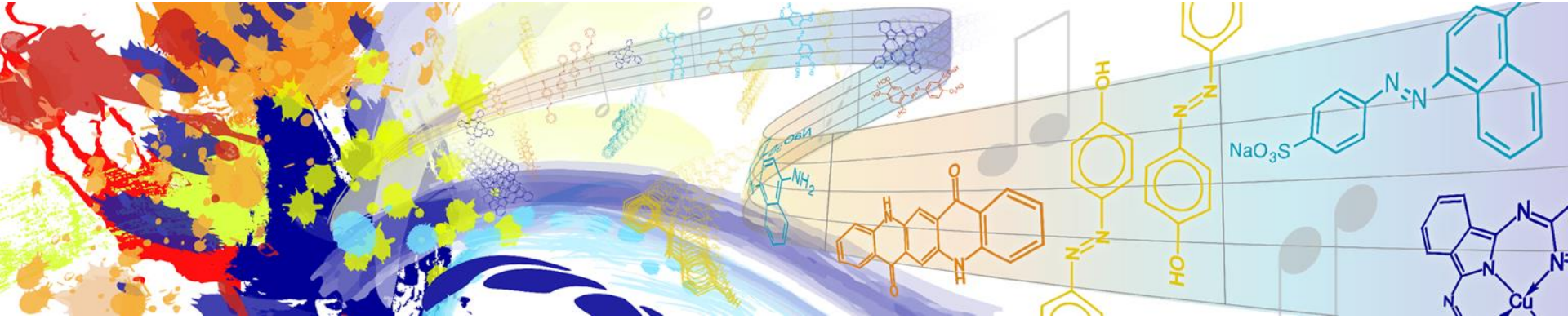
Analytical to Quantum:
Seeing and Hearing the Chemistry of Art



Katherine Phillips
Benjamin Sanchez
Lengeling

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science in the news

Science *vs.* Art

Obtained from http://flavorwire.com/130726/damien-hirsts-medicine-cabinets

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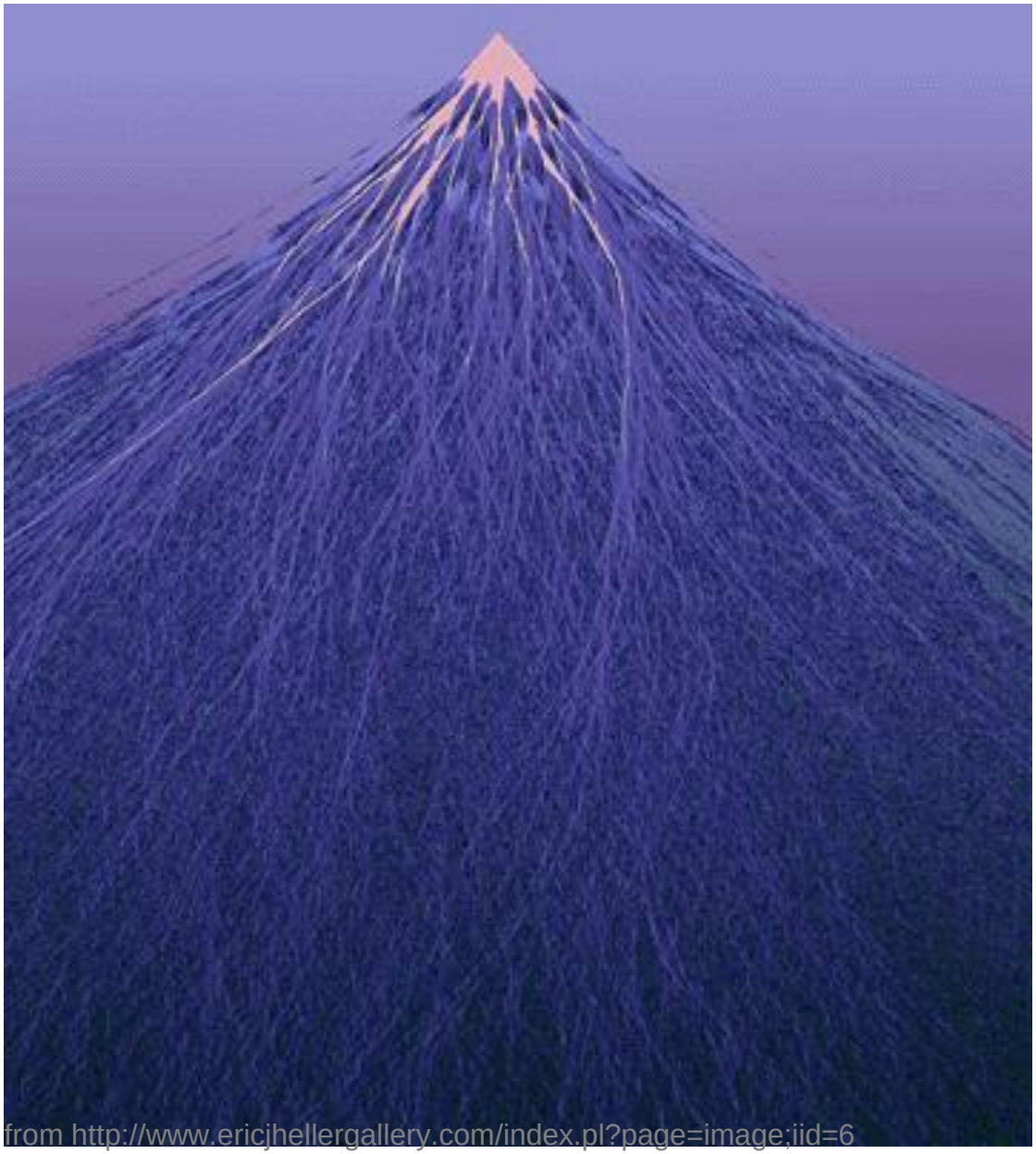
Science *vs.* Art



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Science *vs.* Art

Obtained from http://flavorwire.com/130726/damien-hirsts-medicine-cabinets

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Science *vs.* Art

Installation view, Damien Hirst: ‘Medicine Cabinets’, L & M Arts, 2010. Courtesy of Tom Powel Imaging Inc./L & M Gallery © Damien Hirst and Science Ltd. All rights reserved, DACS 2012. Obtained from damienhirst.com

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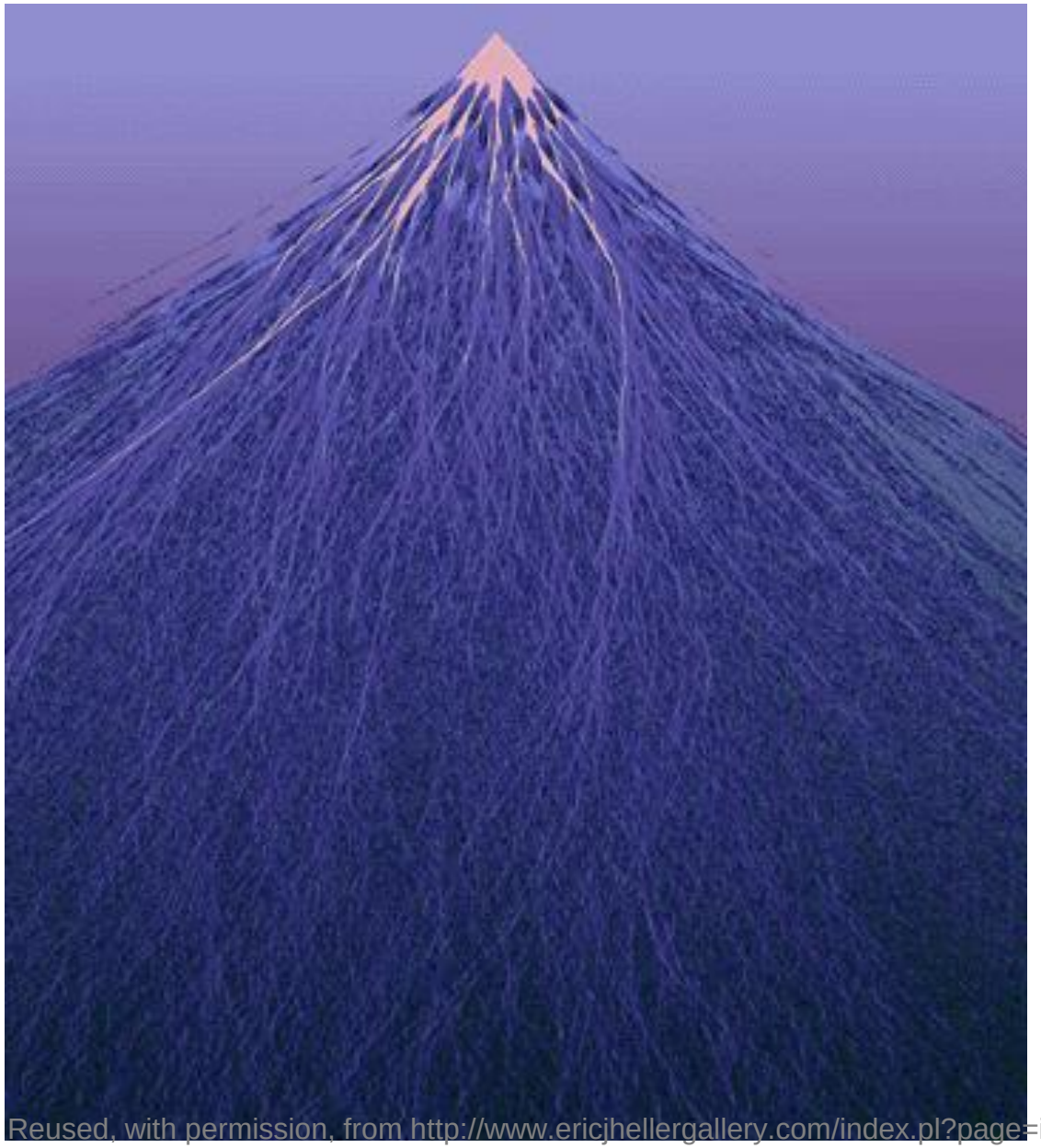
Science *vs.* Art



“Dendrites”

Eric Heller
(chemistry and physics professor at Harvard)

“This image was made in a computer simulation by launching 100,000 electrons from the upper middle of the image, and following their tracks.”

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Science AND Art

Scientific images
can be beautiful!

Koch Institute at MIT
first floor gallery

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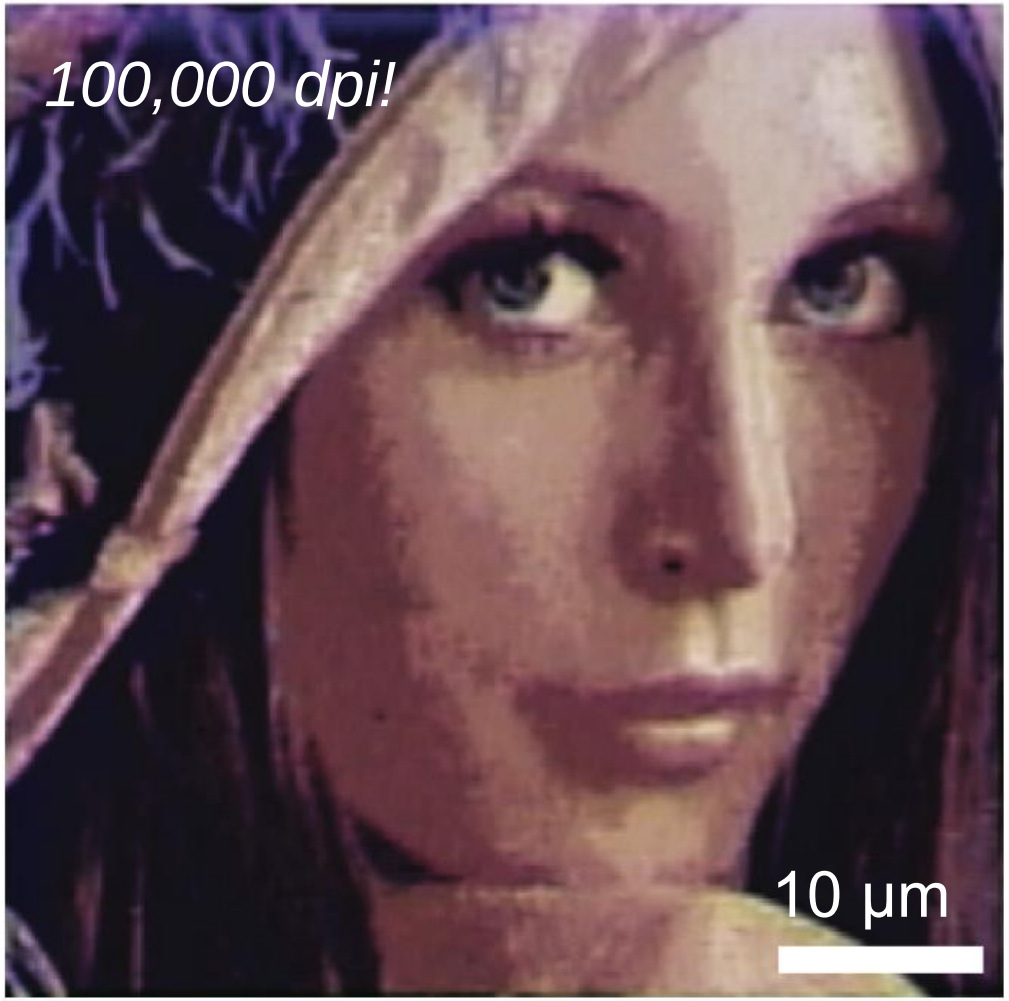
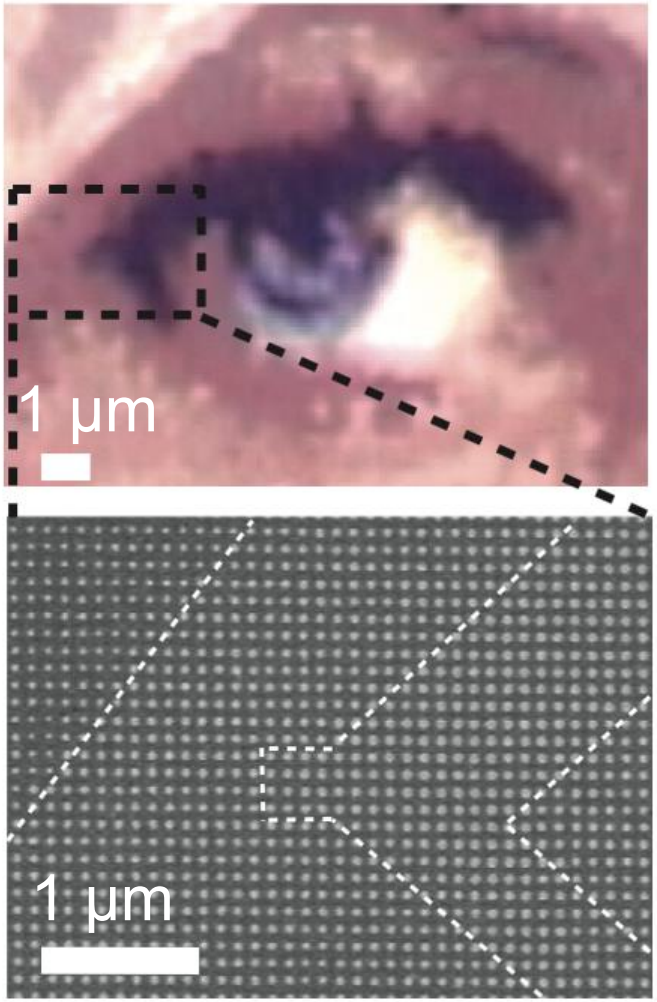
Science AND Art





Obtained from “Printing colour at the optical diffraction limit,” Karthik Kumar, Huigao Duan, Ravi S. Hegde, Samuel C. W. Koh, Jennifer N. Wei & Joel K. W. Yang. *Nature Nanotech.* **7**, 557–561 (2012)

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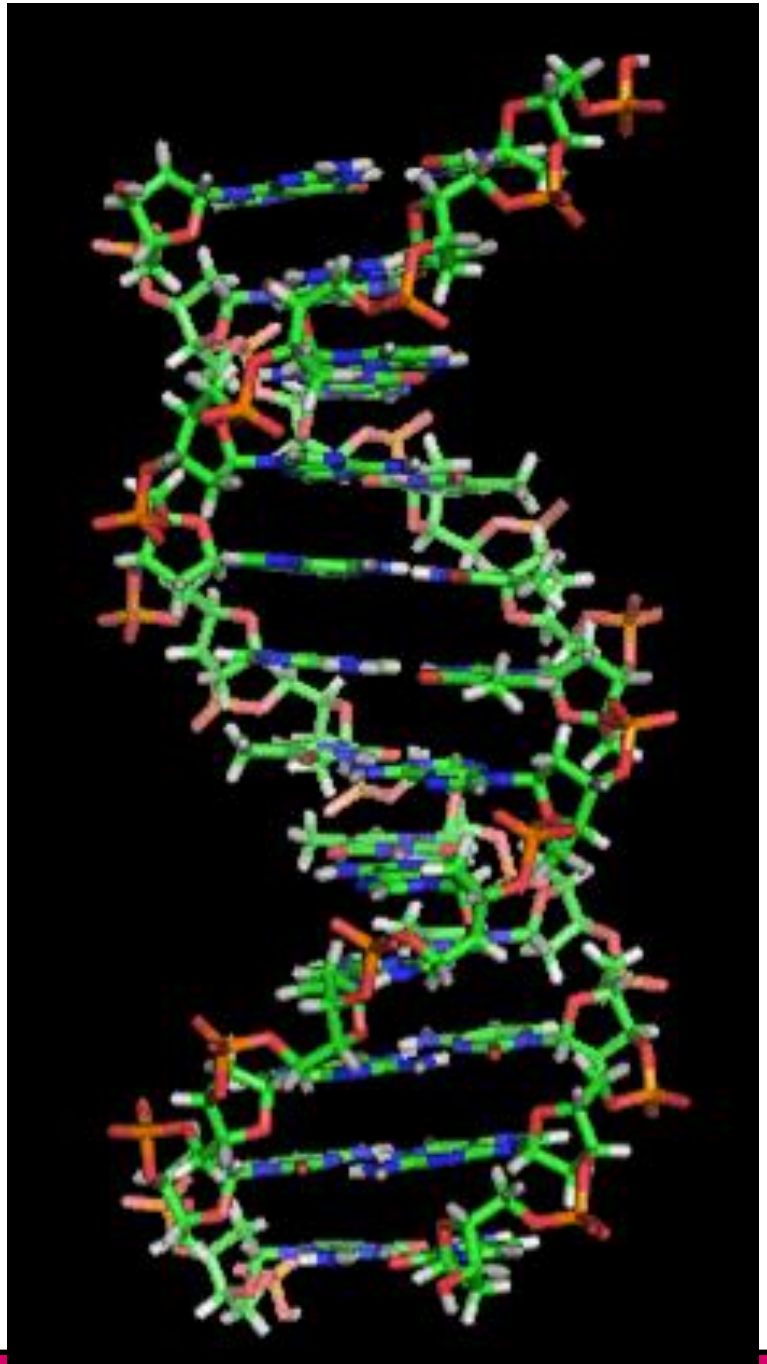
Science AND Art

“Imagination is more important than knowledge. For knowledge is limited to all we now know and understand, while imagination embraces the entire world, and all there ever will be to know and understand.”- Albert Einstein

Cutting-edge science research requires creativity!



Science AND Art

Part 1: SEEING

Using **analytical chemistry** to learn more about art

Part 2: HEARING

Using **quantum chemistry** to make art

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Art Restoration

Art Restoration

Broken statue at the Met, covered in the NY Times

"There were 28 recognizable pieces and hundreds of smaller fragments."

Tullio Lombardo, Adam, ~1490
Metropolitan Museum of Art

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Art Restoration: Lombardo's Adam

Tullio Lombardo, Adam, ~1490
(after restoration 2002-2014)
Metropolitan Museum of Art

Broken statue at the Met, covered in the NY Times:

"There were 28 recognizable pieces and hundreds of smaller fragments."

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Materials matter!

What artwork is made out of can tell us:

- How to alter it without hurting it
  - Prevent future degradation
  - Restore artwork

When I go to an art museum…

Dancer Taking a Bow (The Star)
About 1877

Edgar Degas
French, 1834–1917

Pastel and gouache on paper

The classical ballet occupied Degas's artistic imagination for nearly four decades. Here, a prima ballerina opens and extends her arms in a bow, while other performers are seen backstage or peeking between the painted flats of scenery. This gaslit environment is a world apart from the grassy meadow where the folk dancers pound their steps in *Russian Dancers* on the adjacent wall. Here, Degas's spirited variety of squiggles, crisscrosses, and strokes—formed by a subtle combination of dry and wet pastel, with successive layers of color being fixed and worked over—depict a poised and brightly lit moment at the end of a performance.

Lent anonymously
L.2006.7

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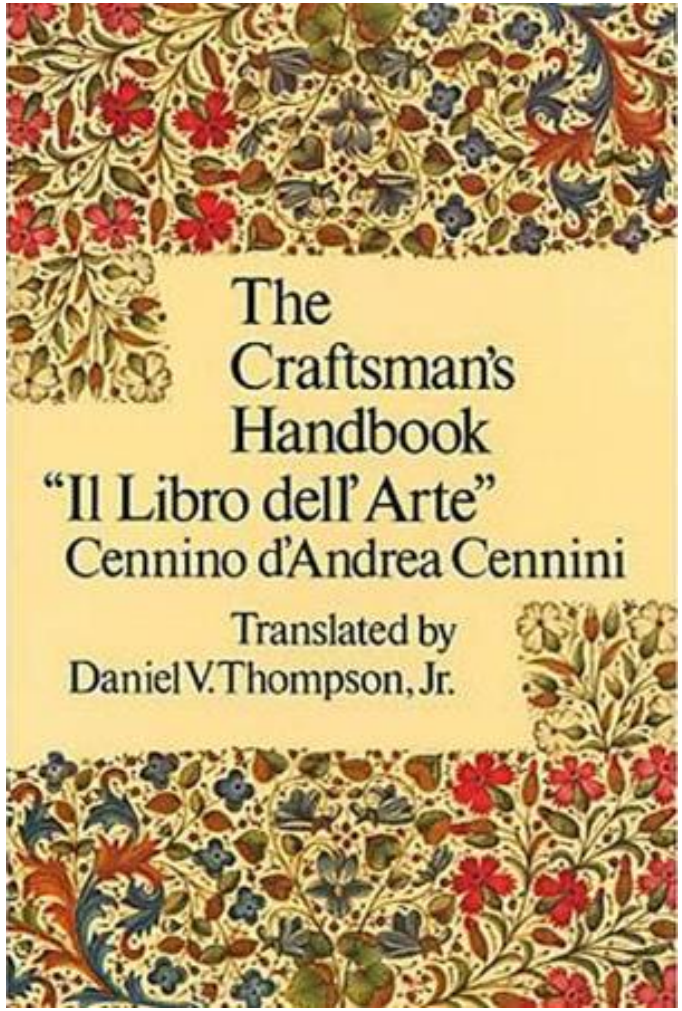
Key Question in Conservation Science

What is this art work made out of?

(and *how* was it made?)



Now, we use analytical chemistry!

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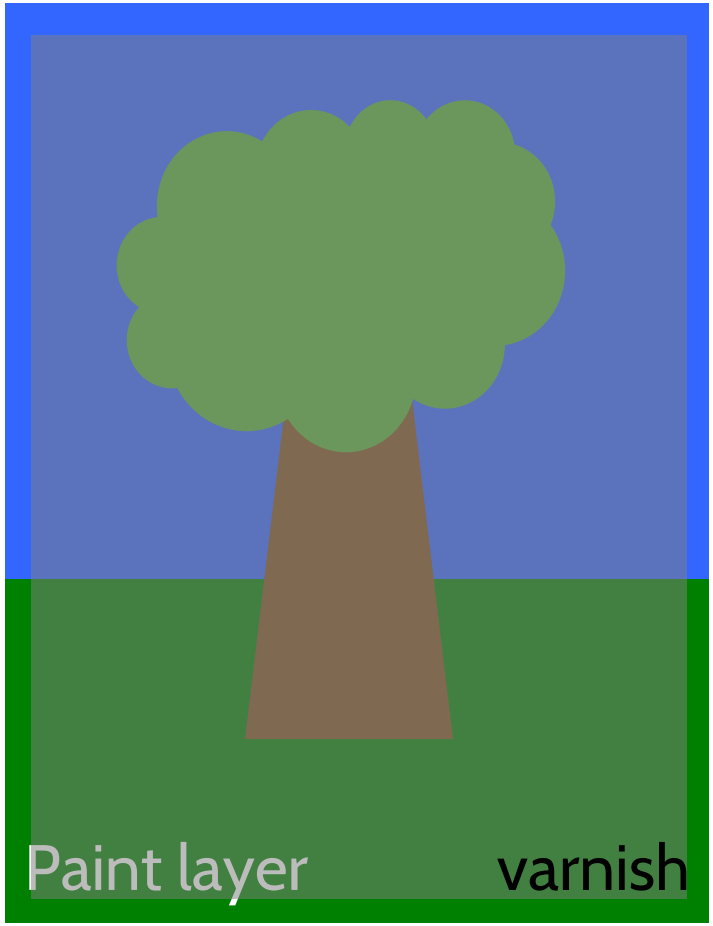
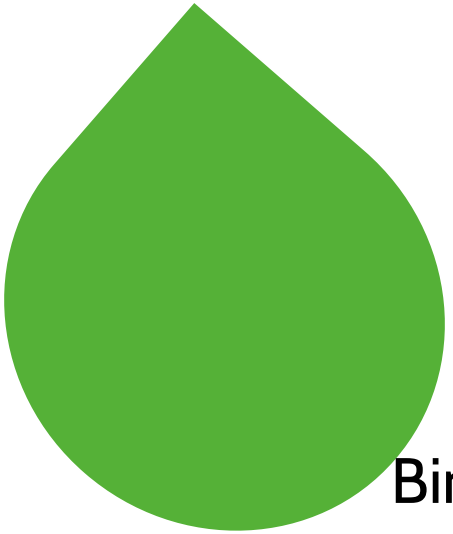
Anatomy of a painting





Pigment: color source (e.g. ultramarine, vermilion)

Binder: keeps the pigment suspended (e.g. oil, acrylic polymer)

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Jackson Pollack - before his time?

Untitled splatter painting attributed to Jackson Pollack

Black paint was found to contain materials that were not developed until 1965 (Pollack died in 1956).

From “A Technical Analysis of Three Paintings Attributed to Jackson Pollock” by Narayan Khandekar, Carol Mancusi-Ungaro, Harry Cooper, Christina Rosenberger, Katherine Eremin, Kate Smith, Jens Stenger and Dan Kirby. From Studies in Conservation 55 (2010), pages 204–215.

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Questions?

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The Conservation Science To

Non-destructive techniques

X-ray imaging
Spectroscopy (Raman, IR, etc)

similar to X-rays or MRI at a hospital

Destructive techniques

Cross sections for spectroscopy or imaging
Chromatography and mass spectrometry (LC-MS or GC-MS)
Peptide mass fingerprinting (PMF) for identifying proteins

similar to blood work or surgery at a hospital

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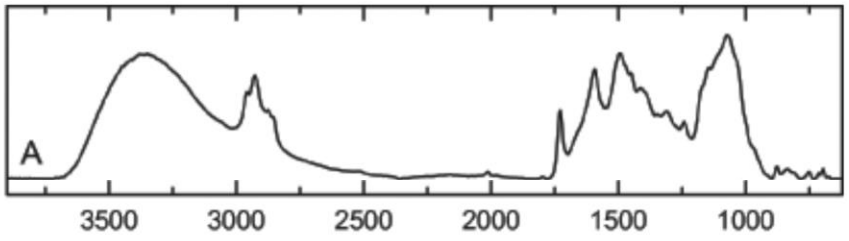
Infrared spectroscopy

Untitled splatter painting
attributed to Jackson Pollack



Painting

Gum arabic reference

AcryloidTM B-67 reference

Pigment Black 1 (PBk1) ref

From “A Technical Analysis of Three Paintings Attributed to Jackson Pollock” by Narayan Khandekar, Carol Mancusi-Ungaro, Harry Cooper, Christina Rosenberger, Katherine Eremin, Kate Smith, Jens Stenger and Dan Kirby. From Studies in Conservation 55 (2010), pages 204–215.

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X-ray imaging

Visible image

X-ray image

Vincent van Gogh, Three Pairs of Shoes, 1886-1887
Harvard Art Museums

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X-ray imaging

http://www.harvardartmuseums.org/tour/art-science/slide/523

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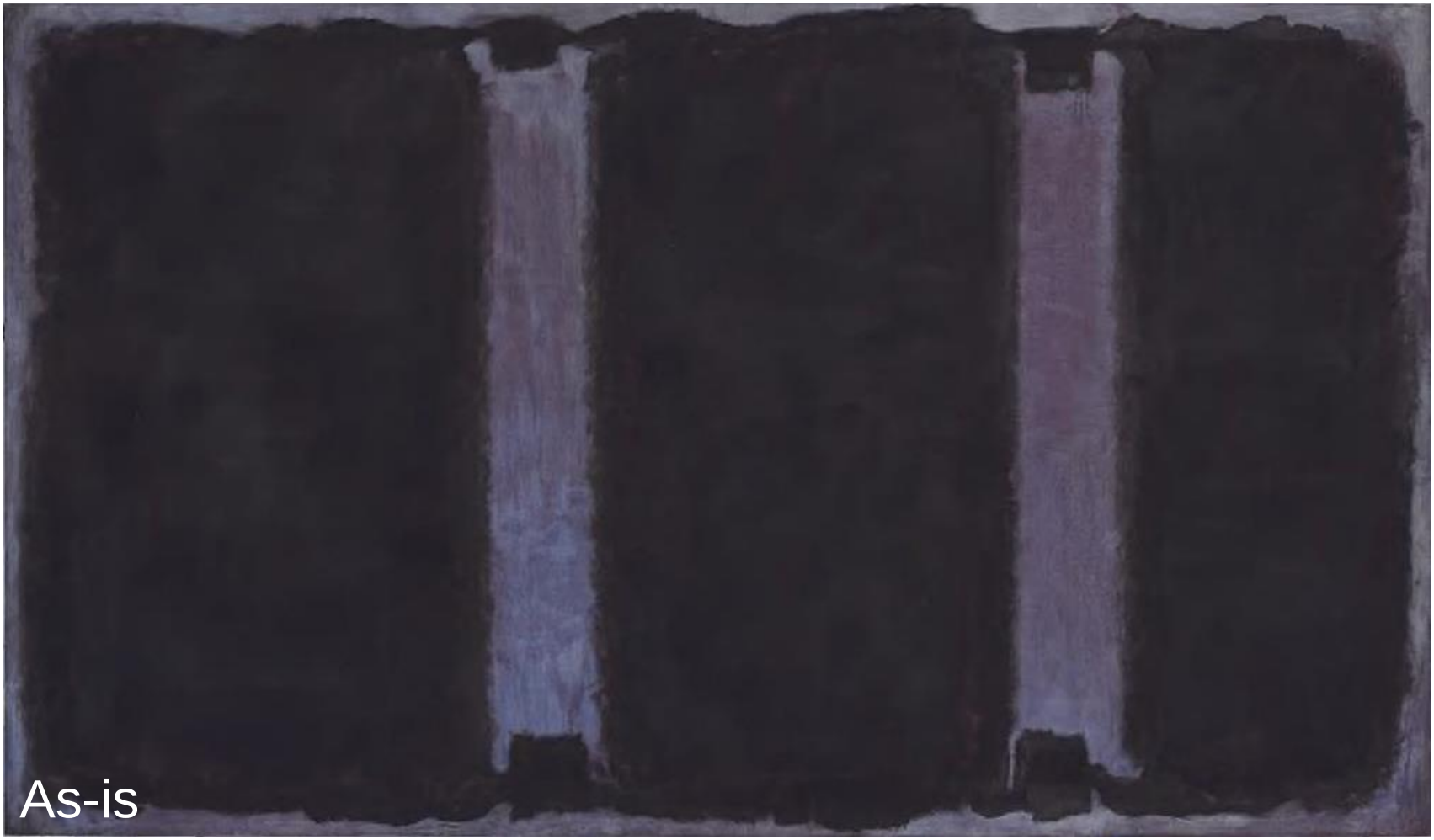
Light projections: Rothko murals



Compare with and without projections here: http://www.harvardartmuseums.org/tour/art-science/slide/512

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Light projections: Rothko murals

Compare with and without projections here: http://www.harvardartmuseums.org/tour/art-science/slide/512

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Questions?

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The Conservation Science Toolbox

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Spectroscopy (Raman, IR, etc)

similar to X-rays or MRI at a hospital

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Cross sections for spectroscopy or imaging
Chromatography and mass spectrometry (LC-MS or GC-MS)
Peptide mass fingerprinting (PMF) for identifying proteins

similar to blood work or surgery at a hospital

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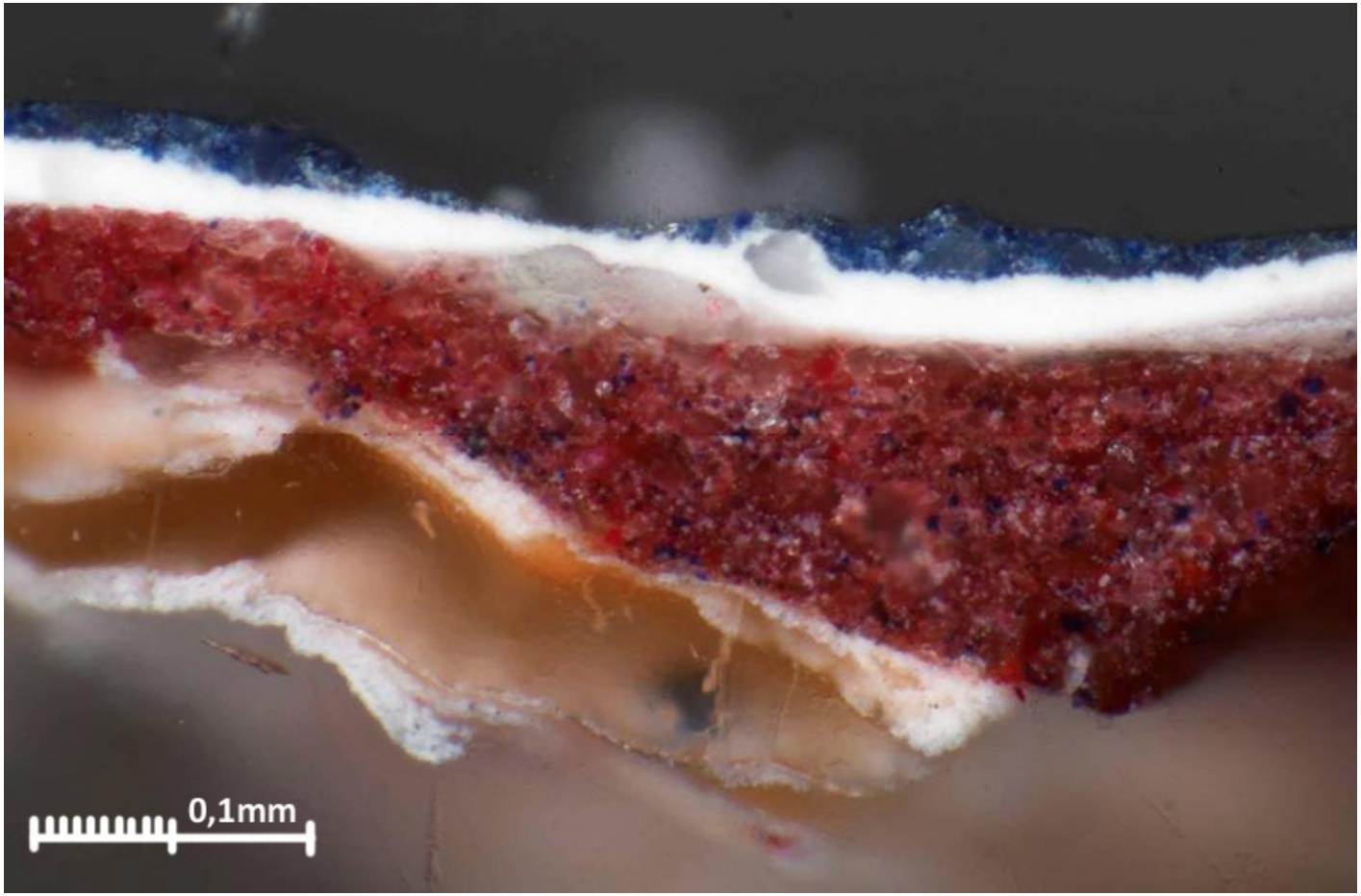
Cross-sections



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Sample size requirement

Images courtesy of Dan Kirby

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Proteins in art work

14th-century altarpiece (attributed to Bernardo Daddi) indicating sampling locations

9th c. Qur'an folio (Harvard Art Museums, Acc. # 1927.163), showing the sampling location along the left edge (inset).

All images courtesy of Dan Kirby

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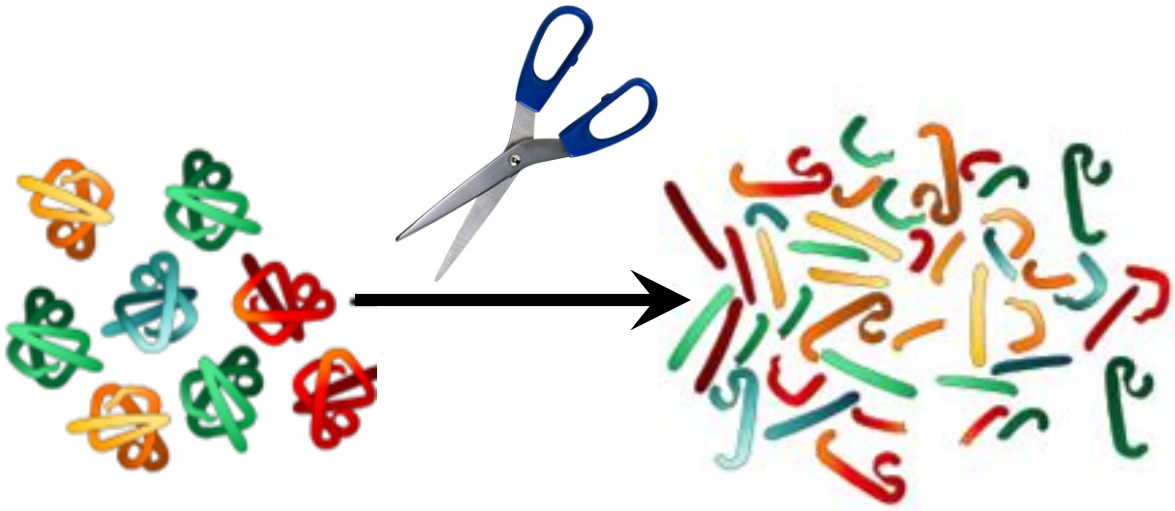
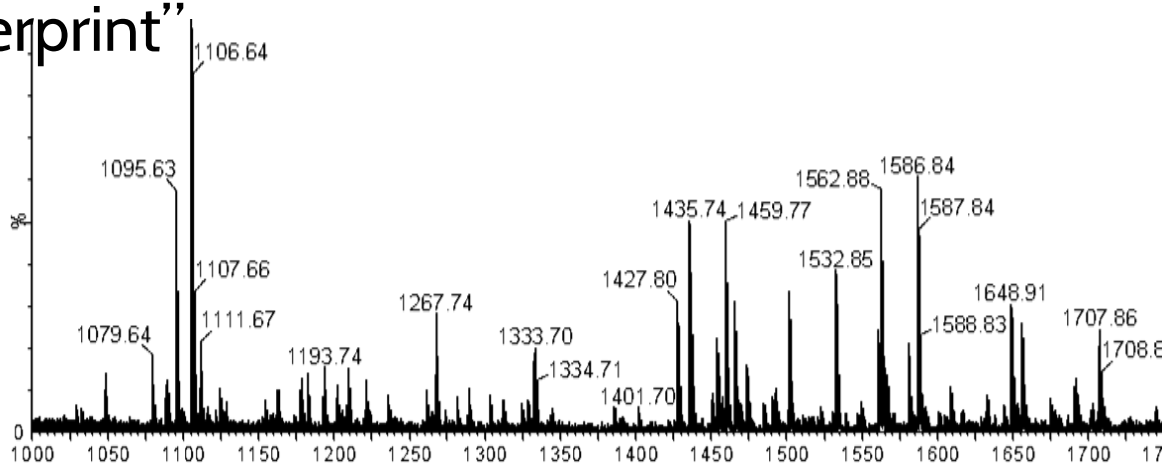
How peptide mass fingerprinting works

1. Cut protein into smaller "peptide" pieces



2. Mass spectroscopy of peptides to see "fingerprint"



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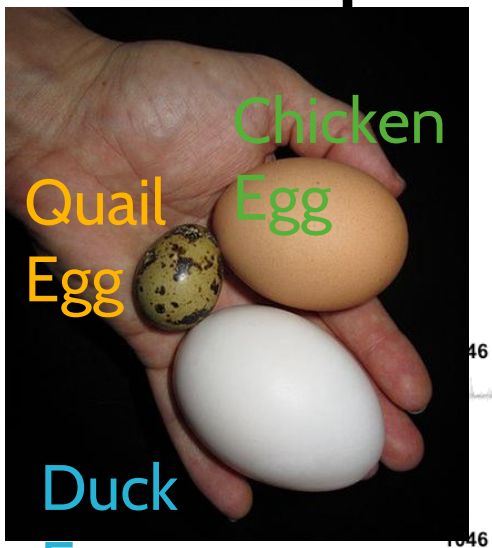
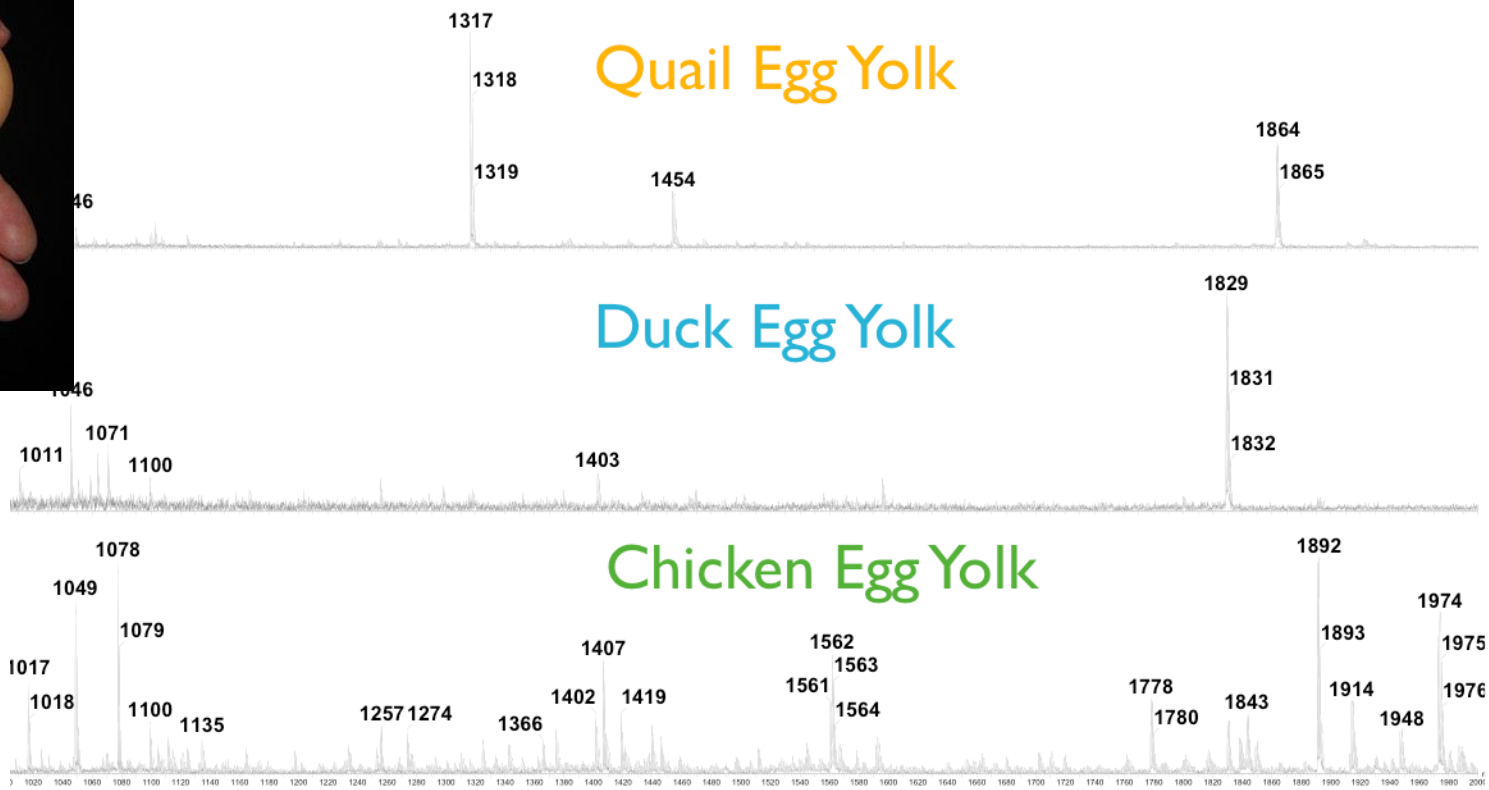
Peptide mass fingerprints (PMF) of egg tempera from different egg species





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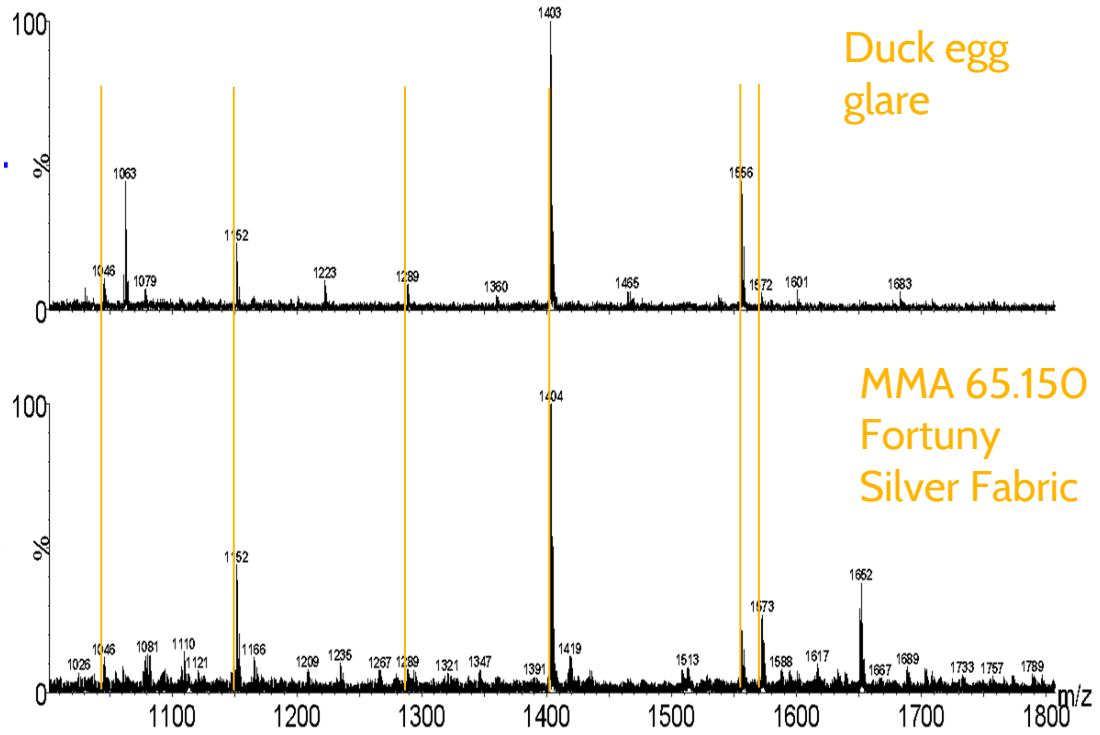
PMF for identifying eggs' species



Peptide mass fingerprint from Metropolitan Museum of Art; Acc. # 65.150, Fortuny Textiles; image courtesy of Dan Kirby

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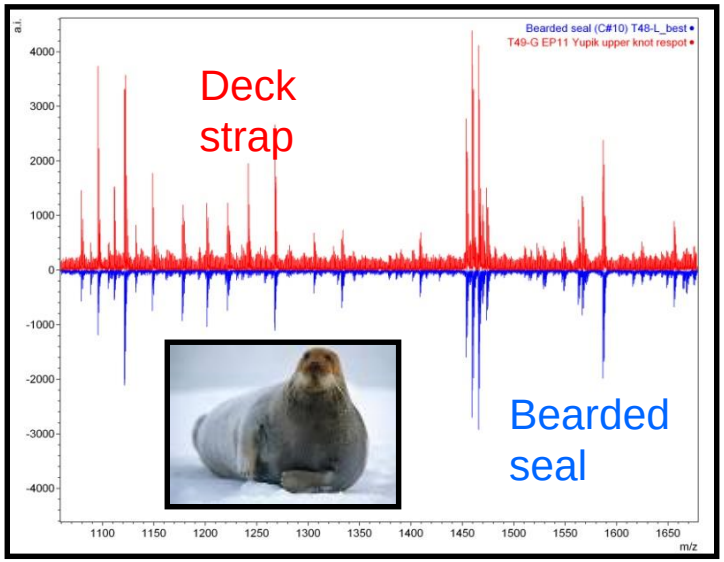
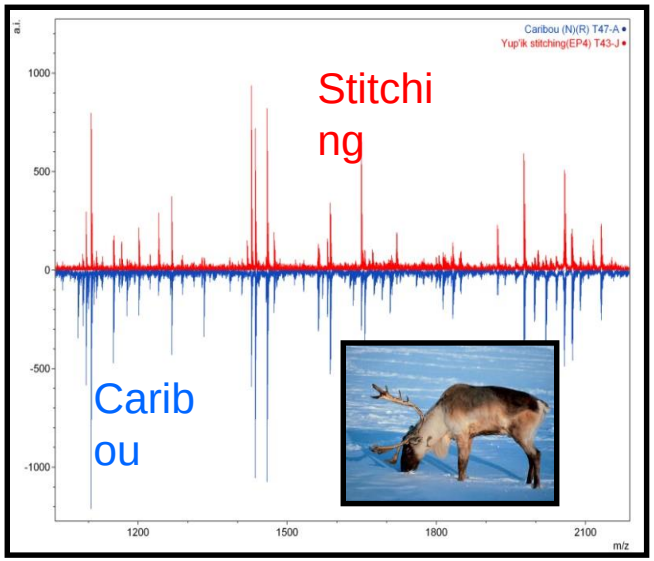
PMF for speciation: Alaskan kayak





Deck and deck strap (Bearded seal)

Stitching (Caribou)

Images courtesy of Dan Kirby

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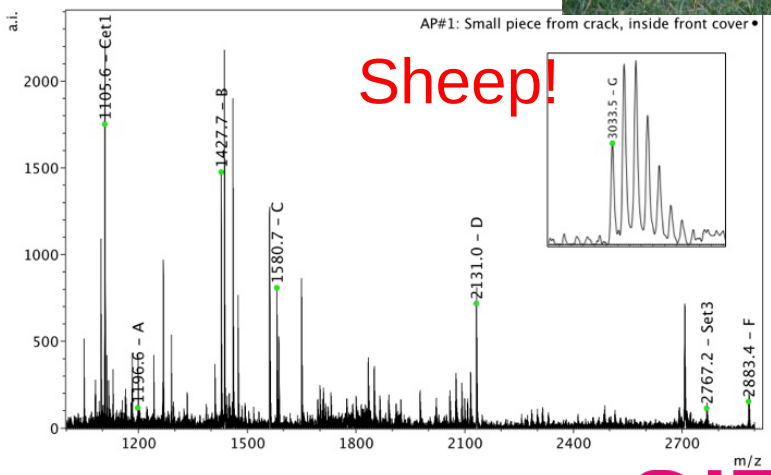
PMF for speciation: Book binding

"The bynding of this booke is all that remains of my dear friende Jonas Wright, who was flayed alive by the Wavuma on the Fourth Day of August, 1632."



Book and spectrum courtesy of Dan Kirby;
sheep photo by Andreas Cappell, used under CC BY 2.0

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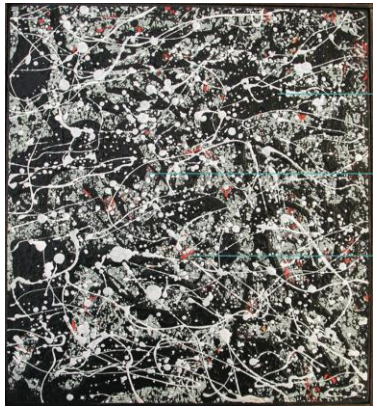
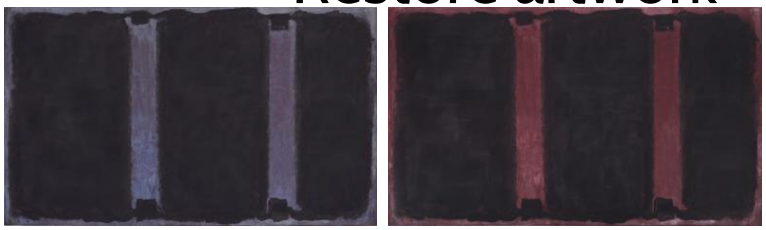
Materials matter!

Using both non-destructive (X-ray imaging, spectroscopy) and destructive (cross sections, peptide mass fingerprinting) techniques, we can learn:



- How/when it was made
  - Learn more about artists/their techniques
  - Identify art forgeries
- How to alter it without hurting it
  - Prevent future degradation
  - Restore artwork



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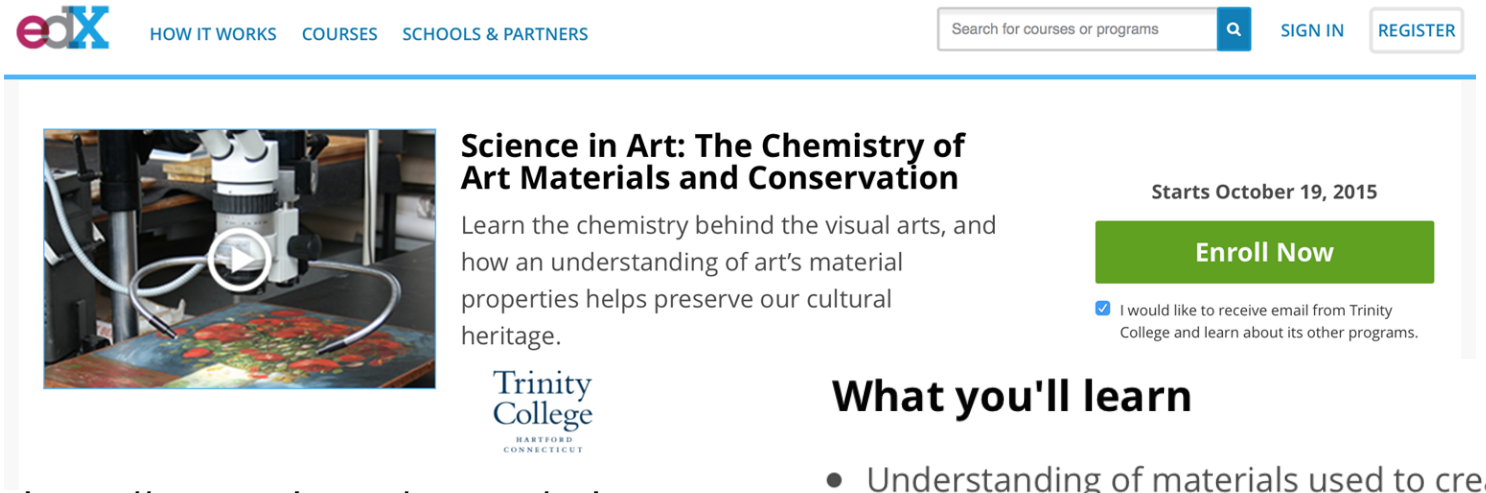
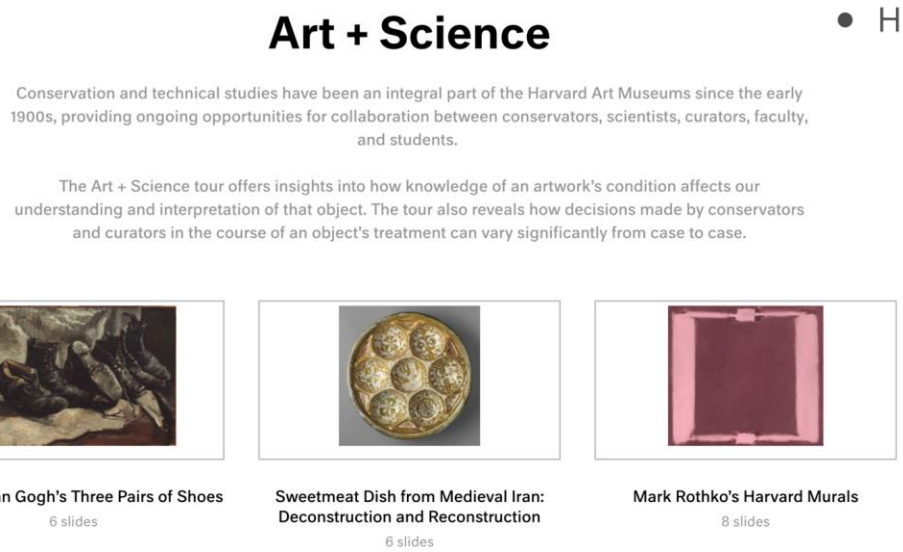
Additional Resources



https://www.edx.org/course/science-art-chemistry-art-materials-trinityx-t001x

Screens
http://w
ws/nano



http://www.harvardartmuseums.org/tour/art-science/

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Questions?

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Science AND Art

Part 1: SEEING

Using **analytical chemistry** to learn more about art

Part 2: HEARING

Using **quantum chemistry** to make art

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Body of slides

- (ben's part goes ehre)

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Thank you!

SITN would like to acknowledge the following organizations for their generous support.

Harvard Medical School
Office of Communications and External Relations
Division of Medical Sciences

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The Harvard Graduate Student Council (GSC)

The Harvard/MIT COOP