AMGUEDDFA CYMRU - NATIONAL MUSEUM WALES
Department of Natural Sciences

Novel detection and removal of hazardous biocide residues historically applied to herbaria

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IDENTIFICATION OF HISTORIC TREATMENTS

This PhD research was prompted through rising health concerns associated with key members of staff and researchers working on the NMW herbarium. Similar medical conditions including rhinitis, hay fever, loss of sense of smell, dry eyes, dry throat and eczema had developed over a period of just 4 months for some individuals and up to five years in others.

Research was undertaken to determine the inorganic and organic biocide contamination on the collections of both lower plant and vascular material. Analysis determined that significant concentrations of naphthalene and mercury, were present on the collections. Literature searches provided confirmation that these chemicals could induce the observed symptoms amongst personnel.

Due to the paucity of historic information regarding the treatments applied and the lack of observable signs, this problem has been largely ignored and has therefore become exacerbated.

Numerous experiments were attempted to provide a method of identification for historic treatments, and finally scanning with a UV lamp (fig. 1) provided a positive response. UV-A radiation caused a fluorescence on the sheets that was not observable in visible light. The fluorescence induced was distinctly coloured, ranging from cream through to orange. Within these coloured areas, mercury was always present, however no other single chemical provided this response.

Fig. 1. Identifying historic treatments applied to herbaria using a UV Lamp. The right image shows and example of example of intense orange fluorescence under UV light..

ANALYSIS

Particle Induced X-ray Emission (PIXE) was employed to measure the metal ion concentration within the fluorescence. This process was also able to map an area of the mount sheet. Figure 2 shows the same piece of herbarium paper under both UV light and visible light. Areas of fluorescence are circled in pencil. PIXE mapped a straight line through the two circles. The bright red areas on the map correlate to high concentrations of metal ion within the fluorescing areas. Accelerated ageing tests were conducted to deduce how mercury was producing this fluorescence. Whatman filter paper was spiked with recognised chemical solutions, in this instance, Kew mixture was used (IMS, mercuric (II) chloride, phenol). (Bridson & Forman, 1998).

Observations were made under UV light of the samples following accelerated ageing tests at 80°C with no RH control along with control samples. The observed fluorescence was then taken for further analysis, specifically X-ray photoelectron spectroscopy (XPS), a sensitive method of determining the valence state of a compound. The results are summarised in table 1.

Mercurous (I) chloride (Hg_2Cl_2) is the mineral calomel. Unlike mercuric chloride (which is always white), calomel ranges in colour from white to yellow to grey, and is often a fluorescent red under UV light. It is possible, therefore, that variation in the concentration of Hg (I), and Hg (II), may well give rise to a range of colours, mostly in the red spectral region (cream, yellow, peach, orange), and mainly fluorescent in nature. The reduction of Hg(II) to Hg(I) is a naturally occurring process, however from the accelerated ageing results, naphthalene is shown to increase the speed of reduction of mercury, hence the enhanced colour relating to increased Hg(I) ions as opposed to Hg (II ions. This is due to the delocalised electrons associated with polycyclic aromatic hydrocarbons.

Sample	Chemical applied		Colour change/ Fluorescence	Binding Energy (eV)	Valence State	Remaining compound after ageing
1	Mercuric chloride	3 days	Cream	99.9 (± 0.2)	0/+1	Mercurous (I) chloride
2	Mercuric chloride	3 days	Cream	100.8 (± 0.2)	+1	Mercurous (I) chloride
3	Naphthalene	3 days	None	Not found	N/A	None
4	Mercuric chloride and Naphthalene	3 days	Peach	100.8 (± 0.2)	+1	Mercurous (I) chloride
Control 1	None	3 days	None	Not found	N/A	N/A
Control 2	Mercuric chloride and naphthalene	0 days	None	Not found	N/A	N/A
Control 3	Naphthalene	0 days	None	Not found	N/A	N/A
Control 4	Mercuric chloride	0 days	None	Not found	N/A	N/A
Control 5	None	0 days	None	Not found	N/A	N/A

Table 1 Results of accelerated ageing tests and XPS analysis

There is a chemical relationship between the historic biocide applications and the cellulose matrix that it binds with. There are numerous potential pathways that the chemicals initiate and figure 4 relates to those associated with transition metal elements, in this case mercury.

$$HOOH + Mn+ \rightarrow M(n+1)+ + HO^{\cdot} + OH- \quad [1]$$
$$HOOH + M(n+1)+ \rightarrow Mn+ + HOO^{\cdot} + H+ \quad [2]$$
$$HOO^{\cdot} + M(n+1)+ \rightarrow Mn+ + O2 + H+ \quad [3]$$

Fig. 4.

Transition metals are likely to be reduced by the peroxide and superoxide species produced during the oxidative processes associated with cellulose degradation. It is probable that in biocide applications, the mercury(II) (in mercuric chloride) will be reduced to Hg(I) in accordance with reaction schemes 2 and 3.

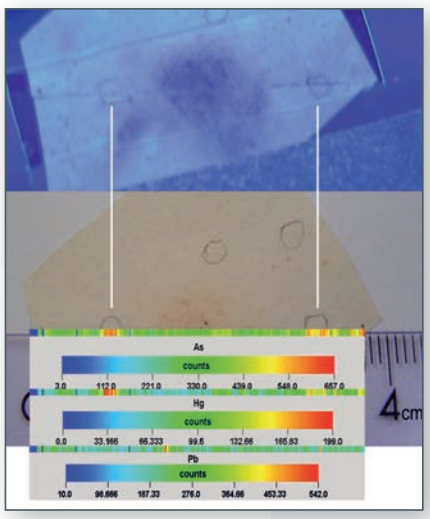

Fig. 3. PIXIE mapping of herbarium paper.

DECONTAMINATION

Reducing levels of both naphthalene and mercury in the NMW herbarium environment were priorities as these were the most prevalent chemicals; mercury is highly toxic and naphthalene is a suspected carcinogen. Once the UV lamp screening technique had been developed, it proved a safe, quick and economically viable method of identifying sheets treated with mercury. Mercury was found to be in concentrations from 0 – 2046µg/g (PPM) throughout the herbarium, and the UV lamp was able to detect the treated sheets indicating which specimens could be selected for a priority re-mounting programme. Removing the contaminated sheets will remove the majority of mercury contamination as a source of inhalation and absorption through the skin.

Naphthalene is a polycyclic, aromatic hydrocarbon with a high vapour pressure for a solid.
The National Toxicological Program (NTP) study states that 9 µg/m3) (NTP, 1992) causes respiratory problems in mice. The odour threshold of naphthalene is reported to be between 99 µg/m3 (USEPA, 1990; von Rotberg, Gagelmann et al., 2005) and 360 µg/m3 (DHHS NIOSH, 1981), therefore if it is detectable by odour, then it is in concentrations high enough to cause harm.

It is absorbed deeply into the matrix of wood and paper and is often present within the herbarium environment long after the source has dissipated or been disposed of. It was expected, because it is volatile, that it could be removed from the herbarium environment with ease, however it is actually very difficult to remove. Three different approaches were employed to remove naphthalene from herbarium sheets: air-drying in a fume cabinet, freeze-drying and heating. The results are tabulated in Tables 2-4.

The most efficient and cost-effective method for the safe removal of naphthalene from the collection has been demonstrated to be air-drying, with a low, continual air flow being maintained over the sample. A maximum loss of 79% naphthalene (by weight) was observed using this method over a 48-hour period. The desorption of naphthalene, however, is not straightforward. Even with a continual airflow over the samples, the surface concentration of naphthalene was observed to increase after the initial 48 hours of treatment. It is believed that this is due to the naphthalene held within the body of the paper being mobilised to the surface, rather than reabsorbed. Further research, however, is needed to understand the kinetics of the process and to determine an effective protocol for optimum success.

For an institution legally required to protect its staff, visitors, volunteers and researchers, the detection and removal of hazardous material from the herbarium environment is a top priority. With most herbaria being vast, the task of decontamination is difficult – both costly and time-consuming, yet this research has provided two simple and economical options that can be readily applied. Following the successful application of these techniques to the NMW herbarium, both biological and environmental contamination was largely reduced.

Time (hours)	[Naphthalene] (ppm) ∑ Test A1, A2, A3	[Naphthalene] (ppm) ∑Control A1, A2, A3	[Naphthalene] (ppm) Total loss
∑	84.16	168.49	84.33
Mean	21.04	42.12	21.08
% Loss	50.05		

Table 2 Naphthalene concentrations across all air-dried sheets, showing total loss (ppm) and % loss.

Time (hours)	[Naphthalene] (ppm) ∑ Test F1, F2, F3, F4	[Naphthalene] (ppm) ∑Control F1, F2, F3, F4	[Naphthalene] (ppm) Total loss
∑	387.77	413.09	25.32
Mean	77.55	82.62	5.06
% Loss	6.13		

Table 3 Naphthalene concentrations across all freeze-dried sheets, showing total loss (ppm) and % loss.

Time (hours)	[Naphthalene] (ppm) ∑ Test H1, H2, H3, H4	[Naphthalene] (ppm) ∑Control H1, H2, H3, H4	[Naphthalene] (ppm) Total loss
∑	77.55	82.62	187.89
Mean	56.18	87.49	31.32
% Loss	35.79		

Table 4 Naphthalene concentrations across all oven-heated sheets, showing total loss (ppm) and % loss.

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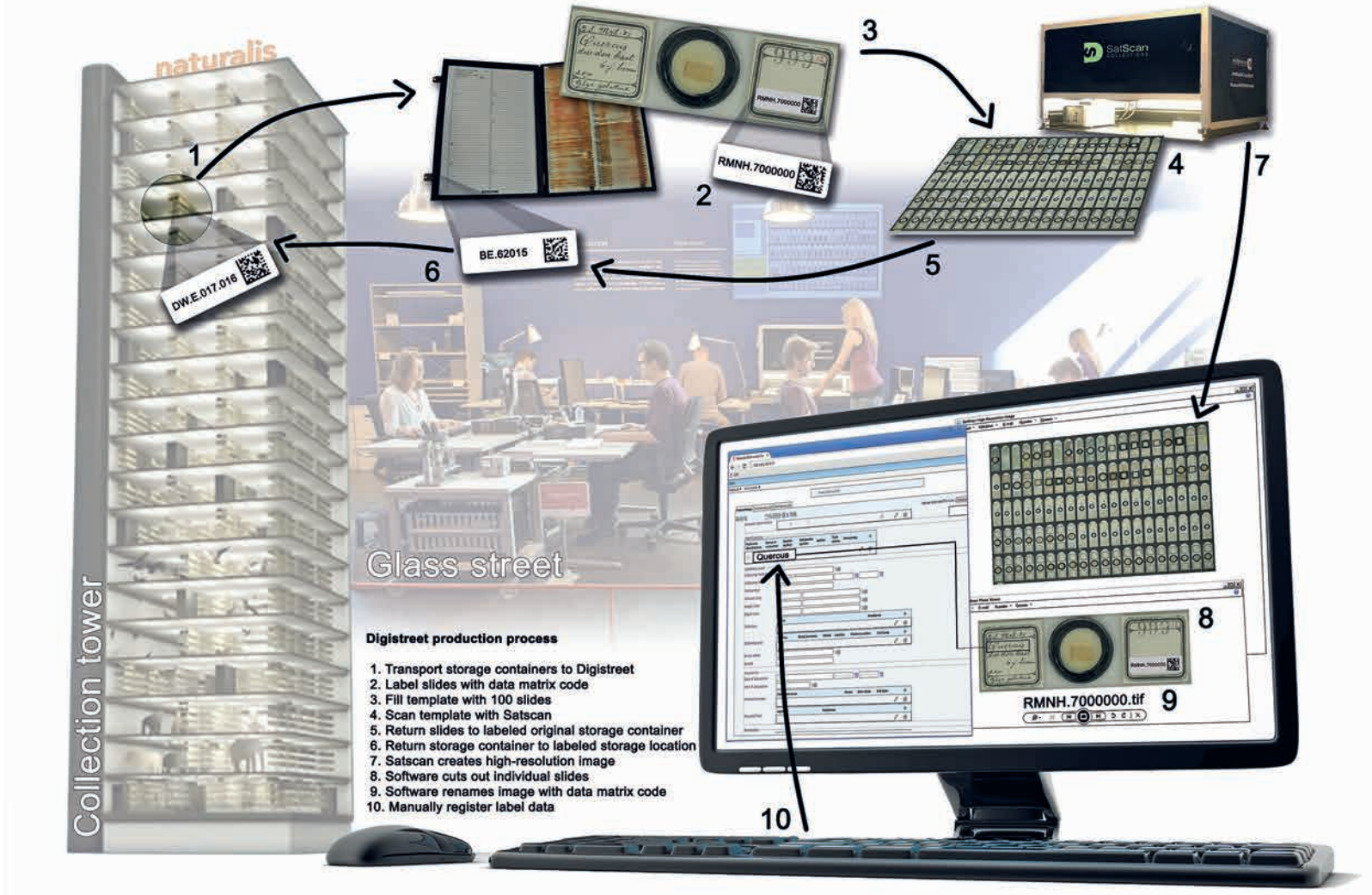
Collection Digitalisation
at Naturalis Biodiversity Center

Naturalis Biodiversity Center, Darwinweg 2, 2333 CR Leiden, Netherlands, www.naturalis.nl

Naturalis Biodiversity Center runs one of the largest projects for natural history collection digitization to date. At least 7 million objects will be digitized in detail from a total collection of 37 million.

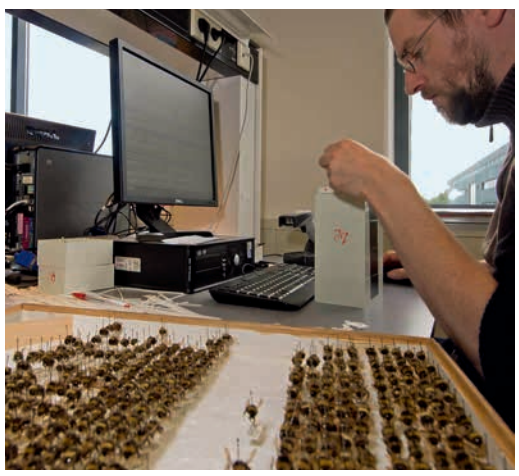


Why digitization?

- Facilitate scientific research
- Provides better means for quality checks
- Allow for virtual disclosure
- Support dissemination to interest groups
- Enables consultancy to business and government
- Promote knowledge through education
- More efficient collection management

Digistreets for different collections

- Wood samples
- Geology and paleontology collections
- Herbarium sheets
- Molluscs
- (In)vertebrates
- Alcohol samples
- Microscopic glasslides
- 2-D material
- Entomology collections



Challenges

- Prioritization in a collection of 37 million objects
- Digitize 7-8 million objects in detail within time and budget
- Combine in-house (3 million) and out-sourced (4 million) approaches
- Register 30 million objects digitally on a high level
- Create infrastructure for continued digitization in the future, longterm sustainable storage and digital publication.
- Crowdsourcing solutions for transcribing object labels

Digitization on demand

The collection digitization expertise is available to others. Consultancy and digitization services are offered to institutes who lack specialized equipment, staff and expertise to digitize themselves.

Contacts

Naturalis Biodiversity Center

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Links

http://science.naturalis.nl/en/collection/digitization/

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Preventing humidity and direct water damage in a dried plant collection (DAO)

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Agriculture and Agri-Food Canada, Ottawa, Ontario, Canada (DAO Herbarium)

1. Where does water come from?

- External flooding
- Internal flooding (water pipes)
- Malfunction of dehumidifiers
- Building alterations and structure lacking vapour barrier
- Open compactor (no sealed cabinets) exposing specimens to greater water risk
- Automatic water sprinklers for fire control

Photographed by Nicholas Wojtas

Open concept compactor system showing potential sources of overhead water damage.

2. What we did?

A risk assessment provided an important document used to inform managers/administrators in order to gain support for the necessary modifications.

- Evaluated risks of overhead water pipe leakage, and installed new water free cooling climate control system.
- Monitored temperature and humidity levels by using automatic data logger readers .
- Installed dehumidifiers.
- Arranged for security check of the facilities at nights, on weekends and holidays.
- Maintained RH at 40-50% and minimized fluctuation.

Photographed by Nicholas Wojtas

Automatic data loggers monitor temperature and humidity

Photographed by Nicholas Wojtas

New High Voltage Alternating Current (HVAC) climate control system without water pipes (below) replaces an older cooling system with many overhead water pipes (above). This new system has been installed in all collection rooms at DAO eliminating the risk of overhead water damage.

3. Problems with water and humidity

Chemical, biological and mechanical deterioration as well as a potential health risk.

- Less than 40% RH may lead to brittleness of specimens, making them vulnerable to breakage.
- At 70-85% RH, molds such as *Erotium herbariorum* can grow resulting in damage to material and compromising DNA analysis due to contamination.
- Lower humidity impedes the ability of *Lasioderma serricorne* , the Cigarette Beetle and other non-temperate pests to reproduce.
- Higher humidity increases the rate of chemical deterioration which is equivalent to natural aging.
- RH fluctuations cause mechanical stress. This occurs when water absorption causes expansion and contraction leading to changes in size and shape leading to cracking, splitting and warping.
- High humidity promotes mold growth which can threaten
- Human health.

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Photographed by Nicholas Wojtas

A Friedrich Model D70BP dehumidifier can effectively control humidity in an 800 square foot room, having the capacity to remove 70 pints/ day.

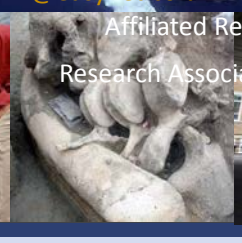
Contact gisele.mitrow@agr.gc.ca

Canada











A Tale of Two Mysticeti

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Abstract

In 2009 the partial skeleton of a large 5,200 year-old baleen whale was excavated in coastal sediments in Abu Dhabi (UAE). In 2013 a similar sized (21m long) skeleton of a 150 year-old finback whale that had been suspended from a ceiling for nearly 20 years outside Cambridge University's Zoology Museum was cleaned, dismantled and moved into temporary storage for the duration of a refurbishment project. In Abu Dhabi the 4m long, 2.3m wide, fragile skull was in a few pieces due to taphonomic processes in the burial environment. In Cambridge the 4.5m long skull was complete and weighed over a tonne.

Despite the whales' very different contexts and ages and the fact that one skeleton had to be lifted from desert sediments and transported several miles whilst the other skeleton had to be removed from its suspended mount and moved fifty metres, they are both large filter-feeding 'baleen' whales (**Suborder Mysticeti)** and some of the processes used in each of the projects were very similar. The excavated skeleton had to be cleaned and recorded, assessing the sediments and taphonomic processes evident at the site. The displayed skeleton had to be cleaned and the way it was mounted and suspended had to be recorded in detail to facilitate remounting in a couple of years. Interesting pathologies exhibited by the bones were noted in both cases. In particular, both projects necessitated constructing protective and supportive frameworks around the skulls and mandibles, bolting together lengths of galvanised steel 'Unistrut' to enable the large and heavy yet fragile specimens to be safely moved with airjacks and cranes.

Excavating and lifting the 5,200 year-old baleen whale skeleton in Abu Dhabi

This almost complete and only slightly disarticulated skeleton was exposed in a low friable sandy cliff of sabkah sediments on the edge of a tidal channel in Mussafah on the outskirts of Abu Dhabi City. First, the overburden had to be removed carefully and the general outline and extent of the bones ascertained. Then the very fragile bones (with the texture and strength of a digestive biscuit) were excavated, with much of the sediment kept for environmental analysis including the identification of molluscs, barnacles, foraminifera and ostracods *etc*.



Above left, the right dentary of the mandible in the foreground, with the skull behind (the skeleton is preserved upside-down); middle, the right limb bones in the foreground (scapula, radius and ulna) with ribs and vertebrae behind; and right, consolidating the right dentary, with parts of the skull in the foreground.

Each of the bones were carefully cleaned with soft brushes and then plotted on the site plan by surveying-in points and drawing in the detail by hand. The site is about 5,200 years old (Optically Stimulated Luminescence and C14 dating were undertaken (Stewart *et al*, 2011)) and the bones were very brittle, occasionally cracked and had little or no mechanical strength. Due to their fragile nature the bones had to be well consolidated and the reversible methacrylate co-polymer Paraloid B72 was applied at 5 to 10% in acetone. Once this had set, the larger bones and any adhering sediment were then covered with acid-free tissue paper and aluminium foil, followed by a thick covering of coarse hessian strips saturated with plaster of Paris to build up a thick protective and supportive jacket. Additional support was given by either wooden splints or a strong rigid metal frame bolted together around the specimen to which the plaster jackets were attached with more hessian and plaster so the large bones could be lifted safely and taken to off-site.




Above: the bones of the right forelimb being consolidated, plotted on the plans and surveyed-in. Below: left, the upside-down skull has been cleaned, consolidated and jacketed with acid-free tissue, foil, plaster and hessian with a few wooden splints. Middle and right, a protective and supporting cage of channelled galvanised steel 'Unistrut' was bolted around the skull, re-enforced with thick wooden batons held in place with plaster & hessian, and with a thick plywood base bolted underneath.



Above right: Once the skull was encased securely in its rigid cage, we had to tunnel underneath the specimen to free it from the concreted sabkah sands on which it lay, leaving it perched on pillars of sediment (far right). The two dentaries of the mandible were protected with similar rigid plaster jackets and cages (right), enabling all three very fragile specimens to be safely lifted on to a flatbed truck with a crane (far right) and taken to the Environment Agency buildings in Abu Dhabi city centre. None of the cages flexed but remained incredibly rigid, so the bones were not damaged in the lifting process.


This project was challenging in many respects. The daytime temperatures were frequently over 40˚C and the humidity was always over 90% so both sunburn and heatstroke were a real risk and simply the glare from the sun and the occasional dust/sand storm posed their own problems. The fragile bones had no mechanical strength and some were already shattered before excavation commenced (in transpired lorries and bulldozers had been moving back and forth above the site recently). The bones were like biscuit, hence the need for plenty of consolidation and the application of rigid protective plaster jackets and, where required, the construction of incredibly strong and rigid cages of channelled galvanised steel 'Unistrut'.

Dismantling the Finback Whale skeleton at Cambridge University Museum of Zoology

At 70ft (21m) long, this particular Finback Whale skeleton is one of the biggest known of this species, which is second in size only to the Blue Whale. This animal was washed ashore dead at Pevensey in Sussex in 1865 and 40,000 people are estimated to have travelled to see it on the beach within the first few days. The skeleton was prepared and subsequently bought for the museum by public subscription. It used to be mounted inside but in the 1990s it was hung from a ceiling outside the museum. After 16 years of being nested in and defecated on by pigeons, the skeleton had to be dismantled and packed away whilst a refurbishment program gutted the building and created a new glass foyer for the whale to be re-mounted in.


The task had to be approached carefully for several reasons: the pigeons had left behind a significant biohazard (not just their faeces but nesting materials and dead bodies); we would be working at height and the bones were considerably heavy; it was not clear how all the metal framework was joined together nor whether the rusty nuts and bolts would be easily undone; and we would be moving large amounts of materials, tools and equipment up a flight of stairs at the start and end of every day and well as carrying the large bones down. Because the specimen would need to be re-mounted in a new position in just a couple of years, meticulous records needed to be made of exactly how it was mounted and the order in which it would need to be reassembled. Therefore copious photos were taken and notes written, and all the bones and metalwork were labelled thoroughly before any dismantling commenced. A simple label on a bone saying what the bone was i.e. 'rib R15' was not enough – every hole where a bolt had been inserted was given it's own tie-on label describing the piece of armature that it had been bolted to, and the matching bit of armature was labelled appropriately as well. WD40 was applied to all the nuts and bolts in advance, being careful not to contaminate the bones. Various parts of the project were videoed and the whole process was recorded with a time lapse camera (you can now see the video on the zoology museum's Facebook page).

Far left: initial cleaning of the bones with a brush and 'Backuum' cleaner. Middle: removing vertebrae from the metalwork. Right: cleaning ribs with Synperonic A7.

Despite the skeleton being cleaned about 10 years previously, the accumulated pigeon faeces were over an inch deep in places. Therefore before anything was dismantled the whole specimen was cleaned as thoroughly as possible with a stiff brush and a vacuum cleaner to get rid of the worst of the pigeon droppings and nesting material as well the general, dust, dirt and cobwebs etc. After being removed from the armature, each bone was thoroughly dry brushed again before being swabbed with the mild conservation detergent Synpeonic A7 in water then the surface was cleaned of the detergent by further swabbing with water, whilst being patted dry frequently with paper towels so the water did not soak in to the bone. The baleen was cleaned very gently with small soft brushes and a vacuum cleaner, and was not 'wet cleaned'. All the rusty metalwork was cleaned with a spinning wire disk clamped to a bench, and then wiped clean with a damp rag, dried, painted and labelled. Where possible, the metal brackets were re-attached to specimens to keep them in context.

Although the skeleton was a mere 150 years old and still had some strength and mechanical integrity (unlike the Abu Dhabi whale), the 4.5m-long skull and mandible were incredibly heavy, estimated at over a ton in weight. To move the skull into position in the 1990s, it required 19 strong men, and injuries were sustained. Unfortunately the sutures of the skull are not fused and it had been sawn in half lengthways when initially prepared, so the whole structure was weaker than it might have been. Therefore, the skull itself could not support its own weight so a cage of galvanised steel Unistrut channel was built around it, bolted to a thick plywood base.

Left: a close-up of the galvanised steel Unistrut system bolted together. Right, the skull and mandible about to be moved by a crane.

The protective cage was designed so that a crane would be able to lift it using straps place underneath. Once the cage was built and Plastazote-lined wooden supports screwed securely underneath the bones, the weight had to be taken off the metal wires it was suspended from. 'Airjacks' were used (strong inflatable rubber 'pillows'). They were placed underneath the base of the cage to lift up the whole structure so that the wires could be undone and the weight transferred. Then a mobile crane moved the skull and mandible – which together with the metalwork weighed 1.6 tons!

Bespoke wooden crates were made for the baleen and forelimbs, wooden shelving made for the ribs (some up to 285cm long) and a large shed was constructed especially to house the skull for the duration of the building project. The main supporting metal beam onto which the vertebrae were threaded was in two main sections, bolted together. The larger of these weighed in the region of 170Kg and was lowered with a system of pulleys.

Conclusions

Both projects presented significant health and safety risks and complex problems that required solving almost every day. But with good planning well in advance both projects were completed within the planned timeframes and within budgets. A good photographic, written and video record was made of each project, and both projects will result in publications. If Unistrut channelling had not been available to make the rigid protective and supportive cages around the skulls and mandibles in both cases, the projects would have taken much longer and the bones would have been much more vulnerable and might well have sustained serious damage. The team looks forward to repeating the Cambridge project - in reverse and at greater height , but thankfully without pigeon issues - in 2016 or 2017.

Acknowledgements

Thanks are due to: the team in Abu Dhabi (Phil Rye, John Stewart, Will Higgs and the funders Abu Dhabi National Oil Company, ADNOC) and the team assisting with the skeleton in Cambridge (Phil Rye, Matt Lowe and various volunteers). With apologies to Charles Dickens for the title of this poster.

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Conservation *vs* investigation of amber:
A risk assessment to determine whether amber is altered by micro-CT or confocal microscopy studies

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Introduction

Amber is a fossil tree resin that represents an invaluable "time capsule" preserving 3D fossil inclusions. The study of animal remains (mostly insects), plant structures, pollen or microorganisms 'trapped' in the original resin has proven invaluable to our understanding of ancient life.

Important amber samples are therefore subject to considerable demand by researchers wishing to examine the trapped specimens.

Typically, organic inclusions are hollow, with few organic remains preserved (Edwards et al., 2007). The study of amber inclusions offers information about the preserved organisms, including their morphology, ecology and mode of life and their as well (Ross, 2010).

The use of standard optical techniques for the examination of amber inclusions is not always possible or accurate due to the characteristics of amber itself, which may be opaque, or contain air bubbles and flow lines, inclusions of limited or no scientific interest and other undesirable impurities.

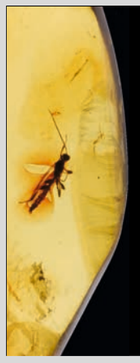
Although µ-CT and CLSM are exceptionally valuable for the investigation of amber inclusions, they have the potential to physico-chemically alter amber.

Thus, access to collections for investigations utilising novel methodologies is currently hampered by a lack of understanding of their potential harmful effects on amber samples, which may consist of specimens of considerable historical importance and palaeontological rarity.

The aim of this study is to ascertain, through analytical means, the impact of these techniques on different amber and copal types, and to investigate their long-term effects upon the amber matrix.

Photographs show specimens from the collections of the National Museum of Scotland, Edinburgh, courtesy of Dr A. Ross and the Natural History Museum, London.

Materials



Baltic, Burmese, Dominican amber, Columbian and East African copal.

Samples selected based on age, maturation stage, provenance, palaeobotanical origins and palaeontological significance, reflecting range of fossil resins frequently examined by researchers.

Each sample cut into sub-samples for µ-CT and CLSM exposure. Two samples irradiated with synchrotron X-rays.

Confocal Microscopy

Confocal microscopy (CLSM) is a well-established optical technique for the 3D visualisation of specimens included in amber with a resolution at or beyond the diffraction limit of light.

Fossils in amber exhibit strong autofluorescence, often maintained even after the organism has decayed (Compton et al., 2010), that can be used as a source of emitted photons for CLSM visualisations (Böker and Brocksch, 2002, Clark and Daly, 2010).

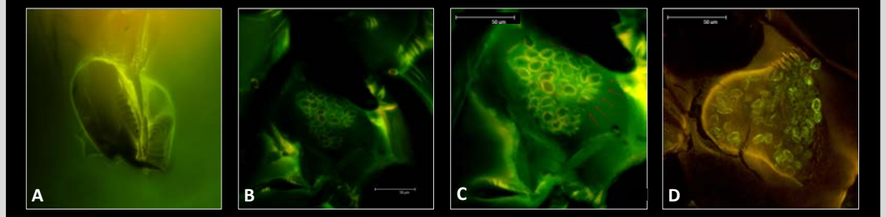


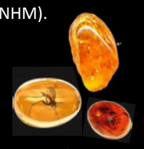
Figure 1. Confocal images of a fossilised fig wasp embedded in amber. **A.** Details of the head (20x). **B** and **C.** View of one of the pollen pockets (20x and 40x respectively). **D.** Detailed image of the pollen pocket of a modern specimen for comparison (40x). Images taken from Compton et al., 2010.

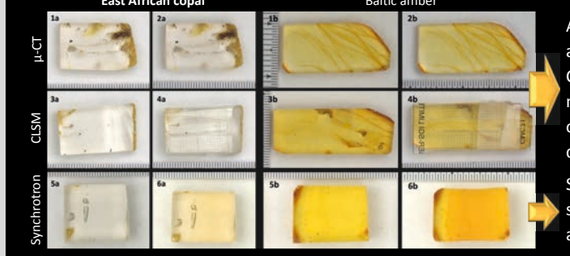
Experimental

Baseline characterisations on amber and copal samples using Raman spectroscopy and FTIR spectroscopy (at V&A), which yield the most information about amber and its degradation pathways and products (Beck et al., 1965; Edwards et al., 1996; Brody et al., 2001; Pastorelli et al., 2013).

Exposure to repeated high doses of X-rays in a µ-CT scanner (at NHM), to hard synchrotron X-rays (at Diamond Light Source, Oxford), and to laser illumination using a confocal microscope (at NHM).

Re-examination to look for chemical and optical changes which might have taken place.





Aesthetic characteristics of amber and copal samples tested using µ-CT and CLSM appeared unaffected: no undesirable colour alterations or visible bleaching could be distinguished.

Samples exposed to high-flux synchrotron X-ray radiation, clearly appeared to have darkened.

Both Raman and FTIR spectroscopy proved ideal for the characterisation and differentiation of ambers and copals, but FTIR spectroscopy was better at discriminating between different provenances, degradation and maturation stages.

X-ray irradiation in the µ-CT scanner and laser illumination using CLSM did not produce any damage observable to either the naked eye or by either Raman or FTIR spectroscopy. In samples exposed to synchrotron X-rays chemical changes could be detected in FTIR spectra only.

Micro-CT

X-ray micro-computed tomography (µ-CT) is a non-destructive method for digitising, investigating and categorising biological inclusions (Dierick et al., 2007).

Minute morphological details and important taxonomic features can be imaged with micron-scale resolution and minimal preparation.

3D reconstructions can be viewed from multiple angles, virtually dissected and used to visualise the internal morphology. Individual X-ray slices can help interpret finer features difficult to resolve.

µ-CT overcomes problems such as the darkening and formation of white emulsion coatings that render the inclusion difficult to view using traditional methods.

Analysis using synchrotron X-rays with propagation phase-contrast is increasingly common (e.g. Soriano et al., 2010), as it allows for increased contrast over absorption techniques, detecting inclusions invisible using traditional CT.

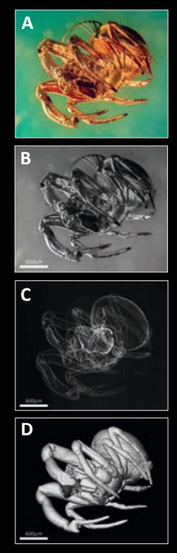
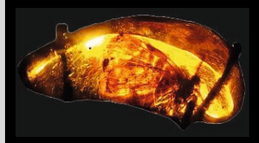


Figure 2. Anapid spider (Anapidae family) in Baltic amber. A. and B. Photographs taken with a stereo-microscope. C and D. Transparent ad solid µ-CT scan reconstructions. Images from Penney et al., 2011.

Conclusions

Our results make a fundamental contribution to the risk assessment for the analysis of fossil resins by µ-CT and CLSM.

These techniques do not seem to impart a detectable damage to copal and amber samples, which appeared aesthetically and chemically unaltered when using the parameters specified in this work.



Hard synchrotron X-rays caused both colour alterations and chemical changes in amber (as revealed by FTIR), and their use should be discouraged until further experiments are done, if the aesthetic of the amber is to be preserved.

References

Brody, R. H. et al., 2001. *Spectrochimica Acta Part A*, (57)6: 1325-1338.; Beck, C. W. et al., 1965. *Archaeometry*, 8: 96-109; Böker, C., and Brocksch, D., 2002. Fascinating amber. *Carl Zeiss: Innovation* 12: 20-23; Clark, N.D.L., and Daly, C.J., 2010. *Journal of Paleontological Techniques*, 8: 1-7; Compton, S.G. et al., 2010. *Biology Letters*, **6**, 838–842; Dierick, M. et al., 2007. Proc. of the 10th International Symposium on Radiation Physics, 580(1): 641-643; Edwards, H.G.M. and Farwell, D. W., 1996. *J. of Raman Spectroscopy*, 35(8-9): 761-767; Edwards, H.G.M., et al., 2007. *Spectrochimica Acta Part A*, 68(4): 1089-1095; Pastorelli, G., et al., 2013. *Polymer Degradation and Stability*, 98(11): 2317–2322; Penney, D., et al., 2011. *Zootaxa*, 2742: 61-68. Ross, A.J., 2010. Amber: The Natural Time Capsule. 2nd Ed., Natural History Museum, London, 112pp; Soriano, C. et al., 2010. *Comptes Rendus Palevol* 9(6-7): 361-368.

Acknowledgements

The Imaging and Analysis Centre of the Natural History Museum for funding this study; Conservation Department of the Victoria & Albert Museum and Diamond Light Source for access to Beamline I12 (EE9244-1) for access to scientific facilities.

Building the Thailand National Insect Collection- Queen Sirikit Botanic Garden, Entomology Section (QSBGE)

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The Entomology Section at Queen Sirikit Botanic Garden (QSBGE) was established in 2005 with the objective of becoming Thailand's premier National collection and to provide a sound taxonomic platform for biodiversity conservation in Thailand. Since then the collection has grown to a total of 93,900 specimens (including 149 holotypes and 1,380 paratypes) housed in modern facilities within the Botanic Garden complex in Chiangmai, northern Thailand. Much of the growth of QSBGE has been achieved through world-wide collaboration and partnership leading to capacity-building in the facility. A synopsis of past and ongoing collaboration is presented showing how these have supported the development of the skills-base, taxonomic infrastructure and facilities. Building through collaboration and partnership is a model that QSBGE is enthusiastic to further develop.

Current project

1. Study on Insect Diversity in Northern Thailand for QSBGE Entomology Museum

2. Study on biodiversity of Black fly in Thailand

3. Field studies in the southeast Asian tropics of northwestern Thailand on the ecomorphological radiation of the rove beetle subfamily Steninae (Coleoptera Staphylinidae) [University Tübingen/QSBGE]

4. Study on biodiversity of Empidoidea in Thailand [National Museum Wales/QSBGE]

Past project

1. International Symposium on Diversity and Conservation of Fireflies 2008

2. Enhancing Taxonomic and Molecular Diagnostics Capacity for Fruit flies (Diptera: Tephritidae) [California Department of Food and Agriculture/QSBGE]

3. Thailand Insect Group for Entomological Research project (TIGER , 2006-2009) [Kentucky university/DNP/QSBGE]

4. Taxonomic Capacity Building in Support of Biodiversity Conservation in Thailand (Darwin project, 2004-2007) [NHM/QSBGE]

Activities

Entomology Section, Queen Sirikit Botanic Garden, Chiang Mai, 50180 Thailand

Discovery of unrecognised J. E. Le Conte specimens in the UK

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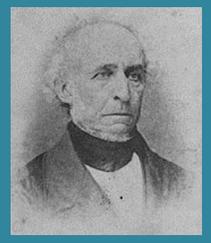


J. E. Le Conte

F. W. Hope

Abstract

During re-curation of the historic Histeridae (Clown beetle) collection, a series of specimens were noted as needing further investigation, due to the style and content of the handwritten labels. After research into the handwriting, using comparisons with archival material, it was determined that the specimens were sent to F. W. Hope (1797 - 1862), the Founder of the Hope Entomological collections, from J. E. Le Conte (1784 - 1860). A prominent early American entomologist, these are the first confirmed specimens attributable to Le Conte outside the USA. Further research into the specimens is required, as there is a strong possibility that some of the specimens are types.

The discovery

In a historic Hope-Westwood cabinet, a series of specimens with interesting labelling were discovered in the Histeridae drawers.

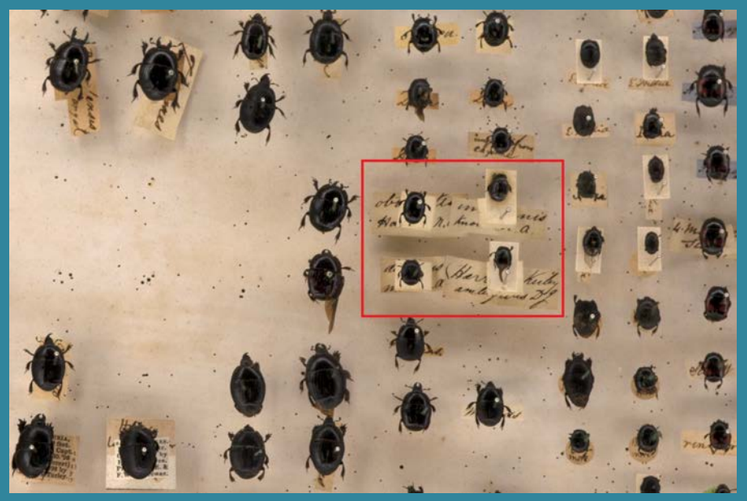


Fig. 1. Original drawer layout, highlighting the specimens

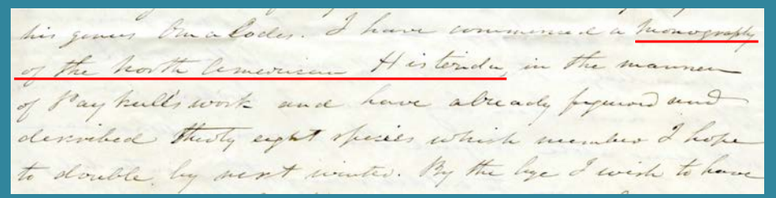
Fig. 2 . *Hister decisus* and associated labels

To date 43 specimens have been discovered. Each specimen has handwritten labels; one with a scientific name and the abbreviation ‘n.a’, the second a number. Nine labels included ‘*mihi*’ after the scientific name (e.g. Fig. 2). This is often significant as it denotes in Latin ‘belonging to me’. This is often used by authors to indicate that a specimen was used in the original description of species new to science, thus making them type.

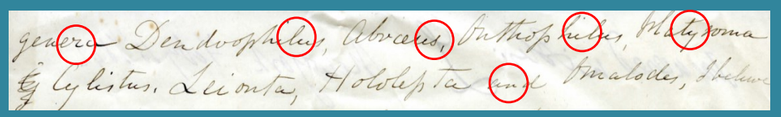
Fig. 3 . *Hister arcuatus* and associated labels

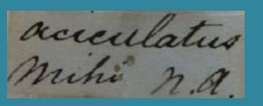
Evidence

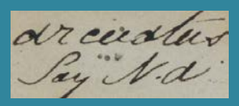
Research into the label names bought attention to the prominent American entomologist J. E. Le Conte. It was essential to establish a link between Le Conte and Hope. This was found in letters in the Museum’s archives from Le Conte to Hope between the years 1830 - 1845. The section of one of these letters below Le Conte writes of his ‘*Monography of the North American Histeridae*’.



A comparison of the handwriting between the letters and specimen labels revealed strong similarities. Many of the characters are the same, this is a clear indication that the beetles were identified, and in some cases described, by Le Conte.







Further research

Investigate the type status of beetles labelled *mihi* .

Singletons of other Le Conte specimens have been discovered in the Hydrochidae and Nitidulidae collections; the search continues.

Museum of Natural History
University of Oxford

Preserving Endangered Specimens and Endangered Skills: A progress report

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The Background

Comparative anatomy and pathology collections have historically played a significant part in UK medical education, but many collections have suffered neglect since the end of the last century. As specimens were used less for teaching and research, collections declined – and with them their documentation and the requisite preservation skills. Recent interest in object-based learning and practical teaching sessions have revived the use of zoological and human pathology and anatomy collections, but there are fewer collections and staff available to facilitate this learning.

The Project

In order to safeguard fluid-preserved specimens and conservation skills, a three year conservation initiative was launched by the Museums and Archives department of the Royal College of Surgeons of England. 'Endangered Specimens, Endangered Skills' is nearing its goal of training new conservators, preserving 900 specimens from the College's collections and injecting more 'wet' preparation skills into the sector through a bespoke training programme.

The Challenges

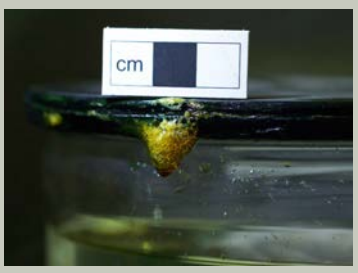
Most specimens were mounted in Perspex or glass containers sealed with silicone or pitch, but a small number of specimens are in jars which were sealed with layers of real and imitation pigs' bladder, tin and lead and painted over with pitch. The main conservation problems were evaporation, discoloration and leakage. Conservation work included removal, handling and remounting often very fragile specimens.

Example of leakage

The dissected stomach of a porpoise - in need of treatment due to signs of evaporation and discolouration

The Fluids

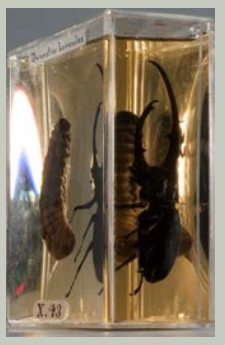
In our collection, most specimens in glass jars have been preserved in alcohol (70%), but some jars contain formalin or Kaiserling III. Additionally, some of these fragile preparations have been preserved in non-standard fluids such as oil of turpentine, methyl salicylate (oil of wintergreen), liquid paraffin, Steedman's method (phenoxytol) or Romhanyi's nicotine/pyridine method. The ESES team is currently assessing new jar sealing methods in order to provide an adequate method of sealing containers in which conventional sealants are dissolved by chemicals, allowing extensive evaporation.



Example of leakage

Preserving Wet Specimens

Around 600 specimens have been conserved since the ESES project started in 2011. Conservation work undertaken in this period included the handling, consolidation and remounting of fragile specimens, fluid top ups, transferring dry specimens and the consolidation of damaged (acrylic) containers.



Before treatment- discolouration and deterioration of acrylic container

After treatment- specimen mounted in new glass jar

External Short Courses

A total of five external training courses have been held involving custodians of similar historical and modern medical collections and entry-level individuals seeking specific skills in conservation to ensure their future employability. These courses were composed of tutorials and practical workshops and aimed to cover the core topics in fluid collection conservation including fluid identification, mounting of specimens in glass jars and standard operating procedures related to fluid changes in and damage to acrylic containers.

Generously supported by the John Ellerman Foundation and the Board of Trustees of the Hunterian Collection

Advancing Integration of Museums into Undergraduate Programs

www.aim-up.org

"I wish to emphasize what I believe will ultimately prove to be the greatest value to our museum - and that is that the student of the future will have access to the original record of faunal conditions …. Right now are probably beginning changes to be wrought in the next few years vastly more conspicuous than those that have occurred in ten times that length of time preceding." - J. Grinnell (1912)

J. Tomasz Giermakowski[1], Anna K. Monfils[2], Steffi Ickert-Bond[3], Scott V. Edwards[4], Eileen A. Lacey[5], Kayce Bell[1], Joseph A. Cook[1]

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Advancing Integration of Museums into Undergraduate Programs

We are an NSF-funded research coordinating network (RCN) that aims to increase the integration of natural history collections into undergraduate education.

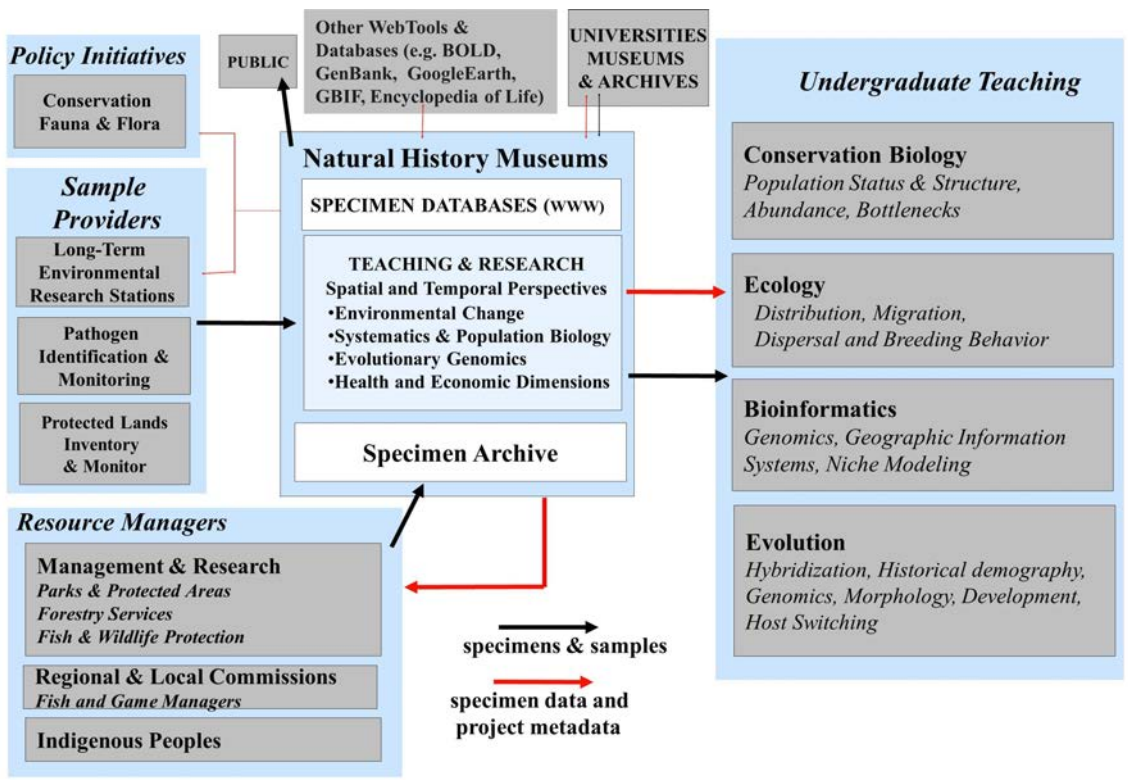
Our goals are to:
1. Train undergraduates in specimen-based research
2. Develop instructional tools that use museum specimens and databases
3. Introduce educators to the instructional power of natural history collections
4. Increase public awareness of the importance of natural history collections

The Challenge

Educators are mostly unaware of the educational potential of collections and associated databases. This even includes students and instructors at institutions with large museums:

- a survey of ~100 undergraduates at U of California Berkeley revealed that:
  - > 70% unaware of the Museum of Vertebrate Zoology
  - < 10% had visited the museum
- the same survey of ~100 undergraduates at U of New Mexico revealed that:
  - about 50% unaware of Museum of Southwestern Biology
  - only about 15% had visited the museum

Clearly, a significant **challenge** is to **inform students and instructors** about the potential **role of collections** in **undergraduate teaching** and research at universities



What do collections-based approaches offer undergraduate education?


Denver Museum of Nature & Science, ZM.2723

- Scale
  - -time and space
- Integration of Data
  - -biotic and abiotic
  - -genomic and organismal
- Complexity
- Web-based Discovery-informatics
- Educational Process
  - -Experiential versus passive
  - -Actual data

Target Audiences
- Natural history collections (academic and free-standing)
- Educators with or without collections

As archival observatories, museums provide a window on historic conditions by establishing the baselines necessary to assess change and predict future impacts. Their impact depends on training the next generation of scientists to creatively explore, utilize and integrate these vast resources into critical science initiatives.

Annual Themes

Year 1 – Integrative Inventories
Year 2 – Geographic Variation
Year 3 – Evolutionary Dynamics of Genomes
Year 4 – Biotic Response to Climate Change
Year 5 – Co-evolving Communities of Pathogens & Hosts, relating to Emerging Disease


Photo: Christopher Witt

Example of a cross-disciplinary seminar: CO-EVOLUTION: Art + Biology in the Museum

Spring 2012 Seminar @ Museum of Southwestern Biology, University of New Mexico

Communication between fields is important within science, but also between biologists, artists, and historians as we build collective knowledge. Natural history collections emphasize spatial and temporal variation and are uniquely situated to bridge the gap between traditionally segregated disciplines, as they foster development of creativity, generative thinking, and rigorous inquiry; all required of future leaders. By incorporating art and history into biology, we begin to strengthen ties between the sciences and the humanities within the university's curriculum and research activities. A common interest in place-based research and inquiry-driven learning underpins integrated and experiential approaches to pedagogy.

Interested?
We are recruiting people to join the network and participate in one of our working groups
- Bioinformatics and Web Presence
- Outreach, Development and Design
- Education
- Network Evaluation

This Research Coordinating Network is partially supported by the National Science Foundation under Grant NSF 0956129. Any opinions, findings, and conclusions or recommendations expressed in this material are those of the authors and do not necessarily reflect the views of the National Science Foundation.

Analysis of William Hunter's Eighteenth Century Insect Cabinet in a Scientific and Cultural Context

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Scotland , UK

Hunterian Museum (Zoology)

New approaches to old collections

William Hunter's (1718-1783) collections, bequeathed to the University of Glasgow, are a fruitful ground for research. Having become a successful doctor and obstetrician in London, Hunter invested in his private museum that housed initially his anatomical teaching preparations. It expanded to cover numismatics, art, books, anthropology and natural history material. His insect cabinets contain about 7,500 specimens including more than 500 primary types of taxonomic significance.

As an entomological resource it is extremely important and was used by contemporary scientists, principally Johann Christian Fabricius (1745-1808). A specimen-based catalogue is being prepared <http://www.hunterian.gla.ac.uk/>. As a source for other studies it has even greater potential. This poster describes some ways in which a collection can be treated beyond its own subject-based context. This approach, using broader viewpoints applying new interpretations to this old collection, has been supported by a Leverhulme Trust research grant.

Print making

Coloured illustrations provide unequivocal visual evidence for identification. Hunter's collection was sourced for several contemporary illustrated works such as Drury[4] and Olivier[5].

Two centuries later digital imaging and electronic mail can speed up the process. A recent email request to the Hunterian Museum (Zoology) solved a taxonomic problem concerning a North American butterfly that was photographed, analysed and web-published within just a few days[6].

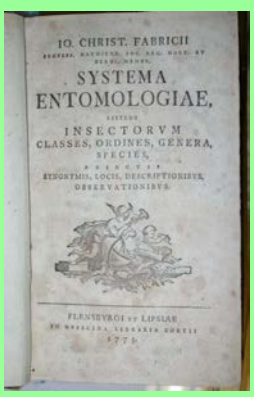
One of the first hand-coloured pulls from Moses Harris' engraved plate of Hunter's Goliath beetle. This species was unique to Hunter's collection and one of his prize possessions (photograph courtesy of The Rt Hon The Earl of Derby).

Over 230 years old many insects are in extremely fine condition. This example helped resolve a nomenclatural problem in 2005.

Taxonomy & biodiversity

The C18th revolution in printed and illustrated reference works rapidly disseminated information. The earliest taxonomists created the framework for what is now called biodiversity. The products of nature were pouring into the capitals of Europe and rapidly being fitted into the new binomial system. Foremost amongst these practitioners was Fabricius, the 'Entomological Linnaeus'. He visited London nine times between 1767-1791 and had access to private museums. The most famous was undoubtedly that of Sir Joseph Banks but Fabricius maintained [1] that Hunter's cabinet was the best. Hunter engaged Fabricius to arrange and augment the collection, including the incorporation of duplicates from Banks and bequests from other famous collectors.

Fabricius, one of Linnaeus' pupils, increased the news species published by a factor of ten. He was able to encompass within his *oeuvres* the entire knowledge of insect diversity. Thereafter the rate of discovery became too great for any individual to operate in such a wide field. In the early nineteenth century separate academic disciplines were to emerge, developing their own epistemologies [3].



The only original examples of this extinct species are in Hunter's cabinet [7]. They were considered lost for many years as they had been described from Dru Drury's cabinet which was later dispersed at auction.

Museum techniques

Eighteenth century developments in curatorial techniques included cabinets containing standardised cork-bottomed and paper-lined drawers with glass lids. These provided an environment for both conservation and study. There was wider use of specimen labels and pins for ease of handling individual insects. It created collections that resemble modern museum practice in all but minor detail.

An historical comparison of collecting, preserving and collection conservation is part of this study on Glasgow. The collection affords a direct means of assessing these procedures after 230 years have elapsed. This is possible because Hunter's collection remained substantially undisturbed in Scotland since the bequest.

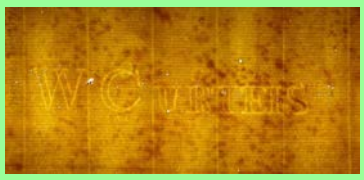
Specific investigations have been made in history of pin manufacture and supply, including metallurgical analysis, for comparison with later styles.

The Madagascan swallowtail in Huunter's collection is heavily repaired when see from underneath, reflecting its rarity. For over 150 years this species was believed to come from the Oriental region. These are the only two extant examples prior to the discovery of its native haunts in Madagascar after which the species was found to be abundant [9].

The collection

Cabinet made in Edinburgh between 1807-1812, one of a pair housing the original drawers

The original eighteenth century drawers fitted into the Regency cabinet. The insects remain as catalogued by Hunter's Trustees arranged by Fabricius (1781) with some later additions



Watermark of W. Curteis of Carshalton, Surrey, used between 1763-1787, from original drawer lining. This provides internal evidence for the integrity of the colleciton

As described by Donovan[2] it was normal to exhibit two examples of each species, one of the pair being displayed upside down if possible. Others were regarded as duplicates and either given away, exchanged or put at the end of the series

Acquisition

From Hunter's collection links can be made with establishment of empire during the Enlightenment. The controlling hand of Sir Joseph Banks, President of the Royal Society, is ever present. The exploration of Africa, for example, with its network of explorers including the botanist Francis Masson in South Africa and Henry Smeathman in Sierra Leone, resulted in them sending many specimens of plants and animals back to London [8] . Hunter got his share of these to enhance his cabinets.

Joseph Banks, naturalist on board *Endeavour*, described by Fabricius in 1775.

Butterfly endemic to New Zealand from Captain Cook's first voyage, collected by

Voyages of exploration were lengthy, dangerous, costly and infrequent. A butterfly species that may be common in New Zealand was in strictly limited supply in eighteenth century London and had a rarity which made them of equal value to works of art in the marketplace.
Any damage sustained to specimens in transit or subsequently would be rectified if possible. A significant number of specimens have been repaired. This has been done skilfully and is often difficult to detect from above. A most interesting discovery is that thin sheets of mica have been used to support wing fractures, an observation which appears to have been previously unrecorded [11] . Methods of preserving specimens in the field developed and became standardised to allow their safe transportation back to Europe [10] .

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