MASTER DEGREE COURSE

SCIENCE FOR THE CONSERVATION-RESTORATION OF CULTURAL HERITAGE

(SCORE)

ACADEMIC YEAR 2025-2026

APPLICATION FOR INTERNSHIPS AIMED AT IMPLEMENTING THE EXPERIMENTAL THESIS PERIOD OF SIX MONTHS ABROAD

Thanks to a generous contribution from Fondazione Flaminia in Ravenna (http://www.fondazioneflaminia.it), 3 scholarships are offered to students enrolled into the 2nd year of the SCORE Master degree programme who intend to implement their experimental thesis outside of Italy.

The first two candidates of the final ranking list may choose one of the experimental projects described in ANNEX 1.

fourth

Eligibility
Internships are open to students enrolled into the 2nd year of the SCORE Master degree programme. Applicants should:

- have completed at least 40 Credits of the SCORE programme
- be fluent in English
- have an arithmetic average course examination score ≥ 27/30
- not be resident in the country where the selected project will be developed[1]

Terms
Successful applicants will get, directly from Fondazione Flaminia Ravenna, a grant amount of 1650,00 € as a contribution for the entire duration of their stay abroad. If, for any reason, it will not be possible to complete the period abroad the scholarship will be reduced proportionally.

Application deadline is October 31th at 18:00

Materials received after this date will result in an incomplete application.

How To Apply

- Complete and submit via email to prof. Giorgia Sciutto (giorgia.sciutto@unibo.it) your application (ANNEX 2). Applicants have to choose among all the research proposal titles by indicating a maximum of 3 with a priority order. The 3 options indicated cannot refer to the same host institution.

[1] Students may apply for projects that will be developed in their own country but they are not eligible for scholarships

- Submit an auto certification of your academic records (downloadable from the University website) with the indication of the score of each course examination and the arithmetic average course score value.
- Submit a personal statement (written in English) indicating the reasons why you want to implement your research project abroad as well as your motivations
- Submit a short Curriculum Vitae

Evaluation

Applications will be evaluated by a Scholarship Commission nominated by the SCORE Steering Committee.

The Commission will:

- Verify that the applications are complete in all the required documentation
- Make sure applicants comply with the eligibility criteria
- Make a selection of possible successful candidates to be interviewed in order to verify their motivation and their level of knowledge of their English speaking and writing.

Successful candidates to be interviewed will be notified through email by November 5th

Interviews will take place on TEAMS, on November 7th at 10 am

For **technical assistance** please contact prof. Giorgia Sciutto (giorgia.sciutto@unibo.it)

According with D.lgs 30.6.2003 n. 196, candidates personal data will be treated exclusively for the purpose of the selection

Ravenna, 14/10/25

ANNEX 1 – EXPERIMENTAL PROJECTS

SUPERVISOR	TITLE	INSTITUTION	ABSTRACT
Irina Sandu	***New scientific approaches to the study of Munch's paintings collection***	Munch museum, OSLO	The scholarship aims to propose greener and non-invasive approaches to the study and treatment of paintings collection at Munch museum. A selection of few case studies with specific research and conservation needs (characterization of materials and techniques, study of surface degradation patterns, cleaning) will be made according the projects running in house. The fellow will join the Conservation section of the museum working closely with the Conservation scientist and paintings conservators. The infrastructure to be accessed is made of a Scientific lab equipped with pXRF and ATR-FTIR spectroscopy, Hirox digital microscope, PLM and SM microscopes and a conservation studio. In addition, access to the library of the museum and exhibition or storage rooms can be made, according needs and upon specific requirements. **Duration**: 5-6 months (January/February-end of June 2026)
Sonia Bujok	***Determination of a safe range of relative humidity variations for illuminated parchment***	Jerzy Haber Institute of Catalysis and Surface Chemistry, Polish Academy of Sciences	The proposed project aims to develop further a material database necessary to develop a 3D physical model of illuminated parchment and through this decisively contribute to the development of evidence-based environmental specifications in museums. The project will aim at the analysis of historical recipes of paints used to illuminate parchment sheets. Using the historical recipes a set of representative samples will be prepared and tested using a universal testing machine and a dynamic mechanical analyser to determine basic mechanical properties at various humidity levels and the moisture response of the specimens. If time allows, using the database and previously obtained material properties of parchment, a model of illuminated parchment will be built using COMSOL Multiphysics software. The safe ranges of relative humidity variations for paintings with craquelures will be determined by subjecting the model of a painting to virtual RH changes of varying amplitude and duration, calculating the energy release rate for the existing crack tips and

			comparing this data with critical values of fracture toughness obtained experimentally
Łukasz Bratasz	***Determination of a fatigue function for brittle historic materials***	Jerzy Haber Institute of Catalysis and Surface Chemistry, Polish Academy of Sciences	The project aims to fill the gap in knowledge about the mechanical properties of historic materials related to fatigue processes. Understanding object vulnerability to environmental variation requires information about critical levels of stress or deformation. So far, this information is limited to single experiments performed in the laboratory. The relation between critical levels and a large number of loading cycles has not been determined successfully for key historic materials. The current environmental specifications are based on the assumption that objects adapt to the environment in which they are stored, but the role of the fatigue process is not fully assessed. In the project, the novel approach to fatigue tests will be tested to avoid challenges with mounting very brittle historic materials into the Universal Testing Machine. It will be based on designing an Euler-like shape using 3D printer. The various places on the shape correspond to various strains in the attached specimen. The specimens, consisting of a thin wooden base, sized with animal glue and covered with gesso, egg tempera and gouache, will be prepared. The UTM will push specimens into an Euler-like shape in cycles. The places of crack formation will be identified using a high-resolution camera. In this way, the S-N curve will be determined for key historic materials, informing safe environmental specifications for museums, archives and libraries.
Qing Wu	***Potential re-tarnishing and passivation of L-Cysteine during silver cleaning*** ***Supervisor: Qing Wu, Haute Ecole Arc Conservation-restauration***	**Haute Ecole Arc Conservation-restauration**	Our recent study demonstrated the strong potential of L-Cysteine (L-Cys) for removing tarnish from both sterling and pure silver. While the immersion approach proved effective and safe, developing L-Cys-incorporated gels (containing limited L-Cys content) would better meet museum conservators' requirements for a more controllable delivery system. However, preliminary experiments indicated that when a minimum effective volume of highly concentrated L-Cys was used, sterling silver underwent initial cleaning but re-tarnished within 24

			hours, whereas pure silver remained clean throughout the test, possibly due to the formation of a passivation layer (see figure below). The proposed Master study aims to investigate and determine a potential threshold of L-Cys for both sterling and pure silver, below which passivation predominates and above which re-tarnishing occurs. In addition to routine analytical techniques, synchrotron-based methods may also be employed to gain a deeper understanding of the dynamic complexation of Cu and/or Ag ions by L-Cys.
Qing Wu	***Sapoline-based eutectogels for the cleaning of copper, iron and their alloys Supervisor: Qing Wu, Haute Ecole Arc Conservation-restauration***	**Haute Ecole Arc Conservation-restauration**	Sapoline is a mixture of the natural surfactant saponin and natural deep eutectic solvents (DESs). It can be loaded onto tissue-type matrices for application on the curved surfaces of metal objects. The proposed Master's study aims to optimize sapoline and sapoline-based gel protocols to achieve enhanced cleaning efficiency for brass and steel. Detailed analyses will also be conducted to better understand the nature of sapoline, specifically whether it is merely a DES solution of saponin or if saponin also contributes to hydrogen bonding with aquoline. In parallel, the physical properties of sapoline gels, such as elasticity and strength, will be investigated. Additional tasks may include developing sapoline from the decoction of natural soap nuts to further reduce costs, as well as establishing protocols that enable simultaneous cleaning of corrosion products and degraded coatings.
Sorim Hermon	***XRF/LIS/RIS scanne R: new application in the field of Culturaal Heritage***	**STARC, The Cyprus Institute**	The topics we offer are related to hyper-spectral imaging, utilizing our in-house built XRF/LIS/RIS scanner, in particular broadening its application domains, optimization of its data processing software (based primarily on PyMca) and its integration with 3D geometry scan data. Possible domains of application are Byzantine and post-Byzantine artworks and icons, archaeological artefacts, Rennaissance paintings, etc., for the characterization of the materiality, state of conservation and painting techniques. We are also interested to explore methods for improving description of data provenance and reasoning, building knowledge graphs on the hyper-spectral imaging workflows. We are also interested to explore the possibility of developing projects within the digital environment of ECHOES, the European Collaborative Cloud

			for Cultural Heritage, in particular the creation of heritage science-based heritage digital twins. Please find some references related to the proposed internship: Moreau, R., Calligaro, T., & Hermon, S. (2023, July). Multi-sensor scanners and machine-learning data processing: a novel instrumentation and data analysis method in heritage science. In *2023 23rd International Conference on Transparent Optical Networks (ICTON)* (pp. 1-9). IEEE. Moreau, R., Calligaro, T., Pichon, L., Moignard, B., Hermon, S., & Reiche, I. (2024). A multimodal scanner coupling XRF, UV–Vis–NIR photoluminescence and Vis–NIR–SWIR reflectance imaging spectroscopy for cultural heritage studies. *X-Ray Spectrometry*, *53*(4), 271-281.
Koen Janssens, Ermanno Abranovich,	***Synergistic degradation of lead- and copper-containing pigments induced by chlorine: kinetic insights***	**Antwerpen Univeristy**	The identification of the atypical mineral *cumengeite* ($21PbCl_2 \cdot 20Cu(OH)_2 \cdot 6H_2O$), a mixed (Pb,Cu) basic chloride salt, in a medieval painted fragment from the vault of the Upper Church of *San Francesco d'Assisi* has raised pertinent questions regarding its potential spontaneous formation *in situ* as a secondary compound (see Fig. 1). Its presence, most likely the result of the transformation of original painting materials, was identified through X-ray powder diffraction [1]. Likewise, *cumengeite* formation was observed in vitro when a mixture of Pb- and Cu-carbonates was exposed to chlorine under alkaline conditions, thereby illustrating a plausible pathway for its formation as a secondary product in wall paintings. In the field of heritage science, *cumengeite* is rarely found in paintings but it has previously been identified in historical bronzes and Roman coins as part of degradation patinas. Until now, this compound had only been detected on painted surfaces by Hradil et al. in a series of wall paintings [2]. In the field of heritage science, *cumengeite* is rarely encountered in painted works, although it has been previously identified

			on historical bronzes and Roman coins as part of degradation patinas. Prior to this, the compound had only been detected on painted surfaces in a study by Hradil et al., which involved a series of wall paintings [2]. In that particular case, the presence of *cumengeite* was interpreted as the result of an intentional application of blue pigment, as no lead-containing pigments or compounds were found near the *cumengeite*. Consequently, its *in situ* formation as a result of paint degradation was excluded, and, given the rarity of *cumengeite* in nature, a historical recipe was suggested to account for its presence as a blue pigment in wall paintings [2]. This project aims to investigate the conditions and kinetics that favor the formation of copper and lead halides and/or their combination into complex secondary compounds, such as *cumengeite*. The research seeks to unravel and clarify the mechanisms and potential causes of *in situ* formation through a multiscale approach applied to specially prepared model samples, both before and after aging. **Goals:** Having previously conducted a series of experiments to determine the spontaneous formation of *cumengeite*, this project will replicate and extend those experiments in order to confirm the results and expand their significance through the application of multiple analytical techniques. Furthermore, based on the insights gained, *in operando* experiments will be designed, employing specially constructed reactors to clarify the kinetics of the chemical reactions involved. The master's student will be involved in the fundamental aspects of the research, which are organized into four primary tasks: • Literature review and sample preparation: The student will develop a comprehensive understanding of the topic to design an appropriate set of model samples for investigation. • Interaction with chlorine and accelerated aging: These models samples previously obtained will then be subjected to harsh environmental conditions to induce the rapid formation of by-products regular, color and diffraction measurements will be employed to monitor the degradation over time in this phase. In

			parallel tests on unbound pigments to define their reaction rate will be performed using an *in operando* strategy. • Characterization of compounds: The student will characterize both the initial and newly formed compounds using X-ray diffraction and FTIR techniques, conducting macro- and microscale investigations [3]. • Data analysis and reporting: The data collected from all experiments will be compiled into a final report. Depending on the outcomes, a manuscript may be prepared for submission to a peer-reviewed journal. The ideal candidate should possess a solid understanding of the fundamental principles behind the aforementioned analytical techniques and be familiar with Linux-based operating systems. A high degree of versatility and adaptability in using and learning new software will also be highly beneficial. **References:** [1] Avranovich Clerici, E. et al., *Molecules* 2023, 28, 6106A. [2] Švarcová, S.; Hradil, D.; Hradilová, *J. et al., Anal. Bioanal. Chem*. 395, 2009, 2037-2050. [3] Cotte, M.; Gonzalez, V.; Vanmeert, F.; Monico, L.; Dejoie, C.; Burghammer, M.; Huder, L.; de Nolf, W.; Fisher, S.; Fazlic, I.; Chauffeton, C.; Wallez, G.; Jiménez, N.; Albert-Tortosa, F.; Salvadó, N.; Possenti, E.; Colombo, C.; Ghirardello, M.; Comelli, D.; Avranovich Clerici, E.; Vivani, R.; Romani, A.; Costantino, C.; Janssens, K.; Taniguchi, Y.; McCarthy, J.; Reichert, H.; Susini, *J. Molecules* 27, 2022, 1997. https://doi.org/10.3390/molecules27061997
Katrien Keune	***Usage of electro-spun nonwoven tissues as a delivering agent for essential oils for varnish removal***	University of Amsterdam	Non-woven tissues are increasingly used in paintings conservation for varnish removal from oil paintings. Its key benefits over traditional cotton swabs are limiting solvent exposure and reducing mechanical action on the paint surface. Within the GoGreen project non-woven tissue are being developed in a sustainable way. This project investigates the interactions between different tissues used for varnish

			removal in oil paintings. The focus is on exploring greener alternatives for varnish removal, such as the use of essential oils in combination with different non-woven tissues. The cleaning efficiency will be assessed using mock-ups and UV, FTIR and laser speckle imaging techniques.
ing prof. Cresnar	***Isotopes Analyses of Animal Bones for Reconstruction of Human Diet and Animal Husbandry in Prehistory***	University of Lijbliana	**Challenge:** Interpreting human bone isotope values ($\delta^{13}C$, $\delta^{15}N$, $\delta^{34}S$) requires robust, site-specific faunal baselines. Species ecology, foddering, manuring, and local geology/soils can shift animal isotope values substantially. Traditional reliance on literature baselines risks misinterpretation; the challenge is to generate a **context-specific faunal isotope framework** that both (1) anchors human dietary reconstructions and (2) reveals **husbandry practices** at the site. **Methodology:** The student will analyse faunal bones from archaeological contexts (herbivores/omnivores commonly linked to human diet, such as cattle, sheep/goat and pig, plus wild taxa where available) from secure archaeological contexts and phases. • **Sampling & screening:** taxon/element selection across stratigraphic units and phases; collagen quality checks (%C, %N, %S; **C:N 2.9–3.6**, **C:S ~3.1–3.5**, **N:S ~10–13**) and diagenesis screening (e.g., FTIR indices where appropriate). • **Collagen preparation:** demineralization, gelatinization, ultrafiltration, lyophilization. • **Isotope measurements:** EA–IRMS for **$\delta^{13}C$ and $\delta^{15}N$**; EA–IRMS (SO_2) for **$\delta^{34}S$**; measured in duplicates, using internal standards, and international references. • **Data analysis:** construct species- and phase-specific baselines; apply trophic enrichment factors (TEFs) to anchor human data; interpret **husbandry signals** (manuring via elevated $\delta^{15}N$, woodland/open grazing via $\delta^{13}C$, locality/mobility via $\delta^{34}S$). • **Integration:** synthesize with zooarchaeology, archaeobotany, and archaeological context.

			Expected results: • **Faunal isotope baseline ($\delta^{13}C$, $\delta^{15}N$, $\delta^{34}S$)** by species and phase for the site. • A **calibrated framework** to interpret human isotope values using local TEF-anchored baselines. • Inferences on **animal husbandry practices**: grazing zones, foddering/manuring intensity, potential mobility. • Open dataset, standard operating protocols, and **recommendations** for future sampling strategies at the site and comparable contexts. **Research group / interdisciplinarity:** The internship will take place at the University of Ljubljana in collaboration between the Faculty of Arts (Department of Archaeology) for archaeological contextualization, zooarchaeology, and FTIR pre-screening, and the Faculty of Chemistry and Chemical Technology for IRMS measurements. The project bridges archaeology, osteology, isotope geochemistry, zooarchaeology, and quantitative modelling, and **connects scientific outputs to cultural heritage interpretation and management** by engaging heritage practitioners to translate faunal baselines and modelling results into site narratives.
prof. Humar	***Wood Identification of Weathered Cultural Heritage Materials Using Hyperspectral Imaging, FTIR and Micro-XRF***	University of Lijbliana	**Challenge:** Identifying wood species in cultural heritage objects is crucial for informed conservation decisions, accurate authenticity assessments, and preventing the illegal trade in protected species. However, traditional microscopy is often destructive and less effective when surfaces are altered by weathering, heating, or exposure to light. The challenge is to establish non-destructive methods that allow reliable identification of wood species even after long-term ageing (degradation/weathering) processes. **Methodology:** The student will investigate wood samples of various species subjected to controlled treatments: heating, UV exposure, natural weathering, and accelerated weathering in an ATLAS chamber. Hyperspectral imaging (HSI) in the NIR/SWIR range will be applied following the

			methodology developed in recent classification studies, combined with data pre-processing (for example: SNV, MSC, Savitzky–Golay derivatives) and machine learning models (Random Forest, SVM). Complementary techniques will include FTIR spectroscopy for chemical characterisation and micro-XRF for elemental mapping of altered surfaces. Comparative analyses will evaluate how weathering affects spectral signatures and classification accuracy. **Expected results:** • Establishment of reference spectral/chemical databases for untreated and treated wood species. • Assessment of the robustness of HSI, FTIR, and micro-XRF for identifying weathered wood. • Recommendations for applying these techniques to cultural heritage artefacts. • Multimodal methodology that links chemical background with wood science and heritage needs. **Research group / interdisciplinarity:** The internship will take place at the University of Ljubljana, Biotechnical Faculty, Department of Wood Science and Technology, in collaboration with the Faculty for Chemistry and Chemical Technology. The team combines expertise in wood protection and cultural heritage science (Prof. Miha Humar, Dr. Boštjan Lesar), hyperspectral imaging and data analytics (Luka Kopač, Dr. Jaka Levanič), and advanced material characterization. The project is inherently interdisciplinary, bridging chemistry, wood science, imaging technologies, and heritage conservation.
Ing. Riccardo Cacciotti	***Experimental methodology for evaluation of climatic effects on built heritage in the wind tunnel***	Institue of Theoretical and Applied Mechanics, Czech Academy of Sciences, Prague	Due to climate change it is foreseen that the frequency and magnitude of extreme climate events such as heavy precipitation, flooding and drought will increase throughout Europe. In recent times, numerous areas suffered from disasters that produced significant damage to cultural heritage. Climate significantly affects the performance of building materials and its changing patterns are posed to increasingly exacerbate the projected impacts. Prevention strategies are indeed necessary to ensure avoiding excessive degradation and serious damage

			to the built environment. In this context, innovative and accessible methodologies and tools are required to investigate and characterize the interaction between material properties and climatic factors. This research focuses on the degradation of brick masonry facades with the intent to determine and validate a methodology for evaluating the vulnerability of historic materials and asses its risk in the context of climate change. Tentatively, protective measures will be also investigated. The aim to provide deeper insights on the performance of building materials when subjected to different environmental scenarios in order to support adequate design of mitigation measures. The study is composed of two main tasks: 1) definition and implementation of the experimental methodology using lab-size and full-size wind tunnel and 2) validation by the selection of case studies in the Czech Republic. The student will have a chance to experience or improve his/her laboratory skills, deepening the knowledge about data gathering and processing. Furthermore, surveying/inspection skills will be also developed during the in-field activities.
Liang, Haida	***Imaging techniques and data processing***	Nottingham Trent University Nottingham NG11 8NS, UK	