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| **Research Group** | **Ancient Life** |
| **Date due** | **w/c 11/1/2021** |

Please complete this form to tell us about your future plans for your Research Group. You are asked to complete a 1 page strategic three-year plan for your Research Group and also to detail your plans for infrastructure and technical support, highlighting areas where investment is required, what academic hires would help to deliver your strategy, and outline your expected research income generation over the next year.

**Strategic Research Plan for next 3 years 2021-2023**

*Please provide a one page strategic plan for your area outlining the following:*

* *main goals and targets to be achieved.*
* *current activities that will grow or reduce.*
* *future areas for expansion and development.*
* *interactions with other RGs, institutes, departments, faculties*
* *brief reflection on impacts to UN Sustainability goals and CO2 footprint*

*Please provide evidence to support the aspirations and how new developments will be realised. It is important that you consider the staff, technical support and infrastructure resources that will be necessary to deliver any increase in activity and to justify these in your plan. Please also indicate any plans for increasing your number of research fellows and how you see PhD studentship increase being generated and grown. Please indicate where you have staff or Early Career Researchers that would benefit from additional support in preparing applications for funding from either your Research Support Manager or an academic mentor.*

**Preamble-** This research group has asked that a preamble be included within this planning document. Due to the ongoing disruption caused by the Covid-19 pandemic, we want to note that we have needed to recalibrate our research ambitions, strategies, and projects as individual PIs and as a group in the course of this global pandemic. When we finally resume a more normal working environment, we plan to perform a “stock take” of the impacts of the pandemic on previous collaborations, research student progress, and the preparation of grant proposals. When the current lockdown is lifted and the situation stabilized we will revisit our group plans and have a better idea about what steps can be taken to build back both in terms of infrastructure and outcomes. We further note that some PIs were unable to contribute to this document within the required timeframe given the pandemic working conditions.

**Ancient Life Group**

The Ancient Life Group (ALG) was established at the University of Manchester (UoM) in January, 2020. Over the past five years this group has brought in £7.2 million income to the University, provided £1.6 million in infrastructure funding for developments in imaging, and has attracted synchrotron facility access charges worth in excess of £2 million. Furthermore, funding for the Mission Jurassic project, a multi-year excavation in North America with Prof. Phil Manning as lead scientist is worth approximately £21 million, and a significant portion of those funds have been allocated to the University of Manchester research team, especially to fund Dr. Victoria Egerton as a Manchester-based co-investigator on this major international project and also to support field teams at the site during each Summer. The nine core group members (Wogelius, Manning, Chamberlain, Sellers, Sansom, Garwood, Buckley, Legg, and Egerton) produced over 280 journal articles over the same time period, a large percentage in high profile journals such as *Science, PNAS, Nature Comms., Nature Ecol. & Evol., Mol. Bio. & Evo*. This group produced the Best Outstanding Output (publication) for the Faculty of Science and Engineering in 2020. In terms of the upcoming REF exercise, we quote Prof. Ray Burgess: "ALG has made a vital contribution to the Department’s REF return which has been appreciated and acknowledged by the Department REF panel and more broadly within the School and Faculty. The ALG has played its part in consistently producing many fine papers over the REF interval which will feature in our return. It has also been one of the groups who have made most effort to engage with the process by completing reviews and proposing top quality outputs”. Based on our research strength, ALG has been able to attract a new outstanding young core member through the addition of Dr. Katrina Jones via a prestigious Royal Society University Research Fellowship. Prof. Andrew Chamberlain retired in 2020 and therefore the addition of Dr. Jones keeps our core membership at 9. We are currently supervising 11 Master’s and 6 PhD projects. For planning purposes below we provide an overview of our ongoing research activities divided up into five major areas.

**Resolving Evolutionary Pathways-** This is the core area of research in this group and covers a broad sweep of evolutionary history. Garwood and Legg are internationally recognized experts in invertebrate evolution and will continue to develop Museum links and their analytical programmes to provide key information concerning the structural aspects of the origins, diversification, and functions of this large and important group of organisms. Manning and Wogelius have also contributed to high impact publications in this area through external collaboration. One of the big questions to be addressed in this research is the colonization of the terrestrial environment by invertebrates. Vertebrate evolution is the second strand in this research area, with Manning, Jones, Sellers, Sansom, Buckley, and Wogelius all contributing to several different areas of interest. Buckley has an extremely well-funded (academic and industrial) research effort which is based on his ZooMS technique development which gives him the ability to track and resolve vertebrate linkages via proteomics with unprecedented resolution. Therefore, he is involved with resolving problems in vertebrate evolution, diversification, extinction, and distribution for systems both archaeological and palaeontological. This work also contributes to our understanding of the kinetics of protein degradation and the identification of fragmentary sub-fossil remains through collagen fingerprinting. Sellers has high profile publications on vertebrate gait and more recently has been funded to study the complex capabilities of the human hand. Manning is currently involved with many projects concerned with vertebrate evolution, including discovering and analyzing specimens from fossil deposits that show exceptional preservation at the KPg boundary and a large death assemblage from the Morrison Formation (Wyoming). Sansom, Manning, and Wogelius are working together on a project to resolve the origins of the vertebrate skeleton and the early structural changes this enabled. Jones has produced well-received high-profile publications on the subtle differences in the vertebral column that have occurred, especially in mammalian evolution and plans to continue this exciting research. Sansom has expertise in understanding the impacts of taphonomy on interpreting the fossil record, and this will be combined with the reaction kinetics knowledge (Wogelius), proteomics expertise (Buckley), and vertebrate taphonomy experience (Manning) in a new proposal intended to compare scanning results of vertebrates from complementary technologies in order to optimize the information content that can be derived from rare specimens. Egerton along with duties for the Mission Jurassic project which involves mostly vertebrate specimens, has been measuring and processing data which contains information about the first appearance of land plants and we are keen to add the aspect of palaeobotany to the range of evolutionary science that our group covers. Garwood, Sansom, and Legg all also perform computational work, developing algorithms and testing hypotheses concerning phylogeny. Finally, all of these diverse areas of research are linked together by group efforts (led by Wogelius) to use and develop the concept of the Palaeometallome such that all of the chemical analyses we complete can be organized in terms of the biochemical pathways which appear and are conserved throughout the evolutionary process to give a parallel methodology to structural analysis for both extinct and extant species.

**Quantifying Major Evolutionary Events-** Another key aspect of research into life on the planet involves understanding singularities, that is, major evolutionary events that produce a step-change in the biological component of the Earth’s surface. This interfingers with the bundle of research discussed above, but is worth discussing separately because these singularities are often difficult to study but provide tremendous insight into the planet’s history. The invertebrate and palaeobotany strands above are both concerned with “Terrestrialization,” a process which had profound impacts on the biology and chemistry of the Earth’s surface. The Tanis project is developing a range of analytical results from a unique and tremendously important location with information crucial to understanding the KPg impact event. Manning has already published on this in PNAS, and we are delighted that the young researcher who has been pivotal in developing this site (DePalma) will be joining ALG in 2021 to complete his PhD here at Manchester. The origin of the vertebrate skeleton is another major step-change in evolutionary history. Sansom, Manning, and Wogelius have been analyzing specimens and have a large data set almost ready to publish on this topic.

**Fieldwork and Museum Collaboration Programmes-**  Manning has led the field programme for this group and here is where the Covid-19 pandemic has ground our research to a nearly complete halt. He has two extremely high profile sites in development: the Mission Jurassic Project, USA (Manning, Egerton) and the Tanis Project- KPg boundary , USA (Manning, Egerton). Both of these hold fundamentally important specimens and chemical data which have already led to important publications, but there will be much more science to be done at both sites. These activities however will be delayed. There is also a Devonian heterostracan locality, here in the UK (Sansom) which has provided useful specimens for the origin of bone project which may become accessible again sooner than travel to North America will be allowed. In a similar vein, this group also requires access to Museum collections. Examples of the ongoing collaborations are as follows. Garwood: Ken Angielczyk (Field Museum of Natural History), Jason Dunlop (Museum fur Naturkunde), Greg Edgecombe (Natural HIstory Museum). Manning: Mark Norell (AMNH, USA), Jennifer Anne (The Children’s Museum of Indianapolis, USA), Anne Schulp (Utrecht University and Naturalis Biodiversity Center, Netherlands). Again, these depend on ability to travel and certain collaborative work may be delayed due to Covid-19.

**Geochemistry-** This area of research is listed separately because one group member is involved with research that does not involve ancient life. Wogelius has continued to do research into trace element mobility and reaction kinetics, most recently concerned with rock matrix diffusion as a process impacting radioactive waste mobility. Wogelius has maintained ties with the MES research group and will continue to produce results in this area of Earth science. It is worth noting that the analytical technique development listed below is also strongly related to the geochemistry research, and also that geochemical analysis is a key component involved in interpreting the analytical results of fossil material.

**Central Facility X-ray Imaging and Analytical Technique Development-** This aspect of our research portfolio is perhaps the most unique feature of this research group. We have ongoing beamline or technique development at several X-ray facilities. Key facilities and collaborators are: Uwe Bergmann (SSRL & Wisconsin, USA), Nicholas Edwards and Sam Webb (SSRL, USA), Steve Parry, Giannantonio Cibin, Tina Geraki, Fred Mosselmans (DLS), P. Tafforeau (ESRF), Loic Bertrand (SOLEIL), Phil Withers and Tristan Lowe (NRF). These collaborations contribute to the invertebrate and vertebrate evolution research, all of the major evolutionary events projects, field and museum collaborations, and are central to the palaeometallome and geochemistry research. We have been able to carry on with some limited work at SSRL and NRF through our close relationships with staff there, however analyses have been challenging during the pandemic. Going forward we expect limited access for as long as the pandemic is affecting travel and work patterns.

**DEES Collaborations-** Finally we note that our group has a number of collaboration within DEES. We have associate group members, van Dongen (MES) contributes organic geochemistry expertise and Schroeder has collaborated on work detailing early stromatolites (Basins). Ongoing collaborative projects also include meteoritics (Joy, Isotopes), Kane (microplastics, Basins), and Shultz (ZooMS, E&E).

**ALG Main Goals- 12 month specific research objectives**

1. Complete in situ XCT of RMD to confirm our conceptual paradigm shift on diffusion length scales as published in Wogelius et al. 2020 (Wogelius).
2. Finish gathering data on early vertebrates and analyze our data set to complete and publish a reappraisal of the origin of vertebrates (Sansom, Manning, Wogelius).
3. Recover facility access and re-group in post-Covid landscape with collaborators to compose a grant proposal combining state-of-the-art XAS spectroscopy, XRF imaging, and XCT advances to develop an integrated set of sample analysis protocols to produce enhanced information output from biomineralized samples.
4. Complete the structural analyses of eggshell from a clutch of Jurassic eggs from the UK, all chemical analyses have been undertaken. Lack of access to thin-section facilities has held-up this project (Manning, Wogelius, Egerton).
5. Complete description and analyses of an embryonic pterosaur from the Hell Creek Formation (Manning, Wogelius, Egerton).
6. Complete and publish projects on morphological clocks, ammonite soft tissues, using simulations to test biodiversity-disturbance models, productivity hypothesis, and the SLOSS debate (Garwood).
7. Complete first draft of morphological insect phylogenetic analysis for NERC grant, ready for inclusion of molecular data in future (Garwood, Sansom)
8. Establish and publish on Imaging Mass Spectrometry protocol for sub-fossil remains (Buckley)

**Outline how you will use university/department infrastructure and technical support in the next year, highlighting where any investment is required**

Technical support used for microtome sectioning of decalcified bone**.**

Thin-section making is essential to complete multiple facets of the palaeo research programme.

Glancing incidence X-ray diffraction is needed for secondary phase identification in the RMD project.

ICP-MS and ICP-OES analyses will be needed for the RMD project.

SEM-EDS will be required for several projects including RMD, vertebrate origin, and others.

XCT imaging will continue via collaboration with Prof. Phil Withers covering vertebrate, invertebrate, and RMD projects. We have been in discussions concerning formalizing the ICAL - National Research Facility collaboration.

FTIR imaging and spectroscopy will provide critical supplementary data to the X-ray techniques discussed above if the FTIR equipment can be moved and reinstalled without delay.

This group will be losing the kinetics laboratory as of February 2021, which had been used for specimen preparation, experiments, and FTIR analysis. We are now planning to move the Spotlight imaging FTIR system into the Palaeo laboratory along with limited amounts of specimen preparation equipment. Because the palaeo lab now has no sink due to conversion of the back room for office space it will not be possible to complete wet experiments in that lab.

Within the Stopford building the Anatomy Lab will be upgraded through a Royal Society grant to Dr. Katrina Jones to include a new surface scanner. She will be using all of the existing equipment and has technical support for XCT data processing. Dr. Jones has requested a larger dissection table and has inquired about a part-time lab manager for this lab.

Dr. Sansom has a taphonomy wet lab within Stopford.

This group also has four Ancient DNA Labs within MIB which are heavily used by the Buckley group for research and contract work.

**Outline any upcoming staffing changes or gaps and opportunities to achieve strategic goals or maintain existing strengths**

Our most important and exciting staffing change is the addition of Dr. Katrina Jones from Harvard who will join our group in early 2021. This addition strengthens the vertebrate palaeontology side of our group and creates new possibilities for collaborative work both within the group and with external collaborators. Her skill set matches well with the strong analytical foundation that this group enjoys. She will be heavily involved with lab XCT and synchrotron X-ray projects.

Thin-section lab and rock-cutting capabilities are crucial for this group. Almost all world-class Earth Science departments maintain a rock preparation facility, because often sample preparation for research is not routine and requires discussion between academic and technician to produce the best surface for analysis. This capability has been of fundamental importance to our group over the past years and the uncertainty surrounding this facility is of deep concern to all members. Lack of bespoke thin sectioning and rock cutting will hamper our research activities.

ICP-OES/ICP-MS. This capability has underpinned geochemistry at Manchester for thirty years. The project with RWM that Wogelius has funding for requires in situ XCT experiments where product fluid analysis is one of the key deliverables. The EPSRC grant we are planning to submit will require ICP analyses. This analytical facility also needs to be available to support the geochemical aspects of this group’s research.

**Research Income Generation for the next year**

Please detail your future plans for research income generation over the next 12 months (identifying the lead academic where possible). Please detail any planned applications in the table provided on the last page.

Sellers & Garwood have a Leverhulme grant in preparation on the advent of burrowing - this currently needs to be costed.

Buckley has a NERC grant about to be submitted.

Buckley also has a Leverhulme grant in preparation on Imaging Mass Spectrometry in fossils.

Manning is preparing a NERC grant on KPg sample imaging.

Wogelius is preparing an EPSRC grant on biomineralization. £700k including PDRA and SEO costs. Planned submission date: August 2021.

Jones has submitted a Leverhulme Grant (w/ Bates, PI; invited for detailed proposal) (2021-2024) - just the cost of a PhD student - 73,452GBP

Jones has submitted a Marie Curie Global Fellowship - Amandine Gillet, submitted Sep 2020. (2021-2024) - 271,732EUR

**UKRI and other UK funders (eg Royal Society, Leverhulme)**

*Please identify developing research programmes, highlight topics, large grant opportunities, UK/US collaborations and fellowships in your research area and your plans for targeting these programmes? When will they occur and who in the group will lead and who will contribute to the activity? Are there any obstacles to delivery?*

**Other funding sources**

*Please identify developing research programmes funded from non-UK sources*

The Children’s Museum of Indianapolis

**Business engagement**

*Please describe the development of current industrial relationships or consortia and your plans for them. Are there any new industrial partnerships or areas of engagement that you see developing? Who in the group will lead these and what is the projected size and timescale? What plans do you have for applications for Industry Collaboration Funding (IAAs, KTPs) Innovate UK competitions and the Industrial Strategy Challenge Fund competitions? Would you like to enlist the help of the Business Engagement Office to support any of the planned activities of your Group?*

i) Currently, Wogelius has funding from Radioactive Waste Management for a project on Rock Matrix Diffusion. This is a continuation of an earlier project, and we plan to continue engagement with RWM on this area of research and related research into fluid flow in low permeability crystalline rocks. We will maintain our relationship with RWM and continue to bid for projects that have a geochemical kinetics and imaging component.

 ii) Buckley has regular industrial income (so far >£30k from over 10 sources over past 5 years and will continue this revenue stream.

*Please list any planned applications over the next 12 months:*

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| **PI and team** | **Sponsor/Call**  | **Research Area/Proposal Title** | **Date**  | **Value** | **Chance of success (%)** | **Comments** |
| Sellers, Garwood | Leverhulme | Burrowing | March 2021 | tbd | 10% |  |
| Buckley  | NERC |  | Jan. 2021 | £400k | 10% |  |
| Buckley | Leverhulme |  Imaging Mass Spectrometry in Fossils | Jan. 2021 | £300k | 10% |  |
| Manning, Wogelius, Egerton | NERC  | KPg Sample imaging | June, 2021 | £500k | 10% |  |
| Wogelius, Manning, Sansom | EPSRC | Biomineralization: Combining Imaging and Spectroscopy | August, 2021 | £700k | 10% |  |
| Jones and Bates (Liverpool) | Leverhulme | Vertebrate spine evolution 1 | Sept., 2020 | £73k | 20% |  |
| Jones | Marie Curie Fellowship | Vertebrate spine evolution 2 | Sept., 2020 | £245k | 10% |  |
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