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# RPPR Final Report

## as of 23-Apr-2023

Agency Code: 21XD

Proposal Number: 80190BBCF

Agreement Number: W911NF-22-1-0060

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**Report Date:** 19-Apr-2023

Date Received: 05-Apr-2023

**Final Report** for Period Beginning 20-Jul-2022 and Ending 19-Jan-2023

**Title:** 2022 Biomineralization GRC and GRS

**Begin Performance Period:** 20-Jul-2022

**End Performance Period:** 19-Jan-2023

**Report Term:** 0-Other

Submitted By: Ph.D. Nancy Gray

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**Distribution Statement:** 1-Approved for public release; distribution is unlimited.

### STEM Degrees:

### STEM Participants:

**Major Goals:** Biomineralization processes have inspired material scientists and engineers to design and develop materials with elaborate structures and desirable physical and mechanical properties for biomedical, dental and industrial applications. Biominerals represent a window to evolution and the history of Earth and have reciprocal and intimate relationships with their environment. In human, biominerals have significant impact on health and if formed in a wrong place or at a wrong time lead to pathology and cancer. It is timely and important for the advancement of research in these areas to continue the Gordon Research Conference (GRC) on Biomineralization, which is a highly interdisciplinary meeting that tackles many challenges in understanding biomineralized tissues formation and function. The accompanying Gordon Research Seminar (GRS) will emphasize on creating new connections between students, postdoctoral fellows and early-career and experienced researchers. While most of the funds will be awarded on the basis of the scientific merits of the submitted abstracts, a portion will be reserved to enhance participation by females and underrepresented groups. Conference funding is being sought to provide partial support for registration fee for participants, including but not limited to post docs and/or graduate students, to attend the 2020 Gordon Research Conference and Gordon Research Seminar on Biomineralization. The proposed program already includes 40% female speakers, and 55.6% female discussion leaders, as well a number of underrepresented minorities. We will address the challenges women face in STEM through the organized platform of "Power Hour".

The objective of the GRC on Biomineralization 2020 entitled "Bridging scientific disciplines to understand biomineral formation in breadth and depth", is to bring together early career and established scientists from around the globe with diverse backgrounds and a variety of expertise including, but not limited to biology, physics, geology, chemistry, engineering, environmental sciences, dentistry and medicine. Speakers and poster presenters will share a broad spectrum of state-of-the-art topics to cover genetic, molecular and cellular mechanisms of formation, structure and function of biomineralized tissues. Interactions of biominerals with the environment, impact on health and disease, as well as the translational aspect of biomineralization in tissue engineering will also be covered. The GRC 2020 conference will cover unicellular and multicellular systems containing calcium carbonate, calcium phosphate, silica, and ferric oxide. Chemical, physical, biochemical and physiological events such as ion transport and homeostasis, genetic and cellular control of mineral deposition, principles of crystal nucleation, growth and phase transformation, macromolecular self-assembly and mineral interactions, pathological mineralization,

## RPPR Final Report as of 23-Apr-2023

structure and biomechanics, and Earth and evolution will be the main subjects of the invited talks.

Findings presented at the GRC on Biomineralization have had lasting impact across diverse scientific communities, from biology to geology, from life sciences to materials science, and from evolutionary sciences to engineering, regenerative medicine and nanotechnology. Hence, there is great potential for the new insights in the formation mechanisms, structures, properties and applications of biominerals that will be presented at this conference to make important contributions in many of these fields. Beyond the direct impact on a number of scientific communities, informal interaction, networking, and mentoring is an important aspect of the meeting.

**Accomplishments:** Biominerals are formed in many multi- and uni-cellular organisms. One of the most noticeable and intriguing characteristics of biominerals is the variety of morphologies, sizes, and shapes seen in organisms, which are completely different from their synthetic counterparts. Under programmed genetic and cellular control these composite materials assemble into hierarchical structures and play crucial roles throughout the lifetime of the organism. In human, biominerals have significant impact on health and if formed in a wrong place or at a wrong time lead to pathology and cancer. Biominerals represent a window to evolution and the history of Earth and have reciprocal and intimate relationships with their environment. Biomineralization has inspired material scientists and engineers to design and develop materials with elaborate structures and desirable physical and mechanical properties for biomedical, dental and industrial applications.

The objective of the Gordon Research Conference (GRC) on Biomineralization 2022 was to bring together early career and established scientists from around the globe with diverse backgrounds and a variety of expertise including but not limited to biology, physics, geology, chemistry, engineering, environmental sciences, dentistry and medicine. Speakers and poster presenters shared a broad spectrum of state-of-the-art topics to cover genetic, molecular and cellular mechanisms of formation, structure and function of biomineralized tissues. Interactions of biominerals with the environment, impact on health and disease, as well as the translational aspect of biomineralization in tissue engineering was also covered.

Held for the fifth time in conjunction with the Gordon Research Seminar (GRS), the 2022 GRC focused on 1) bridging the scientific disciplines to interrogate and understand biomineral formation in breadth and depth, 2) identified universal scientific principles and mechanisms that are common among different mineralized tissues, 3) identified the most advanced in situ, in vitro and in vivo strategies for the study of mineralized tissues, and 4) continued to explore scientific principles for the purpose of material fabrication and translational research.

**Training Opportunities:** Speakers, discussion leaders, poster presenters and attendees simultaneously contributed to and benefited from the collective skills and experience shared throughout the conference.

**Results Dissemination:** The final program has been posted on the GRC website.

**Honors and Awards:** Nothing to Report

**Protocol Activity Status:**

**Technology Transfer:** Nothing to Report

**RPPR Final Report**  
as of 23-Apr-2023

**Partners**

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I certify that the information in the report is complete and accurate:

Signature: Nancy Ryan Gray

Signature Date: 4/5/23 1:46PM



**GORDON RESEARCH CONFERENCES  
FINAL REPORT**  
Army Research Office  
Biomineralization GRC/GRS  
Grant Number W911NF-22-1-0060

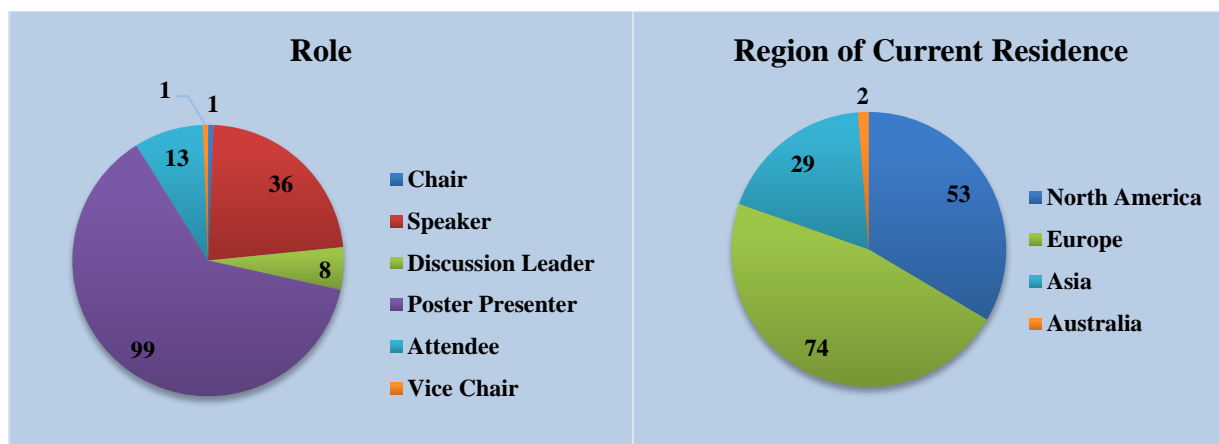
**Operational Summary**

The Gordon Research Conference (GRC) and Gordon Research Seminar (GRS) on Biomineralization were held at the Rey Don Jaime Grand Hotel in Castelldefels, Spain from August 13-19, 2022. The meeting covered a variety of scientific topics and the content presented was highly rated by participants.



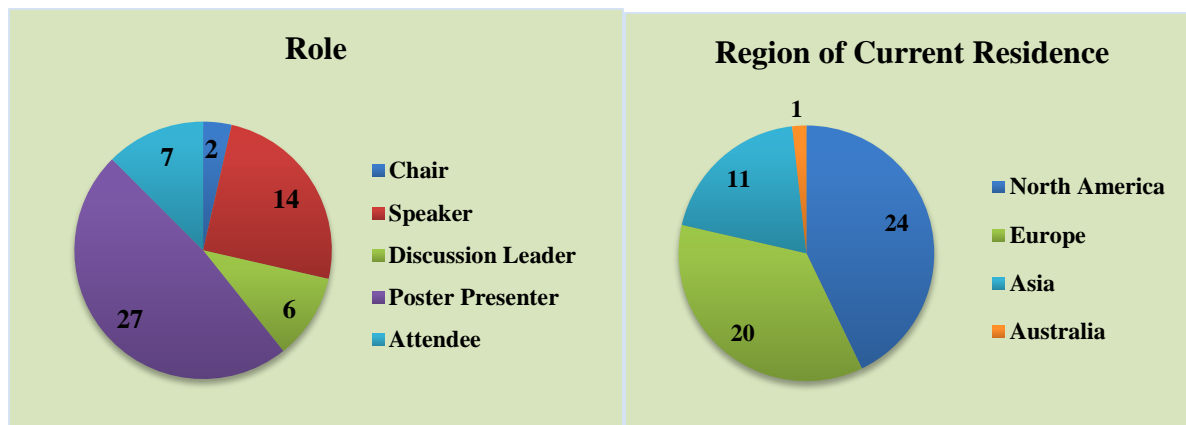
**Conference Participants**

The Conference was well-attended with 158 participants. Scientists from academia represented 95% of the participants while attendees from government accounted for 4% and those from industry represented 1%. The meeting also attracted a strong mix of young investigators and senior scientists. Students and post-docs accounted for 51% of all attendees. Approximately 63% of the participants at the 2022 meeting were women.



**Seminar Participants**

The Seminar was well-attended with 56 participants. Students and post docs combined accounted for 90% of all attendees. Approximately 63% of the participants at the 2022 seminar were women.



**Conference Program**

Biominerals are formed in many multi- and uni-cellular organisms. One of the most noticeable and intriguing characteristics of biominerals is the variety of morphologies, sizes, and shapes seen in organisms, which are completely different from their synthetic counterparts. Under programmed genetic and cellular control these composite materials assemble into hierarchical structures and play crucial roles throughout the lifetime of the

organism. In human, biominerals have significant impact on health and if formed in a wrong place or at a wrong time lead to pathology and cancer. Biominerals represent a window to evolution and the history of Earth and have reciprocal and intimate relationships with their environment. Biomineralization has inspired material scientists and engineers to design and develop materials with elaborate structures and desirable physical and mechanical properties for biomedical, dental and industrial applications.

The objective of the Gordon Research Conference (GRC) on Biomineralization 2022 was to bring together early career and established scientists from around the globe with diverse backgrounds and a variety of expertise including but not limited to biology, physics, geology, chemistry, engineering, environmental sciences, dentistry and medicine. Speakers and poster presenters shared a broad spectrum of state-of-the-art topics to cover genetic, molecular and cellular mechanisms of formation, structure and function of biomineralized tissues. Interactions of biominerals with the environment, impact on health and disease, as well as the translational aspect of biomineralization in tissue engineering were also covered.

Held for the fifth time in conjunction with the Gordon Research Seminar (GRS), the 2022 GRC focused on bridging the scientific disciplines to interrogate and understand biomineral formation in breadth and depth, identifying universal scientific principles and mechanisms that are common among different mineralized tissues, identifying the most advanced *in situ*, *in vitro* and *in vivo* strategies for the study of mineralized tissues, and continuing to explore scientific principles for the purpose of material fabrication and translational research.

The Gordon Research Seminar (GRS) on Biomineralization is a unique forum for graduate students and post-docs with diverse education and expertise to present cutting-edge research and share inspiring ideas.

Biomineralization is a multidisciplinary field focusing on the complex formation pathways, structures and intriguing functions of biominerals. In a multifaceted approach toward understanding both biomineral formation processes and purposes, this meeting aspires to bring scientists of various scientific disciplines together. By bridging geology, chemistry, biology, medicine, materials science, evolutionary sciences and engineering, an integrative environment is provided to share new ideas and discuss recent advances in the field of Biomineralization. Implementing *in vivo*, *in vitro*, *in situ* and *in silico* methodologies, topics such as formation mechanisms, biomolecular-biomineral interactions, biomechanics and bio-inspired materials, and their applications will be addressed.

#### **Conference Budget**

Funding provided by the Army Research Office supported partial registration for 1 professor, 7 post docs and 5 graduate students at the GRC and partial registration for 6 graduate students and 4 postdocs at the GRS.

#### **Conference Feedback**

Participants had an opportunity to provide feedback at the end of the Conference. The feedback collected from the meeting was extremely positive. Evaluations included numerous positive remarks including the wide range of topics, amazing speakers and the networking opportunities. Evaluations from the GRS included positive comments regarding the opportunity to network with other students, great discussions and the cutting-edge science presented.

GRC would like to thank the Army Research Office for its continued support of the meetings. The contributions received have been critical to the success of the conferences and are having a measurable impact in advancing the frontiers of science worldwide.

Dr. Janet Moradian-Oldak, GRC Chair  
University of Southern California

Dr. Nils Kroger, GRC Vice Chair  
TU Dresden

Dr. Dimitra Athanasiadou, GRS Chair  
University of Toronto

Dr. Konrad Hedderick  
Cornell University

Dr. Nancy Ryan Gray  
President and Chief Executive Officer  
Gordon Research Conferences

## Biom mineralization

### Gordon Research Conference

#### Bringing Scientific Disciplines to Understand Biomineral Formation in Breadth and Depth

August 14 - 19, 2022

Chair Janet Moradian-Oldak

Vice Chair Nils Kröger

Rey Don Jaime Grand Hotel

Avinguda de l'Hotel

Castelldefels, B, Spain

#### Conference Program

##### Sunday

2:00 pm - 9:00 pm      Arrival and Check-in

6:00 pm - 7:00 pm      Dinner

7:30 pm - 7:40 pm      Introductory Comments by GRC Site Staff / Welcome from the GRC Chair

7:40 pm - 9:30 pm      Regulation of Morphogenesis  
Discussion Leader: Nils Kröger (TU Dresden, Germany)

7:40 pm - 7:45 pm      Opening Remarks

7:45 pm - 8:00 pm      Introduction by Discussion Leader

8:00 pm - 8:25 pm      Jaroslaw Tyszka (Polish Academy of Sciences, Institute of Geological Sciences, Poland)  
"Active Morphogenetic Control of Biomineralization in Foraminifera"

8:25 pm - 8:45 pm      Discussion

8:45 pm - 9:10 pm      Assaf Gal (Weizmann Institute of Science, Israel)  
"Shaping Mineral Morphologies by Unicellular Algae"

9:10 pm - 9:30 pm      Discussion

##### Monday

7:30 am - 8:30 am      Breakfast

9:00 am - 12:30 pm      Cellular and Genetic Control of Mineral Deposition  
Discussion Leader: Tali Mass (University of Haifa, Israel)

9:00 am - 9:15 am      Introduction by Discussion Leader

9:15 am - 9:40 am      Sylvie Tambutte (Centre Scientifique de Monaco, Monaco)  
"Advances in Molecular, Cellular and Physiological Aspects of Coral Calcification"

9:40 am - 10:00 am      Discussion

10:00 am - 10:10 am      Dvir Gur (Weizmann Institute of Science, Israel)  
"From Colors to Kidney Stones: The Physicochemical and Biological Control of Organic-Crystal forming Cells"

10:10 am - 10:15 am	Discussion
10:15 am - 10:45 am	Coffee Break
10:45 am - 11:10 am	Rivka Elbaum (Hebrew University of Jerusalem, Israel) "Mechanisms of Silica Deposition in Sorghum"
11:10 am - 11:30 am	Discussion
11:30 am - 11:55 am	Monzur Murshed (McGill University, Canada) "Structure-Function Relationships in Matrix Gla Protein, a Potent Inhibitor of Extracellular Matrix Mineralization"
11:55 am - 12:15 pm	Discussion
12:15 pm - 12:25 pm	Diede de Haan (Weizmann Institute of Science, Israel) "Exocytosis of the Silicified Cell Wall of Diatoms involves Extensive Membrane Disintegration"
12:25 pm - 12:30 pm	Discussion
12:30 pm - 1:30 pm	Lunch
1:30 pm - 4:30 pm	Free Time
3:00 pm - 4:00 pm	The GRC Power Hour™ <i>The GRC Power Hour™ is designed to address diversity and inclusion in the scientific workplace by providing a safe environment for informal and meaningful conversations amongst colleagues of all career stages. The program supports the professional growth of all members of our communities, including ethnicity, race and/or gender identity by providing an open forum for discussion and mentoring.</i> Organizers: Netta Vidavsky (Ben-Gurion University of the Negev, Israel) and Alex Gagnon (University of Washington, United States)
4:30 pm - 6:00 pm	Poster Session
6:00 pm - 8:00 pm	Ion Transport, Signaling and Homeostasis Discussion Leader: Marc McKee (McGill University, Canada)
6:00 pm - 6:15 pm	Introduction by Discussion Leader
6:15 pm - 6:40 pm	Rodrigo Lacruz (New York University, United States) "Calcium in Enamel: Not Just Your Regular Mineralizing Cation"
6:40 pm - 7:00 pm	Discussion
7:00 pm - 7:25 pm	Alejandro Rodriguez-Navarro (University of Granada, Spain) "Avian Eggshell Structure and Mineralization"
7:25 pm - 7:45 pm	Discussion

7:45 pm - 7:55 pm Claudia Goettsch (RWTH Aachen University, Germany)  
"The Role of the Endomembrane Homeostasis in Ectopic Calcification"

7:55 pm - 8:00 pm Discussion

8:00 pm - 9:00 pm Dinner

Tuesday

7:30 am - 8:30 am Breakfast

8:30 am - 9:00 am Group Photo

9:00 am - 12:30 pm Chemical and Computational Models of Nucleation, Phase Transformation and Growth  
Discussion Leader: Wendy Shaw (Pacific Northwest National Laboratory, United States)

9:00 am - 9:15 am Introduction by Discussion Leader

9:15 am - 9:40 am Jim Pfaendtner (University of Washington, United States)  
"Energetics and Mechanism of Silica Biomineralization Mediated by Peptoids"

9:40 am - 10:00 am Discussion

10:00 am - 10:10 am Maria Feofilova (ETH Zurich, Switzerland)  
"Frustrated Frustules: Geometric Frustration in Diatom Frustules"

10:10 am - 10:15 am Discussion

10:15 am - 10:45 am Coffee Break

10:45 am - 11:10 am Fiona Meldrum (University of Leeds, United Kingdom)  
"In Vitro Approaches to Understanding Calcite/ Aragonite Polymorphism in Biomineralization"

11:10 am - 11:30 am Discussion

11:30 am - 11:55 am Thomas Koop (Bielefeld University, Germany)  
"Biomolecular Control of the Nucleation and Growth of Ice Crystals"

11:55 am - 12:15 pm Discussion

12:15 pm - 12:25 pm Liza-Anastasia DiCecco (McMaster University, Canada)  
"Visualizing Calcium Phosphate Mineralization Dynamics through Novel in situ Liquid TEM"

12:25 pm - 12:30 pm Discussion

12:30 pm - 1:30 pm Lunch

1:30 pm - 4:30 pm Free Time

4:30 pm - 6:00 pm Poster Session

6:00 pm - 8:00 pm Macromolecules in Biomineralization

Discussion Leader: Elia Beniash (University of Pittsburgh, United States)

6:00 pm - 6:15 pm Introduction by Discussion Leader

6:15 pm - 6:40 pm Michiko Nemoto (Okayama University, Japan)  
"Identification of Proteins Involved in Chiton Tooth Biomineralization by RNA-Seq-Based Analyses"

6:40 pm - 7:00 pm Discussion

7:00 pm - 7:25 pm André Scheffel (Technische Universität Dresden, Germany)  
"The Molecular Mechanism of Calcite Biomineralization in Coccolithophores"

7:25 pm - 7:45 pm Discussion

7:45 pm - 7:55 pm Rachael Deis (Weizmann Institute, Israel)  
"Unraveling the Molecular Mechanisms underlying Intracellular Crystal Formation"

7:55 pm - 8:00 pm Discussion

8:00 pm - 9:00 pm Dinner

#### Wednesday

7:30 am - 8:30 am Breakfast

9:00 am - 12:30 pm Structure and Biomechanics  
Discussion Leader: Peter Fratzl (Max Planck Institute of Colloids and Interfaces, Germany)

9:00 am - 9:15 am Introduction by Discussion Leader

9:15 am - 9:40 am Derk Joester (Northwestern University, United States)  
"From Nano- to Mesoscale: The Structure of Dental Enamel"

9:40 am - 10:00 am Discussion

10:00 am - 10:10 am Neha Mehta (CNRS, France)  
"Spectroscopy Insights into Intracellular Amorphous Calcium Carbonate (ACC) formed by Cyanobacteria"

10:10 am - 10:15 am Discussion

10:15 am - 10:45 am Coffee Break

10:45 am - 11:10 am Elena Sturm (Ludwig Maximilian University of Munich, Germany)  
"What Can We Still Learn from Tooth of Darwin's Dreampond?"

11:10 am - 11:30 am Discussion

11:30 am - 11:55 am Tamara Alliston (UCSF, United States)  
"Osteocyte Control of Bone Structure and Function in Skeletal Aging"

11:55 am - 12:15 pm	Discussion
12:15 pm - 12:25 pm	Liuni Chen (Virginia Tech, United States) "Biom mineralized Light-Guiding Structures in Starfish Protoreaster Nodosus"
12:25 pm - 12:30 pm	Discussion
12:30 pm - 1:30 pm	Lunch
1:30 pm - 4:30 pm	Free Time
4:30 pm - 6:00 pm	Poster Session
6:00 pm - 8:00 pm	Biom mineralization Principles Translated Discussion Leader: Sherif Elsharkawy (King's College London, United Kingdom)
6:00 pm - 6:15 pm	Introduction by Discussion Leader
6:15 pm - 6:40 pm	Luiz Bertassoni (Oregon Health and Science University, United States) "Biomimetic Mineralization in Cell-laden Hydrogels for Tissue Regeneration and Understanding Cancer Metastasis"
6:40 pm - 7:00 pm	Discussion
7:00 pm - 7:10 pm	Jonas Schwan (University of Bayreuth, Germany) "Bioinspired Preparation of Organic-Inorganic Hybrid Microscrolls by Strain-Induced Self-Rolling of Electrochemically Deposited Cobalt Hydroxide Films"
7:10 pm - 7:15 pm	Discussion
7:15 pm - 7:25 pm	Camila Tovani (Sorbonne Université, France) "Self-Assembled Biomimetic Collagen/Apatite Scaffold from Hybrid Microparticles to Reconstruct Hard Tissues"
7:25 pm - 7:30 pm	Discussion
7:30 pm - 7:40 pm	Dimitra Athanasiadou (University of Toronto, Canada) "DNA Hydrogels as Scaffolds for Calvarial Bone Regeneration"
7:40 pm - 7:45 pm	Discussion
7:45 pm - 7:55 pm	Elena Macias-Sanchez (University of Granada, Spain) "Spherulitic Crystal Growth drives Mineral Deposition Patterns in Collagen-Based Materials"
7:55 pm - 8:00 pm	Discussion
8:00 pm - 9:00 pm	Dinner
<b>Thursday</b>	
7:30 am - 8:30 am	Breakfast

8:30 am - 9:00 am Business Meeting  
*Nominations for the Next Vice Chair(s); Complete the GRC Evaluation Forms; Discuss Future Dates and Venue; Election of the Next Vice Chair(s)*

9:00 am - 12:30 pm Biominerals in Pathology  
Discussion Leader: Willi Jahnen-Dechent (RWTH Aachen University, Germany)

9:00 am - 9:15 am Introduction by Discussion Leader

9:15 am - 9:40 am Peter Vekilov (University of Houston, United States)  
"Cooperativity and Reversibility in the Regulation of Hematin Crystallization by Antimalarials"

9:40 am - 10:00 am Discussion

10:00 am - 10:10 am Amit Cohen (Ben-Gurion University of the Negev, Israel)  
"The Relationship between Crystal Properties of Microcalcifications and Breast Precancer Progression in a 3D in vitro Model"

10:10 am - 10:15 am Discussion

10:15 am - 10:45 am Coffee Break

10:45 am - 11:10 am Sunita Ho (University of California San Francisco, United States)  
"Zinc and Phosphorus: Foretellers of Pathologic Mineralization"

11:10 am - 11:30 am Discussion

11:30 am - 11:55 am Sun Peck (Vanderbilt University Medical Center, United States)  
"Extracellular Matrix Microenvironment in Heterotopic Ossification"

11:55 am - 12:15 pm Discussion

12:15 pm - 12:25 pm Olivier Duverger (NIDCR/NIH, United States)  
"Missteps in the Complex Choreography of Ameloblasts: Mechanism leading to Enamel Ultrastructure Disruption in Disease"

12:25 pm - 12:30 pm Discussion

12:30 pm - 1:30 pm Lunch

1:30 pm - 4:30 pm Free Time

4:30 pm - 6:00 pm Poster Session

6:00 pm - 8:00 pm Keynote Session: Geochemistry, Proxies and Evolution  
Discussion Leader: Derk Joester (Northwestern University, United States)

6:00 pm - 6:05 pm Introduction by Discussion Leader

6:05 pm - 6:30 pm Alex Gagnon (University of Washington, United States)

"The Geochemistry of Biomineralization: The Effects of Nucleation, Organic-Mineral Interactions, and Ion Transport on Paleoclimate Proxies"

6:30 pm - 6:50 pm Discussion

6:50 pm - 7:15 pm Andrew Knoll (Harvard University, United States)  
"Silica Biomineralization: Evolutionary and Biogeochemical Consequences"

7:15 pm - 7:35 pm Discussion

7:35 pm - 7:50 pm General Discussion

7:50 pm - 8:00 pm Closing Remarks

8:00 pm - 9:00 pm Dinner

Friday

7:30 am - 8:30 am Breakfast

9:00 am Departure

Contributors



This material is based upon work supported by the Air Force Office of Scientific Research under award number FA9550-20-1-0022. Any opinions, findings, and conclusions or recommendations expressed in this material are those of the author(s) and do not necessarily reflect the views of the United States Air Force.

## **Biom mineralization (GRS)**

### **Gordon Research Seminar**

#### **A Multifaceted Approach Toward Understanding Biomineral Formation Pathways and Purposes**

August 13 - 14, 2022

Chairs Dimitra Athanasiadou and Konrad R. Hedderick

Rey Don Jaime Grand Hotel

Avinguda de l'Hotel

Castelldefels, B, Spain

#### Conference Program

##### Saturday

1:00 pm - 5:00 pm	Arrival and Check-in
3:00 pm - 3:15 pm	Introductory Comments by GRC Site Staff / Welcome from the GRS Chair
3:15 pm - 4:00 pm	Keynote Session: New Insights into Biomineralization Mechanisms Discussion Leader: Laura Zorzetto (Max Planck Institute of Colloids and Interfaces , Germany)
3:15 pm - 3:20 pm	Introduction by Discussion Leader
3:20 pm - 3:50 pm	Peter Fratzl (Max Planck Institute of Colloids and Interfaces, Germany) "Towards an Understanding of Mineralization Logistics in Forming Bone"
3:50 pm - 4:00 pm	Discussion
4:00 pm - 5:30 pm	Poster Session
5:30 pm - 7:30 pm	Underlying Factors of Biomineral Formation / Pathological Biomineralization Discussion Leaders: Jernej Turnšek (University of California, Berkeley, United States) and Elena Tsolaki (Swiss Federal Laboratories for Materials Science and Technology (Empa) & ETH Zurich, Switzerland)
5:30 pm - 5:45 pm	Laura Otter (Australian National University, Australia) "Growth Dynamics and Amorphous-to-Crystalline Phase Transformation in Natural Nacre"
5:45 pm - 5:50 pm	Discussion
5:50 pm - 6:05 pm	Zohar Eyal (Weizmann Institute of Science, Israel) "The biogenesis and development of the crystal forming organelle at high resolution"
6:05 pm - 6:10 pm	Discussion
6:10 pm - 6:25 pm	Victoria Cooley (Northwestern University, United States) "Disrupting Amelogenin Self-Assembly in Vivo: A Progress Report"
6:25 pm - 6:30 pm	Discussion
6:30 pm - 6:45 pm	Geoffroy Gaschignard (Sorbonne University, France) "Calcyanin: A Novel Protein Involved in Intracellular Biomineralization in Cyanobacteria"

6:45 pm - 6:50 pm Discussion

6:50 pm - 7:05 pm Maja Østergaard (Aarhus University, Denmark)  
"Recombinant Parathyroid Hormone Induces Mineralization in Bones from Hypoparathyroidism Patients"

7:05 pm - 7:10 pm Discussion

7:10 pm - 7:25 pm Jing Xue (University College London, United Kingdom)  
"Dementia and Brain Mineralization: Potential Pathological Mechanisms"

7:25 pm - 7:30 pm Discussion

8:00 pm - 9:00 pm Dinner

### Sunday

7:30 am - 8:30 am Breakfast

9:00 am - 11:00 am Observing Biomineral Pathways and Processes  
Discussion Leader: Tilman Gruenewald (Aix-Marseille Univ, CNRS, Centrale Marseille, Institut Fresnel, France)

9:00 am - 9:30 am Tanya Prozorov (US DOE Ames National Laboratory, United States)  
"Keynote Address: DeBUGing the Nature, or Magnetotactic Bacteria as a Model System for Imaging of Biomineralization Processes"

9:30 am - 9:40 am Discussion

9:40 am - 9:55 am Thorbjørn Christensen (Aarhus University, iNANO and Department of Chemistry, Denmark)  
"Hierarchical Structure of the Stomatopod Dactyl Club"

9:55 am - 10:00 am Discussion

10:00 am - 10:15 am Daniel Buss (McGill University, Canada)  
"The avian eggshell-membrane interface revealed in 3D by X-ray and FIB-SEM tomography"

10:15 am - 10:20 am Discussion

10:20 am - 10:35 am Alexander Triccas (University of Edinburgh, United Kingdom)  
"Ptychographic X-ray Computed Tomography Reveals New Findings About Coccolith Mineral Composition and Electron-Dense Deposits Involved in Calcium Transport"

10:35 am - 10:40 am Discussion

10:40 am - 10:55 am Liza-Anastasia DiCecco (McMaster University, Canada)  
"Visualizing Calcium Phosphate Mineralization Dynamics Through Novel in Situ Liquid TEM"

10:55 am - 11:00 am Discussion

11:00 am - 12:30 pm	Poster Session <i>Coffee will be served in the poster area from 11:00 am - 11:30 am</i>
12:30 pm - 1:30 pm	Lunch
1:30 pm - 2:30 pm	Translating Biomineralization into Functional Materials Discussion Leader: Aaron Morgan (Uniklinik RWTH Aachen, IBMT-ZMG, Germany)
1:30 pm - 1:45 pm	Keshet Shavit (Ben-Gurion University of the Negev, Israel) "A Crystalline Photonic Device Enabling Crustaceans to See but Not be Seen"
1:45 pm - 1:50 pm	Discussion
1:50 pm - 2:05 pm	Federica Scucchia (University of Haifa, Israel) "Using Artificial Intelligence to Examine the Biomineralization Response to Ocean Acidification of Newly Settled Coral Recruits"
2:05 pm - 2:10 pm	Discussion
2:10 pm - 2:30 pm	General Discussion
2:30 pm - 3:00 pm	Evaluation Period <i>Complete the GRS Evaluation Forms; Election of Future Chair(s)</i>
3:00 pm	Seminar Concludes

**Contributors**



Colgate-Palmolive Company

This material is based upon work supported by the Air Force Office of Scientific Research under award number FA9550-20-1-0022. Any opinions, finding, and conclusions or recommendations expressed in this material are those of the author(s) and do not necessarily reflect the views of the United States Air Force.

## GRC Attendee List

The list of attendees appears below, sorted by the role recorded in their registration record.

<b>Name</b>	<b>Affiliation</b>	<b>Participation</b>	<b>Gender</b>
Moradian-Oldak, Janet	University of Southern California	Chair	Female
Kröger, Nils	TU Dresden	Vice Chair	Male
Alliston, Tamara	UCSF	Speaker	Female
Athanasidou, Dimitra	University of Toronto	Speaker	Female
Bertassoni, Luiz E.	Oregon Health and Science University	Speaker	Male
Chen, Liuni	Virginia Tech	Speaker	Female
Cohen, Amit	Ben-Gurion University of the Negev	Speaker	Female
de Haan, Diede	Weizmann Institute of Science	Speaker	Female
Deis, Rachael L	Weizmann Institute	Speaker	Female
DiCecco, Liza-Anastasia	McMaster University	Speaker	Female
Duverger, Olivier	NIDCR/NIH	Speaker	Male
Elbaum, Rivka	Hebrew University of Jerusalem	Speaker	Female
Feofilova, Maria	ETH Zurich	Speaker	Female
Gagnon, Alex	University of Washington	Speaker	Male
Gal, Assaf	Weizmann Institute of Science	Speaker	Male
Goettisch, Claudia	RWTH Aachen University	Speaker	Female
Gur, Dvir	Weizmann Institute of Science	Speaker	Male
Ho, Sunita	University of California San Francisco	Speaker	Female
Joester, Derk	Northwestern University	Speaker	Male
Knoll, Andrew H	Harvard University	Speaker	Male
Koop, Thomas	Bielefeld University	Speaker	Male
Lacruz, Rodrigo	New York University	Speaker	Male
Macias-Sanchez, Elena	University of Granada	Speaker	Female
Mehta, Neha	CNRS	Speaker	Female
Meldrum, Fiona C	University of Leeds	Speaker	Female
Murshed, Monzur	McGill University	Speaker	Male
Nemoto, Michiko	Okayama University	Speaker	Female
Peck, Sun H	Vanderbilt University Medical Center	Speaker	Female
Pfaendtner, Jim	University of Washington	Speaker	Male
Rodriguez-Navarro, Alejandro B	University of Granada	Speaker	Male
Scheffel, André	Technische Universität Dresden	Speaker	Male
Schwan, Jonas	University of Bayreuth	Speaker	Male
Sturm, Elena	Ludwig Maximilian University of Munich	Speaker	Female
Tambutte, Sylvie	Centre Scientifique de Monaco	Speaker	Female
Tovani, Camila	Sorbonne Université	Speaker	Female
Tyszka, Jaroslaw	Polish Academy of Sciences, Institute of Geological Sciences	Speaker	Male
Vekilov, Peter G	University of Houston	Speaker	Male
Beniash, Elia	University of Pittsburgh	Discussion Leader	Male

<b>Name</b>	<b>Affiliation</b>	<b>Participation</b>	<b>Gender</b>
Elsharkawy, Sherif	King's College London	Discussion Leader	Male
Fratzl, Peter	Max Planck Institute of Colloids and Interfaces	Discussion Leader	Male
Jahren-Dechent, Willi	RWTH Aachen University	Discussion Leader	Male
Mass, Tali	University of Haifa	Discussion Leader	Female
McKee, Marc D	McGill University	Discussion Leader	Male
Shaw, Wendy J	Pacific Northwest National Laboratory	Discussion Leader	Female
Al-Mosawi, Mohammed	University of Leeds	Poster Presenter	Male
Alamer, Maryam AH	University College London	Poster Presenter	Female
Albéric, Marie	Sorbonne Université	Poster Presenter	Female
Allison, Nicola	University of St. Andrews	Poster Presenter	Female
Alvarez-Lloret, Pedro	University of Oviedo	Poster Presenter	Male
Aram, Lior	Weizmann Institute of Science	Poster Presenter	Female
Arns, Anthea I	Max Planck Institute for Chemistry	Poster Presenter	Female
Avrahami, Emanuel M	Wiezmann Institute of Science	Poster Presenter	Male
Ayieko, Vincent	The Hebrew University of Jerusalem	Poster Presenter	Male
Azulay, David N	The Hebrew University of Jerusalem, Israel	Poster Presenter	Male
Babenko, Iaroslav	TU Dresden	Poster Presenter	Male
Berman, Amir	Ben-Gurion U.	Poster Presenter	Male
Bertazzo, Sergio	University College London	Poster Presenter	Male
Best, Richard Johannes	B CUBE - Center for Molecular Bioengineering, TU Dresden	Poster Presenter	Male
Buss, Daniel J	McGill University	Poster Presenter	Male
Castillo Alvarez, Maria C	University of St Andrews	Poster Presenter	Female
Chan, Ming Chau	Columbia University, Biomaterials and Interface Tissue Engineering Laboratory	Poster Presenter	Male
Chevrier, Daniel M	CNRS	Poster Presenter	Male
Christensen, Thorbjørn E.K.	Aarhus University, iNANO and Department of Chemistry	Poster Presenter	Male
Cooley, Victoria M	Northwestern University	Poster Presenter	Female
Cruz, Marcos	Radboud Institute for Molecular Life Sciences	Poster Presenter	Male
Dauphin, Yannicke	Museum National d'Histoire Naturelle	Poster Presenter	Female
De Goeyse, Siham	NIOZ – Royal Netherlands Institute for Sea Research	Poster Presenter	Female
De Yoreo, Jim J	PNNL/University of Washington	Poster Presenter	Male
Deering, Joseph	McMaster University	Poster Presenter	Male
Deymier, Alix C	UConn Health	Poster Presenter	Female
Duggins, Danielle O.	Northwestern University	Poster Presenter	Female
Ferreira, Claudio	Sorbonne University	Poster Presenter	Male
Flöter, Sebastian	University of Geneva	Poster Presenter	Male
Gabe, Claire	University of Pittsburgh School of Dental medicine	Poster Presenter	Female
Ganss, Bernhard	University of Toronto	Poster Presenter	Male
Gaschignard, Geoffroy	Sorbonne University	Poster Presenter	Male

<b>Name</b>	<b>Affiliation</b>	<b>Participation</b>	<b>Gender</b>
Gerloff, Tim	TU Dresden	Poster Presenter	Male
Gilbert, Pupa	University of Wisconsin-Madison	Poster Presenter	Female
Gorelick Ashkenazi, Anna	Weizmann Institute of Science	Poster Presenter	Female
Gruenewald, Tilman A	Aix-Marseille Univ, CNRS, Centrale Marseille, Institut Fresnel	Poster Presenter	Male
Hardt, Markus	Forsyth Institute	Poster Presenter	Male
Hasberg, Christian	Uniklinik RWTH Aachen IBMT-ZMG	Poster Presenter	Male
Hedderick, Konrad R	Cornell University	Poster Presenter	Male
Hu, Chenhao	Virginia Tech	Poster Presenter	Male
Hunter, Luke	UCL	Poster Presenter	Male
Iijima, Mayumi	The University of Tokyo	Poster Presenter	Female
Jacob, Dorrit E	The Australian National University	Poster Presenter	Female
Jantschke, Anne	JGU Mainz	Poster Presenter	Female
Jung, Kwang-Hwan	Sogang University	Poster Presenter	Male
Khurshid, Benazir	CNRS - SOLEIL Synchrotron	Poster Presenter	Female
Leghziel, Rebecca C	Weizmann Institute of Science	Poster Presenter	Female
Lemanis, Robert	Technische Universität Dresden	Poster Presenter	Male
Lutet-Toti, Camille	CNRS - University of Burgundy - University of Bologna Alma Mater Studiorum	Poster Presenter	Female
Margolis, Henry C	University of Pittsburgh School of Dental Medicine	Poster Presenter	Male
martindale, mark q	Whitney Lab for Marine Bioscience/ Univ. Florida	Poster Presenter	Male
Masic, Admir	MIT	Poster Presenter	Male
Metzler, Rebecca A	Colgate University	Poster Presenter	Female
Micheletti, Chiara	McMaster University	Poster Presenter	Female
Moreno, Bradley K	Northwestern University	Poster Presenter	Male
Morgan, Aaron D	Uniklinik RWTH Aachen, IBMT-ZMG	Poster Presenter	Male
Murgoci, Adrian	University of Cambridge	Poster Presenter	Male
Nudelman, Fabio	University of Edinburgh	Poster Presenter	Male
Okada, Koki	Okayama University	Poster Presenter	Male
Østergaard, Maja	Aarhus University	Poster Presenter	Female
Otter, Laura M.	Australian National University	Poster Presenter	Female
PALAKURTHY, SRINATH	The Smith Institute of Plant Sciences and Genetics in Agriculture The Hebrew University of Jerusalem	Poster Presenter	Male
Palmer, Emily	University of Wisconsin-Madison	Poster Presenter	Female
Perez-Huerta, Alberto	The University of Alabama	Poster Presenter	Male
Pierantoni, Maria	Lund University	Poster Presenter	Female
Prozorov, Tanya	US DOE Ames National Laboratory	Poster Presenter	Female
Radvar, Elham	King's College London	Poster Presenter	Female
Raguin, Emeline	Max Planck Institute of Colloids and Interfaces	Poster Presenter	Female
Rduch, Thomas	EMPA	Poster Presenter	Male
Reyes Amezaga, Alejandra	Utrecht University	Poster Presenter	Female

<b>Name</b>	<b>Affiliation</b>	<b>Participation</b>	<b>Gender</b>
Schmidt, Connor A	University of Wisconsin Madison	Poster Presenter	Male
Scucchia, Federica	University of Haifa	Poster Presenter	Female
Seto, Jong	Arizona State University	Poster Presenter	Male
Shaked, Shai Avraham	Department of Life Sciences, Ben-Gurion university of the Negev, Israel	Poster Presenter	Male
Shaked, Noy	Weizmann institute of science	Poster Presenter	Female
Sharma, Kunal	Lund University	Poster Presenter	Male
Shavit, Keshet	Ben-Gurion University of the Negev	Poster Presenter	Female
Sone, Eli D	University of Toronto	Poster Presenter	Male
Stein, Daniel	Ben-Gurion University of the Negev	Poster Presenter	Female
Stifler, Cayla A	University of Wisconsin-Madison	Poster Presenter	Female
Sutter, Stephan	Cornell University	Poster Presenter	Male
Suzuki, Michio	the University of Tokyo	Poster Presenter	Male
Tang, Tengteng	McMaster University	Poster Presenter	Female
Torkelson, Kaylyn	University of Washington Chemical Engineering	Poster Presenter	Female
Triccas, Alexander	University of Edinburgh	Poster Presenter	Male
Tsolaki, Elena	Swiss Federal Laboratories for Materials Science and Technology (Empa) & ETH Zurich	Poster Presenter	Female
Turnšek, Jernej	University of California, Berkeley	Poster Presenter	Male
Venn, Alexander A	Centre Scientifique de Monaco	Poster Presenter	Male
Victor Jothi, Abisheik John Samuel	Technical University of Dresden	Poster Presenter	Male
Vidavsky, Netta	Ben-Gurion University of the Negev	Poster Presenter	Female
Visakan, Gayathri	University of Southern California	Poster Presenter	Female
Vogelsang, Sophia	University of Wisconsin-Madison	Poster Presenter	Female
Walker, Jessica	Diamond Light Source	Poster Presenter	Female
Weaver, James C	Harvard University	Poster Presenter	Male
Winkler, Camilla Franziska	Uniklinik Aachen	Poster Presenter	Female
Wojtas, Magdalena A	University of Toronto, BME	Poster Presenter	Female
Wong, Stephanie	University of Connecticut Health Center	Poster Presenter	Female
Xue, Jing	University College London	Poster Presenter	Female
Yucesoy, Deniz	Izmir Institute of Technology	Poster Presenter	Male
Zarivach, Raz	Ben-Gurion University of the Negev	Poster Presenter	Male
Zlotnikov, Igor	B CUBE - Center for Molecular Bioengineering, TU Dresden	Poster Presenter	Male
Zoccaratto Favarin, Bruno	Sorbonne Université	Poster Presenter	Male
Zorzetto, Laura	Max Planck Institute of Colloids and Interfaces	Poster Presenter	Female
Constantz, Brent	Blue Planet Systems Corporation	Attendee	Male
Estroff, Lara A	Cornell University	Attendee	Female
Eyal, Zohar	Weizmann Institute of Science	Attendee	Female
Galloway, Johanna M	University of Leeds	Attendee	Female

<b>Name</b>	<b>Affiliation</b>	<b>Participation</b>	<b>Gender</b>
Iijima, Kenji	Osaka University	Attendee	Male
Kaestner, Antonia	Weizmann Institute of Science	Attendee	Female
Lu, Helen H	Columbia University	Attendee	Female
Marin, Frederic G	UMR CNRS 6282 Biogéosciences, Université de Bourgogne - Franche-Comté	Attendee	Male
Peleg Walg, Yarden	Ben-Gurion University, Israel	Attendee	Female
Rossato, Giacomo	Max Planck Institute of Colloids and Interfaces	Attendee	Male
Weiner, Steve	Weizmann Institute of Science	Attendee	Male

## GRS Attendee List

The list of attendees appears below, sorted by the role recorded in their registration record.

Note: Only one primary role is recorded for each registration record, even if the attendee served in multiple roles at the meeting. The recorded role is based on the order of precedence listed below.

Name	Affiliation	Participation	Gender
Athanasiadou, Dimitra	University of Toronto	Chair	Female
Hedderick, Konrad R	Cornell University	Chair	Male
Buss, Daniel J	McGill University	Speaker	Male
Christensen, Thorbjørn E.K.	Aarhus University, iNANO and Department of Chemistry	Speaker	Male
Cooley, Victoria M	Northwestern University	Speaker	Female
DiCecco, Liza-Anastasia	McMaster University	Speaker	Female
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Fratzl, Peter	Max Planck Institute of Colloids and Interfaces	Speaker	Male
Gaschignard, Geoffroy	Sorbonne University	Speaker	Male
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Xue, Jing	University College London	Speaker	Female
Gruenewald, Tilman A	Aix-Marseille Univ, CNRS, Centrale Marseille, Institut Fresnel	Discussion Leader	Male
Morgan, Aaron D	Uniklinik RWTH Aachen, IBMT-ZMG	Discussion Leader	Male
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Feofilova, Maria	ETH Zurich	Poster Presenter	Female
Ferreira, Claudio	Sorbonne University	Poster Presenter	Male

<b>Name</b>	<b>Affiliation</b>	<b>Participation</b>	<b>Gender</b>
Gabe, Claire	University of Pittsburgh School of Dental medicine	Poster Presenter	Female
Gorelick Ashkenazi, Anna	Weizmann Institute of Science	Poster Presenter	Female
Hasberg, Christian	Uniklinik RWTH Aachen IBMT-ZMG	Poster Presenter	Male
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Khurshid, Benazir	CNRS - SOLEIL Synchrotron	Poster Presenter	Female
Micheletti, Chiara	McMaster University	Poster Presenter	Female
Moradian-Oldak, Janet	University of Southern California	Poster Presenter	Female
Moreno, Bradley K	Northwestern University	Poster Presenter	Male
Palmer, Emily	University of Wisconsin-Madison	Poster Presenter	Female
Radvar, Elham	King's College London	Poster Presenter	Female
Reyes Amezaga, Alejandra	Utrecht University	Poster Presenter	Female
Schmidt, Connor A	University of Wisconsin Madison	Poster Presenter	Male
Shaked, Shai Avraham	Department of Life Sciences, Ben-Gurion university of the Negev, Israel	Poster Presenter	Male
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Sutter, Stephan	Cornell University	Poster Presenter	Male
Tovani, Camila	Sorbonne Université	Poster Presenter	Female
Victor Jothi, Abisheik John Samuel	Technical University of Dresden	Poster Presenter	Male
Visakan, Gayathri	University of Southern California	Poster Presenter	Female
Vogelsang, Sophia	University of Wisconsin-Madison	Poster Presenter	Female
Winkler, Camilla Franziska	Uniklinik Aachen	Poster Presenter	Female
Wong, Stephanie	University of Connecticut Health Center	Poster Presenter	Female