

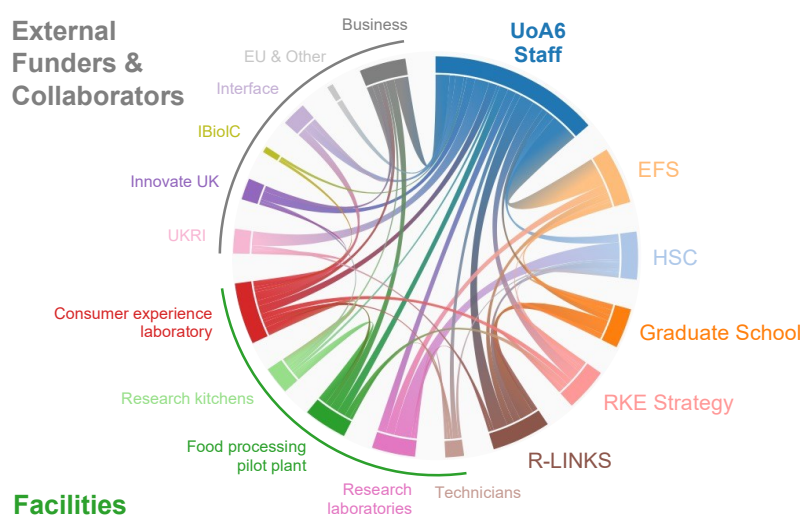
**Institution: Abertay University**

**Unit of Assessment: 6 (Agriculture, Food and Veterinary Sciences)**

## 1. Unit context and structure, research and impact strategy

### 1.1 Unit context and structure

Abertay has been named the top modern university in Scotland (2017 & 2019). Although we are one of the smallest Scottish universities, we produce high-quality research and knowledge exchange and deliver real impact for society. Our university's Research and Knowledge Exchange (RKE) Strategy guides our research activity and brings together School and Divisional planning, staff management, research studentships, and central funding in five-year plans. This strategy, known as R-LINCS (Research-Led Innovation Nodes for Contemporary Society), fosters innovative approaches to address research questions for societal and economic impact. R-LINCS supports interdisciplinary and cross-institutional research through a single Abertay-wide initiative. We have organised our research into four contemporary themes and provide focussed support for our academic and postgraduate student researchers (2014-19). We have refreshed our strategy to use our expertise to target specific challenges presented by modern society in the current RKE Strategy (2020-25). RKE-teaching links are also essential in our academic 'ecosystem' operating context, and we aim to increase the pervasiveness of our research culture underpinning everything we do in basic research, translational research (knowledge exchange), impact, and teaching.



**Figure 1.** UoA6 staff have strong collaborative links with internal and external collaborators and have access to modern research facilities as suggested by this qualitative chord diagram (acronyms are explained in following sections and the glossary).

UoA6 is largely focussed within the Division of Engineering and Food Sciences (EFS) but includes researchers in the Division of Health Sciences (HSC). Both are in the School of Applied Sciences (SAS), and we have strong collaborative links across the University, with external funding bodies and collaborators (see Figure 1). This is our first submission to UoA6, which reflects Abertay's strategic investment in research facilities and equipment (£4 million; see Section 3.3 for details), personnel, and our focus and achievements within the food and drink RKE-teaching domain since 2014. This has brought together new staff and those previously submitted to UoA5 and UoA7 in REF2014 following academic restructuring in 2019, and includes additional research interests pertinent to the Unit. UoA6 currently has twelve academic members contributing to basic and translational research, postgraduate research student supervision, and our research-informed undergraduate teaching programmes. Our team has had eight Postdoctoral Research Associates, two Research Fellows, nine Knowledge Transfer Partnership (KTP) Associates, twenty-nine postgraduate research students since 2014, and is supported by five technicians. UoA6 has a developing research culture and improved research performance during REF2021 that is

evidenced in Section 1.3 below. Our specific areas of research expertise are focussed into five research groups and our commercial arm which are described below.

(i) *Food chemistry and process optimisation* (Profs. Fiore & Walker, Drs Cottin & Lemos)

We investigate the formation of contaminants during food processing and develop strategies to mitigate its occurrence in food. Our product development and reformulation studies focus on improving the nutritional value of food and developing novel mild processing technologies for food preservation and quality. We evaluate novel yeast strains for industrial fermentations, investigate grain alternatives in brewing and distilling, and assess the role of wood compounds in the sensory acceptability of whisky. We collaborate closely with industry and organisations such as the James Hutton Institute (JHI) and the Scotch Whisky Research Institute (SWRI), together with partners in brewing and distilling.

(ii) *Applied food technologies* (Prof. Fiore, Drs Chu, Lemos, Tziboula-Clarke & Wilkin)

We focus on developing novel, environmentally friendly extraction and processing methods of food by-products and food industry waste, and by-product valorisation, aiming to contribute to a more sustainable, circular economy. We actively collaborate with external academic and industrial partners and seek to develop applications with meaningful industrial benefits for food producers.

(iii) *Consumer science and diet* (Drs Barton, Grigor & Wilkin)

We explore links between eating habits and health, and the promotion of health of consumers through diet and life-style intervention. We examine in depth the factors that affect consumer perception and acceptability of food and drink products. Our trained sensory panels are in demand by the food industry to gauge consumer acceptability of potential products prior to market release.

(iv) *Comparative physiology and nutritional health* (Drs Barton, Bennett, Cottin & Chu)

We investigate the underlying molecular biology and physiology of fat deposition in common and grey seals, which can also serve as a model for human obesity and diabetes, as well as the impacts of environmental stressors, such as pollution on wild animals which can inform likely impacts on human metabolic health through dietary exposure and change. We are also interested in antioxidants and understanding the mechanisms through which food components interact and affect metabolic and cardiovascular health.

(v) *Applied and environmental microbiology* (Prof. Walker, Drs Bennett, Cameron & Spiers)

We use soil and plant-associated communities and model bacterial species to investigate the evolutionary ecology of biofilm-formation in experimental microcosms to better understand adaptation to natural and managed environments. We are also interested in the spread of antibiotic resistance genes in wild seal populations and the links this has with environmental and public health. Our zymology focusses on yeast physiology and biotechnology and evaluates yeast strain biodiversity for their potential in brewing and other bio-conversion processes.

(vi) *Food Innovation @ Abertay (FIA)*

Our commercial arm provides a practical innovation support service to food and drink businesses and allows our staff to work collaboratively with industrial partners. We offer creative solutions to business challenges using specialist staff, equipment, and facilities. These are tailored to specifically meet business needs and are delivered on schedule and in a cost-effective manner.

## **1.2 Research and impact strategy**

Our research and impact strategy aligns with Abertay's RKE strategy as well as our School's Operational Plan. It is aimed at increasing research activity with societal and economic impact, through improving individual productivity and excellence within focussed research groups and through internal and external collaborations. It enables research, improves grant application success and quality publications through peer review and collegiate support. Our strategic aims have been to (i) structure our research groups into sustainable and active areas relevant to UoA6

and grow with new academic research appointments; (ii) grow and explore new research opportunities; (iii) increase funding success and consultancy income; and (iv) increase research impact, recognition, and collaboration. In the context of food and drink research, the aim of UoA6 is to further enhance cross-disciplinary and collaborative research pertinent to the food industry to become the leading Scottish University engaged in applied food research.

### **1.3 Strategic aims for research and impact**

#### **1.3.1 Achievement of strategic aims during REF2021 period**

Food research at Abertay has expanded to encompass several elements of food and drink science and technology, and now includes bioprocess technology, sensory science, human nutrition, chemistry, and microbiology. Our basic and translational research activity and research-informed teaching programmes have been consolidated into Division of Engineering and Food Sciences (EFS) with the close collaboration of additional UoA6 researchers in Division of Health Sciences (HSC). The UoA6 submission brings together the RKE activity and success of our core food research with comparative physiology and environmental microbiology, which are also pertinent to this Unit, as well as cross-disciplinary projects with colleagues in our School and the School of Design and Informatics (SDI), and external collaborators.

We have achieved the following strategic aims during the REF2021 period:

- (i) We have consolidated our research experience and interests to form five sustainable and diverse research groups matched with our research facilities. Some staff are active in more than one group. Over-lapping interests, along with mentoring and biannual developmental discussions with the Heads of Division (EFS & HSC), ensure that our groups are resilient to staff turnover yet are sufficiently flexible to include new staff with related research interests.

Four staff have been appointed who contribute to UoA6 in EFS and HSC. These include both experienced researchers and ECRs who have made substantive contributions to our research activity since joining Abertay. A combination of funding success, mentoring and support, have resulted in seven promotions since 2014, and we believe such opportunities are key to staff retention and career development.

Our consistent and competitively won internal funding has allowed us to develop research projects and gain experience which has led to the growth of collaborations and larger grant applications. We have used internal R-LINCS pump-priming funding for projects, equipment, and studentships, plus Abertay's Future Scholarships, to explore cross-disciplinary research opportunities with colleagues from HSC, the Division of Psychology and Forensic Sciences (PFS), the Division of Sport and Exercise Sciences (SES) (both in SAS), and SDI. We have extended this research with co-funded studentships with the Industrial Biotechnology Innovation Centre (IBioIC), JHI, Scottish Overseas Research Student Awards Scheme (SORAS), etc., and other grant awards with a range of external partners (see Section 4.1 for details). Since 2014, we have had twenty nine postgraduate studentships (sixteen completed & thirteen current) which have also allowed us to develop our research. These include nine R-LINCS studentships (six co-funded with external partners), two Future Scholarships, and six studentships funded by Nigeria. Grant awards have also supported eight Postdoctoral Research Associates, two Research Fellows, and nine KTP Associates since 2014.

- (ii) Staff in UoA6 have generated a substantial increase in research income, from £274k in 2014-15 to over £494k in 2019-20, and contributed £2.3 million to Abertay's external research income during REF2021. Our sources of funding are diverse and include the European Commission, UKRI, Scottish Funding Council's Interface (which supports innovation and knowledge exchange in Scotland), IBioIC, SORAS, JHI and SWRI, overseas businesses including Lallemand Biofuels and Distilled Spirits Inc. (Canada), and Scottish businesses including Speyside Cooperage Ltd, Tatlock and Thomson Ltd, etc.

We have changed emphasis from small Interface Innovation Vouchers (£5k) towards larger awards which allow us to develop deeper forms of collaboration in RKE, though we continue to regard Innovation Vouchers as a valuable means of interaction with industry. Funding success has included investigating obesogens in seals as a model for human fat deposition (NERC, £582k), estimating food and nutrient intakes in Scotland (Food Standards Scotland, £112k), and bioenergy production from malt distillery co-products (Diageo Plc., £178k). Current projects include adding value to waste streams through antioxidant recovery from berry waste Colbeggie Fruits, £212k), the measurement and control of acrylamide in food production processes (KP Snacks and others, £307k), and the development of non-thermal physical technologies to preserve fresh and minimally processed fruit and vegetables EU Horizon 2020, £352k of a €6 million project). Our most recent success has been a £1 million grant to develop novel infant foods using insect proteins to improve nutritional health in low socio-economic communities in Zimbabwe (BBSRC-GCRF, 2020-23).

- (iii) Research impact, recognition and collaboration has increased since 2014. Research activity has resulted in 153 publications with 1,123 citations (Scopus), over £1.1 million in research funding from BBSRC, NERC, EPSRC, and UKRI (REF Column 1 funding) and UK Charities, Industry and Commerce, non-EU Industry and Commerce, etc. (REF Column 6 funding). Our impact is demonstrated in the two impact cases studies we have prepared for REF2021, and real-world economic and societal impacts have been assessed externally by Interface to have led to research and development investments of over £1.8 million with companies we have supported. National and international recognition has further developed through collaborations and funding from critical stakeholders, such as Innovate UK, Interface, Scottish Food and Drink Federation, SWRI, and businesses for translational research.

#### *1.3.1.1 Producing high quality research and becoming the leading Scottish University engaged in food research*

We have increased the academic quality and industrial impact of our research by appointing experienced staff with research interests and skills directly relevant to the agri-food industrial sector and ECRs who can contribute to our basic and translational research. By investing in new staff and recruiting research students, together with significant investment in research facilities (£3.6 million) and equipment (£400k) including the new food processing pilot plant and consumer experience laboratory (see Section 3.3 for details), we have become one of the best modern food sciences universities in Scotland (third in the UK, Guardian, 2020; top ten in the UK, Times, 2020). We are committed to developing basic research in food science and technology and related areas and continue to develop our translational research in these areas.

Abertay is currently ranked 7th most active Higher Education Institute in Scotland (5th in 2018) and 43rd in the UK for KTPs, some of which have won awards. For example, the UoA6 Ivan Wood and Sons Ltd project which resulted in a spin-out Peel Tech Ltd, was graded as 'Outstanding' by Innovate UK, won Innovation of the Year at Scottish Knowledge Exchange Awards (2017) and the KTP associate won the 'Building Skills' award for her KTP and company transformation. We have used our experience with small Interface Innovation Vouchers to develop our reputation and grow external collaborations to become more successful with larger applications. We still engage with Scottish Small and Medium Enterprises (SMEs) where we see our most significant societal and economic impact for our translational research, and regard Innovation Vouchers as a useful means of continuing our close collaboration with them.

#### *1.3.1.2 Conducting research with meaningful impact for industry*

Our REF2021 impact cases studies, 'Improving efficiency for alcohol producers: from raw materials to final product' and 'Novel uses of legumes for sustainable agri-food industrial applications', have emerged directly from our strategic research focus. This has been facilitated by specific strategies to further our research engagement with colleagues from industry and external research institutes which has resulted in joint research studentships and collaborative projects. These case studies have supported the beverage and biofuel sectors of industry to



operate more efficiently and to develop new products and have provided tangible outcomes for legume-supported food and feed chains.

We have a strong record of product development and food technology over the past decade. Under the auspices of FIA and with Interface and Innovate UK, we have supported over a hundred Scottish and UK companies in new product development, using our food processing pilot plant, consumer experience laboratory and trained sensory panels to address real-world problems. We offer technically sound and commercially viable solutions developed through knowledge exchange in collaboration between researchers and stakeholders, which also supports our basic research interests. For example, we have supported the development of edible seaweed products (Omega Products Development), the world's first 'climate positive' distilled spirits (Arbikie Highland Estate), chocolate production (Mackie's of Scotland), and the optimisation of mashed potato shelf life (Stirling Potatoes Ltd). Interface has assessed the real-world impact of our Interface-brokered translational research involving seventy-eight industry led R&D projects, which has resulted in the development or improvement of 209 products or processes, and further research and development investments by forty-one collaborating business of £1.8 million since 2014. Three of our knowledge transfer partnerships have been evaluated as Grade A/A<sup>+</sup> by Innovate UK (Diageo, Ivan Wood and Sons Ltd, and Meatsnacks Group Ltd). We are currently 7<sup>th</sup> in Scotland with five on-going projects (North of Scotland KTP Office) and had a 100% success rate with the last three applications we submitted. Our sensory panels have generated £40k in consultancy fees from Scottish companies. This type of consultancy has been used specifically to build trusting partnerships for larger and successful research applications.

We also regularly host guest speakers from industry and academia for talks on emerging research areas which have led to the establishment of closer networking ties with external partners, including Arbikie Highland Estate, Axis-Shield/Abbott Laboratories, Celtic Renewables, Concept Life Sciences, Diageo Plc., JHI, Moredun Institute, and the SWRI.

#### *1.3.1.3 International reputation for research*

We have established collaborative research networks with a range of academic and industrial partners across Europe and the rest of the world (see Section 4.1.3) which have resulted in joint research awards, co-authored papers, and researcher exchanges. We have increased our international reputation by engaging with academic, professional, and industrial groups. For example, Dr Barton organized the Nutrition Society Spring Conference (2019) and Prof. Walker the biannual international 'Alcohol Schools' (see Section 4.2), expanded our research network through our EU Horizon 2020 project involving twenty-one research groups across Europe, and have received awards such as the Interface UK's Innovation of the Year (2017), USA Fuel Alcohol Workshop's Award of Excellence (2018) [Walker], and the Emerging Leader Network awarded by the Institute of Food Science (2019) [Wilkin].

#### 1.3.2 Future strategic research aims and goals (2020-25)

Our strategic research aims and goals are aligned with Abertay's RKE Strategy for 2020-25, which is committed to producing quality research and knowledge exchange with real impact for society. This differs from the earlier strategy principally with the introduction of up-dated 'Challenge Spaces' to address future research opportunities and associated 'Pooled Excellence' recognising the research skills in which Abertay has developed capability and recognition. UoA6 basic and translational research will contribute to 'Health and Care across the Lifespan' and 'Sustainable Development and Inclusive Living' spaces. Together with other Abertay researchers, we contribute to the parallel 'Pooled Excellence' in 'Experimentation and systems modelling' through our basic research, 'Co-creation and external engagement' through our translational research, and 'Human interaction and user experience' and 'Social identity and human behaviour' through our sensory science and human nutrition research.

Our UoA6 research groups are operating in areas in which we believe significant RKE with societal and economic impact can continue to develop and we retain our earlier strategic aims (listed in Section 1.2), which will require continued investment in staff and facilities, R-LINCS and Future Scholar studentships, and support for networking activity leading to grant applications (including support for postdoctoral research and KTP associates) and further collaborations. Leadership within UoA6 and each of our research groups, plus staff and research student mentoring and

support, are critical in providing sustainable and effective research activity and impact. Effective research-focussed management is also required to maintain RKE-teaching links and balance within the Abertay's academic 'ecosystem' and to grow our research culture.

Our goals for 2020-25 include maximising the recent investment in infrastructure and facilities through quality research output and impact and income generation through grant awards and consultancy. We will develop research excellence in food science and technology, sensory and consumer science, public health and human nutrition, comparative physiology, and microbiology. Our food processing pilot plant and consumer experience laboratory, in combination with our trained sensory panels, places us in a unique position in Scotland to develop impact from our basic research through translational research with external collaborators. Experience and income from translational research will be re-invested to expand our basic research interests in food science and technology and related areas pertinent to UoA6.

We are mindful of the impacts of Brexit on the funding landscape and international collaborations. Our research groups (which are diverse but each of which focus on a distinct area of expertise, compact size and organisation) allow us to be agile and responsive to future research opportunities. We will make use of our academic and industrial networks, including professional societies (such as the Association for Nutrition, Institute of Brewing & Distilling, Institute of Food Science & Technology, International Maillard Reaction Society), in future-scanning to align ourselves with changes in food science and technology, and to respond to collaborative and funding opportunities when they appear.

#### *1.3.2.1 Support ongoing research expansion by investment in resources*

Abertay has invested heavily in the development of facilities, with significant new-build and refurbishment of research and dual-use teaching spaces in 2016 (£3.6 million) and new equipment in 2016-17 and 2018-19 (£400k) (see Section 3.3 for details). This has had a direct impact on UoA6 by enabling new research areas to be developed, supporting more industrial collaborations, and generating consultancy in consumer sensory experience, product development and testing. In the next five years, Abertay will also invest in and support around fifteen fully funded R-LINCS PhD studentships, funded PhD studentships for newly appointed academic staff (subject to the approval of a research plan that is aligned with the R-LINCS2 objectives), Abertay Futures Scholarships, Pump Priming awards, and Open Access Publication awards.

We will use this investment in resources to build trust in partnerships, increase research activity, collaborations, and studentships, and to invest in new equipment and staff where possible. Competitive R-LINCS funding and Future Scholarships will also be used to support ECRs and to develop cross-disciplinary research projects within Abertay and with external collaborators. SAS maintains and replaces core equipment, and our experienced technicians provide further support in operating these and in training new users. Competitive cases for partial or full funding can be made to SAS for additional equipment where appropriate.

#### *1.3.2.2 Growing industrial networks by providing opportunity for co-creation*

Our continued success in KTPs have led to a sustained development in organising research and impact in our local and national industry. For example, Abertay is leading a new £670k project as a part of a drive to support low carbon innovation and manufacturing capabilities across Scotland. Transforming Net-Zero, led by SDI, will have input from all Abertay's Academic Schools and aims to provide advice to Food and Drink SMEs on energy use, waste utilisation, water technology and carbon sequestration, while also preparing companies for new net-zero market opportunities. The project is one of only three university-led collaborations funded through Scottish Enterprise's Low Carbon Challenge Fund and the European Regional Development Fund, with Abertay providing match-funding.

The industrial networks we manage provides a clear path to affect societal, economic, and policy change. For example, Dr Barton's estimation of food and nutrient intake in Scotland using data from the Office of National Statistic's Living Costs and Food Survey (2013-15) has fed into policy development by Food Standards Scotland, and she is now a reviewer of funding applications and project reports for them too. We engage with business in almost all areas of our research and

teaching, and this allows our staff to develop further skills and support the Scottish Government Ambition 2030 programme.

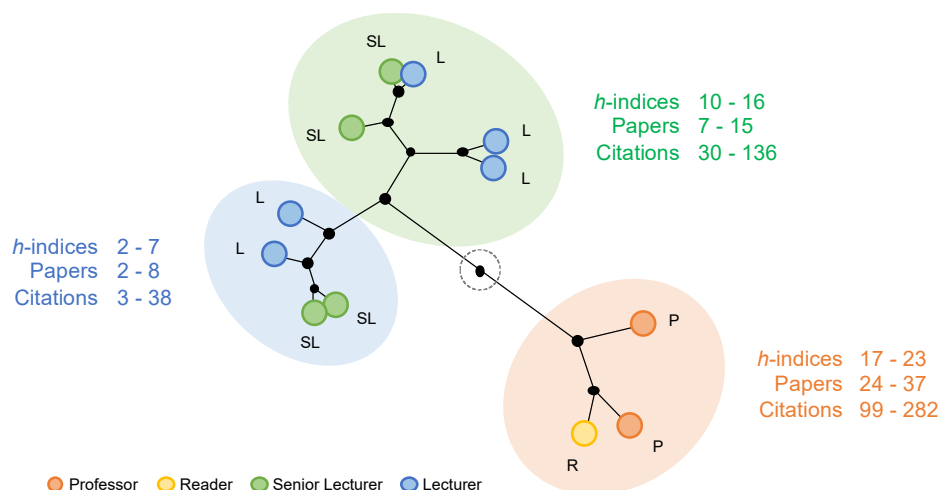
## 2. People

### 2.1 Staffing Strategy and Development

#### 2.1.1 Staffing strategy

As indicated in Section 1.3.1, we have recruited four additional research-active academic staff and had seven internal promotions since 2014, which reflects a real commitment to developing staff careers within our Unit and Divisions (EFS & HSC). The current UoA6 core staff of twelve comprises a healthy balance of skills and experience, with two professors (Grade 10), one reader and four senior lecturers (Grade 9), and five lecturers (Grade 8 & 7). All our staff undertake annual development discussions and are eligible for various in-house and external training.

Our expertise spans across the disciplines of food science and technology, sensory and consumer science, public health and human nutrition, comparative physiology, and microbiology, and includes experienced researchers and ECRs. We recognise that research output varies according to research discipline, experience, and teaching loads. More generally, we recognise the effect that individual circumstances may have on the output of researchers and their contribution to overall output (see Figure 2) and help ensure that research activity and personal development is supported in a manner that also promotes equality and diversity.



**Figure 2.** Metrics including *h*-index, publications, and citations differentiate UoA6 staff as shown in this Hierarchical cluster analysis dendrogram, with three groups reflecting differences in age, career, and research discipline. Papers and citations listed are from the REF2021 period only. Data from Abertay PURE.

#### 2.1.2 Staff development

Abertay University is a signatory to the Concordat to Support the Career Development of Researchers and the San Francisco Declaration on Research Assessment (DORA) Declaration. Consistent with the Concordat, line managers are committed to staff well-being, and all UoA6 staff have biannual developmental discussions with their Head of Division (EFS & HSC) to appraise research objectives, discuss training and development needs, and review any well-being or workload issues. Our research depends on a supportive academic 'ecosystem' in which teaching duties and research are effectively managed. Our workload planning provides UoA6 staff with 20% of their time for research or research-associated activities as a basic allowance, with more provided on actively funded grants. Each of our research groups includes at least one experienced researcher who can provide leadership and advice. The collegiate nature of the groups and Unit provides additional support and informal mentoring for individual staff and research students, while academic support and training through the Graduate School and the cross-institutional Teaching, Research and Academic Mentoring Scheme (TRAMS) provides more formalised support for staff

development (currently eight UoA6 mentees & two mentors). New appointments including ECRs are given additional support in the form of a reduced teaching load in their first year to allow them time to establish their research.

Abertay provides training to develop staff research capabilities and other academic skills, in line with the Vitae Researcher Development Framework which is administered by the Graduate School. A wide range of development needs are met within the institution, which provides over 100 seminars annually on topics such as research design, statistics, project management, and academic writing, with Drs Bennett, Cameron and Spiers contributing to this delivery. Courses on GDPR, Open Research Data, data management, and ethical conduct, etc., are also run regularly to ensure research is conducted according to appropriate frameworks and standards. All UoA6 staff are expected to complete induction and annual training as required, and a teaching-free afternoon each week allows them to participate in other training events as appropriate. All UoA6 staff have completed an Epigeum course before supervising research students. UoA6 staff have participated in the Aurora leadership programme and the Advance HE Scotland Academic Leadership Programme [Barton], as well as ERASMUS+ placements at the AIJU Instituto Tecnológico (Spain), University of Naples Federico II and University of Udine (Italy) [Barton], and the Institute of Molecular Biology and Genetics (Ukraine) [Spiers]. Current proficiencies and continued professional development of UoA6 staff is also reflected in professional society memberships and certified status (e.g., Association for Nutrition, Institute of Food Science & Technology, Institute of Brewing & Distilling, Royal Society of Biology, Royal Society of Chemistry; CBiol, AfN Registered Nutritionist, etc.) as well as in teaching qualifications and recognition (e.g., PgCert HET, PGCAP, F/SFHEA).

There have been two important environmental improvements during REF2021 affecting staff research and career development. First, staff research is now supported by internal funding initiatives. R-LINCS provides funding for research studentships including RCUK-level stipend, registration fees, and budget for consumables, equipment, and travel, as well as 'pump-priming' for research projects and equipment. UoA6 staff have been awarded nine completed or on-going R-LINCS studentships (corresponding to a mean of £56k for each) and two pump-priming grants (£10k) since 2014, and in-kind support of £13k has been provided for one UoA6 staff member. The Future Scholarship initiative which began in 2018 has awarded two further UoA6 studentships based on fee-waiver of £4,407 pa. These have allowed UoA6 staff to establish research at Abertay, publish, develop external funding applications, and gain supervisory experience. Further support of this kind will be provided over the next five years (see Section 1.3.2.1).

The second important environmental improvement during REF2021 has been the very significant investment in research facilities and equipment (a total of £4 million) referred to in Section 1.3.2.1 that has enabled new research areas to be developed as well as the growth of external collaborations and consultancy activity.

### 2.1.3 Training and supervision of postgraduate research students

Our postgraduate research students are recognised for their contribution to both our research output and culture, with four MSc by Research (MbRes) and twelve PhD students completing their degrees during REF2021 and a further thirteen PhD students currently enrolled (no MbRes students have enrolled during the Covid19 pandemic). UoA6 postgraduate students are members of the Abertay's Graduate School which provides critical mass for our research community, support, and training. The School was launched in 2014 as part of our Abertay's RKE Strategy and during REF2021 it has transformed the quality of our postgraduate research environment and the university's research culture. The School was commended as an area of good practice during our last Enhancement-led Institutional Review (2016-17), and notably of the five institutions reviewed in that year, all but Abertay had postgraduate research students highlighted as a concern.

Our students maintain a reflective record of personal development and training needs structured around the Vitae RDF with the same opportunities for training as those described for staff in Section 2.1.2. The Research Degrees Academic Panel (RDAP) is responsible for monitoring student progress through annual progression panels. Students have at least two academic supervisors, one of whom will be the lead researcher with discipline-specific knowledge as well as



experience in supervision, and this can be expanded to include additional advisors as the project matures. Our regulations also allow degrees to be co-supervised with external partners, and UoA6 have supervised eight Abertay-registered studentships with co-funded studentships with BBSRC, IBioC, JHI, SORAS, SWRI, and other industrial partners since 2014.

Abertay's Chancellor's Fund provides support for those students who are unable to attract external funding for conference, academic visits, and training. Three UoA6 have benefitted from support from the £7k awarded across Abertay since 2014. Several PhD students have also received support to attend conferences or training through professional societies (Microbiological Society; Federation of European Microbiological Societies), ERASMUS+, or additional support from their funding bodies (Nigerian Petroleum Technology Development Fund).

#### 2.1.4 Supporting and promoting equality and diversity

The University is committed to equality and diversity and this is evidenced by awards in national schemes. Abertay joined the Athena SWAN Charter in 2014 and made a successful application for the Institutional Bronze Award in 2015. In 2016, Abertay became, and remains, the first and only Higher Education Institution in Scotland to hold the Race Equality Charter Mark Bronze Award.

UoA6 includes five female and seven male full-time staff (we do not have any part-time staff). We have not included any further data about protected characteristics as, due to the small size of our team, these data would make individuals identifiable. Abertay provides support for flexible working, maternity, and paternity leave. We currently have one male UoA6 member on a flexible working contract to accommodate child-care responsibilities. Staff have been working remotely during the Covid19 pandemic with restricted access to campus facilities. Abertay's new Digital Strategy due to be implemented later in 2021 will further enable and continue to support remote working in the future.

Promoting research opportunity across all staff has been an important focus for our School and Divisions (EFS & HSC) during REF2021, particularly in terms of gender equality. Drs Tziboula-Clarke and Spiers were members of the School's Athena SWAN Self-Assessment Team that made a successful application for a Departmental Bronze Award in 2018, though academic re-organisation in 2019 meant that the award could not be retained. Although the gender proportion for some of our undergraduate programmes and associated staffing are historically biased, this has been improved with appointments of women to leadership positions at Abertay (e.g., Dean of Research and Graduate School, SAS Dean, and Heads of EFS and HSC). Two female UoA6 staff were provided with funding to attend an Equate Scotland workshop and a Women in Cognitive Science event (USA). Drs Barton, Cameron, and Tziboula-Clarke have also attended the Advance HE Academic Leadership Programme. In-line with our commitment to equality and diversity, we have also made progress in ensuring research responsibilities and opportunities are now much more equal across the genders through annual development discussions and announcements of opportunities.

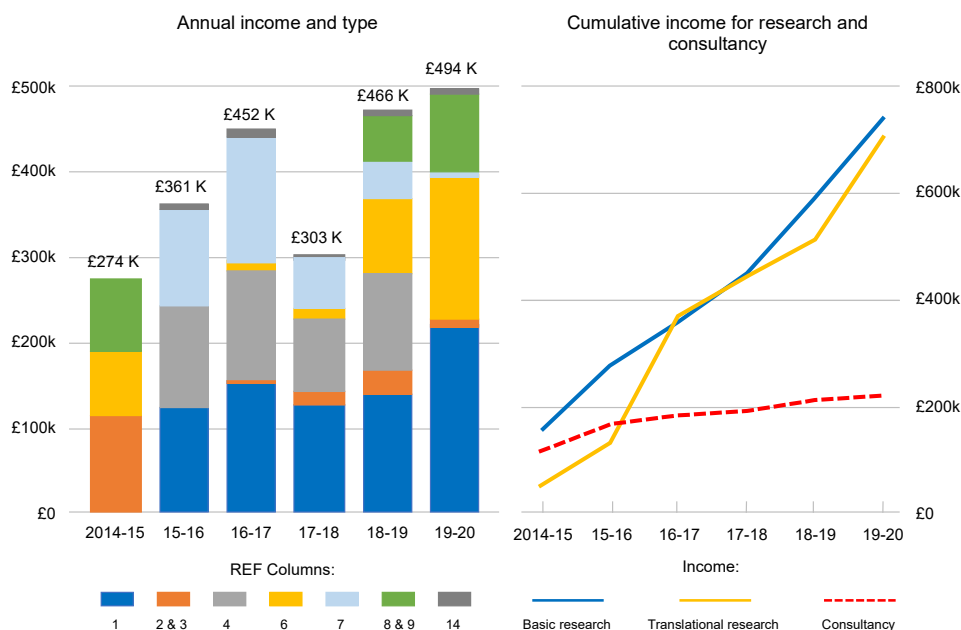
UoA6 staff are well-represented on committees that work to ensure that equality and diversity are promoted across the University. Drs Bennett and Cameron are Lead Voices for university-wide equality and diversity groups (Gender and LGBT+), and others are representatives on the Staff Engagement Advisory Team and UCU Union committees. Dr Spiers is an R-LINCS Theme Leader and Prof. Walker, Drs Bennett, Grigor, and Spiers, are members of the University RKE Committee and RDAP. All UoA6 staff have undergone mandatory unconscious bias training to combat the influence of social category membership cues on decision-making, consistent with Concordat commitments.

### **3. Income, infrastructure and facilities**

#### **3.1 Income**

Abertay has received £10 million of external research income during the REF2021 period which has increased from an annual mean of £1.1 million in 2013-18 to £2.2 million in 2018-20. UoA6 contributed £2.3 million to this total and has seen external income increase from £274k in 2014-15 to £494k in 2019-20. Our income is from Columns 1, 2, 3, 4, 6, 7, 8 and 9, and the relative contributions of each to annual incomes has varied over the REF2021 period (see Figure 3 for

annual external research income totals & type). This variation reflects a genuine change in our sources of income as we have become more successful with larger UKRI awards and industrial funding.



**Figure 3.** Annual UoA6 income and breakdown are shown on the left. Cumulative basic and translational research (pooled across REF Columns) and consultancy income are shown on the right. REF Columns are: 1, BBSRC, NERC, EPSRC & UKRI; 2 & 3, UK Charities (open competition process) and other UK Charities; 4, UK Central Government, Local Authorities & Health; 6, UK Charities (open competition process), BIS Research Councils, Industry & Commerce, non-EU Industry and Commerce, and other sources; 7, Other UK sources; 8 & 9, EU Government bodies & EU Charities; 14, Non-EU Other.

Funding for research by BBSRC, NERC, EPSRC and UKRI (Column 1 funding; see Fig. 3 legend for column funding descriptions) increased over 2018-20 and provided 45% of our income at the end of REF2021. Funding for translational research from UK Industry, etc., (Column 6) also grew from 25% 2014-15 to 34% in 2019-20. Funding from EU Government and Charities (Columns 8 & 9) provide 18% of funding at the end of REF2021. The over-all increase in annual external research income dropped in 2017-18 because of the completion of two large projects in the previous year and our change of emphasis from small Interface Innovation Vouchers (13 projects with a total of £65k in 2016-17) towards larger translational research projects. The trajectories for basic and transitional research confirm these upward trends (Figure 3) and we have generated a further £89k from consultancy during REF2021 (very little consultancy activity occurred during 2019-20 due to Covid19 restrictions).

### 3.2 Infrastructure

Abertay provides a range of infrastructure supporting UoA6 research activity, including Abertay's Research Enterprise and Innovation and Library Services, and Finance, who maintain a current research information system (PURE) to manage funding applications and awards, as well as to provide a record of research activity, and Abertay's Bell Street Ventures provides support for academic enterprise. Information Services provide computing facilities and support across campus, with £2.1 million invested in PC and Wi-Fi replacements and a further £3.5 million for the new Digital Strategy in 2021-25. The Graduate School's facilities are often used for research events and they also provide training for staff and students. SAS have nine technicians who are responsible for maintaining laboratories and equipment. They have acquired considerable experience operating a variety of food and analytical equipment, and provide training for students,

KTP associates and new staff when required. Mrs Dolder is specifically responsible for our research kitchens and coordinates access to equipment and maintains supplies as required, with four other technicians supporting food science and technology, chemistry, and microbiology [Boyle, Graham, Lindsay & Milne]. Technical staff also contribute to research by helping with or running experiments when time permits (£444k of RKE in the REF2021 period) and help support undergraduate Honours projects.



**Figure 4.** UoA6 staff and students have access to modern laboratories that support a range of research activities.

### 3.3 Facilities

UoA6 staff and students have access to a range of modern facilities, including eleven laboratories (705m<sup>2</sup>) dedicated to analytical chemistry, cell science and biochemistry, PCR/qPCR, and microbiology (see Figure 4), a food processing pilot plant (96 m<sup>2</sup>), consumer experience laboratory (20m<sup>2</sup>), and three research kitchens (197m<sup>2</sup>) where food can be prepared and tested. Our teaching spaces were designed to be dual-use, supporting teaching delivery during term-time, and providing space for specialist equipment as well as fume and laminar-flow cabinets, air/N<sub>2</sub>/vacuum lines, fridges, incubators, etc., and providing additional bench space for research when needed. We have additional equipment and spill-over bench space in three teaching laboratories, and our technicians' centre includes preparatory and maintenance areas, food, and chemical storage facilities. We also have access to a variety of seminar and small-group meeting rooms which can be used by research groups and for teleconferences.

Our new research facilities, including the pilot plant and consumer experience laboratory, were formally opened in 2017 (see Figure 5). An estimated £7.6 million is being used in upgrading the Abertay Estate in 2020-22, with a minimum of £1.8 million in central funding for classroom and laboratory renovations across the campus in 2020-26. We will also benefit from £5.6 million invested in Abertay's Digital Strategy and PC and Wi-Fi replacement programme in 2020-26.

Our research facilities and equipment have enabled the development of new research areas and an expansion in our knowledge exchange activities. The food processing pilot plant is designed to food manufacturing and environmental health standards and provides an adaptable laboratory space with flexible power and water supplies and drainage. Our freezing and spray drying facilities, as well as the UHT and ultrasonication equipment, currently support soft fruit waste valorisation (Colbeggie Fruits, £212k) and fish net recycling and utilisation of waste (W&J Knox Ltd, £160k). Similarly, the consumer experience laboratory, with twelve climatically controlled booths designed for the sensory analysis of food and drink, has allowed us to develop two trained sensory panels for chocolate and for salmon and trout, with the support of Interface UK and several Scottish companies. These have since generated £40k in consultancy. Our growing reputation in consumer

experience assessment has been a major part of our participation in current and proposed collaboration with UK and international partners. We have obtained funding directly linked to sensory and consumer research of £493k, which includes a new £177k project to design artificial intelligence for sensory evaluation in potato breeding programmes (Agrico UK Ltd). A current R-LINCS studentship focusses on sensory sensitivity using psychophysiological measures and self-reporting techniques. One of our goals in this interdisciplinary area is replace self-reporting with analytical measurements such as those from facial electromyography to provide insight into the dynamic affective state of consumers whilst evaluating food products.



**Figure 5.** The Chief Scientific Adviser for Scotland, Dame Glover, and the Principal of Abertay University, Prof. Seaton, at the official opening on 30 May 2017 of Abertay's new research facilities including the food processing pilot plant (middle) and consumer experience laboratory (right, split-image showing panel booths and serving area).

Investment in specific equipment has also allowed us to expand our research into analytical food chemistry. New GCMS and LC-MS/MS have allowed us to investigate acrylamide, phenolic compounds, and food processing contaminants (Innovate UK, £307k; BBSRC-GCRF, £1 million; EU Horizon 2020, £325k), as well as reduction of toxicant formation in electronic cigarettes using plant antioxidants (Carnegie Trust, £50k). A food texture analyser has allowed beef jerky and mashed potato production to be optimised (Meatsnacks Group Ltd, £128k; Stirling Potatoes Ltd, £115k) and a better understanding of the texture of seaweed products (Omega Product Developments Ltd, £93k), while the rheometer has been used in the processing of Fava (Fava) bean kernels as a brewing adjunct. Our HMRC-licensed microbrewery allows us to produce beers which can be tested using the Consumer experience laboratory. External partnerships provide access to additional resources and facilities. For example, we have assessed new potato varieties for product development and sensory analysis through Agrico UK Ltd; we have conducted farm-scale field trials for legume-cereal intercropping as part of our project on legumes for agri-food applications with the JHI; and we collaborate with several Scottish companies on large-scale brewing and distilling projects that have resulted in commercial production of entirely new ranges of beverages.

#### **4. Collaboration and contribution to the research base, economy and society**

##### **4.1 Collaborations and networks**

Abertay recognises the importance of developing internal and external collaborations for research and staff development. UoA6 staff have developed interdisciplinary research collaborations across Abertay through R-LINCS studentships and external collaborations in the UK and across the world have allowed us to extend our research interests further and develop real-world applications for our food and drink research.

##### **4.1.1 Internal and UK collaborations**

Our internal collaborations with R-LINCS PhD research studentships include characterising fat tissue in grey seals as an animal model of extreme fat deposition and mobilisation; investigation of barley as a source of polyphenols for the mitigation of advanced glycation end products in food; development of a product development tool using facial electromyography with sensory attribute selection (with colleagues from SES, HSC, PFS, and SDI). We have a close research relationship



with JHI and are Associate Partners with them in a BBSRC proposal for up to thirty PhD Collaborative Training Partnerships in the Dundee-based International Barley Hub. We collaborate with projects on the effects of pollution on seals and monitoring bacterial antibiotic resistance genes in marine systems with the Moredun Institute, University of St Andrews, and Queen's Medical Research Institute. Our research on electronic cigarettes and food polyphenols is undertaken in collaboration with the Universities of Birmingham, Edinburgh, and St Andrews. We additionally collaborate with Food Standards Scotland and the Scottish Government on understanding health survey data and food policy development.

UoA6 staff also actively engage with UK funding bodies and research institutions (e.g., BBSRC, Carnegie Trust, Food Standards Scotland, Leverhulme, and NERC) by participation on award panels and by reviewing applications. We act as PhD examiners and examination chairs within SAS and for Abertay through RDAP. Our academic networks have led to external examinations for eleven UK universities and institutions since 2014, peer reviewer professoriate appointments (e.g., Edinburgh Napier University, University of Bath, and the University of Nottingham), and TRAMS mentorships. We also support UK and international journals as Editorial Board members (e.g., BMC Ecology & Evolution, Antonie van Leeuwenhoek, Beverages, and the Journal of the Institute of Brewing) and we contribute to the manuscript review process for more than fifty journals.

#### 4.1.2 Industrial links

We interact extensively with industry, mainly through our commercial arm, FIA, which provides a link to UoA6 staff and a lead-in to KTP. Our food processing pilot plant, consumer experience laboratory, and our trained sensory panels are unique in Scotland and provide a seamless route from product and process development to consumer testing. We have developed strong links with critical stakeholders, such as Innovate UK, Interface, Scottish Food and Drink Federation, SWRI, as well as with Scottish businesses, including whisky and beer producers. This has been facilitated in part by hosting guest speakers from industry to strengthen networking ties and to consider new collaborative opportunities (see Section 1.3.1.2). Several PhD projects are also undertaken in collaboration with industrial partners who additionally provide funding and joint supervision (e.g., Arbikie Highland Estate, SWRI, and Tatlock & Thomson Ltd.). Support from Innovate UK and Scottish businesses allowed us to recruit and train our two sensory panels which generated £40k in consultancies since they were established, and are they are now being used in new collaborative research projects. The Pooled Excellence groupings in Abertay's RKE Strategy for 2020-25 (see Section 1.3.2) will provide us with an additional means to interact with industry by offering different multidisciplinary mixes of experimental expertise for new challenges and opportunities.

#### 4.1.3 Growing international networks

Through our UK-based networks and growing reputation in food science and technology, we have established collaborative research networks with a range of academic and industrial partners across Europe as well as in Australia, Brazil, Canada, New Zealand, Singapore, South Africa, Ukraine, Vietnam, and Zimbabwe as mentioned in Section 1.3.1.3. These networks have resulted in international peer reviewer professoriate appointments (e.g., Copenhagen University, Oregon State University, Swedish University of Agricultural Sciences, and University of West Attica (Athens)), and grant reviewing activity for a range of national funding agencies (e.g., the Australian Research Council, Danish Council for Strategic Research, National Research Foundation (Ukraine), National Science Centre (Poland), and the United States – Israel Binational Science Foundation). We have also undertaken PhD examinations for eleven universities in Africa, Australasia, the Caribbean, and Europe since 2014. Our networks have also allowed us to develop new collaborations to support large grant applications which have been successful. These include £1 million to develop new insect protein-based infant foods to improve nutritional health in Zimbabwe (BBSRC-GCRF, 2020-23), £325k to develop new technologies to preserve fresh and minimally processed fruit and vegetables involving twenty-one European research groups (EU Horizon 2020, 2019-23), with staff also working with LMIC countries under different funding schemes such as the United Nations Sustainable Development Goal 6 (clean water & sanitation for all) in Malawi.

**4.2 Wider activities and contributions to the research base, economy, and society****4.2.1 Wider research community**

UoA6 staff recognise that they are members of a larger science and technology community, and actively engage with academic and professional networks to contribute to research, industry, and policy. For example, yeast research at Abertay has benefitted the activities of international biofuels and distilled spirits companies through the acclaimed 'Alcohol Schools'. Under the scientific stewardship of Prof. Walker, these events are held biannually variously in Canada, Scotland, France, Austria, Thailand, and the Caribbean. During the REF2021 period, over one thousand industrialists have attended these industrial workshops and gained valuable transferable knowledge of alcohol production and Abertay yeast research.

Some collaborations have resulted in the development of projects outside of our immediate areas of interest. For example, an early collaboration with Abertay colleagues with academic links to Nigeria has led to six PhD research studentships since 2014 funded by the Nigerian Petroleum Technology Development Fund and the Tertiary Education Trust Fund. These have focussed on Nigerian pollution issues resulting from invasive aquatic weeds and petroleum contamination. Prof. Walker and Dr Boon have supervised studentships investigating the commercial use of aquatic weeds for bioethanol production and as a source of novel pharmaceuticals, and Drs Cameron and Spiers studentships characterising bacterial surfactants from soil microbes with application in biotechnology including food processing and the remediation of petroleum contaminated soil.

Our work with seals as a model of fat deposition and sentinels for marine pollution has resulted in Dr Bennett sitting on the UK Government's Special Committee on Seals. Our work on food nutrition and food technology has led to Dr Barton reviewing funding applications and project reports for Food Standards Scotland, and Dr Wilkin becoming a member of the Food for the Scottish Government Cross Party Group. Prof. Walker and Dr Tziboula-Clarke have participated in UK and Scottish Parliament events and the Scottish Science Advisory Council promoting Abertay food and drink research (2015, 2018 & 2019).

**4.2.2 Student experience and STEM**

We support student research experience and training opportunities as part of our commitment to equality and diversity and in support of local, UK and international STEM efforts. UoA6 staff have hosted nineteen summer studentships, including ERASMUS+, International Association for the Exchange of Students for Technical Experience, and secondary-school Nuffield placements. Dr Spiers engages with the East Scotland STEM Ambassador Hub in support of local authority schools. Drs Barton and Wilkin work with Developing the Young Workforce, Food and Drink Federation Scotland, Scottish Schools Education Research Centre, and Tayside Schools and run events directly aimed at STEM teachers to encourage pupils to take forward careers in Food and Drink, and Dr Spiers was a panel member for the undergraduate Royal Society of Biology Scotland Outreach Champion Awards (from 2018-19).

We have a broader interest in promoting science and technology in Dundee and across Scotland, and have contributed to Café Science, Pint of Science, the Dundee and Edinburgh Science Festivals, the Edinburgh Festival, BBC Television and Radio interviews.

**Glossary of Abertay & Scottish Acronyms**

FIA, Food Innovation @ Abertay; James Hutton Institute; PFS, Division of Psychology and Forensic Sciences (in SAS); PURE, Abertay's Research Information System; RDAP, Research Degrees Academic Panel; R-LINCS, Research-Led Innovation Nodes for Contemporary Society; SAS, School of Applied Sciences; SDI, School of Design and Informatics; SES, Division of Sport and Exercise Sciences (in SAS); SORAS, Scottish Overseas Research Student Awards Scheme; SWRI, Scotch Whisky Research Institute; and TRAMS, Teaching, Research and Academic Mentoring Scheme.