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# Plant Nutrition, Stress, and the Forgotten Element, Silicon

Emanuel Epstein

University of California, Davis



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# Plant Nutrition



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<b>Macronutrient</b>	<b>Micronutrient</b>	<b>Other</b>	<b>Mammals</b>
<b>K</b>	<b>Fe</b>	<b>Na</b>	<b>F</b>
<b>Ca</b>	<b>Mn</b>	<b>Co</b>	<b>I</b>
<b>Mg</b>	<b>Zn</b>	<b>Si</b>	<b>Se</b>
<b>N</b>	<b>Cu</b>		<b>Cr</b>
<b>P</b>	<b>Ni</b>		<b>V</b>
<b>S</b>	<b>B</b>		
	<b>Cl</b>		
	<b>Mo</b>		



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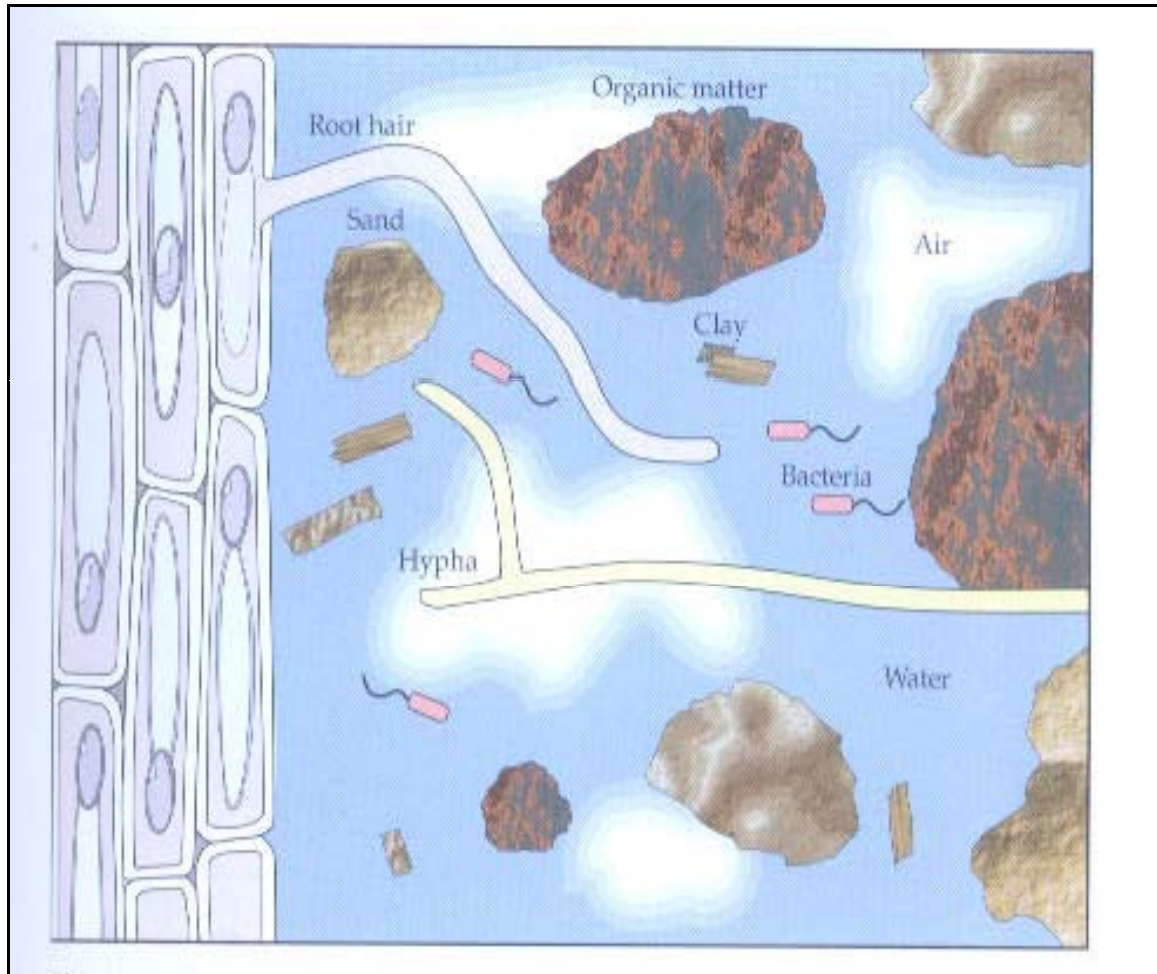
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# Beyond the Numbers: Root cells vs. ours



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“I doubt that there exists in any other system presented for scientific or practical study a comparable degree of complexity. Indeed, scientifically considered, this complexity occasionally takes on an almost appalling aspect.”

**Dennis R. Hoagland**



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## Permeability vs. active transport

“...ideas concerning permeability do not in themselves suffice...Salts can be pumped...with the use of metabolic energy, in the utilization of which an aerobic respiratory system is involved.”



1. Ions are pumped into root (and other) cells by metabolically driven processes.
2. Ions are accumulated against electrochemical diffusion gradients.
3. Their transport is not indiscriminate but selective.



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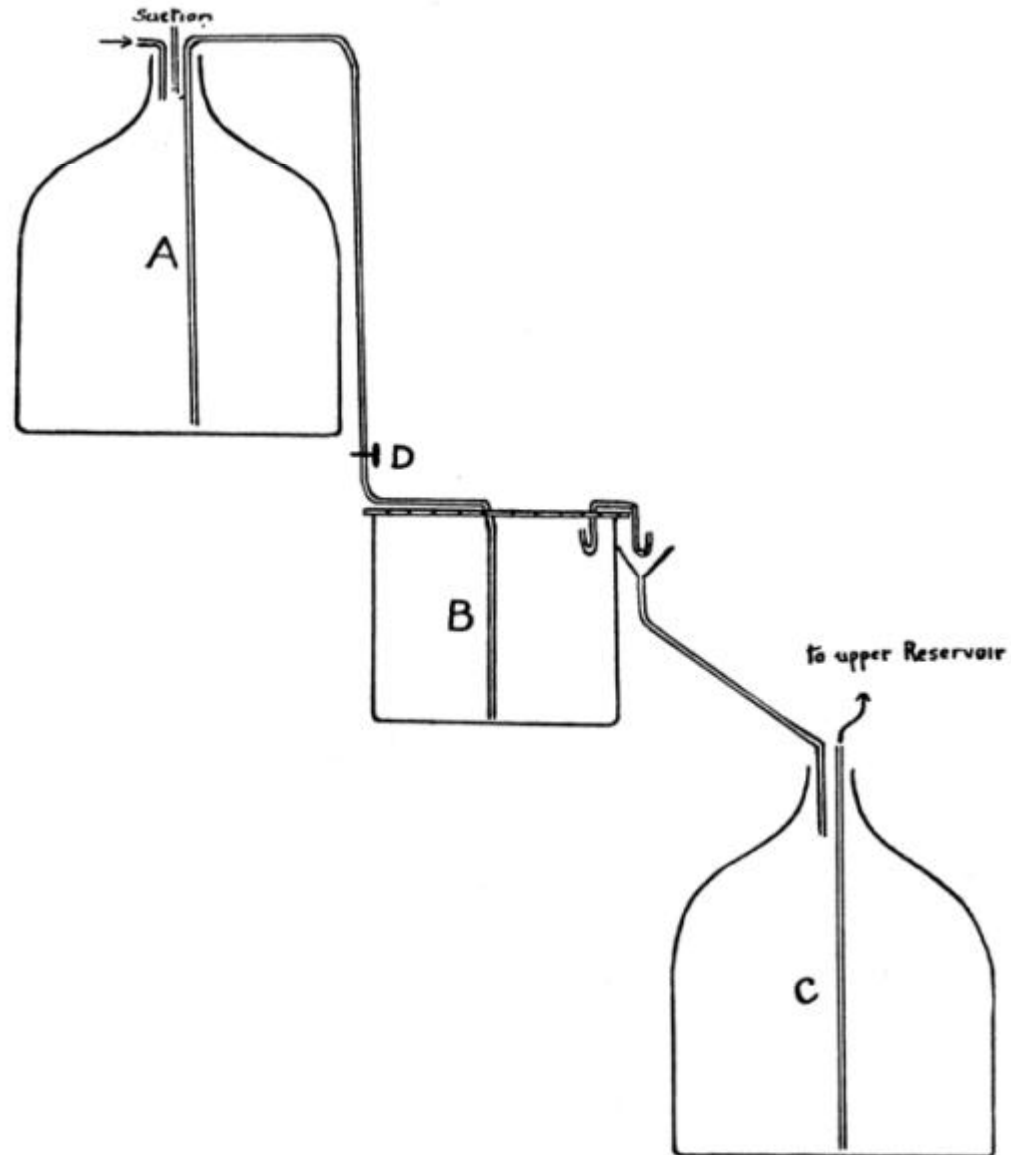
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**Hoagland solution concentrations vs.  
soil solutions. J.H. Teakle.**



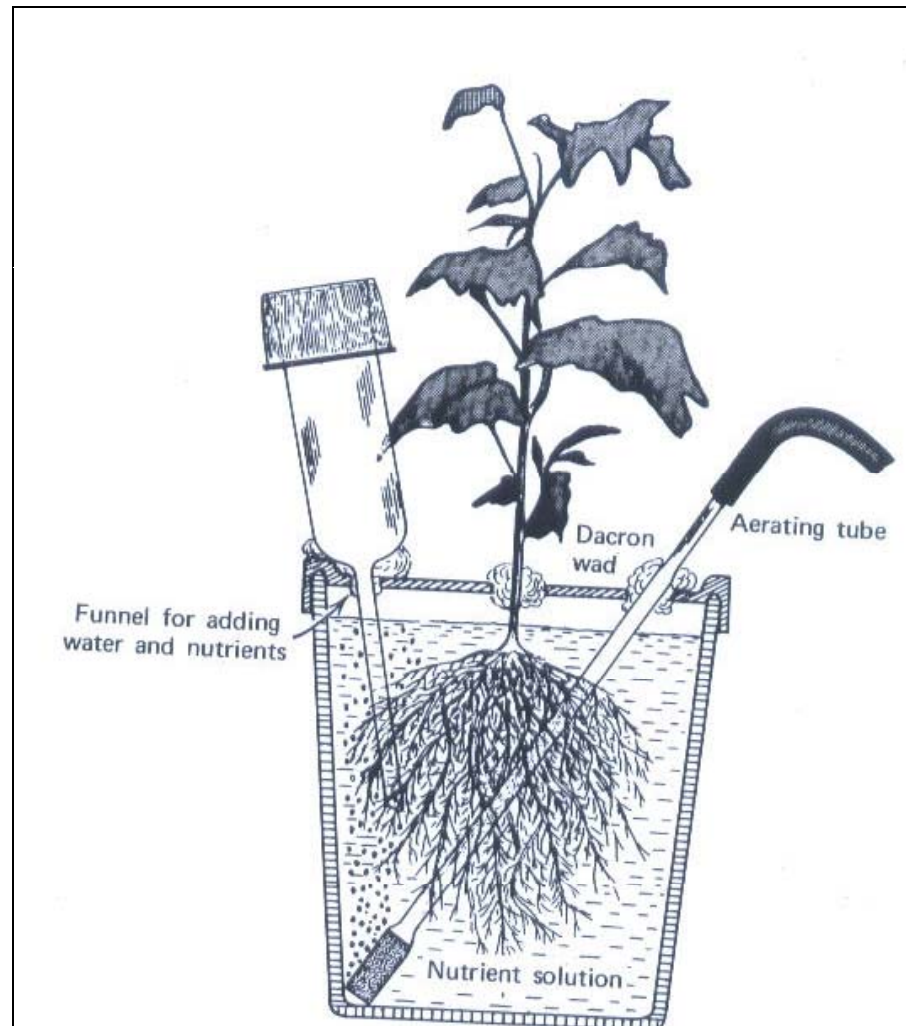
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## Solution culture





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# High-affinity mechanisms



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# Root morphology



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# “Terrascentian”



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# Plant Nutrition

Its status here and elsewhere



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# Stress

Aquatic vs. terrestrial plants



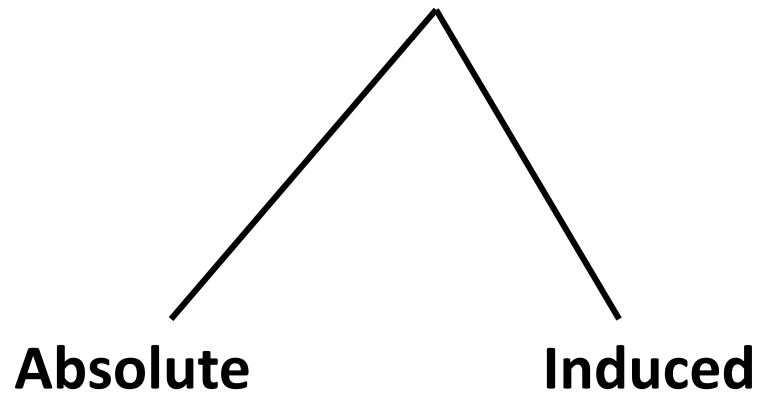
Condition	Aquatic	Terrestrial	Remarks
Steady water availability	Yes	No	Variable on Land
Physical homogeneity of the medium	Yes	No	
Chemical homogeneity	Yes	No	
Large temperature fluctuations	No	Yes	
Gravitational pull	No	Yes	
Need for long-distance transport	No	Yes	
Mobility	Yes	No	For terrestrial plants: Yes for propagules
Mycorrhizae	No	Yes	



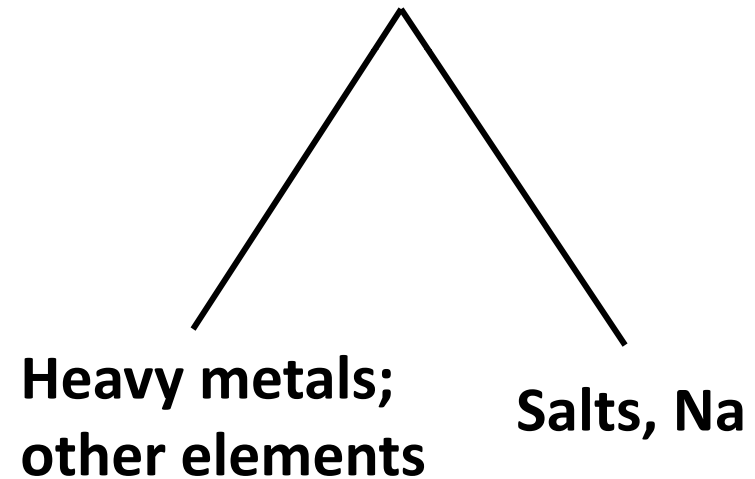
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## Deficiencies



## Excesses





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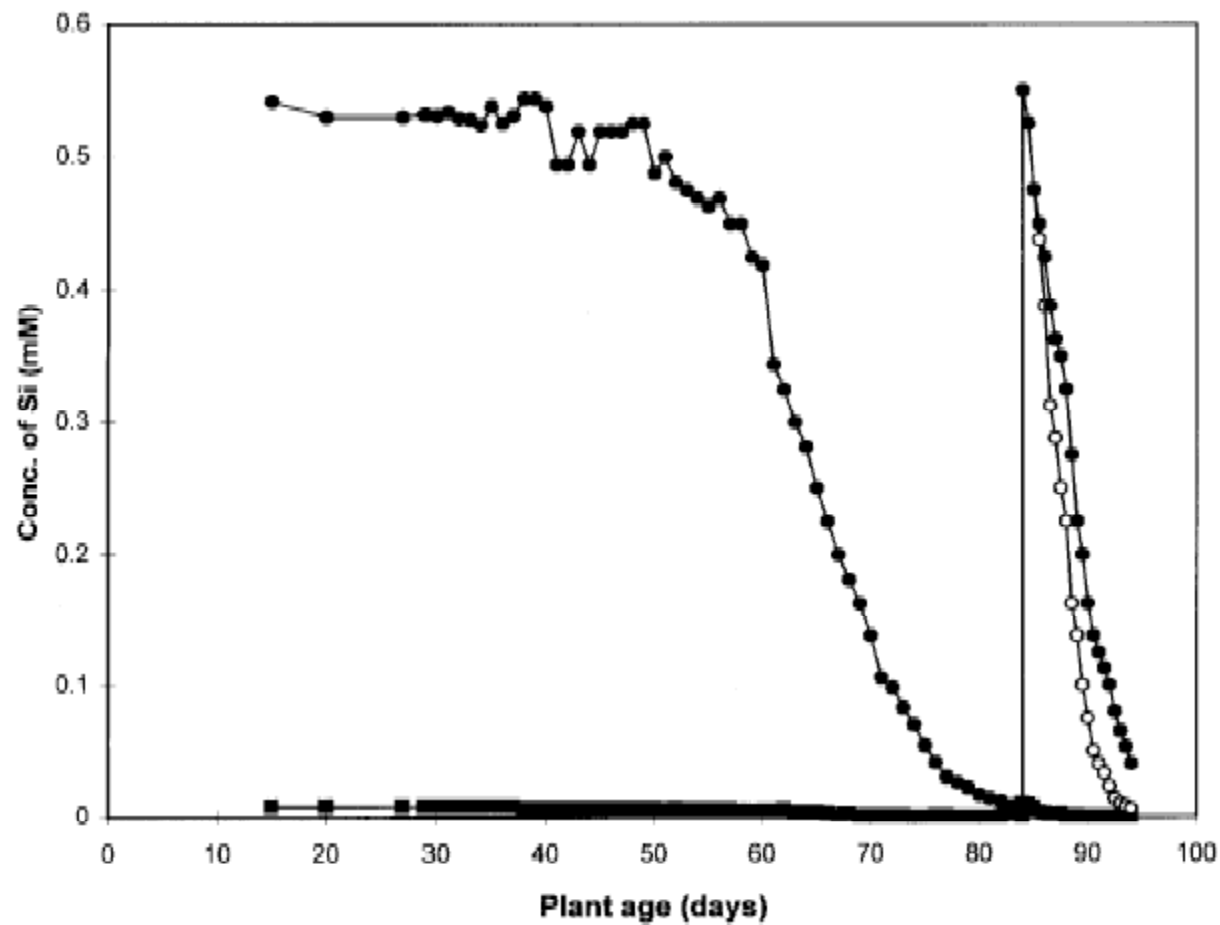
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# Silicon

A plant nutritional oddity

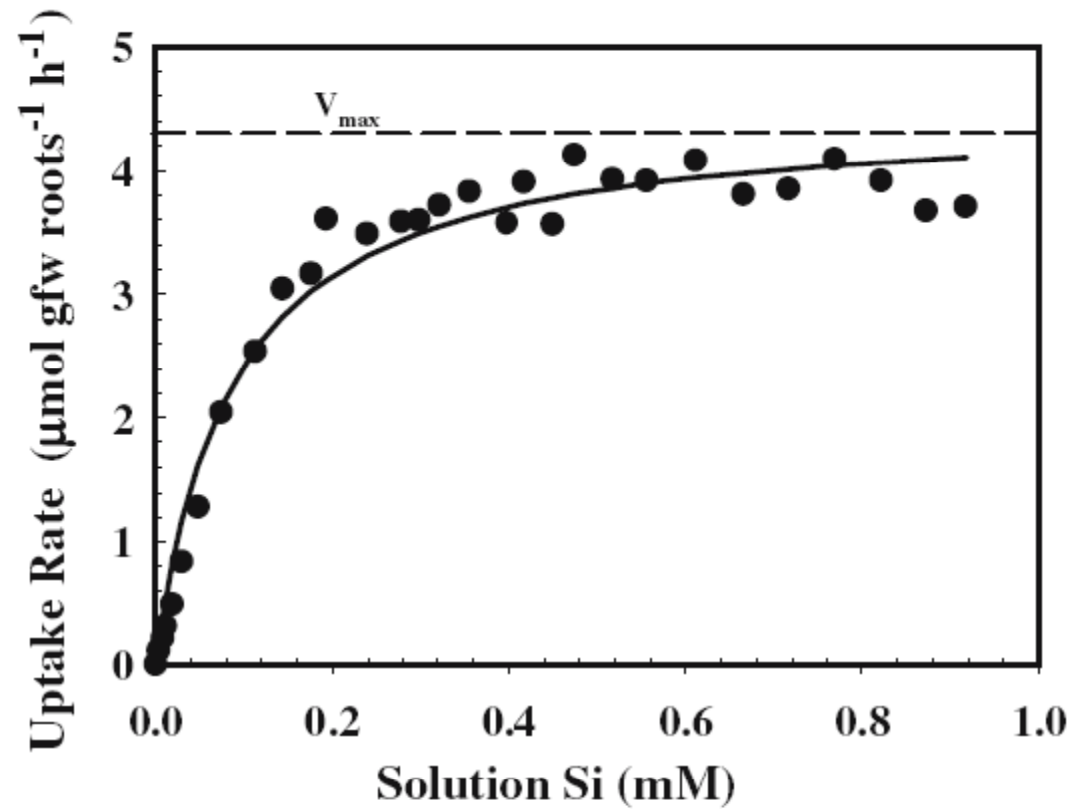


## Silicon absorption by wheat



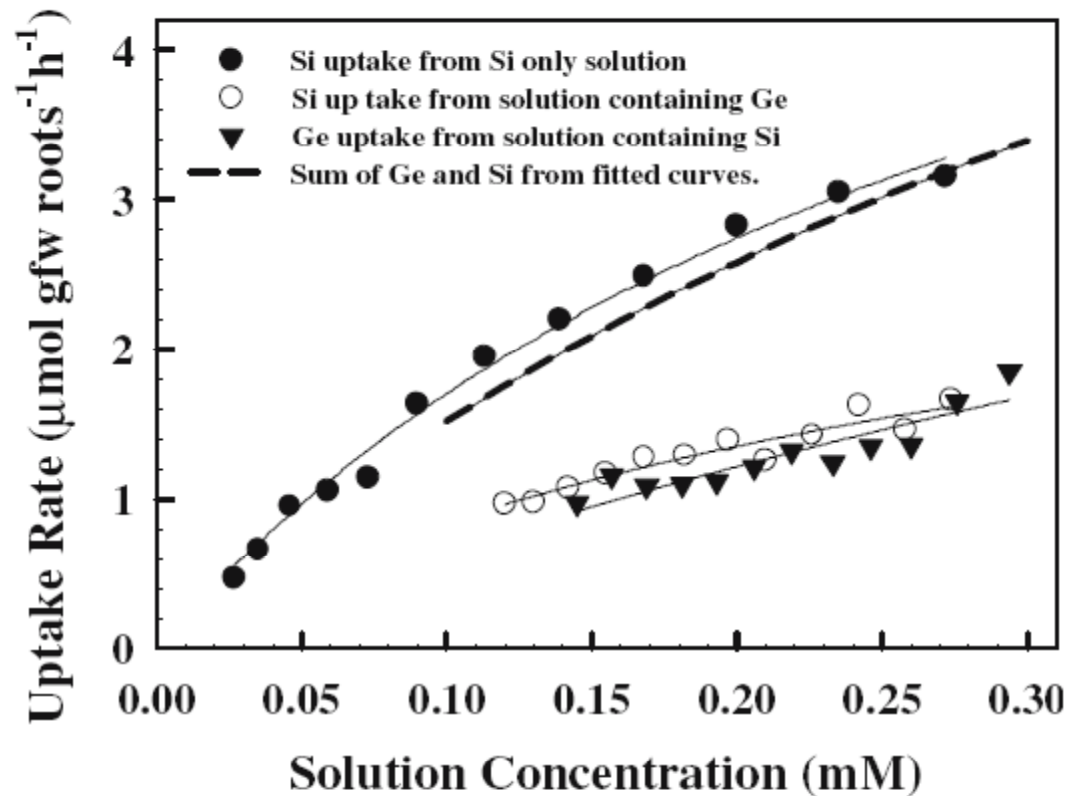


## Silicon absorption by wheat





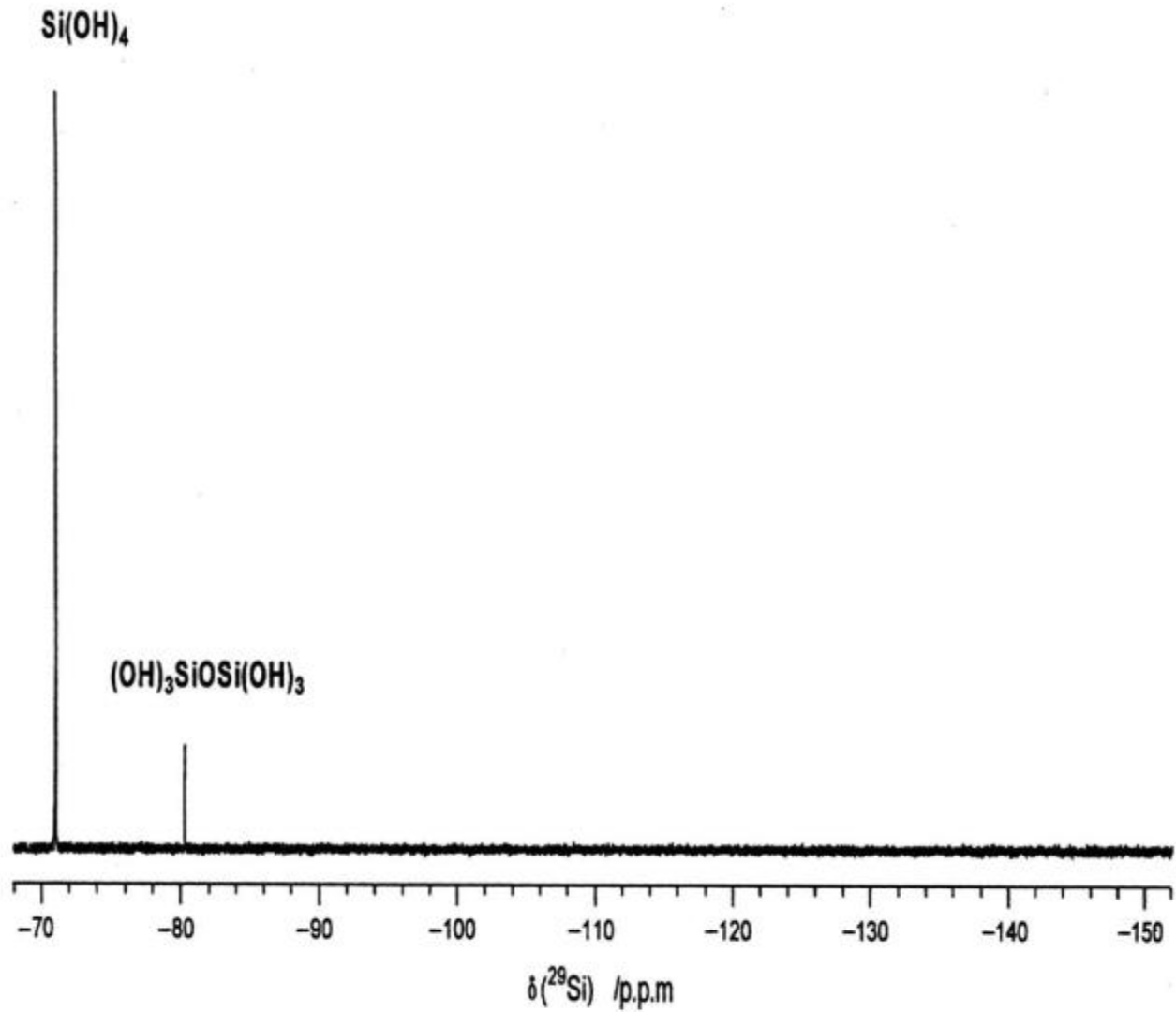
## Silicon absorption by wheat





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# Comparison with K transport



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# The role of silicon is defense



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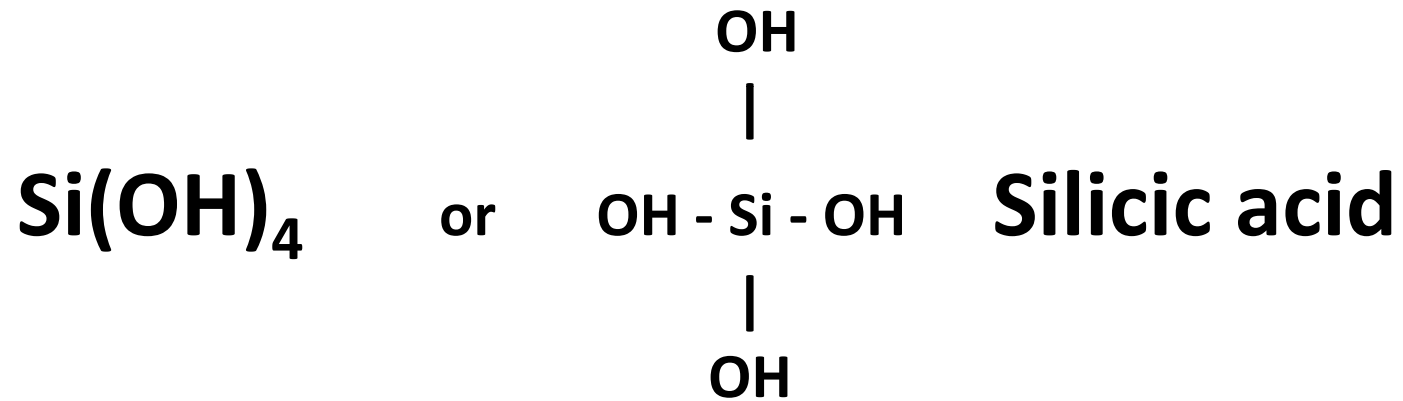
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# Defense: Physical



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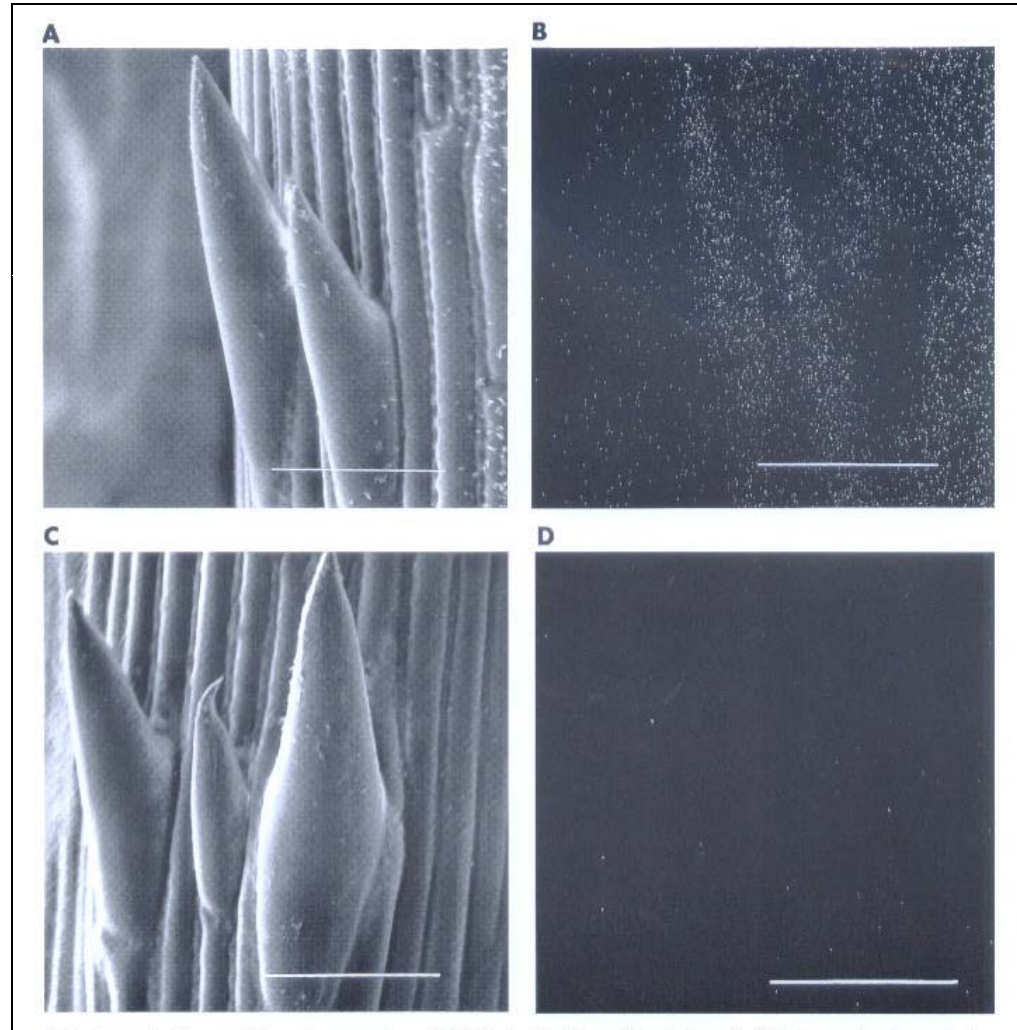
**SiO<sub>2</sub>**

**Silica**





## Wheat trichomes with/without silica





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# Defense: Chemical



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**Secondary Metabolites: 200,000. Terpenoids,  
alkaloids, phenolic compounds**

**Silicon: an inorganic secondary nutrient**

**Up- and down- regulation of genes**



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# Present Status



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# Conclusion



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U.S. Department of Agriculture

U.S. Department of Energy

National Science Foundation

Edward A. Dickson Emeriti

Professorship



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# Acknowledgments

Malik Rafi

Richard Falk

Bob Zasoski

Muhammad Aslam

Bill Casey

Jay Black

Bill Rains

Chris Derr