 7Bn Euros. It has the sixth-largest agrochemical market (all crops) in the EU, and ranks third for products intended for cereals, potatoes and rape.⁷⁰
- Europe's share of crop protection R&D investment has fallen from 33.3 % in the 1980s to 7.7 % this decade.⁷¹
- Biological control agents, such as predatory mites and parasitic wasps, made up 55 % of pest control method applications by area on UK crops in 2014. This was 5 times greater than the area treated with insecticides.⁷²
- In 2013, the European Commission restricted the use of three neonicotinoid pesticides out of concern for honey bees.⁷³
- Septoria tritici blotch, a fungal disease, is the most important wheat disease in the UK, with reported losses of up to 50 % in some wheat varieties.⁷⁴
- Herbicide resistance in black-grass has been confirmed in 35 counties in England. Resistance also occurs in wild oats (detected in 28 UK counties), rye-grass (33 counties) and has recently emerged in poppy (9 counties) and common chickweed (13 counties).⁷⁵
- Wheat yield losses due to black-grass are reported to be 0.4-0.8 tonnes per hectare (T/ha), with losses of over 2 T/ha recorded.⁷⁶
- No herbicides with novel modes of action have been brought to market for over 20 years.⁷⁷

Pollinators

- Insect pollination is important for at least 87 types of leading global food crops, from which >35 % of the global food supply is produced annually (by volume).⁷⁸
- 5-8 % of current global crop production, with an annual market value of \$235billion- \$577billion US dollars, is directly attributable to animal pollinators.⁷⁹
- There are 630,000 beekeepers and 16M hives in the EU.⁸⁰
- As of 2012, there were almost 20,000 managed bee colonies in the UK.⁸¹
- Replacing bee pollination with hand pollination would cost £1.5Bn annually, more than the market value of the crops.⁸²

- In absence of animal pollinators, changes in consumer prices and loss of profits would generate annual losses of up to \$191 billion globally to consumers and producers, with knock-on effects to other industries of up to \$497 billion.⁷⁹
- Grassland provides more nectar for pollinators than other types of land in Britain.⁸³

Food Waste

- Global food waste and loss across the food supply is estimated to be 1.3Bn tonnes annually.⁸⁴
- The majority of food waste occurs outside the home.⁸⁵
- Sub-optimal agricultural and commercial practices (pre-consumer) waste 1.2-2Bn tonnes (30-50%) of all food produced, equating to almost 1.4Bn hectares of agricultural land.⁷⁸
- In high-income regions, more food is wasted in the later stages of the food supply chain, while in low-income regions more wastage occurs at the early stages.⁸⁶
- Food loss/wastage amounts to US\$680Bn in industrialised countries and US\$310Bn in developing countries, but roughly the same quantity of food is wasted by each (670M and 630M tonnes each).⁸⁷
- Around 10M tonnes of food and drink is wasted in the UK supply chain every year.¹¹
- Food manufacturing wastes 1.2M tonnes of food per year; around half of what is available.¹¹
- The average UK household threw away £470 of edible food in 2015 (11); 4.2M tonnes (£12.5Bn) of avoidable household food waste occurs annually.⁸⁸
- Avoidable food wastage in the UK fell by 21% between 2007 and 2012.⁸⁸
- In 2015, 0.66 million tonnes of food surplus was diverted to make animal feed.¹¹

Climate Change

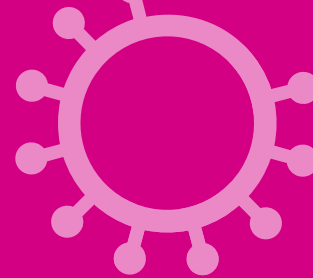
- Sources of greenhouse gas emissions from agriculture include livestock, agricultural soils, stationary combustion sources and off-road machinery.⁸⁹
- Agriculture produced 10% of UK greenhouse gas emissions in 2015. Emissions from agriculture have declined by 17% since 1995.⁹⁰
- Production and consumption of meat and meat products contributes up to 12% of all greenhouse gases generated by private product and service consumption in the EU.⁹¹
- If all potential environmental improvements for meat and dairy production and consumption were combined, the environmental impacts of the industry could be reduced by 20%.⁹¹

- Agriculture contributes 84% of the UK's emissions of N₂O, but only 1% of its CO₂ emissions.⁹²
- 90% of agriculture's N₂O emissions are from soil microbial activity after application of fertiliser and manure. The Committee on Climate Change has urged Defra to meet its policy target for all soils to be sustainably managed by 2030.⁹³
- Emissions generated by the application of synthetic fertilisers are the fastest-growing source of emissions in agriculture.⁹⁴ World fertilizer nutrient consumption was estimated to have reached 186.9M tonnes in 2015.⁹⁵
- Great British farmers apply on average 146kg of mineral nitrogen fertiliser per hectare of cropped land.⁹⁶
- Climate change threatens UK agriculture through the increased risk of flooding and drought, with over 1 million hectares of high-grade agricultural land projected to be at high risk of flooding by the 2050s under a 4°C climate scenario, whilst the agricultural water supply-demand gap could be up to 115 billion litres a year in a dry year England in the 2020s.⁹⁷

Genetic Modification

- GM crops acreage has been increasing steadily since 1996, with an increase of ~10-20M acres per year for the last 20 years.⁹⁸
- On average, GM technology adoption has reduced chemical pesticide use by 37%, increased crop yields by 22% and increased farmer profits by 68%.⁹⁹
- Chickens genetically modified to prevent them spreading bird flu have been produced by researchers at the universities of Cambridge and Edinburgh.¹⁰⁰
- The creation and production of GM organisms is regulated by national government.^{101,102} and international governing bodies.^{103,104}

Industrial Biotechnology and Bioenergy



SECTOR FIGURES

US\$293.5Bn – the estimated global revenue from the biotechnology industry in 2015¹⁰⁵

US\$314.7Bn – the projected global revenue from the biotechnology industry by 2021¹⁰⁵

Industrial biotechnology market demand in the EU is expected to grow from **€28Bn** (2013 estimate) to **€50Bn** in 2030¹⁰⁶

£2.9Bn – UK industrial biotechnology and bioenergy sector annual turnover from direct activities, 2013/14¹⁰⁷

£4.1Bn – projected turnover for UK industrial biotechnology and bioenergy in 2020¹⁰⁷

2.5Bn tonnes carbon dioxide (equivalent) – the potential climate change mitigation from industrial biotechnology achievable by 2030¹⁰⁸

10% – the proportion of the UK's future energy demands that could be met with bioenergy¹⁰⁹

225 companies employ approximately **8,800 people** in UK industrial biotechnology¹⁰⁷

£1.5Bn – the equivalent contribution of IBBE to UK exports¹⁰⁷

Economics

- UK industrial biotechnology saw an 11 % compound annual growth rate over the period 2009 to 2013 (employment growth rate was 5 %).¹¹⁰
- In 2015 UK biotechnology businesses spent approximately £1.8Bn on equipment, materials and services (£1Bn+ with domestic suppliers).¹⁰⁷
- The agro-industry and biofuels segments account for 42 % of employment and 45 % of turnover in the UK industrial biotechnology sector.¹¹¹
- Industrial biotechnology and bioenergy accounts for around 23 % of exports from UK bioeconomy sectors, worth £7Bn in 2014.²
- Biofuels generate €6Bn for the EU, employing 150,000 people.¹¹²
- The UK Pharma market is expected to undergo an average annual growth rate of 4-7 % to 2021.¹¹³
- Europe produces 60 % of the world's enzymes¹¹⁴ – the European enzyme industry has an annual turnover of around €800M and employs approximately 5,000 people.¹¹²
- The UK's revealed technological advantage in biotechnology (its share in biotechnology patents relative to its share in total patents) is the third highest in the world.²

Biomaterials and Biochemicals

- Around 150,000 people are employed in biomaterials and biochemicals in the EU, turning over approximately €50Bn.¹¹²
- The UK bio-based chemicals and bioplastics industry is estimated to have a turnover of around €4.6 billion, and provides approximately 16,200 jobs. The industry is expected to grow in Europe and the UK.²
- The majority of global bioplastics are used in packaging; 88,000 tonnes of European-made bioplastics are used in non-food packaging.¹¹⁵
- The current annual domestic demand for bioplastic products is 4,000 tonnes, of which 1,000 tonnes are produced in the UK, supporting around 1,000 jobs and providing a GVA of £50.4M to the UK economy.¹¹⁵
- The global biomaterials market is projected to reach USD 149.17 billion by 2021, driven largely by innovation in orthopaedic biomaterials and the growing demand for them as populations age.¹¹⁶

Bioenergy

- Temperatures in the UK have increased 1°C in the last 100 years; half of this increase has occurred since the 1970s.¹¹⁷
- 190 countries were involved in the 2015 Paris Climate Conference, which set a legally binding target of reducing greenhouse gas emissions by 80 % by 2050.¹¹⁸
- The world's total primary energy supply more than doubled between 1973 and 2013, and the proportion of this supplied by biofuels and waste increased from 2.3 % to 5.5 %.¹¹⁹
- Global bioenergy demand is projected to increase by 39 % by 2030.¹²⁰

- 72 % of the UK public support the use of bioenergy and 81 % support converting waste to energy.¹⁰⁹
- The most common biofuel crops grown in the UK are oilseed rape, sugar beet and wheat. In 2015, 93,000 hectares of UK agricultural land (just under 2 % of arable land) were used for bioenergy, mostly for transportation-related biofuels.¹²¹
- In 2015, there was a 20 % increase in the plant biomass used to generate electricity in the UK compared to 2014. Its energy content was equivalent to 4M tonnes of oil.¹²²
- It has been estimated that biofuels could add £60Bn to the bioeconomy.¹²³
- 498M litres of renewable fuel were supplied to the UK in 2015-2016, 3.3 % of all road and mobile machinery fuel.¹²⁴
- UK-produced biofuels made up 25 % of biofuels used on British roads in 2015/2016,¹²² up from 9 % in 2008-2009.¹²¹
- In 2015-16, biofuel use created an aggregate greenhouse gas saving of 68 % compared to fossil fuels- the equivalent of taking 1.21 million cars off the road.¹²⁴
- In 2015-16, 30 % of the UK's biofuels originated from crops grown in the UK.¹²² The UK exported 22 % of its biodiesel supply in 2015.¹²⁴

Feedstocks and sustainability

- The target of recycling 50 % of household waste by 2020 has been set by the EU Waste Framework Directive.¹²³
- The UK generates almost 300M tonnes of waste annually.¹²³ 100M tonnes of this is carbon-containing waste, around a quarter of which could potentially be converted to bioethanol.¹⁰⁹
- It is estimated that the UK could produce £2.4Bn worth of bioethanol from waste.¹²³
- In 2015-16, 59 % of biofuel meeting Renewable Energy Directive sustainability requirements was made from waste or non-agricultural residue.¹²⁴
- 19 % of biodiesel is made from used cooking oil sourced from the UK.¹²⁸
- An estimated 100M tonnes of UK waste could be fed into biogas production.¹²³ Manures and slurries comprise the majority of this (67M tonnes).¹²³
- 44.3 % of UK household waste was recycled in 2015, increasing from 40.4 % in 2010; the EU target for household waste recycling in 2020 is 50 %.¹²⁵
- Bioisoprene monomers can be used to make synthetic rubber tyres without the need for a petroleum-based feedstock.¹²⁶
- Around 25M tonnes of seaweeds and algae are harvested internationally each year, for uses such as food, laboratory chemicals and cosmetics.⁴⁹

Healthcare and IB

- In 2014 the UK biopharmaceutical industry employed 73,000 people and generated a trade surplus of £5Bn.¹²⁷
- In 2012, biotech products accounted for 71 % of the revenue generated by the 10 top selling drugs worldwide, a dramatic increase from only 7 % in 2001.¹²⁸
- The UK biopharmaceuticals industry supplies 90 % of all medicines used by the NHS, and are researching and developing over two-thirds of the current medicines pipeline.¹²⁹
- Sales of clinical biotechnology products reached US\$163Bn in 2012.¹²⁸
- In 2014, five vaccines each posted worldwide sales exceeding US\$1Bn.¹³⁰
- 457 people died in the UK as a result of the swine flu (H1N1) outbreak in 2009.¹³¹ The UK spent £505.42M on pharmaceuticals such as antivirals, vaccines and antibiotics in the response to H1N1.¹³¹
- Biologic medicines (medicines manufactured in a living system) are projected to make up 15 % of New Active Substances to become available between 1996 and 2020.¹³²
- Monoclonal Antibodies (MABs) and human insulin underpin much of the growth in biologics, with four out of the world's top five biologics in 2012 being MABs.¹³³
- Biologics are expected to improve the treatment of various autoimmune diseases, with spending in this area expected to reach \$75-90BN by 2021.¹¹³
- In 2014, the meningococcal group B vaccine became the first biologic to be given a FDA Breakthrough Therapy Designation.¹³²

Bioscience for Health

SECTOR FIGURES

Global life expectancies range from **49** in Swaziland to **84** in Hong Kong and Japan¹³⁴

79 and 82 years – the life expectancy of men and women born in the UK in 2012¹³⁵

64.2 years – the healthy life expectancy of people born in the UK in 2011¹³⁵

11.6M – the number of UK residents aged over 65 in 2015¹³⁶

40 years – the median age of UK residents in 2015, the highest ever recorded¹³⁶

16M people aged less than 70 die prematurely each year from non-communicable diseases worldwide¹³⁷

40M people die annually (worldwide) from cardiovascular diseases, cancer, respiratory diseases and diabetes¹³⁸

£538M and £14M – the cost of *Campylobacter* and *Salmonella* respectively to the UK each year¹³⁹

5Bn – the trade surplus generated by the UK health life sciences industry per year¹⁴⁰

Economics

- 137.3 million working days were lost due to sickness or injury absences in the UK in 2016.¹⁴¹
- 30.4 million working days were lost due to work-related illness or injury in the UK in 2015-16.¹⁴²
- Birmingham City Council's Be Active scheme provided free exercise and leisure facilities – every £1 invested in the scheme saved £23 through health benefits¹⁴³
- Nearly 1.8 million people are employed across the UK in health-related businesses,¹⁴⁴ with 235,000 employed in Medical Technology and Biopharma sectors ("health life sciences") in 2016.¹⁴⁵
- The UK health life sciences industry's turnover from sales represents 6 % of world market sales.¹⁴⁰
- Two thirds of employment in UK health life sciences is outside of London and the South East.¹⁴⁵
- SMEs with fewer than 250 employees make up 96.5 % of total UK life health science companies.¹⁴⁵

Healthy Ageing

- In the early 1950s, global life expectancy at birth was 47 years. In the late 2000s it had increased to 69.⁷⁸
- Increases in healthy, disability-free life expectancy for UK residents are not matching increases in lifespan in over-65s.¹³⁵
- Men and women born in the UK in 2040 can expect to live for 84.5 and 87.7 years respectively.¹³⁵
- Since mid-2005, the UK population aged 65 and over has increased by 21 %, and the population aged 85 and over has increased by 31 %.¹³⁶
- Around 103,000 people under the age of 75 die from preventable diseases in the UK each year.¹⁴⁶

- An estimated 850,000 people in the UK are living with dementia, around 1.3 % of the population.¹⁴⁷
- It is estimated that around 3M people in the UK have osteoporosis.¹⁴⁸
- 50 % of people over 80 fall at least once each year; fall-related injuries cost the NHS £2.3Bn each year.¹⁴⁹
- Approximately 80,000 people are treated for a hip fracture in the UK each year, at an annual cost of £2Bn.¹⁵⁰

Diet and Nutrition

- Public expenditure on malnutrition in healthcare in England (2011-2012) was around £15.2Bn.¹⁵¹
- In 2015 approximately 795M people were undernourished, 167M fewer than in 2005.¹⁵
- Around 1.3M people over 65 in the UK are malnourished at any one time and 50 % of people admitted to hospital from care homes are at risk of malnutrition.¹⁵²
- The WHO recommends that adults consume less than 5g of salt per day.¹⁵³ Salt consumption in the UK decreased from 9.5g per day in 2003 to 8.1g per day in 2011; in the same period, UK deaths from ischaemic heart disease and stroke fell by 42 % and 40 % respectively.¹⁵⁴
- Fewer than 10 % of children meet the 'five-a-day' recommendation for fruit and vegetables.¹⁵⁵
- 45 % of men and 41 % of women in the UK eat fewer than 3 portions of fruit and vegetables a day, versus 25 % of men and 28 % of women who eat 5 or more.¹⁵⁶
- UK adults consume less than 40 % of the recommended levels of oily fish, whilst children under 10 consume less than 10 %.¹⁵⁵
- Soft drinks and fruit juice compose 30 % of the sugar intake of 11-18 year olds.¹⁵⁵

Obesity

- Worldwide obesity has more than doubled in the last 35 years.¹⁵⁷
- In excess of 1.9Bn adults worldwide were overweight in 2014, of which 600M were obese.¹⁵⁷
- In 2013, 42M children aged under five worldwide were overweight or obese.¹⁵⁷
- High body mass index is the fourth most important risk factor for disease for people in the UK.¹⁵⁸
- In 1980, 39 % of people in the UK were overweight or obese;¹⁵⁹ in 2014 the figure was 61.5 %¹⁶⁰
- Around 27 % of adults in the UK are obese, and a further 41 % of men and 31 % of women are overweight. 28 % of children aged 2 to 15 are overweight or obese.¹⁶¹
- Overweight and obesity related health problems cost the NHS £5Bn each year.¹⁶² Reducing cardiovascular events by just 1 % would save the NHS at least £30M each year.¹⁶³
- The cost of obesity to the NHS could reach £10Bn by 2050, while the wider cost of obesity to UK society could reach £49.9Bn.¹⁶⁴

Gut Health

- The human body is composed of an estimated 37.2 trillion cells¹⁶⁵ but the human gut is home to tens of trillions of microorganisms, including more than a thousand different species of bacteria.¹⁶⁶
- We carry as many as ten microbial cells for every human cell in our bodies.¹⁶⁷
- Humans have 20,000-25,000 genes, but more than 10M unique genes are found within the microbes of our guts.¹⁶⁶
- The microbial cells we carry can weigh up to 2kg.¹⁶⁷
- The gut microbiota's composition and health is thought to have significant effects on human metabolism and immunity, with implications for obesity, disease and autoimmune conditions.¹⁶⁸
- Irritable Bowel Disease (IBD) affects up to 11 % of people globally.¹⁶⁹
- More than 300,000 people in the UK are affected by Crohn's Disease and ulcerative colitis, the two main types of IBD.¹⁷⁰ The cost of IBD to the NHS was conservatively estimated to be £470M per annum.¹⁷¹

Nutraceuticals

- The vitamin supplement industry is worth around £675M to the UK and US\$30Bn to the US.¹⁵⁵
- The global probiotic market was valued at US\$62.6Bn in 2014 and is predicted to rise to US\$96Bn by 2021.¹⁷²
- The global nutraceuticals market was valued at US\$182.6Bn in 2015 and is expected to reach almost US\$279Bn in 2021.¹⁷³

- 55 % of food, 36 % of pharmaceuticals and 90 % of biotech firms are actively researching nutraceutical products.¹⁷⁴
- Establishing verified health claims for probiotics would support growth – a 1 % increase is worth £2M per year to the UK market.¹⁷⁵

Zoonotic Disease

- About 75 % of recently emerging infectious diseases affecting humans are diseases of animal origin; approximately 60 % of all human pathogens are zoonotic.¹⁷⁶
- Human hepatitis E cases have increased significantly in recent years and it is increasingly being recognised as a major zoonosis. There were 1,054 cases reported in the UK in 2014, a 33 % increase from 2013.¹⁷⁷
- In 2015, the Food Standard Agency recorded 277 incidences of food contamination by pathogenic micro-organisms.¹⁷⁸
- *Campylobacter* was responsible for around 321,000 cases of food poisoning in England and Wales in 2008, costing £583M in hospital admissions and other expenses.¹⁷⁹
- Up to four in five cases of *Campylobacter* poisoning in the UK come from contaminated poultry.¹⁸⁰
- Salmonella causes around 2,500 hospital admissions each year in the UK.¹⁸¹

Companion Animals

- As of 2015 there were 8.5M dogs and 7.4M cats in the UK.¹⁸²
- Around half of UK households own a pet, not including fish.¹⁸²
- Total spending on pets and pet products in the UK reached £4.58Bn in 2016, almost doubling since 2005. The cost of pet services including veterinary care made up £3.5Bn of this.¹⁸³
- It is estimated that pet ownership in the UK may reduce NHS costs by £2.45 billion a year, through improvements in owner wellbeing and health, and use of trained animals to assist patients with certain conditions.¹⁸⁴
- 75 % of over 65s believe that their pet gives them a better social life.¹⁸⁵
- 55 % of animal medicines bought in the UK in 2015/16 were for companion animals.¹⁸⁶
- In 2016, 84 % of pet owners had their pet vaccinated with a primary course of vaccines, an increase of 7 % since 2015.¹⁸⁷
- A record £706m was paid out by pet insurers in 2016, or £1.8m per day. This reflects the expanding range of treatments available and rising vet bills.¹⁸⁸

Bioscience for Health

Vaccinology

- The World Health Organization has a target of 95 % for key human immunisations.¹⁸⁹
- UK coverage of routine childhood vaccinations at one and two years fell from 92.7 % in 2013-2014 to 92.3 % in 2014-2015.¹⁸⁹ The UK spent £136M on vaccines for animals in 2015.¹⁸⁶
- There are approximately 600 vaccine candidates in development against an estimated 110 human pathogens worldwide.¹⁹⁰
- The UK market for animal vaccines in 2014-15 was £136M,¹⁸⁶ an increase of £54.4M.¹⁸⁶

Antimicrobial Resistance

- Efforts to tackle drug-resistant infections are predicted to require a global fund of at least £5 billion per year.¹⁹¹
- 700,000 deaths each year (worldwide) are attributable to antimicrobial resistance.¹⁹²
- By 2050, the global number of deaths attributable to antimicrobial resistance (AMR) annually could reach ten million, reducing GDP by 2-3.5 % and costing US\$100 trillion.¹⁹²
- The European Centre for Disease Prevention and Control (ECDC) estimates that antimicrobial resistance (AMR) costs the EU about €1.5Bn annually.¹⁹³
- Infectious diseases of humans costs England around £30Bn annually.¹⁹⁴
- Between 2010 and 2013 antibiotic consumption in the UK increased by 6 %.¹⁹³
- 79 % of UK antibiotic prescriptions are issued through general practice.¹⁹⁵
- The highest incidence of AMR is in *Escherichia coli* (18 % of infections resistant to fluoroquinolones, 10 % to cephalosporin and 10 % to aminoglycosides).¹⁹⁴

Allergies

- More than 17M Europeans suffer from food allergies; 25 % of school age children in Europe have an allergy.¹⁹⁶
- Around 2 % of the UK population (1.2M people) has a food allergy.¹⁹⁶
- Walnuts, hazelnuts and peanuts are responsible for half of all life-threatening allergic reactions in the UK.¹⁹⁶

Use of Animals in Research

- Overall the public (British adults aged 15+) is supportive of the use of animals in scientific research. 68 % agree it is acceptable 'so long as it is for medical research purposes and there is no alternative'.¹⁹⁷
- 76 % of the public believe more work should be done to find alternatives to using animals in such research.¹⁹⁷
- In 2015, 4.14 million animal experimental procedures were completed- an increase of 1 % from 2013.¹⁹⁸
- 61 % of animal experimental procedures performed in 2015 were carried out on mice.¹⁹⁸
- Approximately half of procedures performed on animals in 2015 were related to the creation or breeding genetically altered animals; the remainder were experimental procedures. Experimental procedures have increased by 3 % since 2013, and an extra 1 million procedures to breed/create genetically altered animals were carried out.¹⁹⁸
- 0.8 % of procedures were carried out on specially protected species (non-human primates, cats, dogs and horses).¹⁹⁸
- Between 2004 and 2014, the National Centre for the Replacement Refinement & Reduction of Animals in Research invested £40 million into research that minimises the use of experimental animals and improves their welfare.¹⁹⁹ Over half of its investment has been into efforts to replace animal usage with alternatives such as computational models.²⁰⁰

New Tools and Technologies

SECTOR FIGURES

US\$11.7Bn – the predicted value of the global DNA sequencing market by 2018 versus US\$3.5Bn in 2012²⁰¹

£815M – the value of the UK genomics industry, 10 % of global market value²⁰²

DNA sequencing is the largest component of the UK genomics sector with a value of **£530M**²⁰²

£25Bn – the estimated value of big data to UK businesses in 2011, via efficiencies, innovation and business creation; this may reach an annual value of **£41Bn** by 2017²⁰³

Public molecular data and services contribute to the wider realisation of future research impacts worth **£920M** annually²⁰⁴

The European Bioinformatics Institute (EBI) is the UK branch of the intergovernmental European Molecular Biology Laboratory (EMBL). EMBL-EBI underpins future research impacts worth **£335M** annually²⁰⁴

New genome editing techniques such as CRISPR/Cas9 have cut the time taken to make changes to the mouse genome from six months to one month²⁰⁵

Big Data

- 10 % of the data at EMBL-EBI is genomic data. The amount of genomic data stored more than doubles every year.²⁰⁶
- 15 European nations and EMBL-EBI are participating in ELIXIR, a project that provides sustainable, distributed infrastructure for managing, safeguarding and sharing biological data.²⁰⁷
- The UK has the first non-US node of the iPlant Collaborative (now CyVerse) which provides computational capacity for big data for all life science research.²⁰⁸
- Maintaining the European arm of the protein database PDB costs less than 10 % of price of generating the data that is deposited each year.²⁰⁷
- EMBL-EBI is one of the world's largest repositories for biological data, storing 20 petabytes of data on genes, proteins and small molecules.²⁰⁶
- EMBL-EBI had an estimated 198 000 direct active users during the year to May 2015, who accessed data 88M times.²⁰⁴
- The first whole cell computational model, published in 2012, incorporated 1900 parameters. It was built to predict the biology of the simple bacterium *Mycoplasma genitalium*.²⁰⁹
- The UK BioBank contains biological and lifestyle data from a cohort of 500,000 participants, along with their health records over time. It has been used to discover factors affecting a broad range of health conditions. An estimated one in thirty Britons has taken part in large prospective cohort studies such as this.²¹⁰
- The Registry of Research Data Repositories lists over 900 life science data repositories worldwide, where data is stored permanently and made accessible to the public and other researchers.²¹¹

Next-Generation Sequencing

- DNA sequencing techniques were first developed in the 1970s.²¹²
- The first genome was sequenced in 1972- a single-stranded RNA virus with a tiny genome of 3,569 bases.²¹³
- The nematode worm *Caenorhabditis elegans* was the first animal to have its genome sequenced in 1998, in collaboration between the UK's Sanger Institute and the Genome Institute in Washington.²¹³
- The first plant genome, or *Arabidopsis thaliana*, was published in 2000.²¹⁴
- The amount of DNA sequenced worldwide doubles approximately every seven months.²¹⁵
- The human genome is around 3.0×10^9 bases (Adenosine, Thymidine, Cytidine or Guanosine molecules) long.²¹⁶
- The first human genome sequence cost around £300M and was completed in 13 years – a complete genome sequence was published in 2004. With NGS the cost of sequencing a whole genome now costs as little as US\$1000²¹⁷ and takes only a couple of days to complete.²¹⁸
- 1012 animal species (including 245 mammals), 354 plant species, and almost 95,000 prokaryote species have had their genomes sequenced.²¹⁹
- Four of the top five crops by production (maize, rice, wheat and potato)²⁰ have had their genomes sequenced.²²⁰ Sequencing of the fifth, sugarcane, is in progress.²²¹
- The wheat genome sequence is 17Bn bases long, approximately five times larger than the human genome.²²²
- Computational modelling and high-throughput sequencing approaches are providing increasingly viable alternatives to animal usage in toxicology studies, with at least 63 methods that refine, reduce or replace animal usage approved by regulatory authorities.²²³

New Tools and Technologies

Synthetic Biology

- Synthetic biology is “the design and engineering of biologically based parts, novel devices and systems as well as the redesign of existing, natural biological systems”.²²⁸
- The UK aims to achieve a £10Bn UK synthetic biology market by 2030.²²⁹
- The UK has invested £300M of public funds in synthetic biology over the last eight years²²⁹, including over £12M for DNA synthesis facilities and training.²³⁰
- The first ‘synthetic’ organism *Mycobacterium laboratorium* was created in 2010. An artificial genome was transplanted into an empty cell which then survived and reproduced.²³¹
- UK scientists are part of an international consortium to create Sc2.0, an entirely synthetic yeast genome. They have reduced genome size by almost 8% without impacting survival, and have inserted, deleted or altered 1.1 megabases. The genome has been made available for customisation by the research community, creating opportunities to answer novel research questions with relevance to eukaryotic genomes such as our own.²³²
- In 2013 Amyris began commercial production of artemisinin, an anti-cancer drug using an engineered yeast strain.²³³
- The UK is considered to be a world leader in the emerging field of GM insect technology, with scope for further commercial development.²³⁴ Oxitec, a UK biotechnology company that developed sterile mosquitos for disease control, was sold for £102M in 2015.²²⁹
- The emerging genome editing tool, CRISPR-Cas9, has a success rate more than double that of earlier endonuclease-based editing technologies.²³⁵
- The development of the CRISPR-Cas9 technology involved tool-sharing between more than 80 laboratories.²³⁶
- The first phase I CRISPR-Cas9 medical trial on human patients is now underway in China, editing the T-cells of metastatic lung cancer patients to attack cancer cells.²³⁶

Microscopy

- The first published account of microscopy was written in 1665 by Robert Hooke, a Fellow of the Royal Society of London.²²⁴
- The diffraction limit was first broken in 2000 by the use of stimulated-emission-depletion (STED) microscopy.²²⁴ Since then, super-resolution microscopy has bypassed the diffraction limit by about 100-fold.²²⁵
- The world’s first commercial scanning electron microscope was launched at Cambridge University in 1965. The spinout Cambridge Instrument Company sold more than 200 in the first 3 years of production.²²⁶
- Cryo-electron microscopy, a technique for analysing the atomic structure of proteins, has reduced the number of particles required per analysis from millions to as few as 10,000. Increases in processing power and cloud computing have reduced the costs of analysis to USD1500 per protein.²²⁷

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