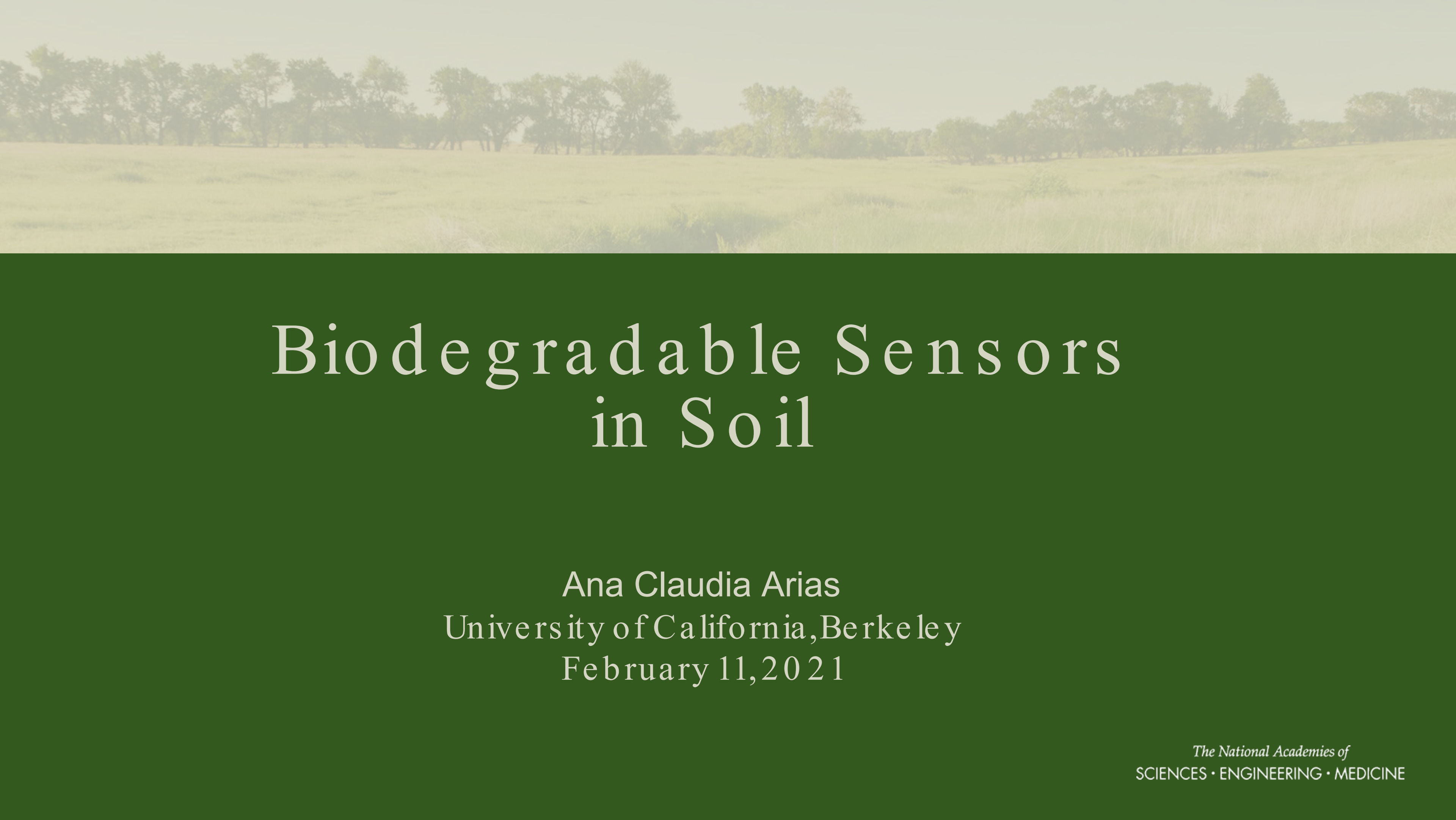




Biodegradable Sensors in Soil

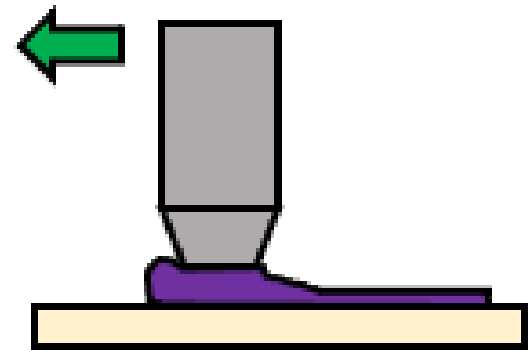
Ana Claudia Arias
University of California, Berkeley
February 11, 2021



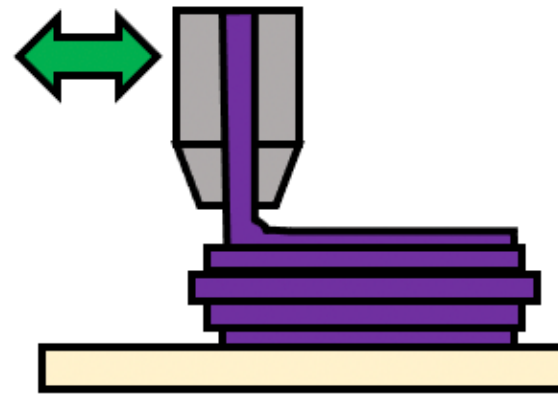
Printed Flexible Electronics

- ✓ Electronic/sensing materials are deposited from solution
- ✓ Only deposit materials in areas that need the functionality
- ✓ Large area capability
- ✓ Distributed Electronics – low density/large area
- ✓ Customization ease
- ✓ Lower capital investment
- ✓ Extremely thin
- ✓ Rigid or flexible substrates
- ✓ Large Area Systems – Photovoltaics, Displays, Imagers
- ✓ Heterogeneous integration allows sophisticated functionality

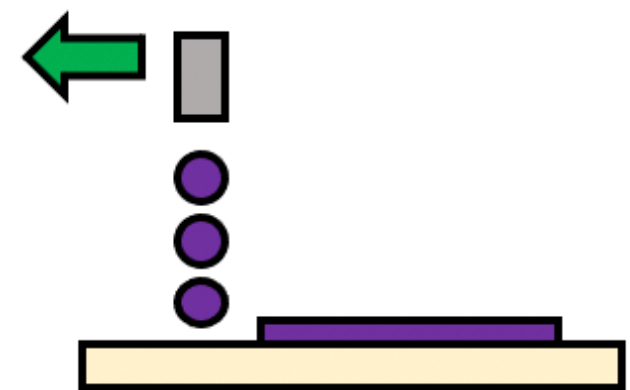
Electronic components printed using methods developed for graphic arts and document printing



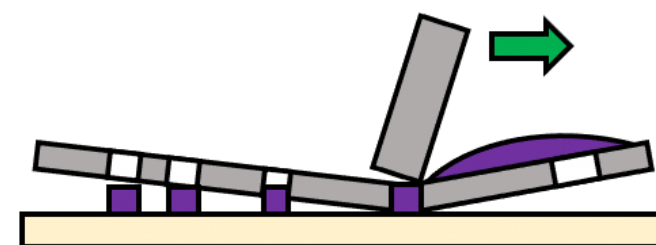
Blade Coating



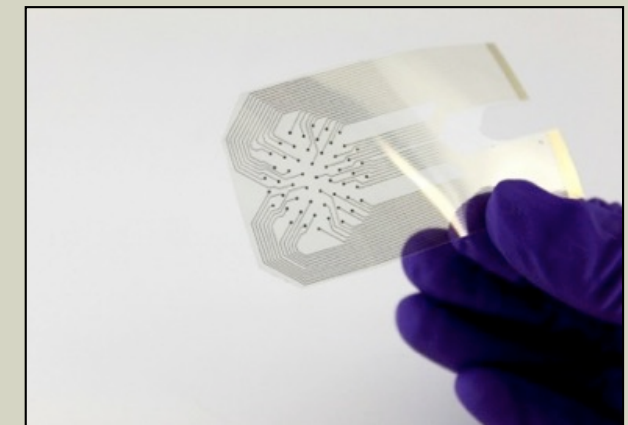
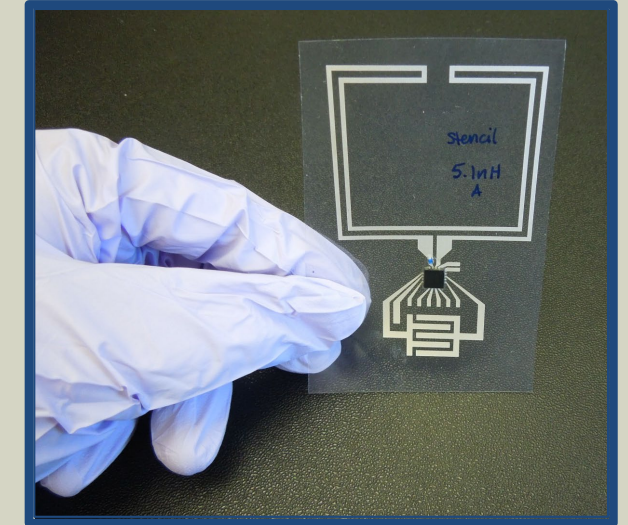
3D Printing



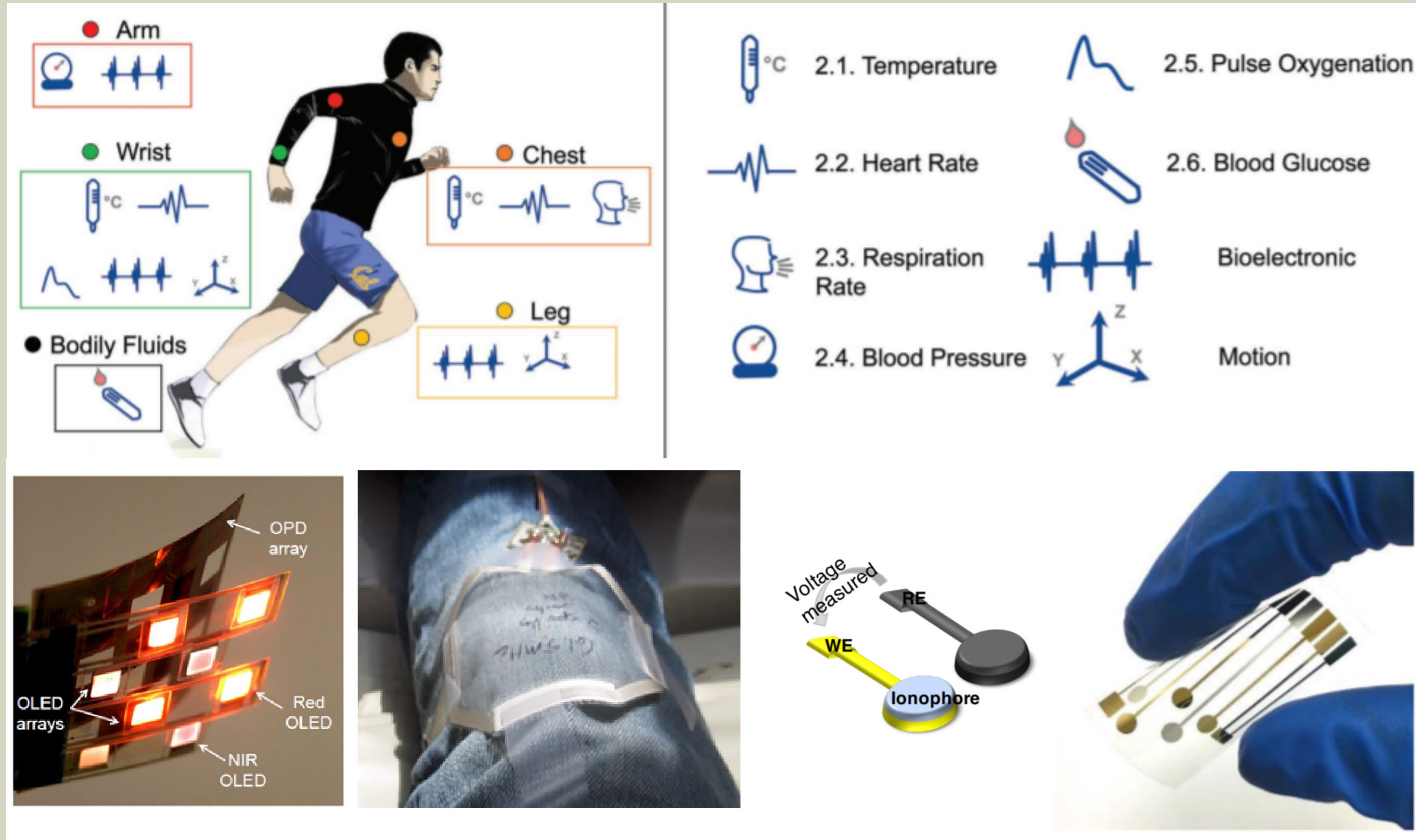
Inkjet Printing



Screen Printing



Printed Flexible Electronic Systems



Chemical sensors are used for health monitoring, food quality and agricultural sensing.

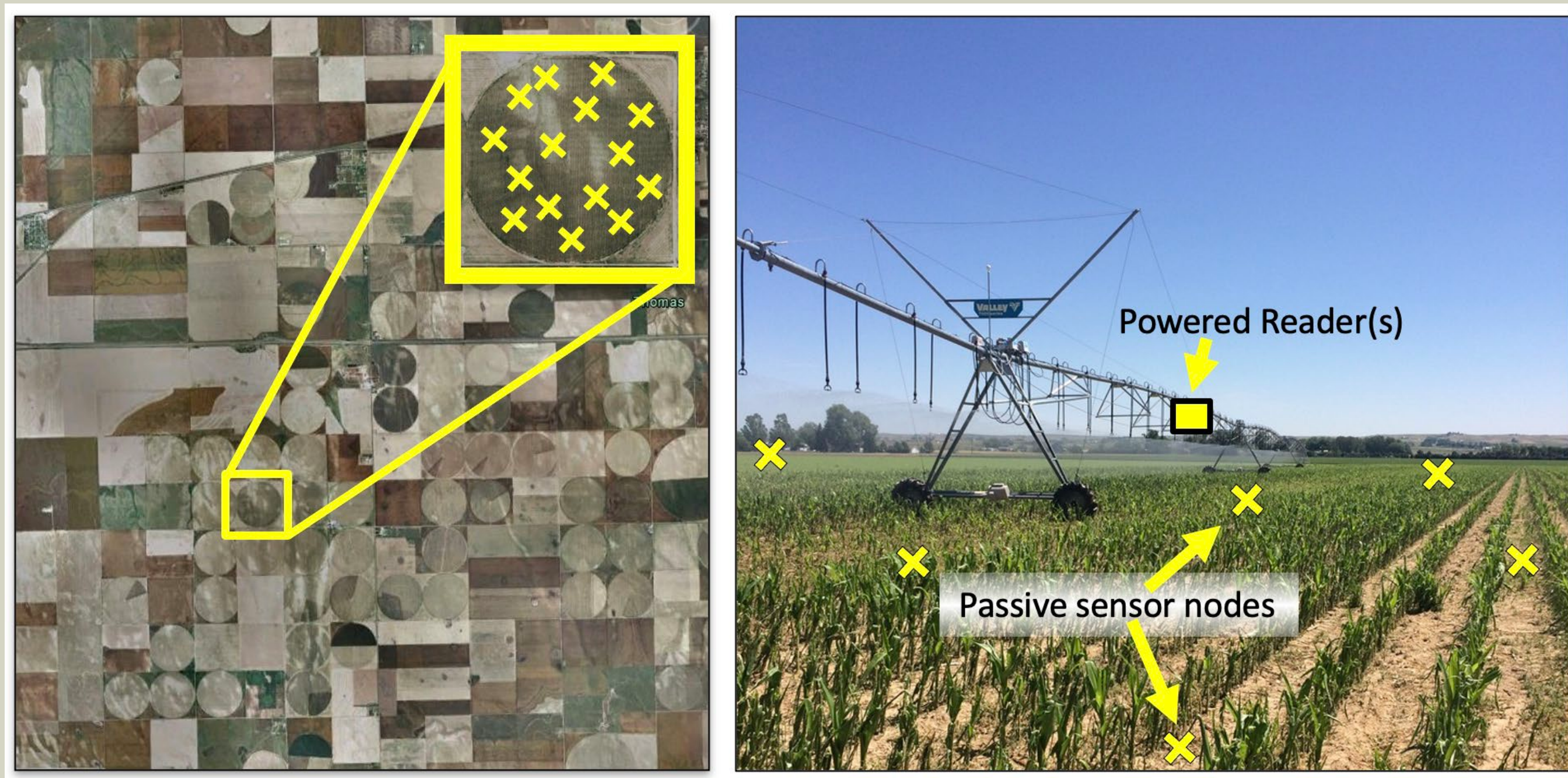
PANDAS: Precision Agriculture using Networks of Distributed Analytical Sensors



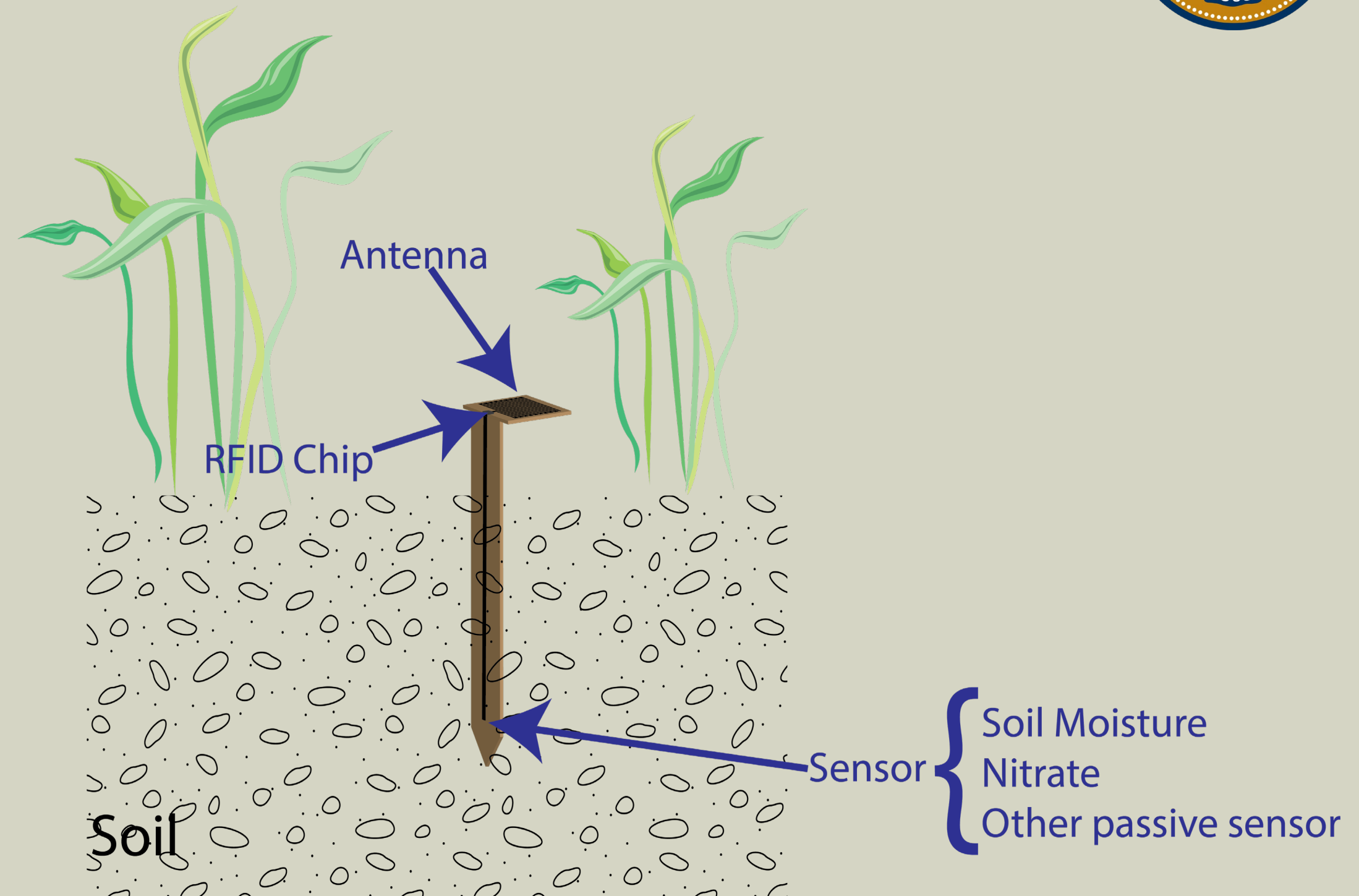
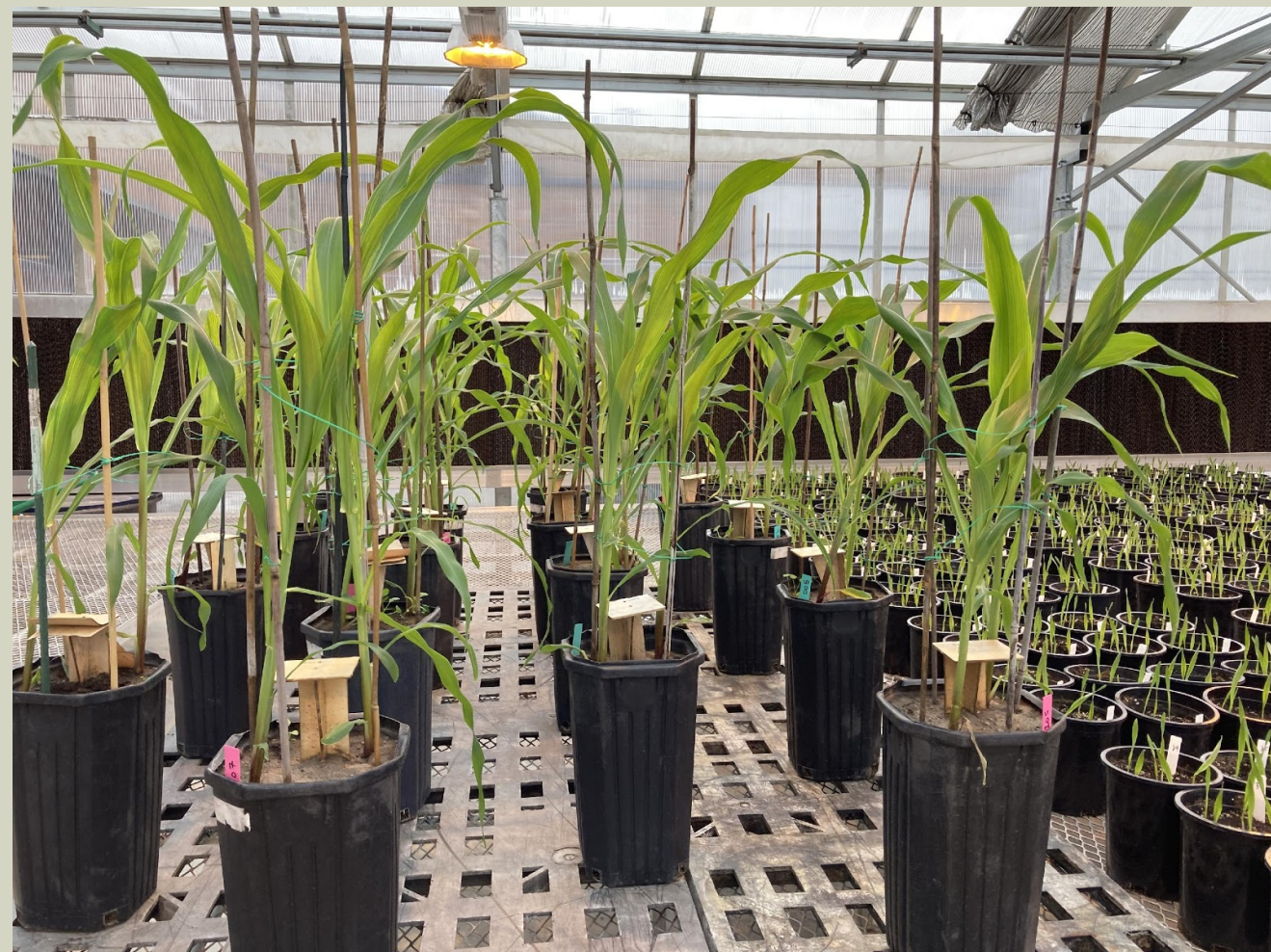
PANDAS: Precision Agriculture using Networks of Distributed Analytical Sensors



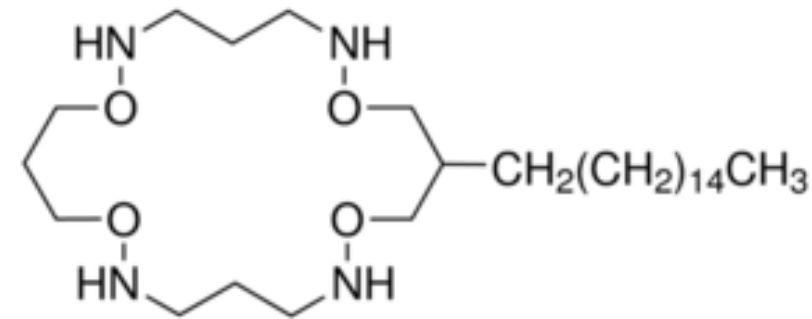
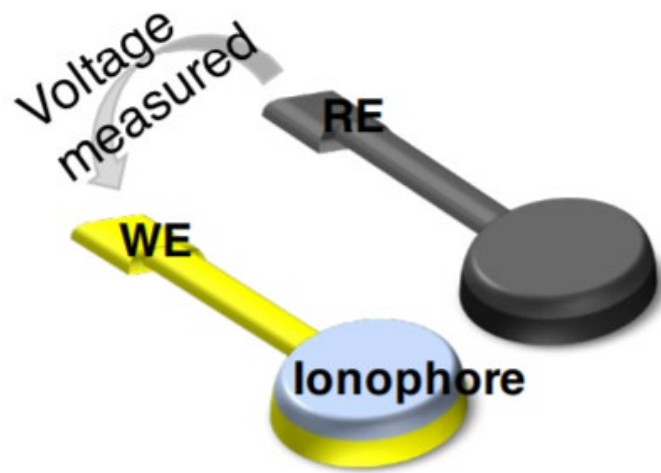
PANDAS: Precision Agriculture using Networks of Distributed Analytical Sensors



Sensor Node



Potentiometric Sensors



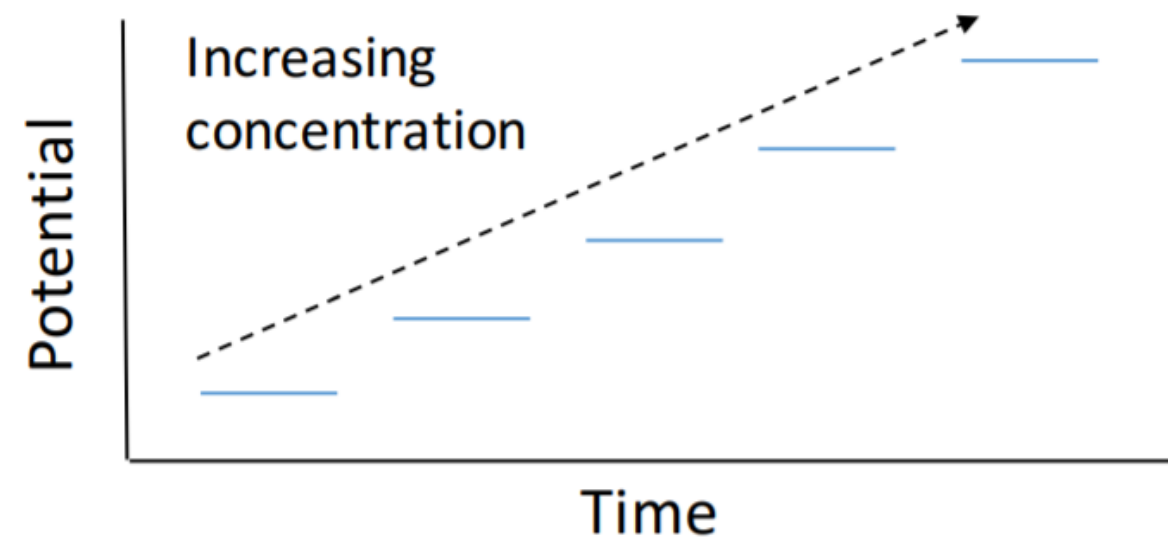
$$C = 2.3026 \frac{RT}{zF} = \frac{59.1mV}{z}$$

R = universal gas constant (8.314 J K⁻¹ mol⁻¹)

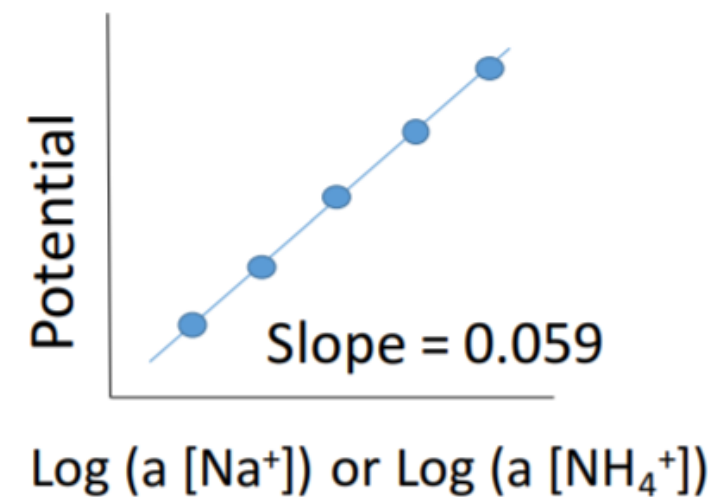
T = Temperature in Kelvin (assume 298K or 25C)

F = Faraday constant (9.649 x 10⁴ C mol⁻¹)

z = number of electrons transferred in reaction



$$E = E^0 + C \log a$$



Chemical activity of species of interest

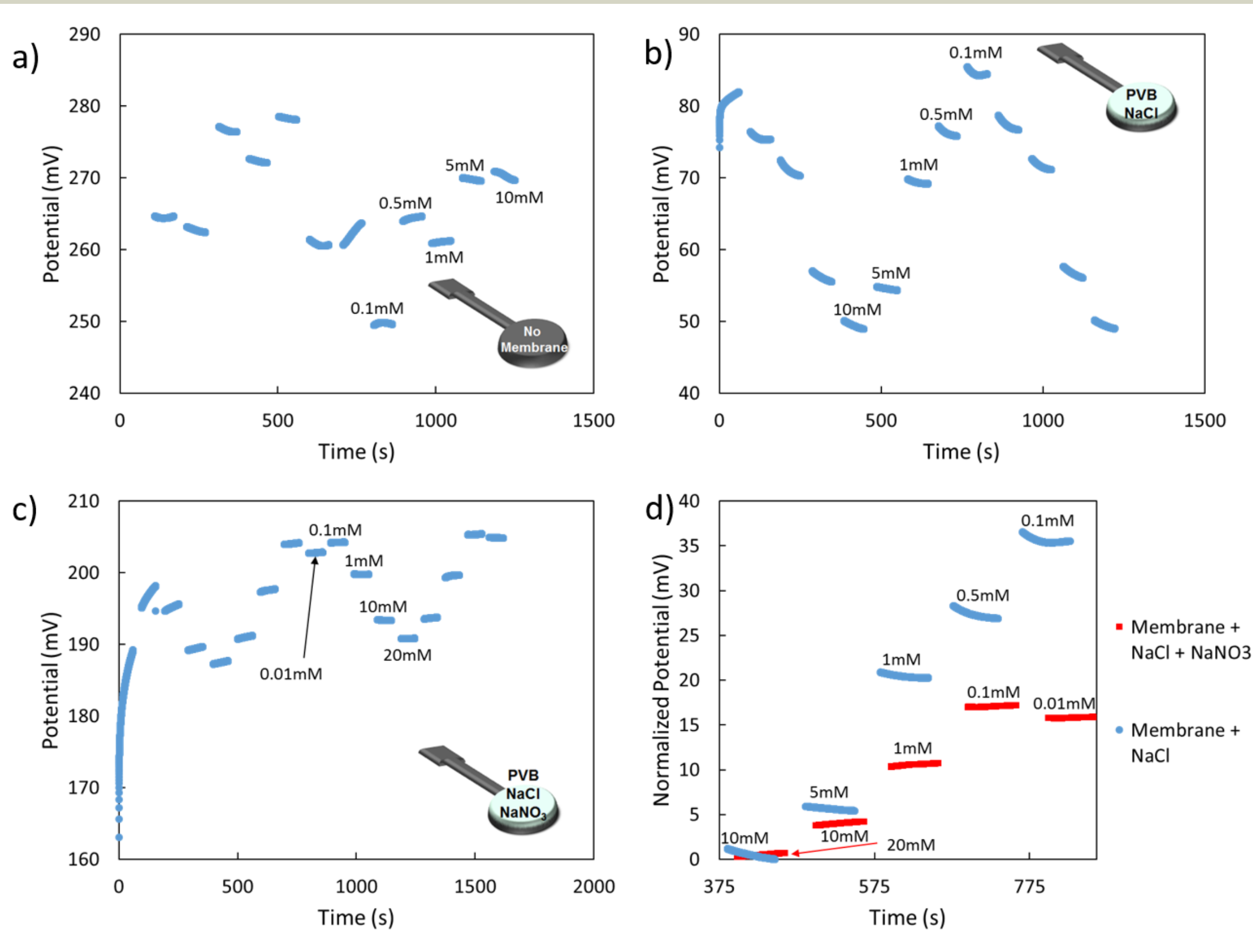
$$a_{ion} = C_{ion} \gamma_{ion}$$

C = concentration in solution
 γ = activity coefficient (1 at low concentrations)

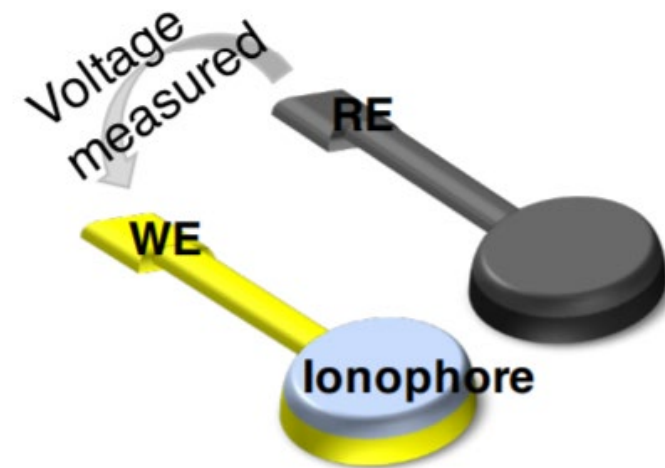
Potentiometric Sensors are highly selective and less affected by other salts present in solution and soil



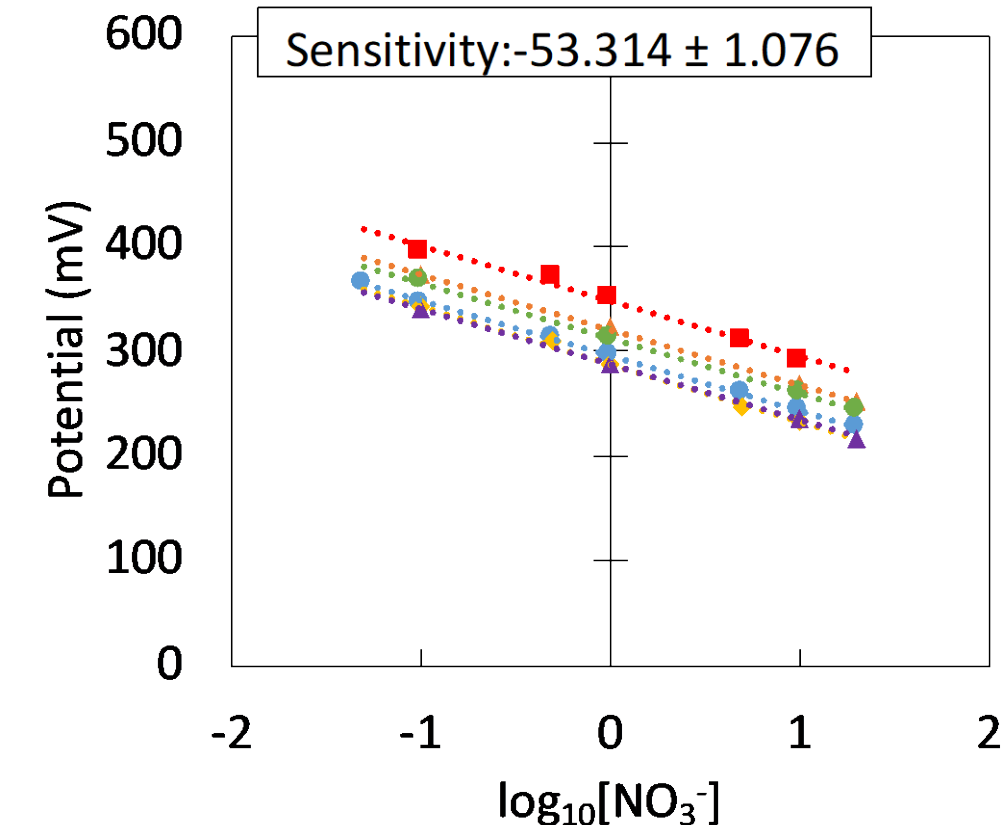
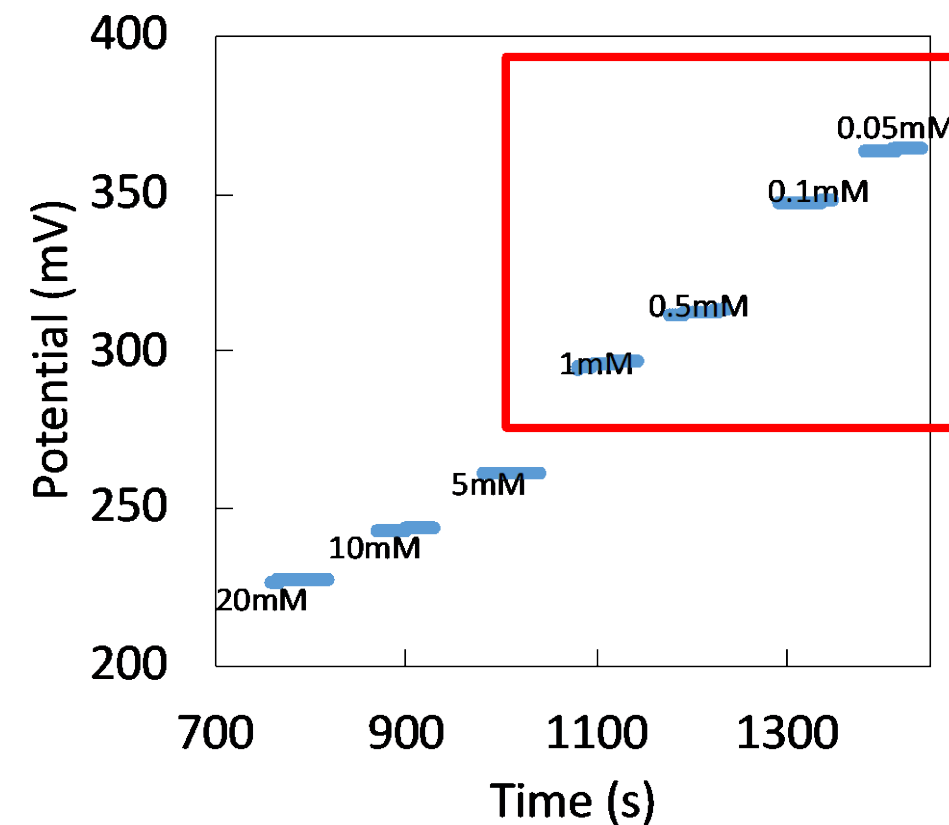
Reference Electrode



Potentiometric Sensors



- The ionophore selectively reversibly binds with the ion of interest
- Gathered charge at the surface of the sensor changes the potential compared to the reference
- These sensors are less susceptible to interference from other salts!



Printed working electrode measured against commercial reference electrode, spans range of 3.2ppm to 1240ppm

Ions found in soil



A & L WESTERN AGRICULTURAL LABORATORIES

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REPORT NUMBER: 18-120-063

CLIENT NO: 4246



GROWER:

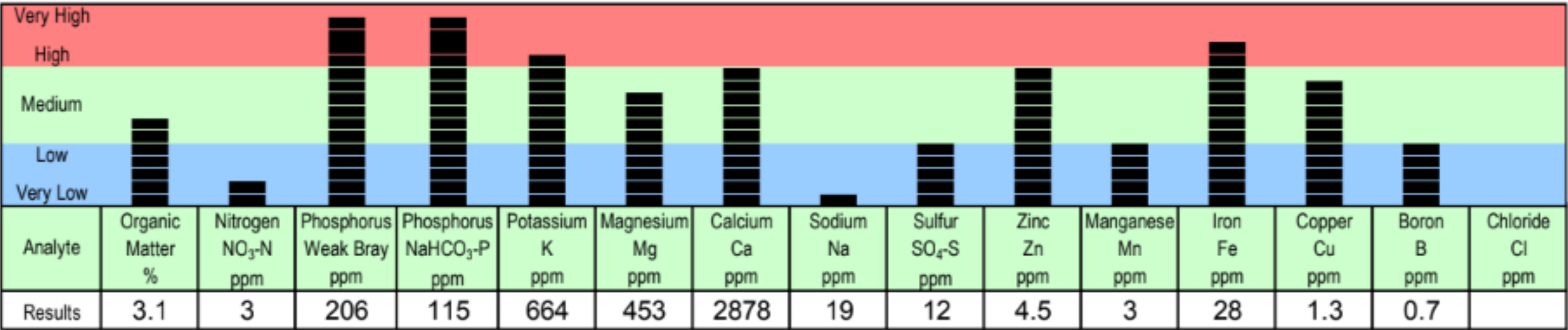
Graphical Soil Analysis Report

DATE OF REPORT: 05/03/18

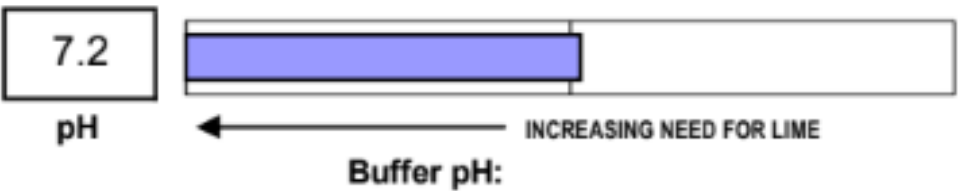
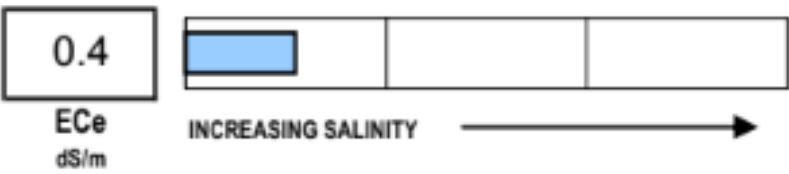
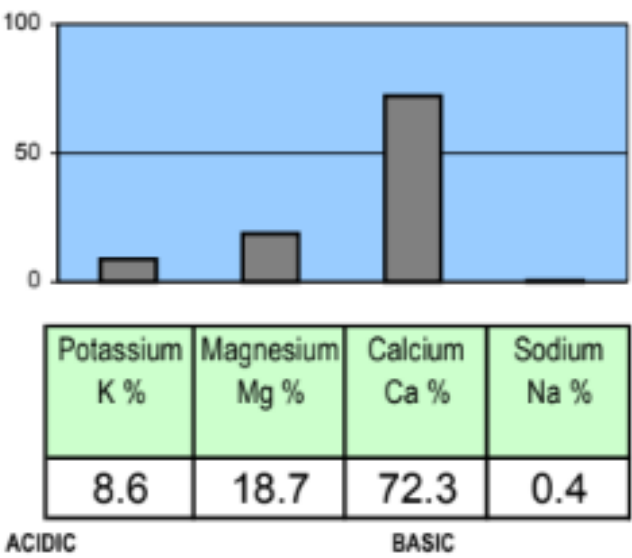
LAB NO: 50830

SAMPLE ID: STRIP

PAGE: 1

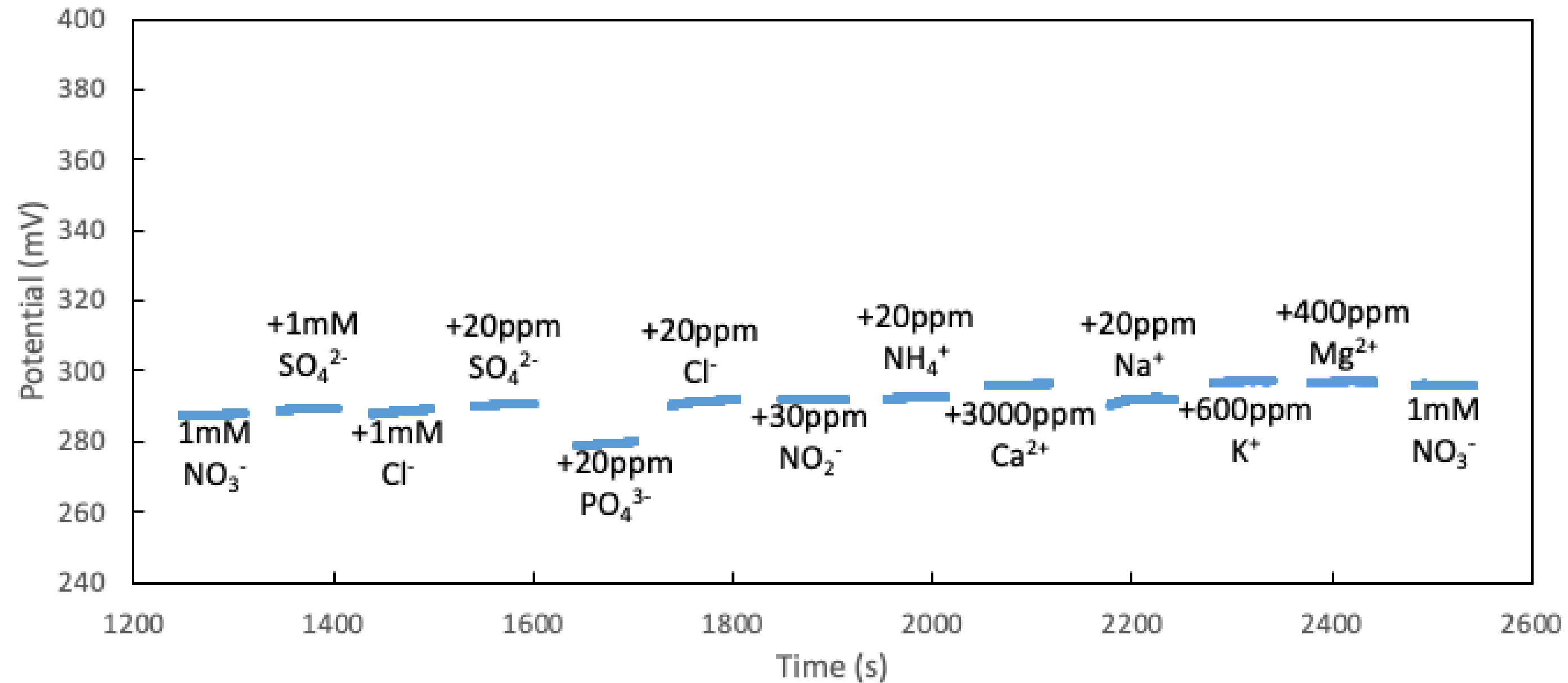


Percent Cation Saturation (computed)

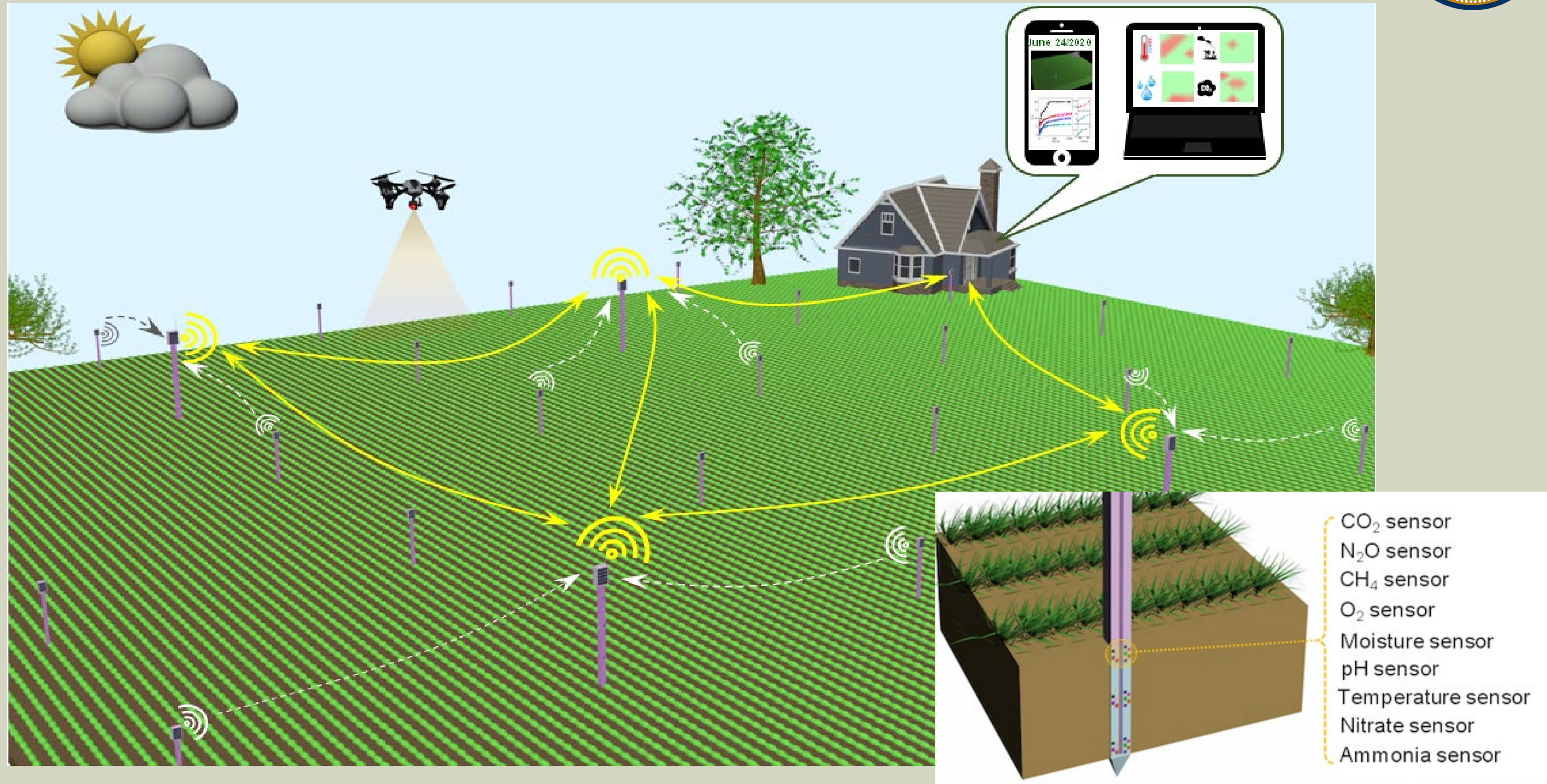




Sensor Selectivity



Impact on Agricultural Yield and GHG emissions



Acknowledgments



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Payton Goodrich



Carol Baumbauer



Anju Toor



Greg Whiting



Raj Khosla

The National Academies of
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