From Undergraduate Researchers to Tenure-track Faculty: Our Story of the Continued Impact of Past, Present, and Future NASA Space Grant Support in Louisiana

Arden Moore Ph.D., Mary Caldorera-Moore Ph.D., and Rachel Hegab

Louisiana Tech University
Arden Moore, Ph.D.

Assistant Professor in Mechanical Engineering
Past

2004: LaSPACE LURA
2004: 1st USRP, NASA-Stennis

Present

2005: 2nd USRP, NASA-Stennis
2005-10: Graduate School, UT-Austin

Future

2011-13: Thermal Advisory Engineer, IBM
2013- pres. Assistant Professor LA Tech

Conclusion

LaSPACE: Catalyst for Lifelong STEM Careers
Important Research Skills Acquired Through LURA

Project: An Efficient Solver for Flows in Partial Chemical Equilibrium

Mentor: Dr. Carey Cox, La. Tech

Supported via a 2004 LaSPACE Undergraduate Research Assistantship (LURA) award

Technical Skills Acquired:
• Computational Fluid Dynamics (CFD) best practices
• Computational grid generation, evaluation, and refinement
• Writing and compiling C++ code
• Working within a UNIX environment
• Numerical solutions to PDEs
• Experience with a finite-rate viscous chemistry solver (Loci/CHEM) for aerospace applications

Communication Skills Developed:
• Proposal writing
• Academic literature searches
• Scientific publishing
• Oral and written communication of scientific information

http://www.tetraresearch.com/locichem/about-locichem/
LURA Springboard to NASA Center Experience

Project: Evaluation of the CHEM/Loci Finite Rate Chemistry Solver for Reacting Flows

Mentor: Dr. Russell Daines, Lockheed-Martin, NASA-Stennis

Supported via a 2004 NASA Undergraduate Student Research Program (USRP) award

Technical Skills Acquired:
- Writing and compiling C++ code for parallel computing
- Working with a high performance computing (HPC) cluster
- Research-grade CFD practices
- Experience with finite-rate viscous chemistry solvers for aerospace applications (SSME in particular)

Mach number contours of an SSME nozzle with attached diffuser
LURA Springboard to NASA Center Experience

Project: Evaluation of the Loci-STREAM Pressure-based Flow Solver

Mentor: Dr. Russell Daines, Jacobs Sverdrup, NASA-Stennis

Supported via a 2005 NASA Undergraduate Student Research Program (USRP) award

Technical Skills Acquired:
• More advanced CFD practices
• Experience with finite-rate viscous chemistry solvers for aerospace applications (actuated rocket fuel valve in particular)
• First research publication

Continued Impact: Graduate School

Project: Experimental and Theoretical Investigation of Thermal and Thermoelectric Transport in Nanostructures

Mentor: Dr. Li Shi, Univ. of Texas at Austin

LaSPACE-acquired skills used:
- Numerical modeling of thermal/fluid systems
- Numerical solutions to PDEs
- Oral and written scientific communication
  - 2,642 citations to-date via Google Scholar

Introduction

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Position: Thermal Advisory Engineer

Responsibilities: Design, analyze, test, and validate thermal management solutions for midrange server systems and associated hardware

LaSPACE-acquired skills used:
• Computational fluid dynamics
• Numerical modeling of thermal/fluid systems
• Oral and written scientific communication
  • Essential in my role as technical liaison to management in meetings and critical situation (CritSit) events
Continuing Impact: Assistant Professor, Louisiana Tech

Project: Low Altitude Unmanned Aerial Vehicle (UAV) from Sustainable Materials

Supported via a 2015 LaSPACE Higher Ed/Senior Design Award

Skills Students Acquired:
- CFD for aerospace design
- Aerodynamics
- Engineering decision-making
- Systems integration
- Wireless communication
- Non-traditional engineering materials
- Additive manufacturing
- LiPo electrical energy storage
- Oral and written communication
Low Altitude Unmanned Aerial Vehicle (UAV) from Sustainable Materials
Continuing Impact: Assistant Professor, Louisiana Tech

Post-Secondary Teacher of the Year in Louisiana Award – Region 8, Louisiana Association of Computer Using Educators (LACUE), 2016

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Continuing Impact: Assistant Professor, Louisiana Tech

New Follow-on Project Sponsored by Industry Partner
Students:

- **Taylor Ashton** - supported through LaSPACE REA award, graduated M.S. in 2015, now at Dow Chemical in Plaquemine, LA

- **Abdullah Nammari** - former LURA student, now in graduate school, co-author on three papers from his time as a LURA student
Continuing Impact: Assistant Professor, Louisiana Tech

Project: Measurement of UVA, UVB, and UVC Irradiance at High Altitudes

Supported via a 2016 LaSPACE LaACES Award

Skills Students Are Acquiring:
• Mechanical and thermal design under tight weight restrictions
• Solar physics
• Wireless communication/control
• Data acquisition and recording
• Sensor calibration and integration
Thank you for planting the seed to my STEM career!
Mary Caldorera-Moore, Ph.D.

Assistant Professor in Biomedical Engineering
LaSPACE: Catalyst for Lifelong STEM Careers

2003: 1st LURA

2004: 2nd LURA

2005: Awarded NSF Grad. Fellowship

2005: Publication of LURA Research

2010: Ph.D

2010-13: Post-Doctoral Fellow

2013- pres. Assistant Professor LA Tech

Nanoscale internally referenced oxygen sensors produced from self-assembled nanofilms on fluorescent nanoparticles
Important Research Skills Acquired Through LURA

Project: Development of Oxygen BioSensors
Advisor: Dr. M. McShane

Technical Skills Developed:
- Chemical wet lab experience
- Analysis of nanoparticles
  - Zeta potential
  - Absorbance
- Cell culture
- Light, fluorescence, and confocal microscopy

Professional Development Skills:
- Oral presentation
- Written communication
- Proposal writing

Guice, K.B., Caldorera, M.E., and McShane M.J. Journal of Biomedical Optics. 2005
Important Research Skills Acquired Through LURA

Project: Microfluidic Cell Culture System
Advisor: Dr. M. McShane

Technical Skills Developed:
• Microfabrication
  o Photolithography
  o Soft lithography
• Metrology
  o profilometry
  o scanning electron microscopy
• Experimental Design

Professional Development Skills:
• Oral presentation
• Written communication
• Proposal writing
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2004: 2nd LURA

2005: Awarded NSF Grad. Fellowship

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Nanoscale internally referenced oxygen sensors produced from self-assembled nanofilms on fluorescent nanoparticles
Continued Utilization of LURA Acquired Skills

Foundational Skills:
- Chemical Wet Lab
- Nanoparticle Analysis
- Microfabrication
- Metrology
- Oral & Written Communication
- Cell Culture
- Proposal Writing

Development of Shape and Size Specific Disease-Responsive Nanocarriers
- Fabrication of monodisperse, geometry specific nanocarriers using S-FIL
- Development of stimuli-responsive carriers
- In vitro characterization of nanoparticle swelling behavior is comparable to bulk hydrogels
- In vitro performance is dependent on particle shape, size and surface properties
- Nanocarriers enhance transport of interferon alpha in in vitro performance transport studies

Development of pH Responsive Nanocarriers for Oral Delivery of Chemotherapeutics
- Synthesis of novel, hybrid pH-responsive hydrogels nanocarriers
- Nanocarriers enhance transport of interferon alpha in in vitro performance transport studies
LaSPACE: Catalyst for Lifelong STEM Careers

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- 2005: Published LURA Research
- 2005: Awarded NSF Grad. Fellowship
- 2010: Ph.D
- 2010-13: Post-Doctoral Fellow
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Nanoscale internally referenced oxygen sensors produced from self-assembled nanofilms on fluorescent nanoparticles
Continuing Impacts of Space Grant Program

Intelligent Nanotechnology in Our Laboratory

Environmentally responsive biomaterials
- pH and temperature
- Biomolecule degradable

Nanoscale systems
- Nanocarriers
- High aspect ratio biomaterials
- Multicomponent systems with rapid environmental sensing and release

Applications
- Targeted drug delivery
- Oral delivery
- Wound healing
- Regenerative medicine
- Personalized medicine
Continuing Impacts of Space Grant Program

Project: High-Surface Area Ration Patterned (HARP) Hydrogels for Regenerative Medicine Applications
Student: Luke Villermin

Technical Skills Developed:
• Chemical wet lab experience
• Biomaterial synthesis and characterization
• Micro- and nanoscale synthesis
• Metrology

Professional Development Skills:
• Oral presentation
• Written communication
• Proposal writing
Continuing Impacts of Space Grant Program

Project: Optimizing muscle regeneration for replacement of damaged or weakened tissue
Collaborator: Dr. Jamie Newman
Student: Anna “Katie” Whitehead

Technical Skills Developed:
• Chemical wet lab experience
• Biomaterial synthesis and characterization
• Quantification of biological agents
• Cell culture
• Metrology

Professional Development Skills:
• Oral presentation
• Written communication
• Proposal writing

Characterization of cell differentiation.
Immunofluorescence of muscle specific protein expression α-Actinin (red) and Cx43 (green) in differentiated mESCs. Overlap in staining corresponds with area of contractility. Nuclei stained with DAPI. Image at 20x.
Continuing Impacts of Space Grant Program

Project: Senior Design: Development of Next Generation 3D, Variable Material Printer System and Life Resin
Student: Danielle Eschete, Andrew LaBlanc, David Plaisance, Ethan Sullivan, & Luke Villermin

Technical Skills Developed:
• Chemical wet lab experience
• Biomaterial synthesis and characterization
• Metrology

Professional Development Skills:
• Project management
• Teamwork
• Oral presentation
• Written communication
• Proposal writing
Continuing Impacts of Space Grant Program

Project: Development of Drug Delivery Carrier Systems for Controlled of Vasodillator Drugs for Improved of Cardiovascular Health of Astronauts
Student: Rachel Hegab

Technical Skills Developed:
• Chemical wet lab experience
• Biomaterial synthesis and characterization
• Micro- and nanoscale synthesis
• Metrology

Professional Development Skills:
• Oral presentation
• Written communication
• Proposal writing
LaSPACE: Catalyst for Lifelong STEM Careers

Foundational Skills:
- Chemical Wet Lab
- Nanoparticle Analysis
- Oral & Written Communication
- Microfabrication
- Cell Culture
- Metrology
- Proposal Writing
Continuing Impacts of Space Grant Program

Rachel Hegab

Major: Biomedical Engineering

Undergraduate (sophomore) at Louisiana Tech University

Future Plans:
Graduate School for Doctoral Degree in Biomedical Engineering
Continuing Impacts of Space Grant Program

My Research

• **LURA 2015-2016**: Optimization of Environmentally Responsive Hydrogels for Oral Administration of Vasodilators for Improved Cardiovascular Health for Astronauts

• **LURA 2016-2017**: Development of Drug Delivery Carrier Systems for Controlled Release of Vasodilator Drugs for Improved Cardiovascular Health for Astronauts
Continuing Impacts of Space Grant Program

Introduction:
Nitric Oxide and Hydrogen Sulfides as Biological Messengers

- Increase circulation
- Lower cholesterol
- Initiate ischemic vascular remodeling
- Poor oral bioavailability

Project Objective
To develop and optimize pH responsive, anionic hydrogels for the oral delivery of vasodilators.
Continuing Impacts of Space Grant Program

Introduction:
Controlled Drug Release

- Controlled Delivery
- Time/Dosage Administration

Plasma Level

- Toxic Level
- Conventional
- Minimum Effective Concentration
- Zero Order Delivery

Therapeutic Range

Time/Dosage Administration

Past  Present  Future
Continuing Impacts of Space Grant Program

Introduction: Hydrogel Biomaterials

Monomers:

Acrylic acid (AA)  Methyl methacrylate (MMA)

Crosslinker:

Triethylene glycol dimethacrylate (TEGDMA)

Past  Present  Future
Continuing Impacts of Space Grant Program

Results

SEM of microparticles synthesized

<table>
<thead>
<tr>
<th>P(MMA-co-AA)</th>
<th>% Loading</th>
</tr>
</thead>
<tbody>
<tr>
<td>10% MMA</td>
<td>56.89 ± 39.54</td>
</tr>
<tr>
<td>20% MMA</td>
<td>62.87 ± 18.14</td>
</tr>
<tr>
<td>30% MMA</td>
<td>74.74 ± 9.81</td>
</tr>
</tbody>
</table>
Continuing Impacts of Space Grant Program

What’s next?

• *In vitro* transport studies
• *In vivo* studies
• Nanoparticles
Continuing Impacts of Space Grant Program
How has LURA helped me?

Presentations


State: Louisiana Academy of Science Consortium (LAS) 2016, Gulf Coast Vascular Research Consortium 2016, LaSpace Consortium 2016
Continuing Impacts of Space Grant Program

How has LURA helped me?

Publications

- Finalizing a characterization paper for Soft Matter or Journal of Controlled Drug Release.

Professional Development

TEXAS

The University of Texas at Austin

Cornell University

Past  Present  Future
Acknowledgements

Collaborators:
• Dr. Jamie Newman (LA Tech)
• Dr. Christopher Kevil (LSUHS)

Funding:
From Undergraduate Researchers to Tenure-track Faculty:

Our Story of the Continued Impact of Past, Present, and Future

NASA Space Grant Support in Louisiana