Design Matter(s): An Architecture and Nanoscale Chemistry Collaborative Pop-Up Museum

Summer Research Experiences for Teachers (SRET) 2023

Department of Chemistry and David Ravin School of Architecture, University of North Carolina at Charlotte:
Christopher Bejger, Associate Professor of Chemistry, Rachel Dickey, Associate Professor of Architecture

Charlotte Teachers Institute & University of North Carolina at Charlotte Collaborative Project:
Krystal Dehaney, Lawna Gamble, Tam Hawk, Evelyn Metcalf, and Scott Gartlan

Abstract

Pop-up spaces are mobile and less expensive than traditional brick and mortar settings. The mobility of such a space will allow us to exhibit in numerous locations and reach a large audience. This is important because the average museum visitor is a 45-54 year old non-Hispanic white adult.[117] The pop up approach democratizes attendance by targeting demographic groups less likely to frequent museums. We partnered with the Charlotte Teachers Institute's Summer Research Experience for Teachers (SRET) this summer and four Charlotte-Mecklenburg Teachers from Mountain Island Lake Academy, Parker Academic Center, Albemarle Road Middle School, and Wilson STEM Academy to develop curricula that will supplement an existing university student-created design. In this way, these pop-up events situated at schools will serve as a fun way to promote science, architecture, the University, and the mission of the NSF.

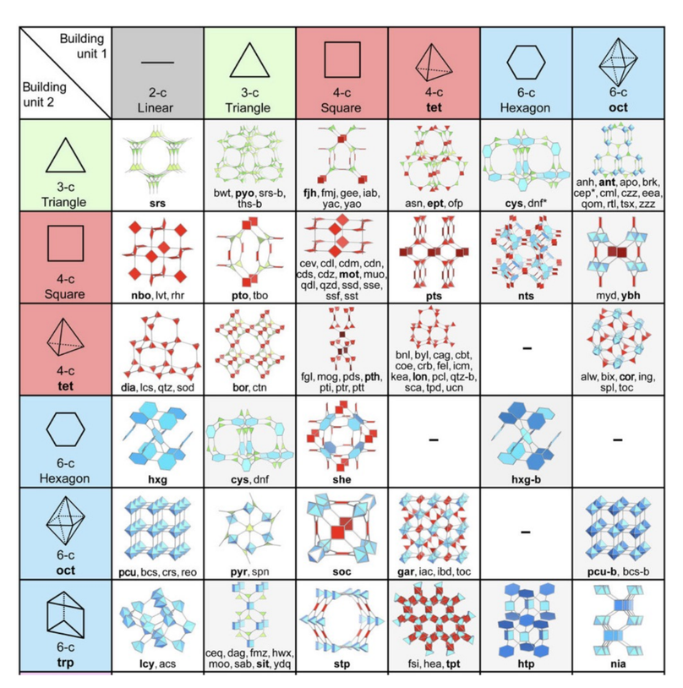
This SRET is part of an ongoing collaborative project between professors Rachel Dickey (Architecture) and Christopher Bejger (Chemistry). At the heart of the collaboration is the construction of a Pop-Up Museum that will be fabricated in the spring/summer 2023 and travel to local K-12 (CMS) schools and community events. During phase one, teams of MS level Architecture students spent a one-semester studio course working with their peers in Chemistry to design and fabricate full scale models of potential museums. The installations are based on the design, synthesis, and properties of metal-organic frameworks (MOFs). The winning museum concept was selected by a jury and is now being refined and constructed. We aim to transform the museum from a fixed institution into a transportable community-driven and event-driven organization, democratizing museum attendance by targeting demographic groups less likely to frequent them. The mobile museum will create an atmosphere to enliven urban gatherings and local school events alike. Using curricula developed by these four teachers, the Pop-Up Museum will travel to their four schools in 2023-2024 to engage hundreds of K-12 students in the intersection of science and art.

Background

Mobile Museum

The goal: Design and fabricate a collaborative mobile museum at the intersection of chemistry and architecture based on materials known as metal organic frameworks (MOFs)

Examples of various pop up museums.



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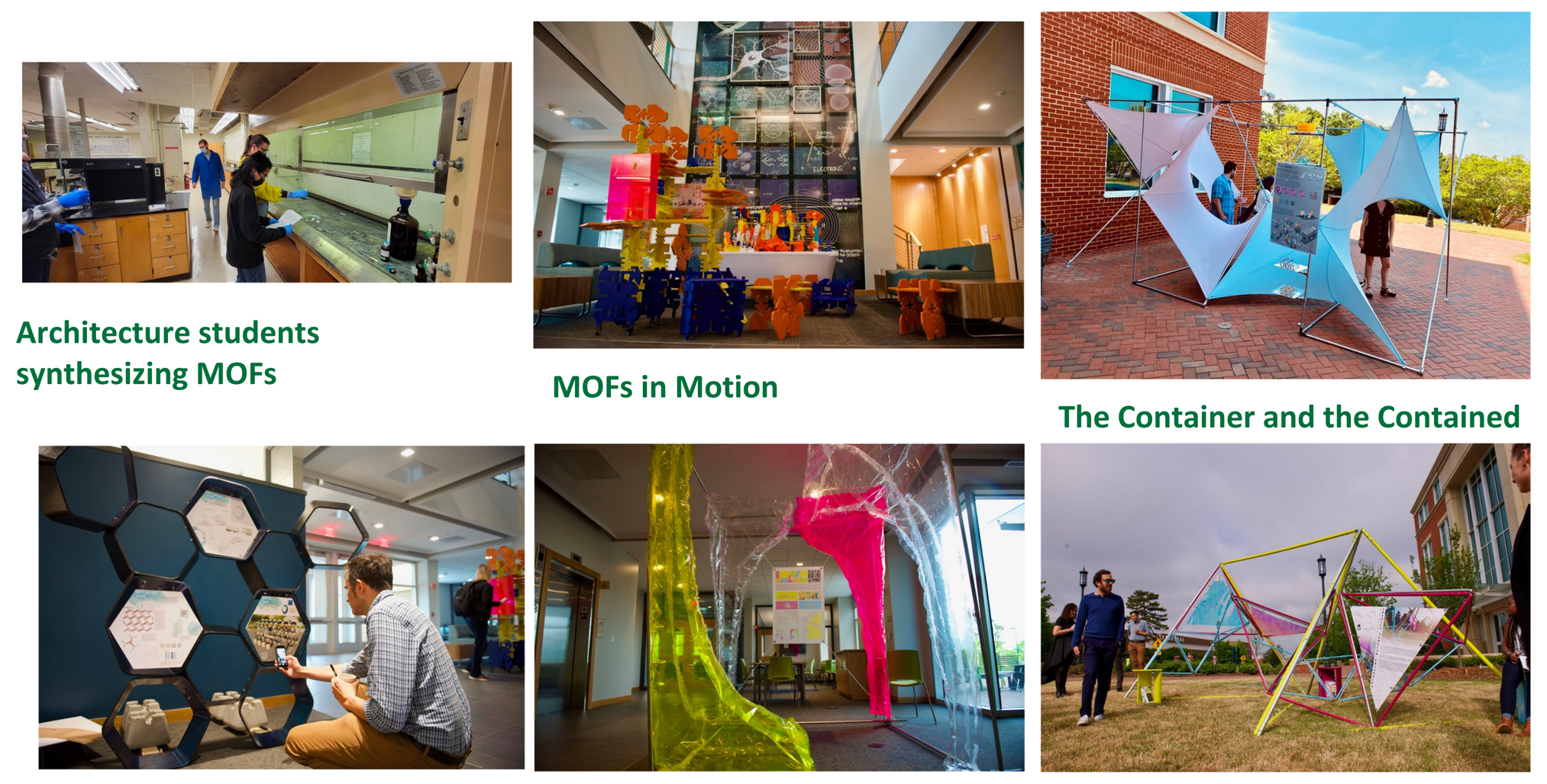
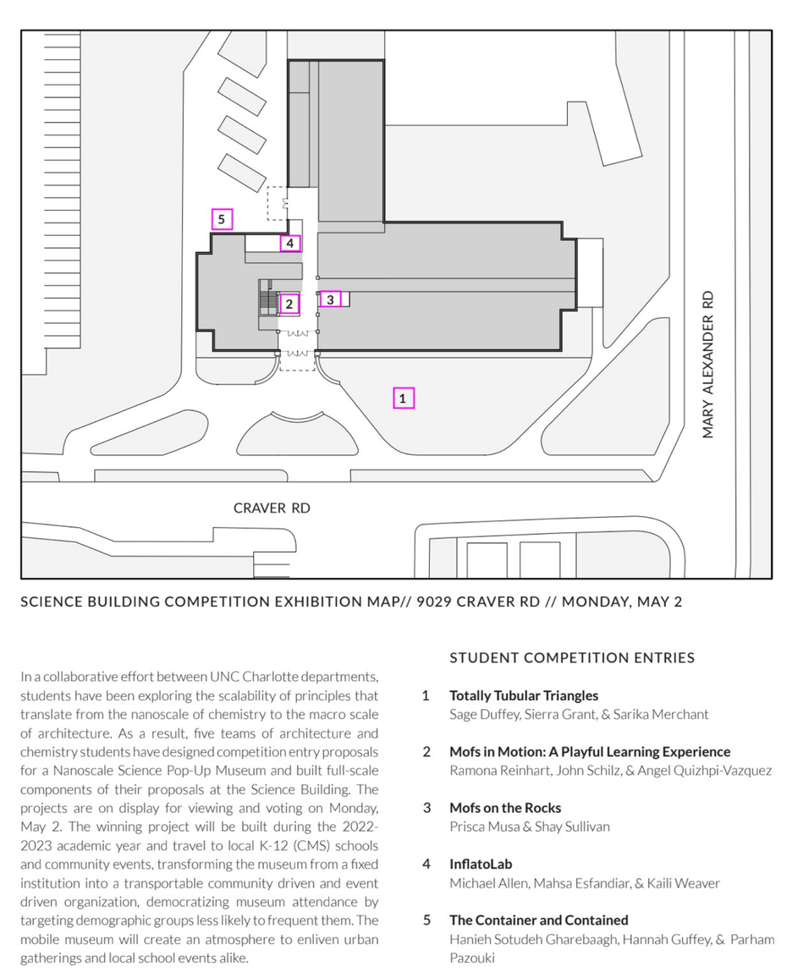
Phase One: A Collaborative Chemistry • Architecture Studio

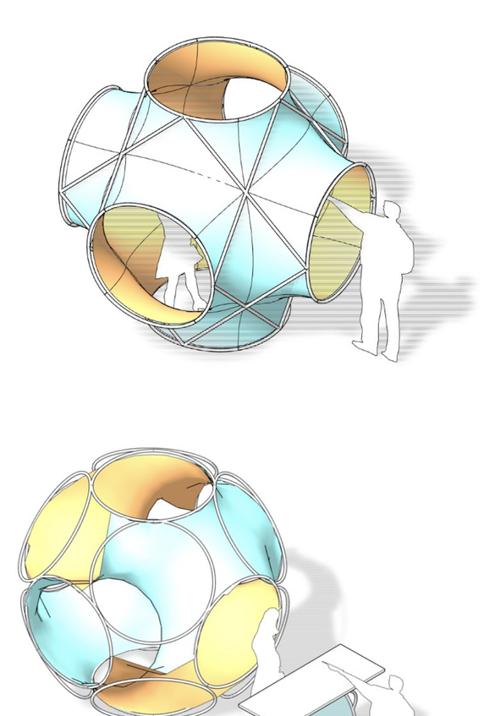


Architecture students synthesizing MOFs | MOFs in Motion | The Container and the Contained | MOFs on the Rocks | Inflatolab | Totally Tubular Triangles

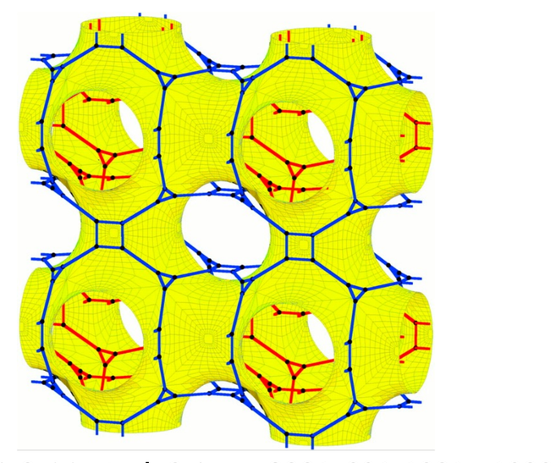
Nanoscale Science Pop Up Museum Competition



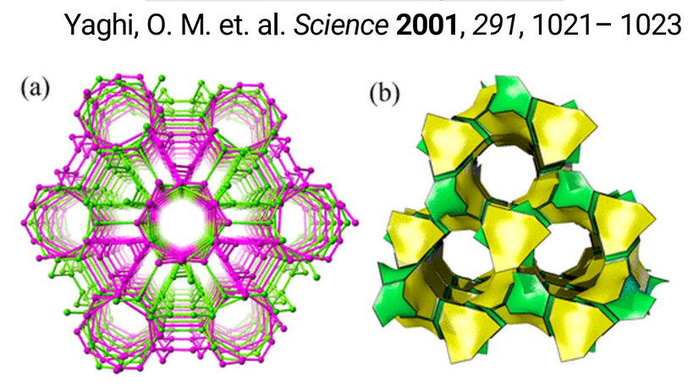
Phase Two: Refinement and Construction of Minimal Surface MOF Museum



Installation by Hanieh Sotudeh Gharebaagh



Yaghi, O. M. et. al. *Science* **2001**, *291*, 1021– 1023



Wei Xu et al. Inorg. Chem. 2019, 58, 20, 13766−13770

Experiencing the MOF sculpture through ELA

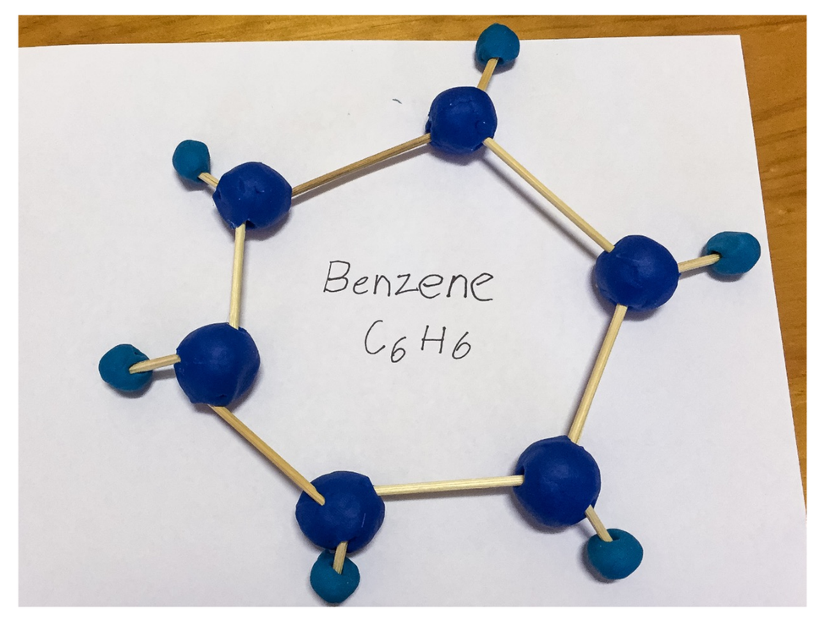
Evelyn Metcalf, Grades 2-3 Horizons Teacher

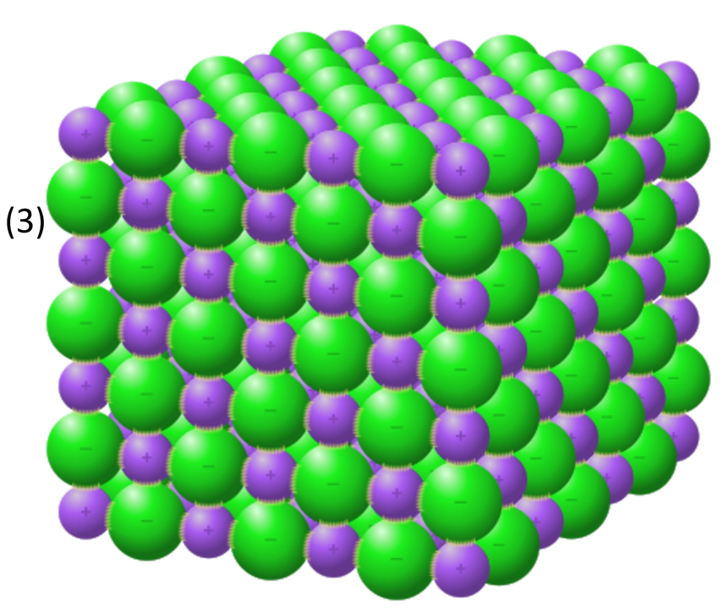
What do scientists, philosophers, artists, authors, inventors, and mathematicians have in common? Ideas come in dreams, the physical world, and in their cultivated and rich imaginations! Young students sometimes feel 'stuck' coming up with ideas. Tools and acronyms like SCAMPER and FFOE can help. In the lesson I've written for the MOF Pop Up Museum, I encourage teachers to help their students look at the MOF Sculpture in a way that fosters fluency, flexibility, originality and elaboration (FFOE). Students are given the task of observing the sculpture, and then writing a fictional or nonfictional piece of writing. If they are at a loss for ideas, the SCAMPER (Substitute, Combine, Adapt, Modify, Put to other uses, Eliminate, Reverse) tool helps them make their own sculpture, which hopefully brings out a more original piece of writing since they've altered the design to make it their own. Six out of seven Durable Skills are addressed: Adaptability, Collaboration, Communication, Critical Thinking, Learner's Mindset, and Personal Responsibility. Students who don't require scaffolding, observe the sculpture and then write about it for 10 minutes. Students have a choice to write a description of what it looks like, feels like, or they can choose to write something based on their imagination. Students are prompted with: "What does it make you *think* of?" "How does it make you *feel*?" "What do you *wonder*?"

Substitute
Imagine replacing a part of the sculpture with something else.
Put to Another Use
Imagine the things you could use it for
Adapt
Imagine it in a new shape.
Reverse
Notice any patterns. Imagine making them in a new order.
S Substitute
A Adapt
C Combine
M Modify
P Put to Another Use
E Eliminate
R Reverse
Combine
Imagine combining it with something else
Modify
Imagine changing the size, materials, color, or form.
Eliminate
Imagine taking something away.

Krystal Dehaney, 8th Grade Science

In the Bejger lab, we worked on synthesis of Metal-Organic Frameworks and Covalent Organic Frameworks. These are complex molecules but have their origins in basic chemical bonding. In Intro to Chemical MOF's students can learn about how elements come together on the basic atomic level to become compounds that they interact with everyday. Once they have built a simple compound like C6H12O6, sugar, or H2O, they will then be able to experience the complex structure of a MOF by building a 3-D model out of clay in the way a scientist would build it out of atoms.





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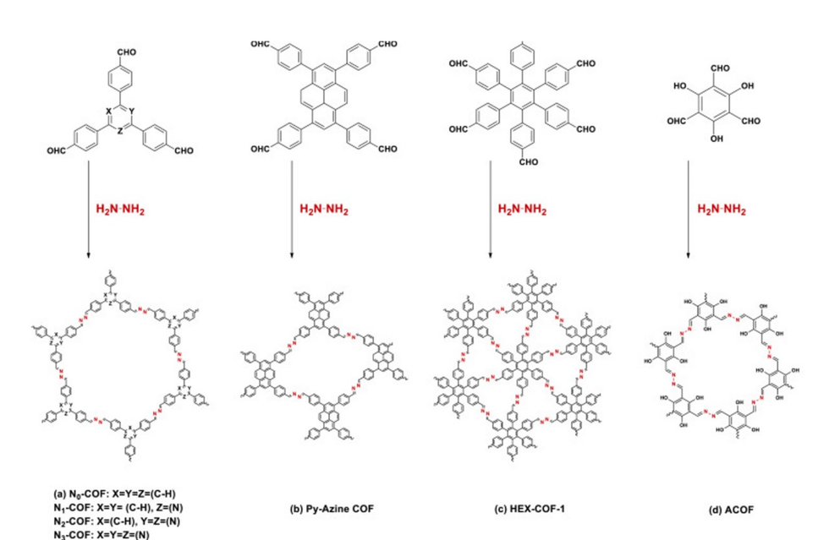

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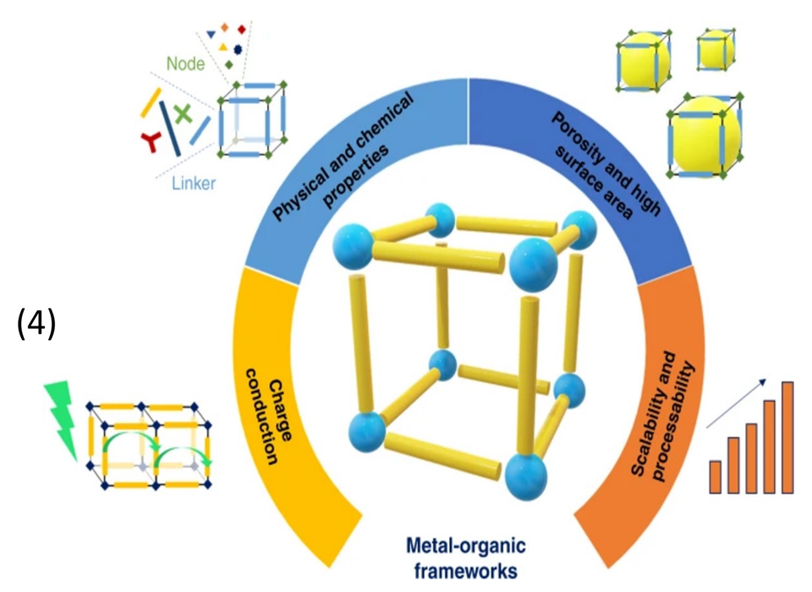


References

(1) Wikipedia. 2023. "Carboxylate–based metal–organic frameworks." Wikimedia Foundation. Last modified March 7, 2023. https://en.wikipedia.org/wiki/Carboxylate%E2%80%93based_metal%E2%80%93organic_frameworks.
(2) "Sodium Chloride." Wikipedia, July 30, 2023. https://en.wikipedia.org/wiki/Sodium_chloride#cite_note-1.
(3) Baumann, Avery E., David A. Burns, Bingqian Liu, and V. Sara Thoi. "Metal-Organic Framework Functionalization and Design Strategies for Advanced Electrochemical Energy Storage Devices." Nature News, July 26, 2019. https://www.nature.com/articles/s42004-019-0184-6.

Art/Architecture

Lawna Gamble, K- 5th Grade Visual Art

This lesson introduces students to the fascinating world of Metal-Organic Frameworks (MOFs) and their connection to Neurographic Art, fostering a creative exploration of scientific concepts. During the 1-2 hour session, students will learn about MOFs, porous materials with diverse applications, and Neurographic Art, a form of expression using interconnected lines and patterns to depict complex ideas. Students will create their Neurographic Art inspired by their interpretations of MOFs, encouraging interdisciplinary thinking and creative expression. This lesson plan highlights the powerful combination of science and art, inspiring students to explore and communicate complex concepts through their artwork. A variety of materials can be used to adapt or extend this lesson to include: permanent markers, straws, sticks, yarn, construction paper, or watercolor paints.

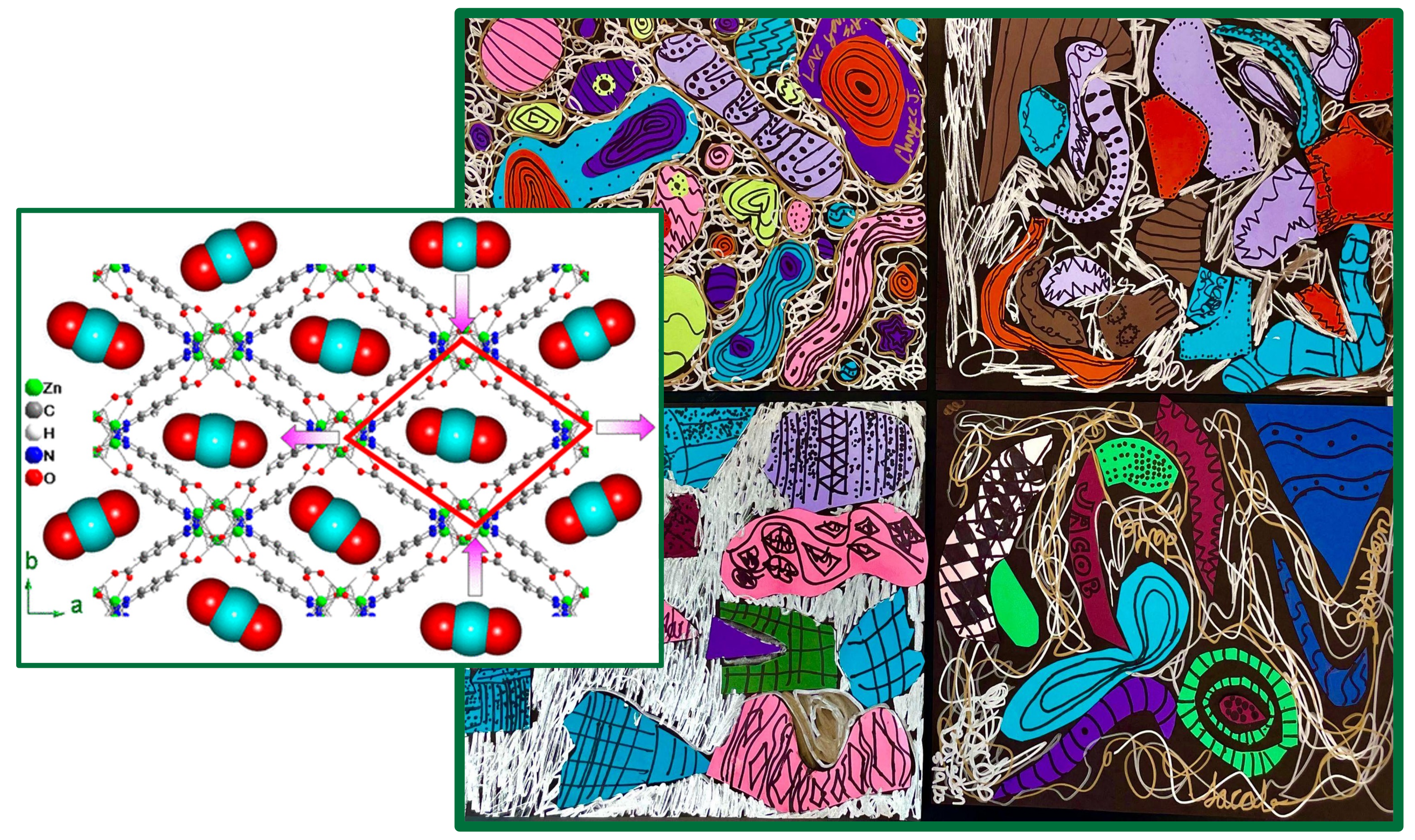


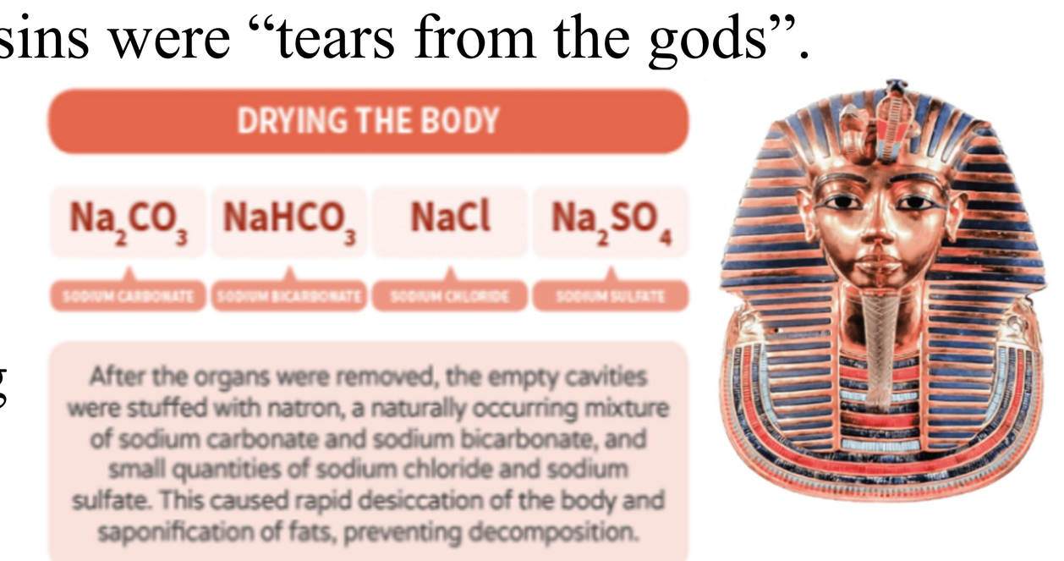
Image: (Left) A Flexible Metal–Organic Framework; (Right) Elementary School students rendition of MOFs based on Reggie Laurent art history lesson. J. Phys. Chem. C 2015, 119, 17, 9442–9449, Publication Date:April 13, 2015, https://doi.org/10.1021/acs.jpcc.5b02359, Copyright © 2015 American Chemical Society

Tam Hawk, 6th Grade Individuals & Society

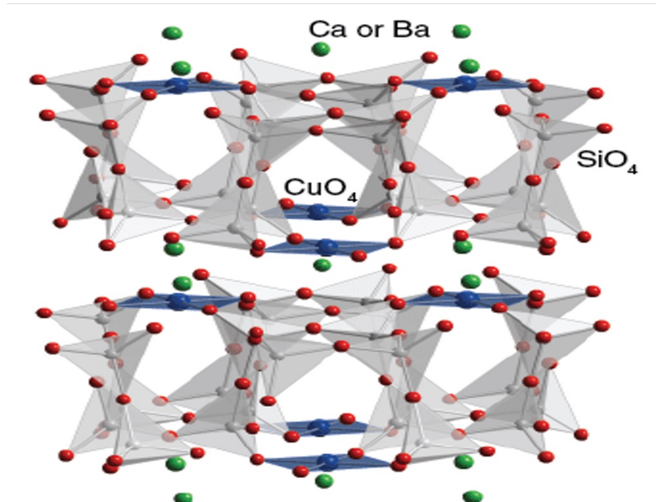
Chemistry and The Ancient World. This lesson will focus on how various materials have impacted society throughout history from a chemistry perspective. For example, some scholars believe the Ancient Egyptians were thought to be the best chemists of the ancient world. They interconnected their mythology with chemistry. They associated Horis with magnetite and tree resins were "tears from the gods".

THE CHEMISTRY OF MUMMIFICATION

Osiris, the Egyptian god of the dead, was associated with natron, which is what they used for mummification. A mixture of baking soda and salt will mimic natron for a class project of creating a mummy apple.

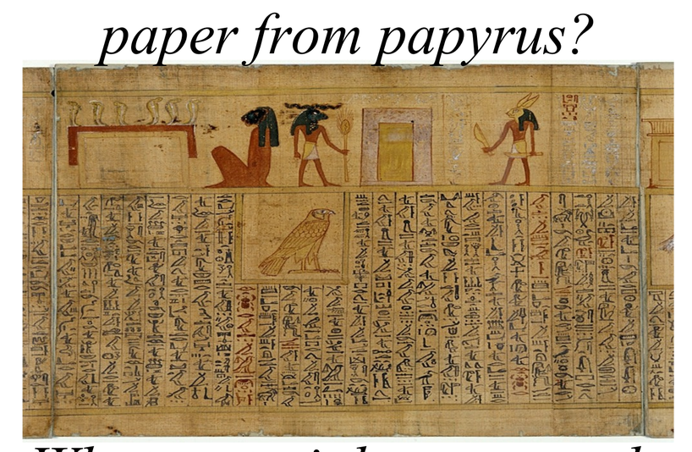


DRYING THE BODY
Na2CO3
NaHCO3
NaCl
Na2SO4
After the organs were removed, the empty cavities were stuffed with natron, a naturally occurring mixture of sodium carbonate and sodium bicarbonate, and small quantities of sodium chloride and sodium sulfate. This caused rapid desiccation of the body and saponification of fats, preventing decomposition.



(photo left) Chemical compound of Egyptian Blue, developed around 2600 BC. The exact formula is not known but they had to have specific materials heating at specific temperatures.

What process was used by ancient Egyptians to make paper from papyrus?



What materials were used in building the pyramids?

Students will analyze the importance of the invention of materials such as papyrus, concrete, iron and other materials which helped transform society. Students will develop compelling questions about materials used in ancient civilizations.

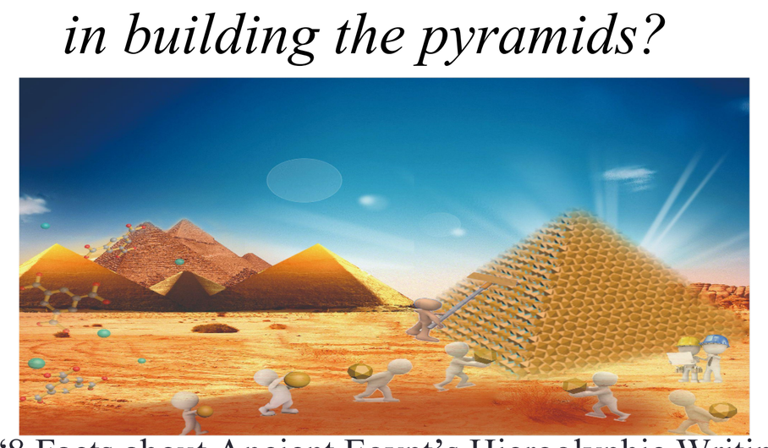
Egyptian Blue Color Widely used in ancient Egypt

Roman Concrete how does it compare with modern concrete?

Ancient Egyptian makeup also protected against infections. How?

Early MOFs…Porous Materials

Ancient Civilizations used porous charcoal for medicinal purposes.



"8 Facts about Ancient Egypt's Hieroglyphic Writing." History.com. Accessed July 31, 2023. https://www.history.com/news/hieroglyphics-facts-ancient-egypt. .
Brack, Paul. "Egyptian Blue: More than Just a Colour." Chemistry World, January 27, 2020. https://www.chemistryworld.com/features/egyptian-blue-more-than-just-a-colour/9001.article.
Day, Gregory S., Hannah F. Drake, Hong-Cai Zhou, and Matthew R. Ryder. "Evolution of Porous Materials from Ancient Remedies to Modern Frameworks." *Communications Chemistry* 4, no. 1 (2021). https://doi.org/10.1038/s42004-021-00549-4.
Andy Brunning, and Christine Kim. "The Chemistry of Mummification." Compound Interest, October 27, 2016. https://www.compoundchem.com/2016/10/27/mummification/. "Progress on the Crystallization Mechanism for a Metal–Organic Framework Achieved by Prof. Zhao Xuebo's Group." english. Accessed August 3, 2023. https://english.upc.edu.cn/info/1022/1572.htm.