The EPSRC Centre for Doctoral Training in Science and Engineering in Arts, Heritage and Archaeology (SEAHA) at University College London, University of Oxford and University of Brighton (http://www.seaha-cdt.ac.uk/), in collaboration with Tate (http://www.tate.org.uk/) and Conservation by Design (http://www.conservation-by-design.com/home.aspx?pagename=home) is seeking applications for a fully funded studentship on the topic “Modelling the chemical and physical degradation of plastic objects in museum collections using a System Dynamics approach”. Funded by the Engineering and Physical Sciences Research Council (EPSRC) through the SEAHA Centre for Doctoral Training, the four year doctoral research project will be supervised jointly by the UCL Institute for Sustainable Heritage, UCL Chemical Engineering, Tate and Conservation by Design.

This project will develop new methods for studying material degradation, developing mathematical models based on systems of partial differential equations incorporating multiple chemical and physical processes. These models will be applied in the context of the conservation of plastic objects in museum collections, adding in parameters describing storage and display conditions. This work will be done in the framework of the ERC Starting Grant funded project “COMPLEX: The Degradation of Complex Modern Polymeric Objects in Heritage Collections: A System Dynamics Approach”.

Plastic objects exist in large numbers in museum collections, for example as works of modern art and design. However, they can be among the most fragile artefacts, with material degradation sometimes reported within a few years of acquisition by a museum. Their preservation is thus a significant challenge.

Degradation of plastic objects is complex, involving multiple processes such as the diffusion of substances through the material and chemical responses to environmental parameters such as temperature and light. The way such processes interact as a complex system within a single object, and the way observed material degradation depends on composition, structure or environment is not well understood. This project will address this using a system dynamics approach, i.e. modelling multiple degradation processes mathematically in a single system. This research will thus both develop a new method of modelling material degradation that can be applied in many fields, such as medicine or defence, and provide practical solutions for heritage professionals, such as providing guidance on controlling museum storage environments.

The SEAHA student for this project will work with other students and postdoctoral researchers as part of COMPLEX, including those with expertise in mathematical modelling and chemistry.

The project addresses the following research questions:

1. How are chemical and physical processes relevant to the degradation of plastic artefacts in museum collections expressed mathematically in relevant literature? What relevant processes require further experimental study?
2. How can these processes be modelled as a system of partial differential equations? What analytical and numerical methods can be used to solve these equations?
3. How can this model be optimised to provide an accurate description of observed material behaviour? What key behaviours need to be incorporated?
4. What parameters have the most influence on model dynamics? Can key leverage points be identified that can be used to change future behaviour and thus improve the preservation of plastic objects in collections?
The successful student will first conduct a literature review, identifying relevant chemical and physical processes involved in polymer degradation and appropriate ways of modelling them. This will lead to the development of a model (focussing first on a single polymer, likely cellulose acetate), based on partial differential equations, able to describe the spatial evolution within the material of the variables characterizing the system, such as local moisture content, concentrations of organic acids and the local degree of degradation of the material. The model, in its original form or suitably simplified (for instance, by means of perturbation methods), will then be solved numerically and validated experimentally. Working in collaboration with Tate, the research will be informed by the expertise of conservation scientists and conservators, including preventive conservators, and the model will be tested against its ability to simulate realistic museum scenarios using real environmental data and material properties. The Vensim® software from Ventana software has been identified as a tool that has been designed for and is widely used for systems dynamics modelling. Other software tools such as Matlab from Matworks® or MapleSim™ from Maplesoft will also be used.

The work will then continue to optimise the model and also to develop models for other relevant plastics. This will involve: (1) Incorporating new chemical and physical processes into the model. (2) Identifying key parameters that have a strong impact on the outcomes of the model. This work will start by using existing mathematical workflows from literature. (3) Optimising and validating the model. This will require validation of the model in collaboration with the laboratory-focussed researchers, who can develop model systems for testing, and with Tate, who can provide real museum data for validation.

**Academic entry criteria:** The candidate will ideally have a background in Physics, Maths, Computer Science, Astronomy, Computational Physics, Engineering or a related field.

**Training path:** The student will be part of the EPSRC Centre for Doctoral Training SEAHA (Science and Engineering for Arts, Heritage and Archaeology). Students will register for the one year MRes SEAHA at UCL in year 1 and then continue to PhD studies for years 2-4 of the studentship. The student will be encouraged to spend time working at both Tate and Conservation by Design.

**Funding:** The SEAHA Studentship will cover fees for both UK and EU students and a stipend of up to a maximum of £18,172 per year (current rate) for eligible applicants (http://www.seahacdt.ac.uk/opportunities/eligibility-criteria/), and a substantial budget for research, travel, and cohort activities. Non-EU applicants are not eligible for funding.

**Enquiries:** Please contact the academic supervisor for further information (k.curran@ucl.ac.uk)

**Application Deadline:** 6pm Monday, 31st July 2017

**How to apply:**

Your application should include:

- A substantial covering letter (2-3 pages) including:
  - a clear explanation of your motivation for applying for this project
  - a statement of your understanding of your eligibility according to the information provided at: http://www.seaha-cdt.ac.uk/study-with-us/studentships/eligibility-criteria/ and https://www.epsrc.ac.uk/skills/students/help/eligibility/
- A short research proposal (max. 2000 words) taking into consideration the project research questions
- A full CV
- Contact details for two academic references (names, postal and email addresses)
- Proof of meeting the UCL English language proficiency requirements where necessary. For SEAHA candidates, an advanced level certificate is normally required (details of English language proficiency requirements can be found at: http://www.ucl.ac.uk/prospective-students/graduate/life/international).
Interviews are likely to take place in early August. Please mention in your covering letter if you will not be available at this time. Remote interviews (e.g. via skype) are possible if necessary.

The application should be submitted by email direct to the UCL SEAHA Administrator and not by the UCL online admissions system. Please email applications to:

Dr Robyn Parker  
SEAHA Centre Manager  
manager@seaha-cdt.ac.uk

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