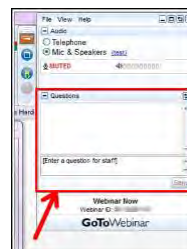
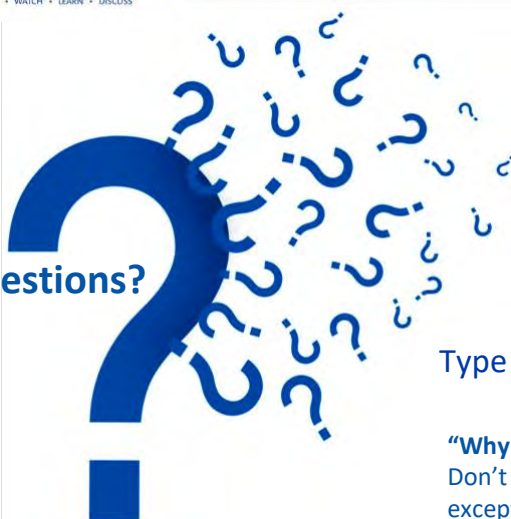




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**Reactions:** Chemistry Science Videos & Infographics



## DEATH AND DECOMPOSITION



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### Are Human Burial Practices Messing Up Earth's Ecosystems?

Life depends on death — living things die, decompose and eventually become nutrients for other life. But when humans die, we're often embalmed and buried or cremated.

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### Enhancing Research Productivity Through Student-Led Laboratory Safety Teams



Date: Thursday, November 4, 2021 @ 2-3pm ET

Speakers: Jessica Martin, ACS Division of Chemical Health and Safety / Kall Miller, ACS Division of Chemical Health and Safety / Monica Nyansa, ACS Division of Chemical Health and Safety / Sarah Zinn, ACS Division of Chemical Health and Safety

Moderator: Ralph Stuart, ACS Division of Chemical Health and Safety

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#### What You Will Learn:

- The motivation behind graduate student-led safety initiatives
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- How LSTs can empower future lab leaders to collaborate on resolving safety continuity challenges

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### Careers in Science and Engineering:

Everything that You Need to Know



Professor Ashutosh Sharma  
Institute Chair Professor,  
Indian Institute of  
Technology, Kanpur

Date: Wednesday, November 10, 2021 @ 7:30am ET (6-7pm IT)

Speaker: Ashutosh Sharma, Indian Institute of Technology, Kanpur  
Moderator: Deeksha Gupta, American Chemical Society

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- Future sustainable innovations being developed in corporate R&D
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# Bloodstains & Biomolecules

From Crime Scene to the Silver Screen



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Bloodstains & Biomolecules: From Crime Scene to the Silver Screen



**THERESA STOTESBURY**  
Assistant Professor, Forensic Science,  
Ontario Tech University



**MONICA MATTESI**  
Science Educator,  
Stony Brook University

*Presentation slides are available now! The edited recording will be made available as soon as possible.*

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# Bloodstains & Biomolecules

## From Crime Scene to the Silver Screen

Dr. Theresa Stotesbury

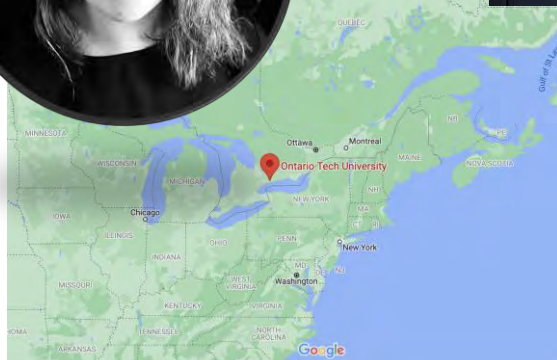
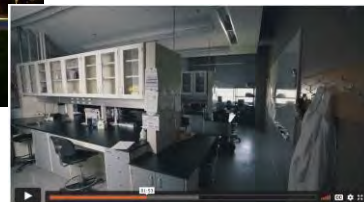


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## Where in the world



HI EVERYONE!



Ontario Tech University acknowledges the lands and people of the Mississaugas of Scugog Island First Nation. We are thankful to be welcomed on these lands in friendship. The lands we are situated on are covered under the Williams Treaties and the traditional territory of the Mississaugas, a branch of the greater Anishinaabeg Nation, including Algonquin, Ojibway, Odawa and Pottawatomi. These lands remain home to a number of Indigenous nations and people.

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<https://studentlife.ontariotechu.ca/services/community/indigenous/land-acknowledgement/>



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## Outline

- **Bloodstain Pattern Analysis**
  - *tricks* of the domain
  - forensic chemistry
- **Fake Blood**
  - blood substitutes
    - *Jack-o-* all trades or per use basis?
  - forensic blood substitutes
    - hybrid inorganic-organic sol-gel materials
    - Case specific examples
- **Forensic Tissue Simulants**
  - bonus *treat!*



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## Bloodstain Pattern Analysis

Bloodstain pattern analysis (BPA) is a field that primarily focuses on the study of the *size, shape and distribution of bloodstains in order to determine the physical events which gave rise to their origin*

**Who? What? Where? When? Why? How? What else?**

**Who?: DNA**

- identifying the blood source

**What?: Is it blood**

- presumptive testing methods

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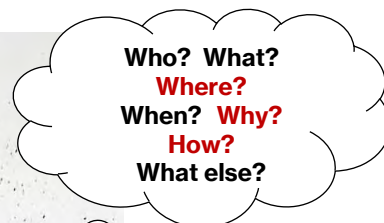
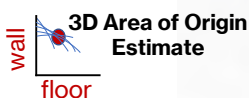
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## Bloodstain Pattern Analysis

Bloodstain pattern analysis (BPA) is a field that primarily focuses on the study of the *size, shape and distribution of bloodstains in order to determine the physical events which gave rise to their origin*

### Hypothesize - impact pattern

- **Why?:** Stain size, shape, distribution
- **How?:** A bloodstain pattern resulting from an object striking liquid blood
- **Where?:**

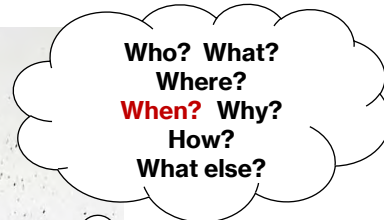
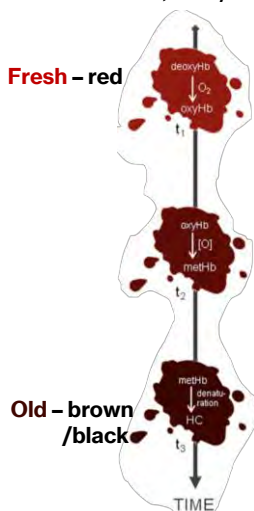


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## Bloodstain Pattern Analysis

Bloodstain pattern analysis (BPA) is a field that primarily focuses on the study of the *size, shape and distribution of bloodstains in order to determine the physical events which gave rise to their origin*



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Zadora G, Menzyk A. In the pursuit of the holy grail of forensic science – spectroscopic studies on the estimation of time since deposition of bloodstains. Trends Anal Chem 2018 Apr;105:137-65.

16



## Bloodstain Pattern Analysis

Bloodstain pattern analysis (BPA) is a field that primarily focuses on the study of the *size, shape and distribution of bloodstains in order to determine the physical events which gave rise to their origin*

### Training:

- Basic BPA
- Advanced BPA
- Fluid Dynamics
- Chemical Enhancement
- Fabrics
- Understudy
- ...much more

All (most) which require handling blood



Who? What?  
Where?  
When? Why?  
How?  
What else?

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Other blood sources?

Semi-synthetics?

Synthetics?

**So what happens if human blood cannot be sourced or used in forensic research and training?**

Validation?

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# Audience Survey Question

ANSWER THE QUESTION ON BLUE SCREEN IN ONE MOMENT

## So what makes a good forensic blood substitute?



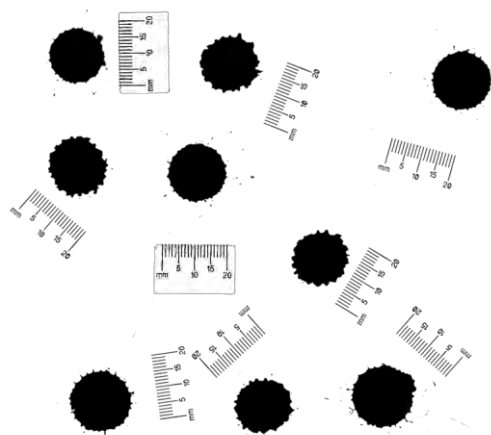
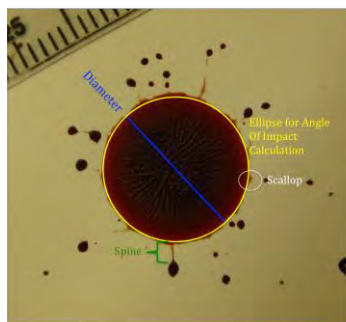
- Visual appearance (opacity, chromophore shifts, etc.)
- Oxygen transport
- Viscosity
- Wettability and other surface interactions
- Something else? (Let us know in the chat!)

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ACS Reactions. The Chemistry of Hollywood Fake Blood. (27 October 2017) <https://www.youtube.com/watch?v=8OC5rjstl>

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## Requirements of silver screen ≠ crime scene



Fluid	Splashing = Spreading Score (1/2)	Stain Formation = Angle of Impact (1)	Candidate Molecule	Found in	Reason for Inclusion	Observed Outcome
Whole Human Blood (Male, EDTA anticoagulant)	12	1	Glycerol	SBS 002	High molecular weight	More "blood-like" than "water-like" drip stains
50% v/v Pam's Liquid Clover Honey	12	1	SBS 003		Used in previous research	
10% v/v Devil's Cloak Paint	11	1	SBS 005		Promotes sheet forming behavior	More "blood-like" than "water-like" drip stains
SBS 000	8	1	SBS 001		Powder of complex glucose molecules	Increased "blood-like appearance"
Bond Substrate	6	1			Used in some SBS to observe flow w/ ultrasound technology [11]	High sedimentation rate
SBS 004	0	1				
50% v/v Devil's Cloak Paint	4	1				
SBS 003	1	1				
10% v/v Pam's Liquid Clover Honey	0	1				
5% v/v Pam's Liquid Clover Honey	0	1				
75% v/v Devil's Cloak Paint	0	1				
Spatula Blood	0	1				
75% v/v Pam's Liquid Clover Honey	0	1				
SBS 001	0	1				
Water (Millipore, 1% v/v dye)	0	1				
SBS 002	0	1				
Raw Devil's Cloak Paint	0	1				
Raw Pam's Liquid Clover Honey	0	1				
Control Oil	0	1				

- 2 stars did not firm and therefore was not measured.

ACS Webinar\_2021\_Stotesbury

Stotesbury T, Taylor MC, Jerry MC. Passive drip stain formation dynamics of blood onto hard surfaces and comparison with simple fluids for blood substitute development and assessment. Journal of forensic sciences. 2017 Jan;62(1):74-82.

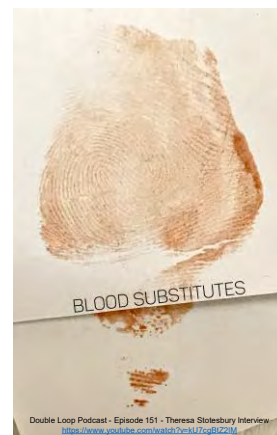
20

## So what makes a good forensic blood substitute?

Forensic blood substitutes are essentially  
**standard reference materials**

### Design considerations suggest an FSB:

1. is chemically safe, and preferably free of biohazardous risks
2. holds scientific validity in a relevant forensic context
3. uses practical fabrication and demonstrative processes
4. offers advantageous features for implementation in education and training



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21

Stotesbury T, Bruce C, Illes M, Hanley-Dafoe R. Design considerations for the implementation of artificial fluids as blood substitutes for educational and training use in the forensic sciences. *Forensic Science Policy & Management: An International Journal*. 2016;7:81-6.

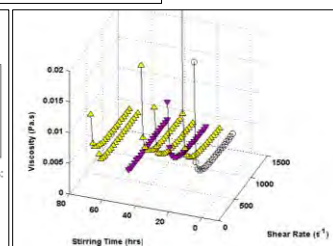
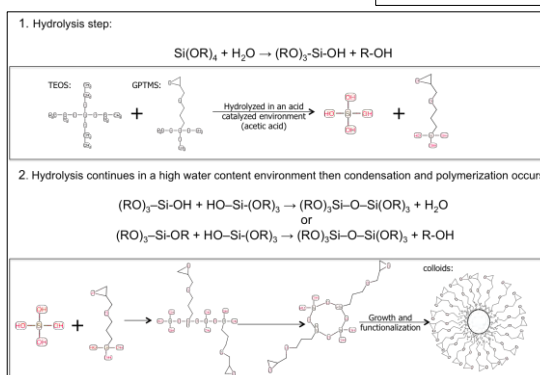
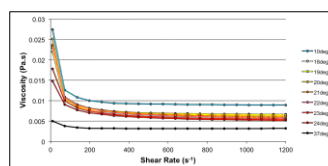
## Sol-gel based FBS

- **Solution-gelation (sol-gel) chemistry is a 2 step process:**
  - Formation of a colloidal suspension of solid particles, or *sol*,
  - And then polymerizes to form a *gel*

- **BPA mechanisms parallel deposition processes used in sol-gel applications**

- **Not your typical sol-gel**
  - Hybrid inorganic/organic material
  - High R value (silicon:water) to promote long-term stability

- **3 sol-gels characterized for:**
  - Physical
  - Chemical
  - Biological simulations

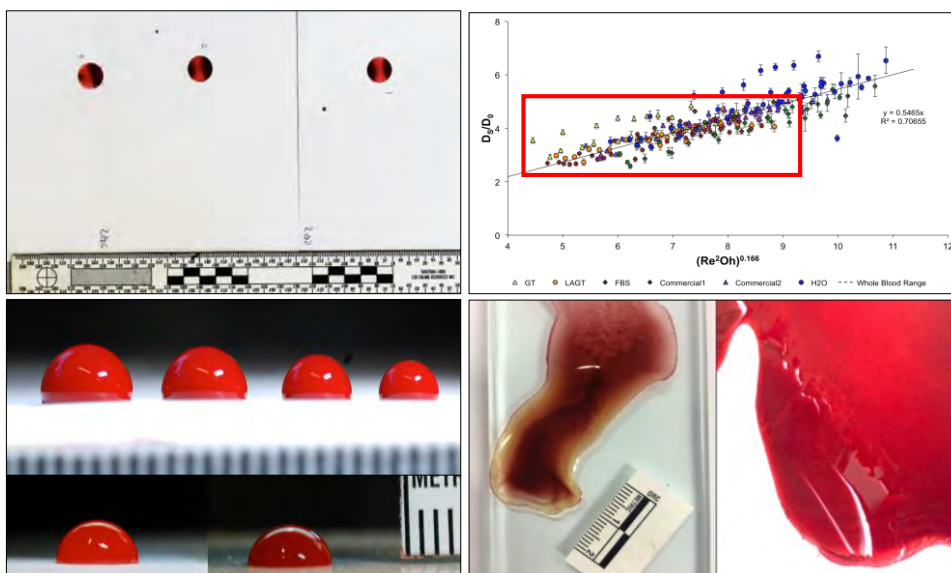


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Stotesbury T, Illes M, Wilson P, Vreugdenhil AJ. The application of silicon sol-gel technology to forensic blood substitute development: Investigation of the spreading dynamics onto a paper surface. *Forensic Science International*. 2017 Jun 1;275:308-13.

## Sol-gel based FBS

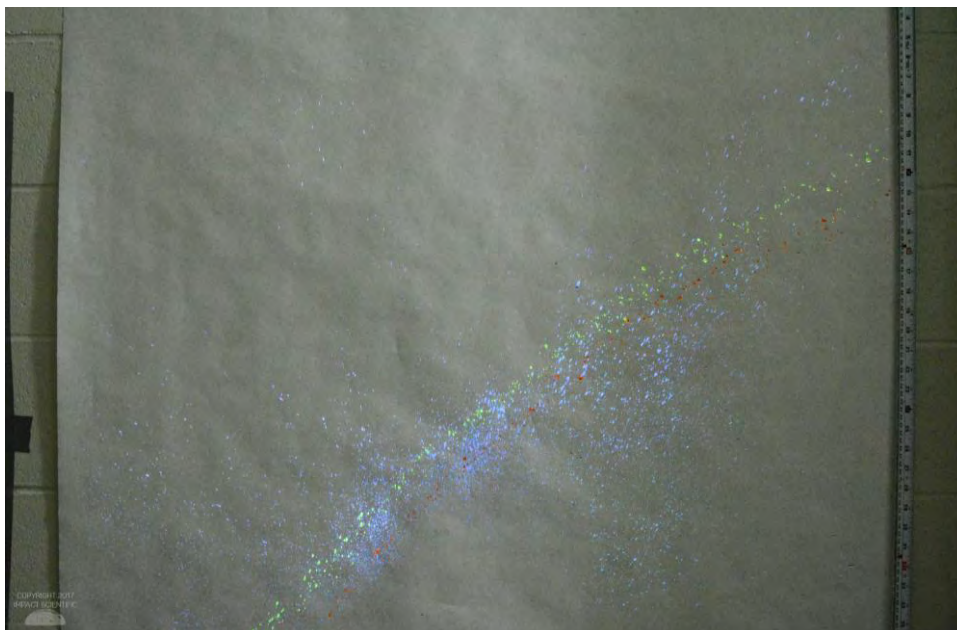


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Stotesbury T, Illes M, Wilson P, Vreugdenhil AJ. The application of silicon sol-gel technology to forensic blood substitute development: Mimicking aspects of whole human blood rheology. *Forensic science international*. 2017 Jan 1;270:12-9.

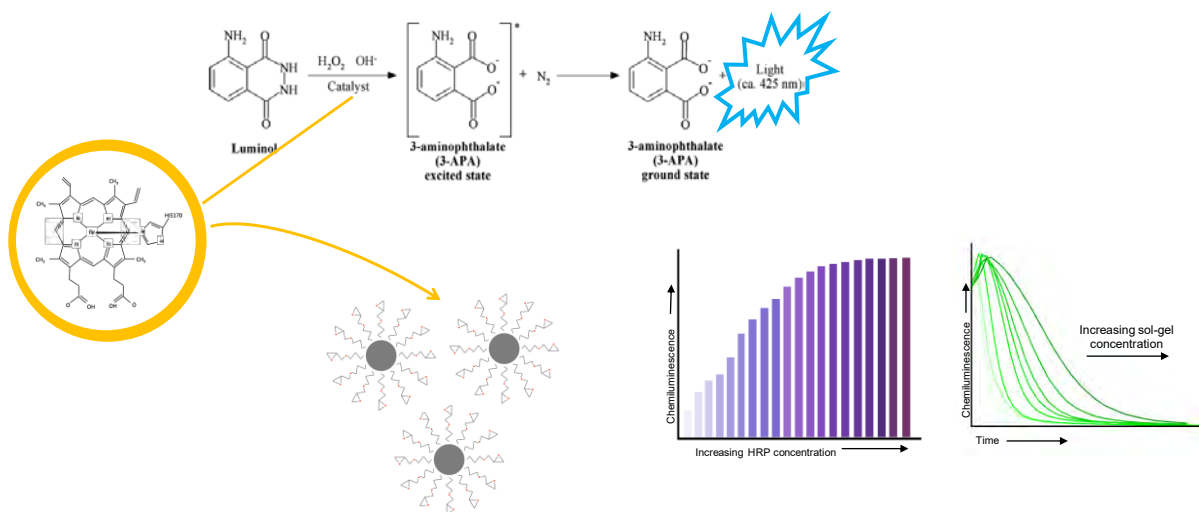
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## The training advantage



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## Chemical enhancement



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## Chemical enhancement



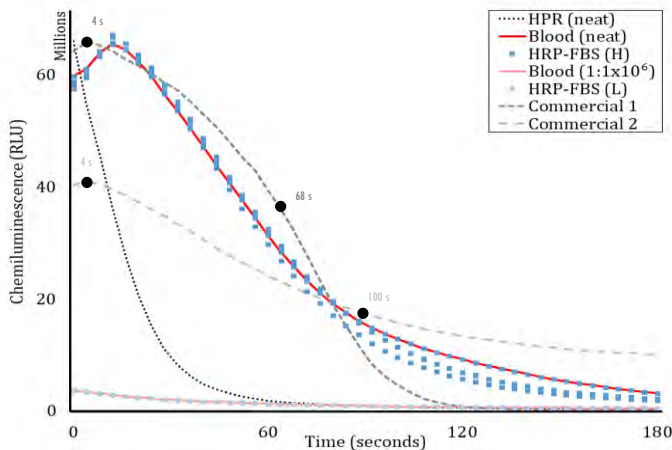
### FBS high & low intensity materials

- similar kinetic profiles to that of neat whole blood and  $10^6$  dilution

### Commercial products

- product 1 = liquid for training
  - similar emission maximum, with different kinetic profile
- product 2 = card for control test
  - different kinetic profiles

	R <sup>2</sup>	p-value
FBS (High; Low)	0.995; 0.995	0.835; 0.998
Commercial 1	0.566	0.003
Commercial 2	0.379	<0.001

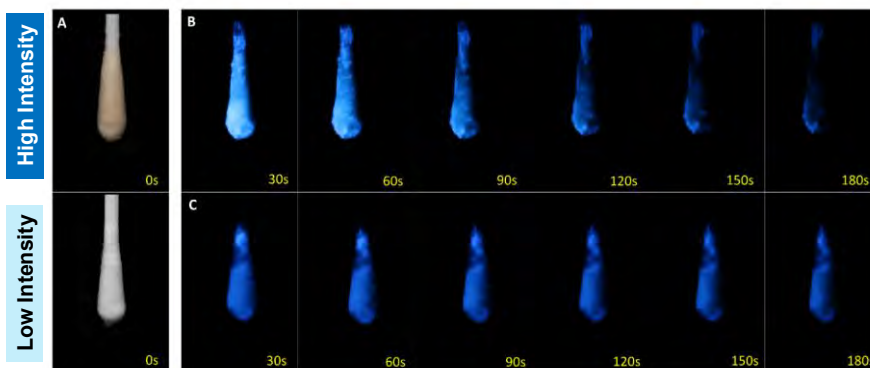


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Polacco S, Wilson P, Illes M, Vreugdenhil A, Stotesbury T. Luminol reagent control materials in bloodstain pattern analysis: a silicon sol-gel polymer alternative. *Forensic Chemistry* 12(1):91-8.

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## Chemical enhancement



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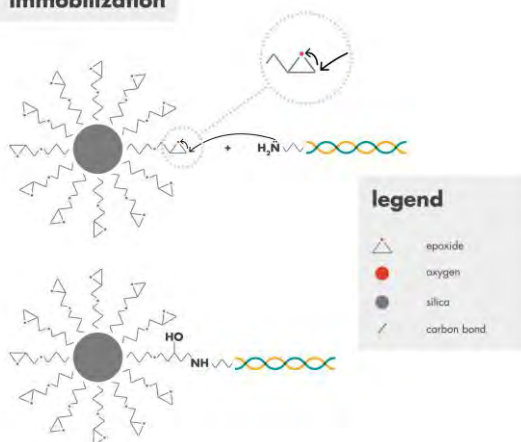
Polacco S, Wilson P, Illes M, Vreugdenhil A, Stotesbury T. Luminol reagent control materials in bloodstain pattern analysis: a silicon sol-gel polymer alternative. *Forensic Chemistry* 12(1):91-8.

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## DNA containing materials

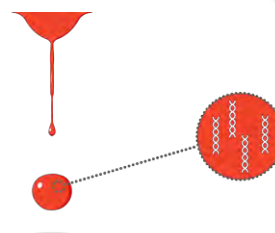


### DNA immobilization



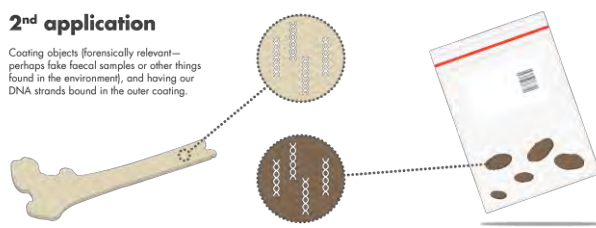
### 1<sup>st</sup> application

Having the DNA bound within a Forensic Blood Substitute (FBS).



### 2<sup>nd</sup> application

Coating objects (forensically relevant—perhaps fake faecal samples or other things found in the environment), and having our DNA strands bound in the outer coating.

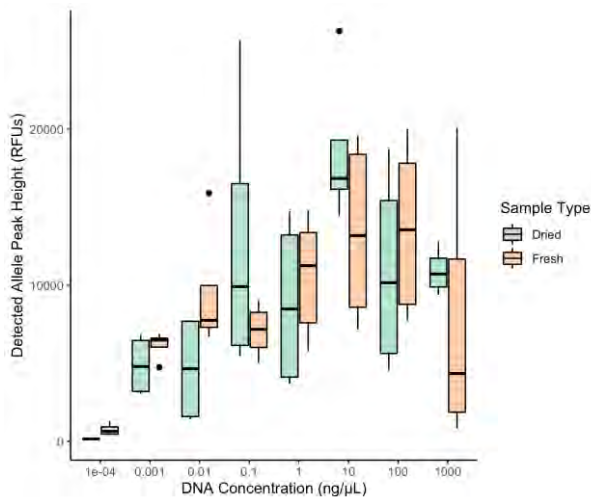
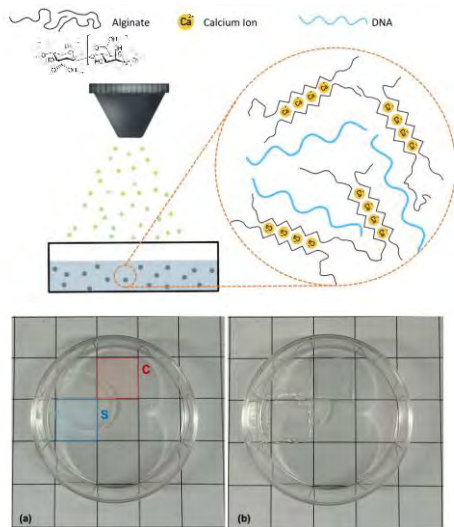


ACS Webinar\_2021\_Stotesbury

Orr A, Wilson P, Stotesbury T. Inclusion of deoxyribonucleic acid in sol-gel based forensic blood substitutes for application to forensic science. (poster presentation) Canadian Society of Forensic Science, 2018 Gatineau, QC.

28

# It doesn't stop at blood!

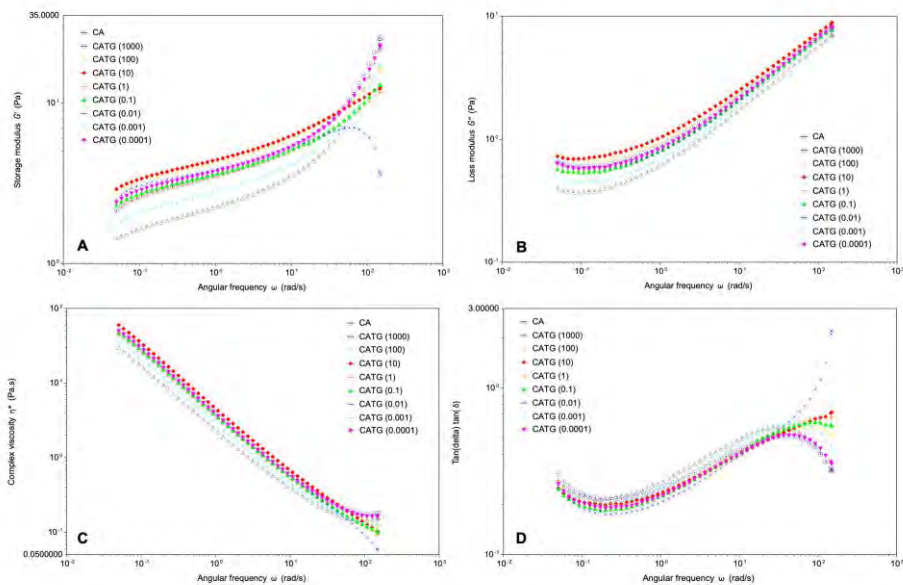


ACS Webinar\_2021\_Stotesbury

Orr A, Wilson P, Stotesbury T. Calcium-Alginate Tissue Gels (CATG): Proof-of-Concept Biomaterial Development. *Forensic Science International*. 2021 Oct 13:111055.

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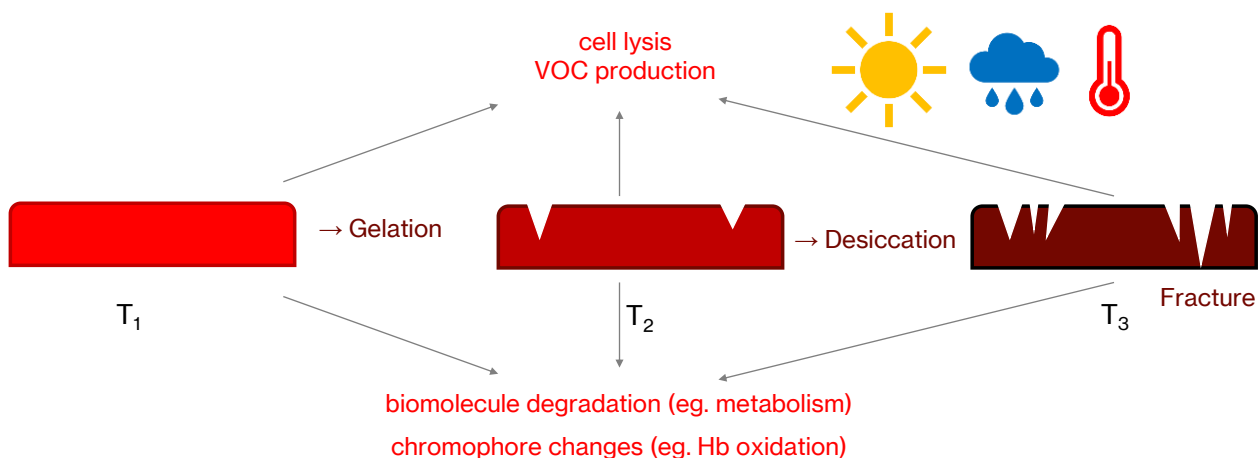
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Orr A, Wilson P, Stotesbury T. Calcium-Alginate Tissue Gels (CATG): Proof-of-Concept Biomaterial Development. *Forensic Science International*. 2021 Oct 13:111055.

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## Where are we headed next?

**Chemical** and **physical** changes occur to a bloodstain over **time**



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## Summary

- Bloodstains and bloodstain patterns contain a **wealth of biological, chemical and physical information** useful to a forensic scientist
- Forensic blood substitutes are still being developed as standard reference materials for **ex-vivo blood simulation**
  - Silicon sol-gel chemistry has demonstrated its utility in creating safe, robust, stable and valid FBSs
  - Alginate-based biomaterials are demonstrating promise in soft tissue simulants (including blood)



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 **THANK YOU!**



#### Want to discuss further?



On Twitter:  
[@theresasstotes](https://twitter.com/theresasstotes)



By email:  
[theresa.stotesbury@ontariotechu.ca](mailto:theresa.stotesbury@ontariotechu.ca)



#### Collaborators & Co-PIs:

- Dr. Andrew Vreugdenhil
- Dr. Mark Jermy
- Dr. Michael Taylor
- Dr. Mike Illes
- Dr. Naomi Stock
- Dr. Paul Wilson



Trent  
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# Bloodstains & Biomolecules

## From Crime Scene to the Silver Screen



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## Bloodstains & Biomolecules: From Crime Scene to the Silver Screen



**THERESA STOTESBURY**  
Assistant Professor, Forensic Science,  
Ontario Tech University



**MONICA MATTESI**  
Science Educator,  
Stony Brook University

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<https://youtu.be/OBWNPo9UufE>

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So are we breaking the circle of life? Also, check out episode 1 of [Vitals!](#)

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## Enhancing Research Productivity

### Through Student-Led Laboratory Safety Teams



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Moderator: Ralph Stuart, ACS Division of Chemical Health and Safety

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- How lab productivity is often inextricably linked to lab housekeeping
- How LSTs can empower future lab leaders to collaborate on resolving safety continuity challenges

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## Careers in Science and Engineering:

### Everything that You Need to Know



Professor Ashutosh Sharma  
Institute Chair Professor,  
Indian Institute of  
Technology, Kanpur

Date: Wednesday, November 10, 2021 @ 7:30am ET (6-7pm IT)

Speaker: Ashutosh Sharma, Indian Institute of Technology, Kanpur

Moderator: Deeksha Gupta, American Chemical Society

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- What are the current career options and job opportunities for chemistry graduates in India
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## Enhancing Research Productivity Through Student-Led Laboratory Safety Teams



Date: Thursday, November 4, 2021 @ 2-3pm ET

Speakers: Jessica Martin, ACS Division of Chemical Health and Safety / Kall Miller, ACS Division of Chemical Health and Safety / Monica Nyansa, ACS Division of Chemical Health and Safety / Sarah Zinn, ACS Division of Chemical Health and Safety

Moderator: Ralph Stuart, ACS Division of Chemical Health and Safety

[Register for Free!](#)

### What You Will Learn:

- The motivation behind graduate student-led safety initiatives
- How lab productivity is often inextricably linked to lab housekeeping
- How LSTs can empower future lab leaders to collaborate on resolving safety continuity challenges

Co-produced with: ACS Division of Chemical Health and Safety ACS Committee on Chemical Safety

## Careers in Science and Engineering:

Everything that You Need to Know



Professor Ashutosh Sharma  
Institute Chair Professor,  
Indian Institute of  
Technology, Kanpur

Date: Wednesday, November 10, 2021 @ 7:30am ET (6-7pm IT)

Speaker: Ashutosh Sharma, Indian Institute of Technology, Kanpur

Moderator: Deeksha Gupta, American Chemical Society

[Register for Free!](#)

### What You Will Learn:

- What are the current career options and job opportunities for chemistry graduates in India
- How to choose a career based on personal strengths and values
- How to bridge gaps to increase your chance of employability

This special broadcast is targeted for an audience based in India and is co-produced with ACS International and ACS Publications.

## Sustainability Through Innovation

A Conversation with Industry Experts



Date: Wednesday, November 10, 2021 @ 2-3pm ET

Speaker: Lee Ellen Drechsler, Procter & Gamble

Moderator: Rebekah Paul, American Chemical Society

[Register for Free!](#)

### What You Will Learn:

- Real life innovations where the chemical industry has incorporated sustainability into their operations
- Future sustainable innovations being developed in corporate R&D
- Professional opportunities for the next generation in the chemical industry

Co-produced with: ACS Communications and ACS Industry Member Programs

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