

# Common Design Strategies for Exploring Signaling Networks in Biology and Intellectual Geographies in History

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# Embedding Subjective User-Specific Perspectives into Visualizations

## Architecturalizing Mass Cytometry Data

- Constructing User-Specific Mental Models
- New Direction: Tapping into Perceptual Potentials By Using Natural Forms and Qualitative Features

## Mapping the Republic of Letters

- Allowing User-Defined Data Models
- New Direction: Tapping into Domain Expertise by Building Contextual Schema Through an Interactive Visual Interface



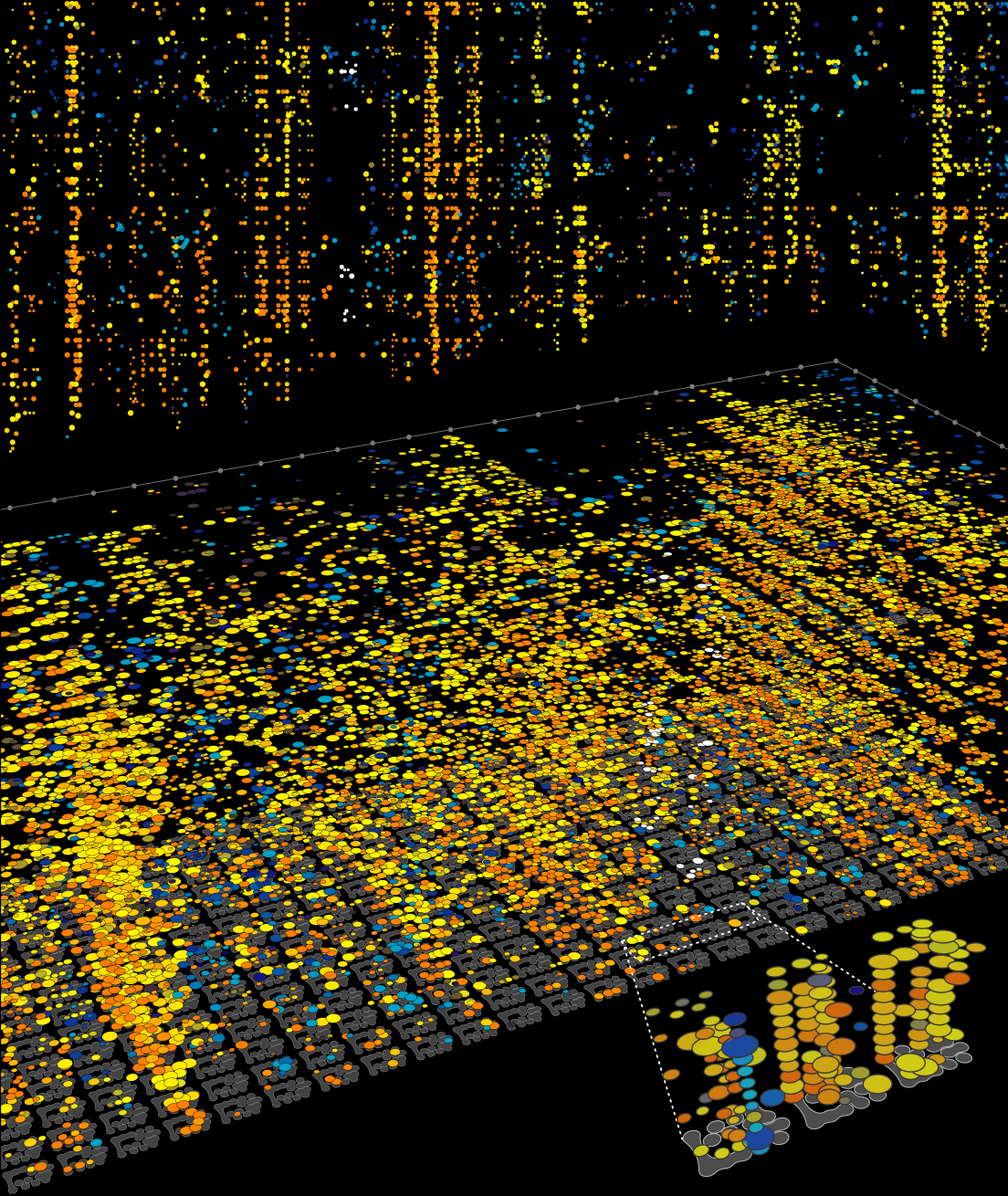
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# Mass Cytometry Data on Biological Systems is Large, Hyper-Dimensional, and Complex

1.2B data points:

1 patient blood sample

24 drugs

2M cells per drug

25 phospho-proteins per cell

*reduced and visualized as*

113,000 data points:

1 patient blood sample

24 drugs (x axis)

12 stimulation conditions (z axis)

12 cell types (y axis)

14 phospho-proteins per cell

(nested diagram)

2 drug measures (circle size & color)

*Cover of Nature Biotech, Sept 2012.*

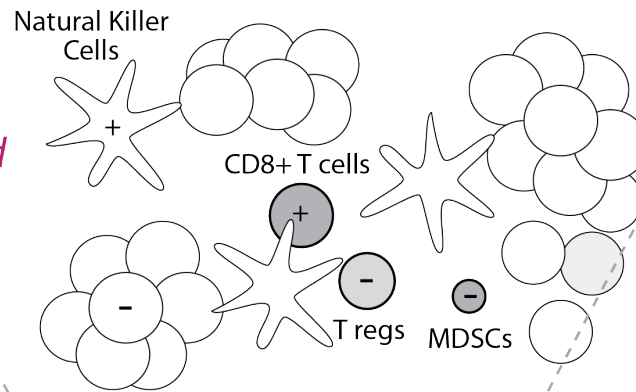
# Extended Information Context

**Patient Stratification** allows for the development of therapies per “type” of cancer, and for physicians to ultimately be able to treat each patient uniquely

**Patients** have very different cancers

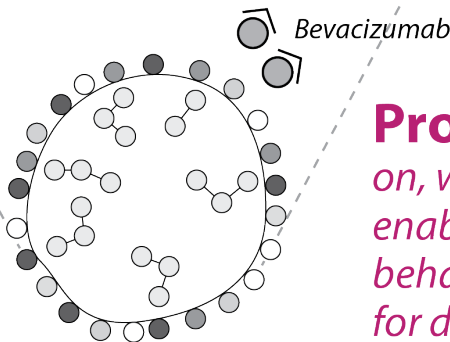


**Tumors** consist of a variety of types of cells, including cancer cells and immune cells



**Cell Types** have unique and shared behaviors; some cells fight cancer cells while others reinforce them; cell types can indicate the aggressiveness of cancer; they can also be used as cell therapies

**Single Cells** have variations of behaviors even within a cell type

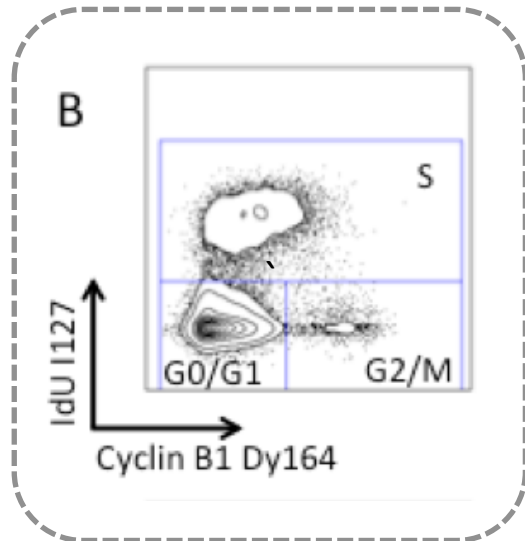


**Proteins** on, within and secreted by cells enable us to identify specific cell behaviors; they are often targeted for drug therapies

# Current Visualizations Do Not Suffice for Data Exploration

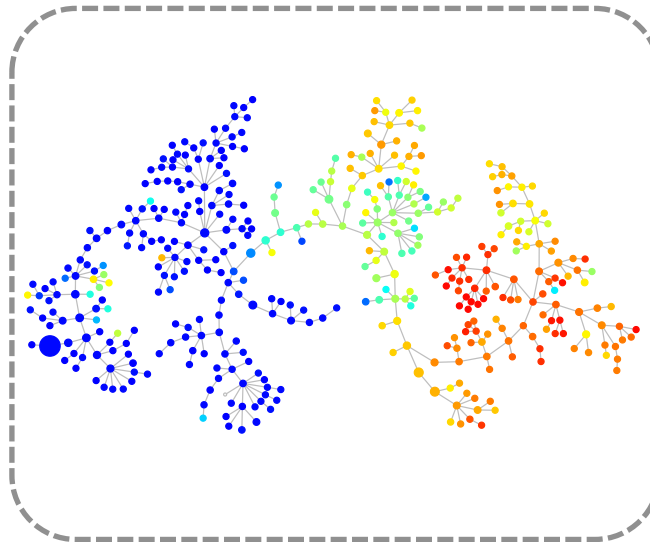
For a single patient and single experimental condition...  
(assuming 30 cell types and 30 proteins measured)

900  
biaxial plots

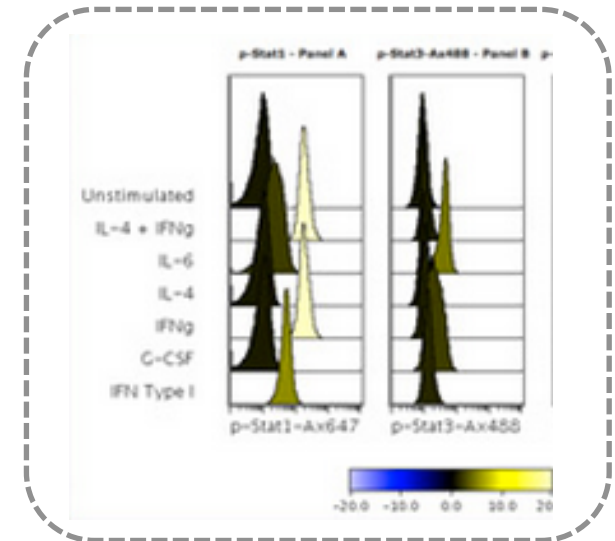


*Behbehani, Cytometry, 2012*

30  
SPADE trees

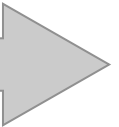


900  
histograms



[www.cytobank.org](http://www.cytobank.org)

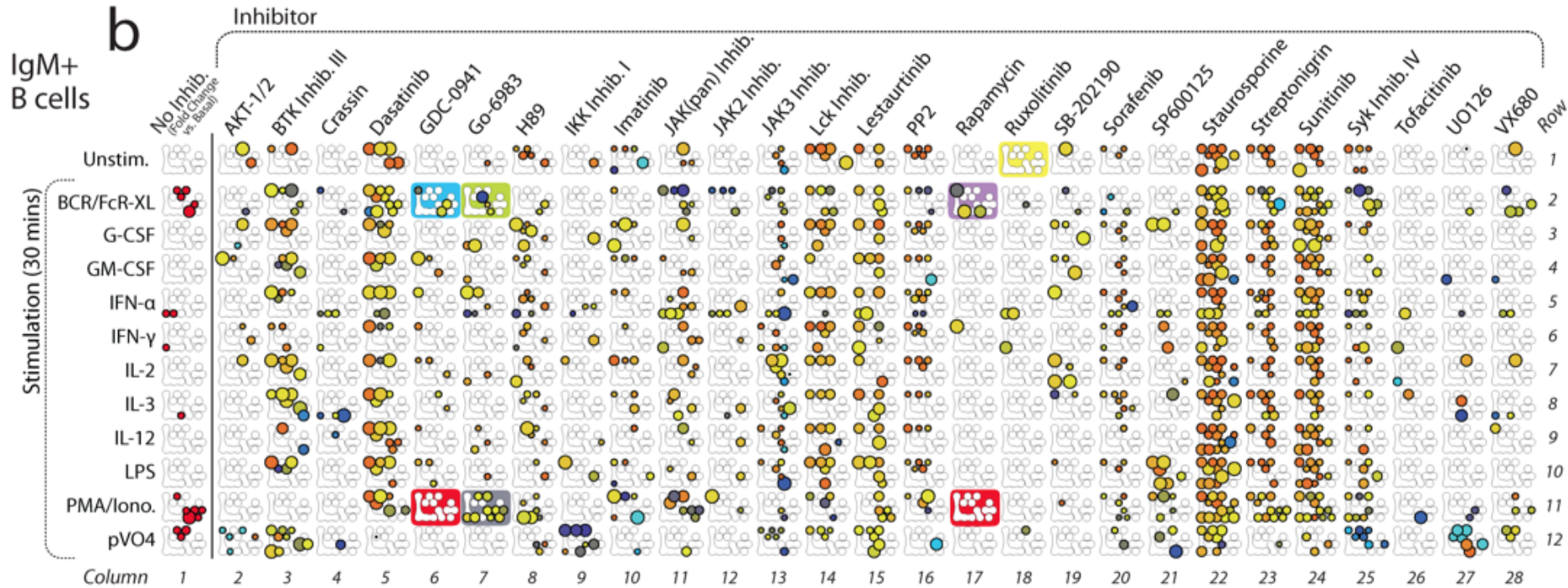
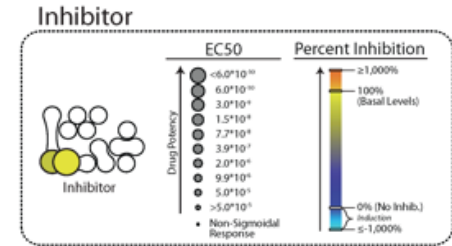
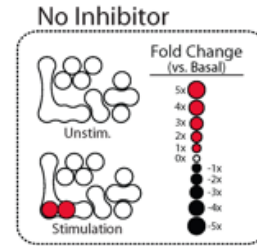
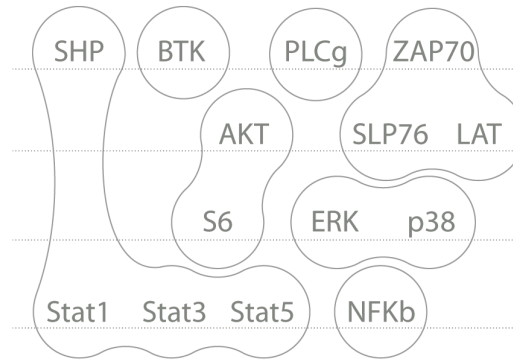
increasing scale of data context





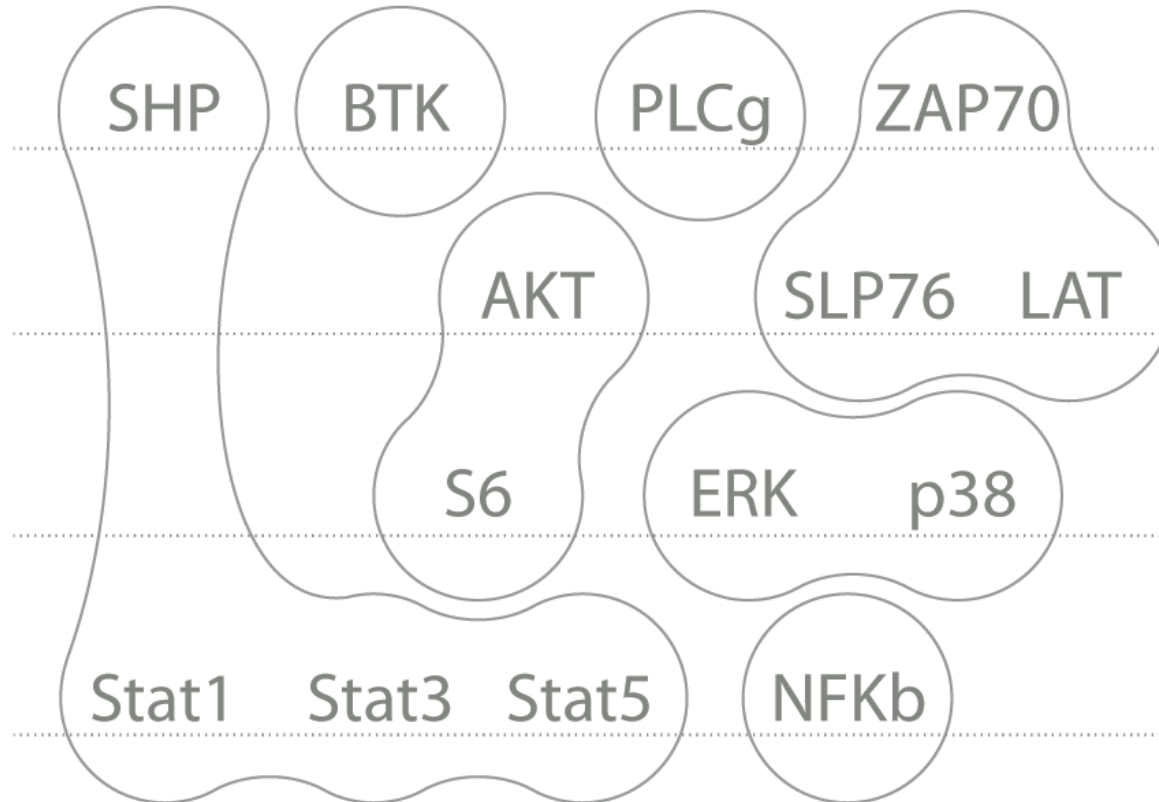
# Nested Organizations Visualize Data Across Scales

The diagram provides a layer of **organization** to view more data, and embeds **contextual** information to ease interpretation.





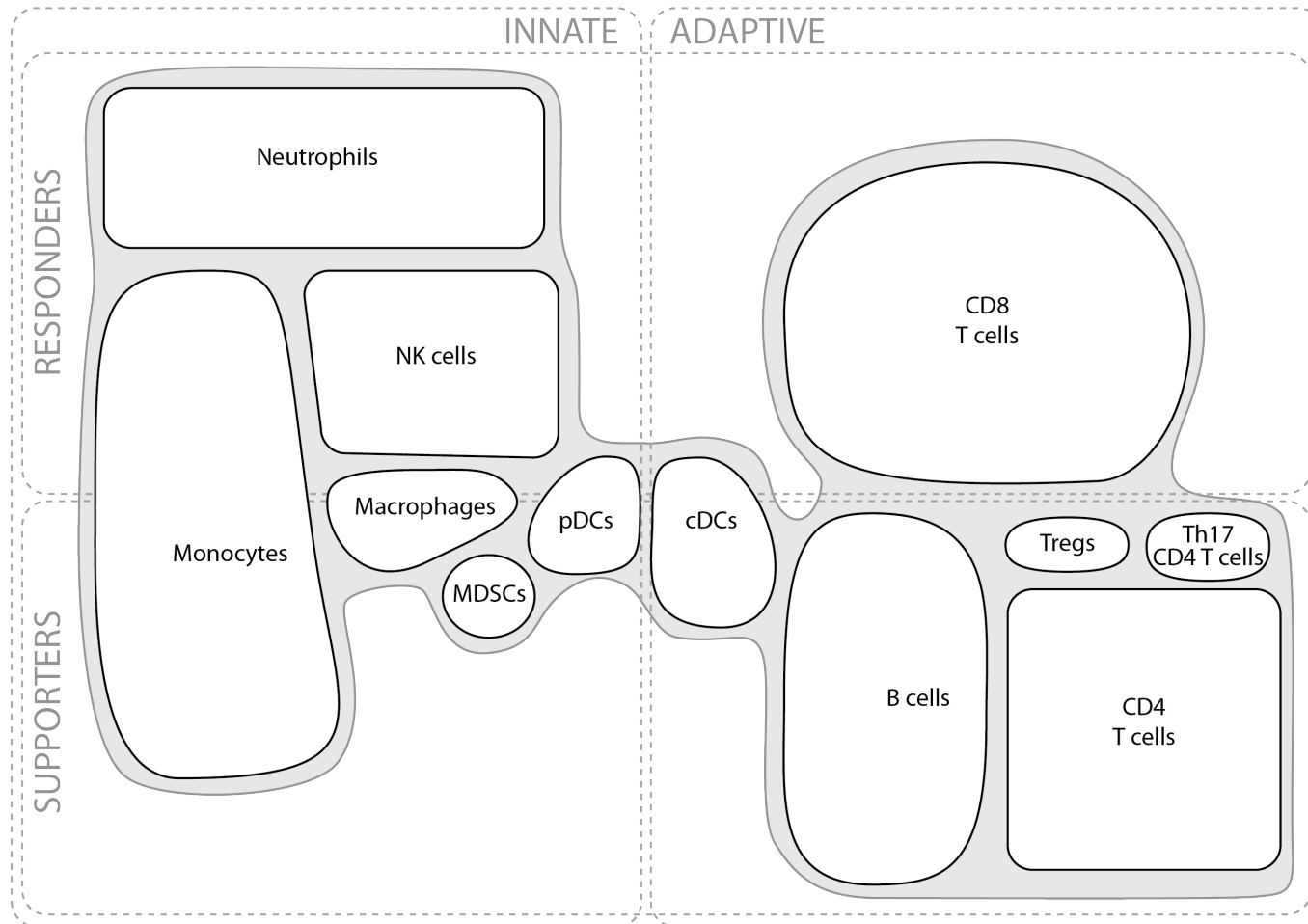
# Contextual Mental Models Support Our Memory of Data



Example of a conceptual diagram for organizing signaling data on single phospho-proteins – a “signaling network,” so to speak

*Erica Savig and Bernd Bodenmiller*

# Contextual Mental Models Support Our Memory of Data

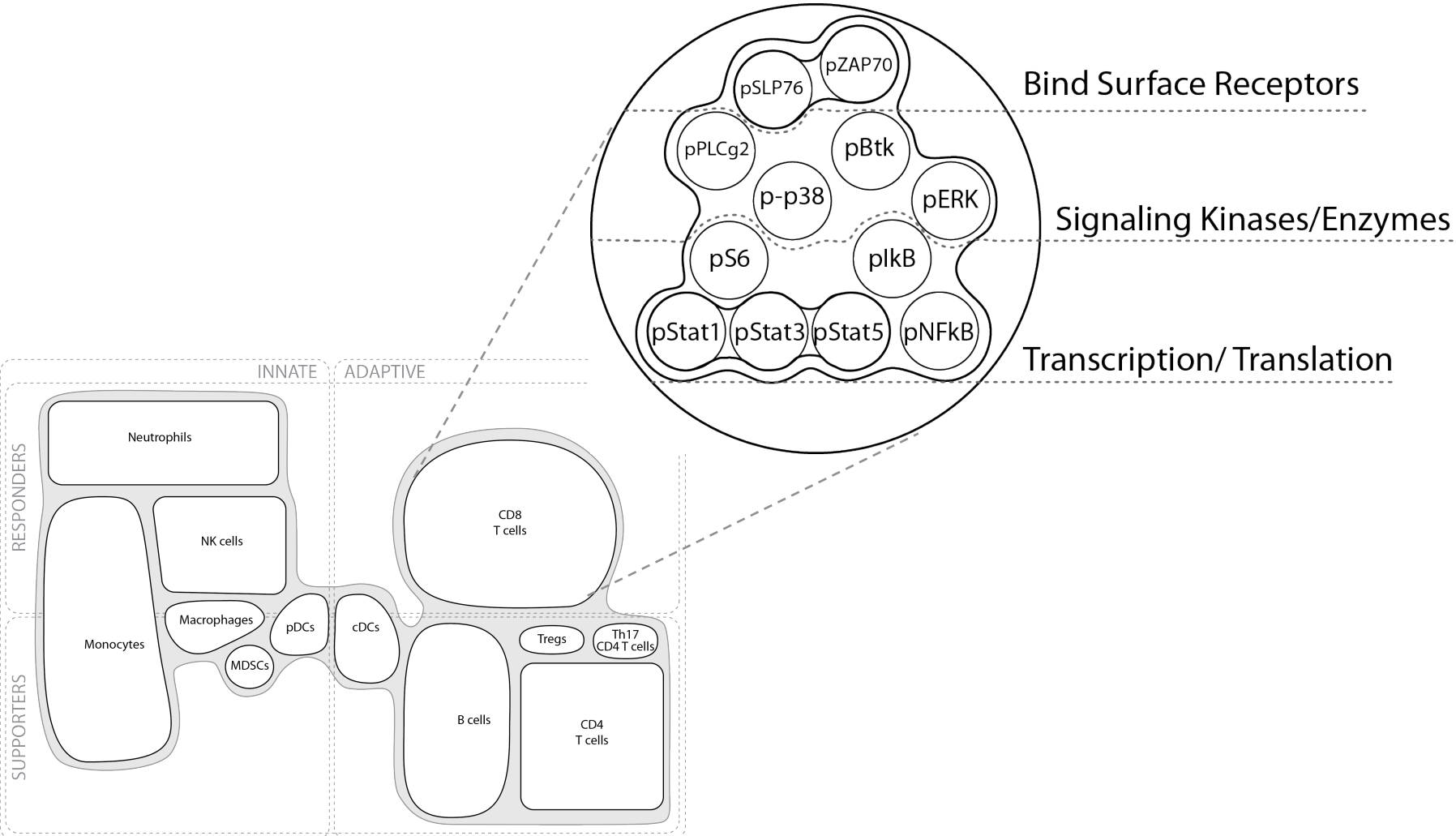


A conceptual diagram for organizing immune **cell types**.

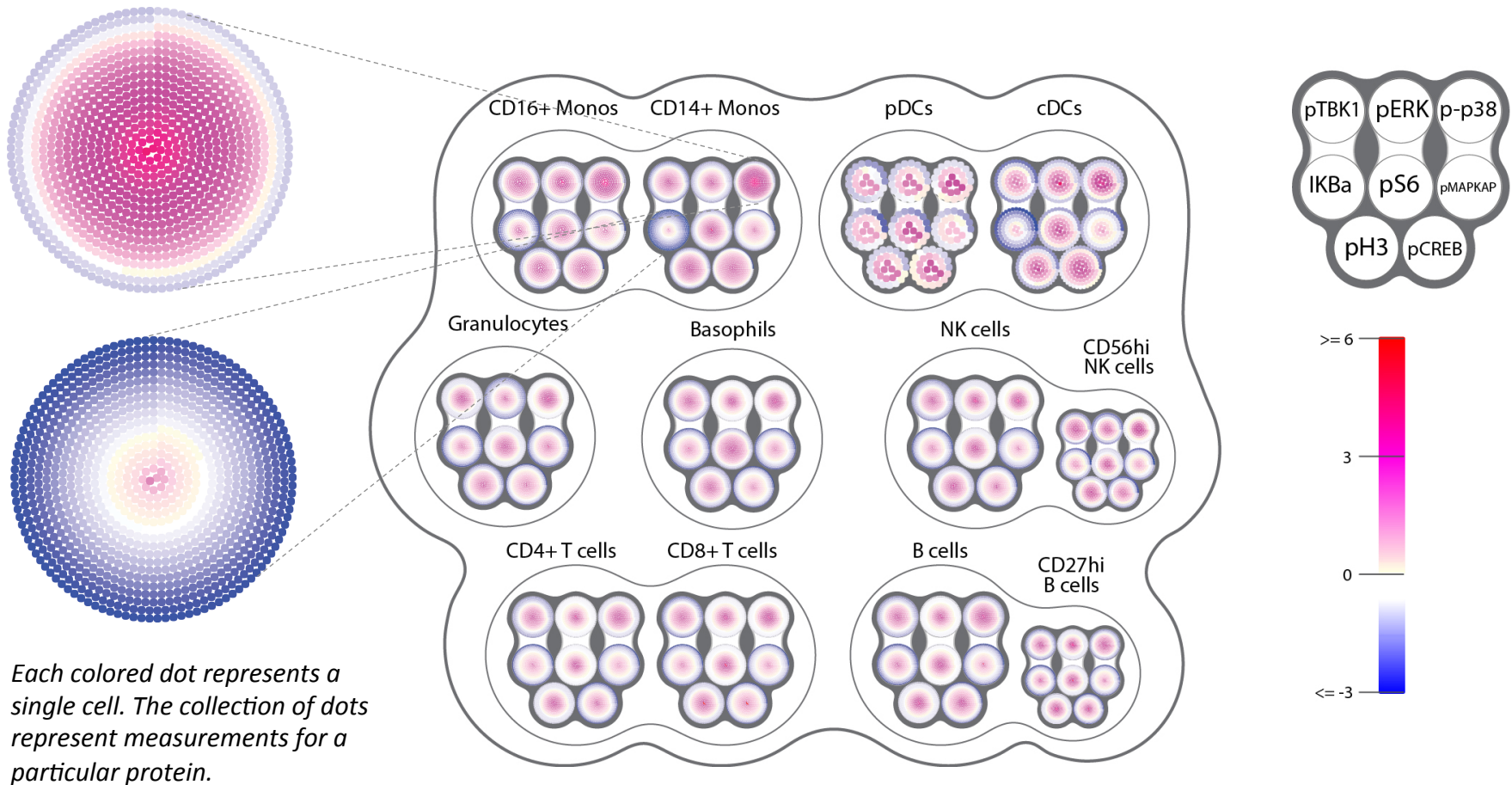
*Erica Savig and Gabi Fragiadakis*

# Nesting Contextual Organizations Supports Synthesis of Data Across Scales

A conceptual diagram for organizing signaling **proteins**



# Mental Maps and Nesting Improve Data Exploration

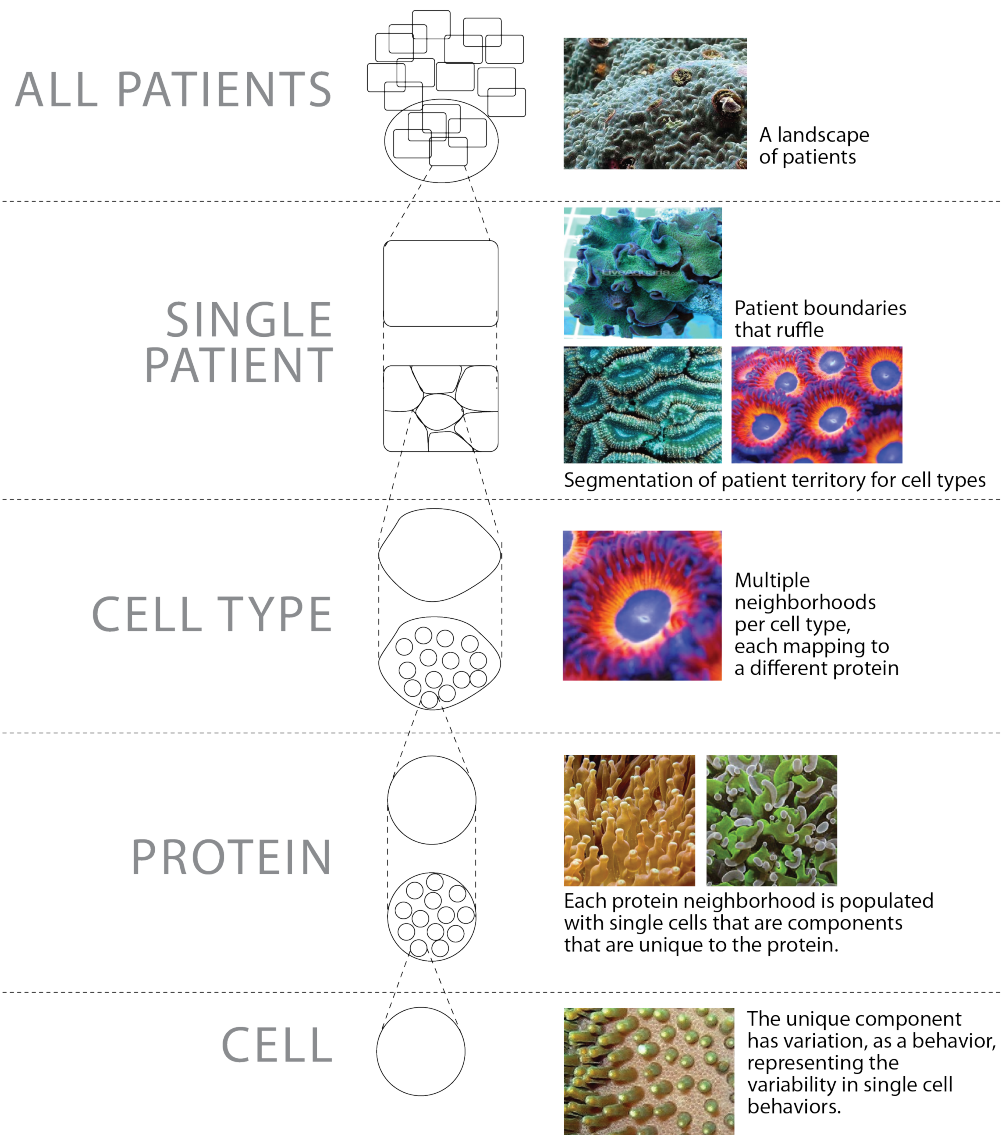


*Flagelin stimulation of peripheral blood mononuclear cells\_ the difference in protein levels between the stimulation state of single cells and the basal/unstimulated state of the median per cell type.*

*Erica Savig, Elena Hsu and Bill O'Gormon*

# New Direction: Tapping into Perceptual Potentials

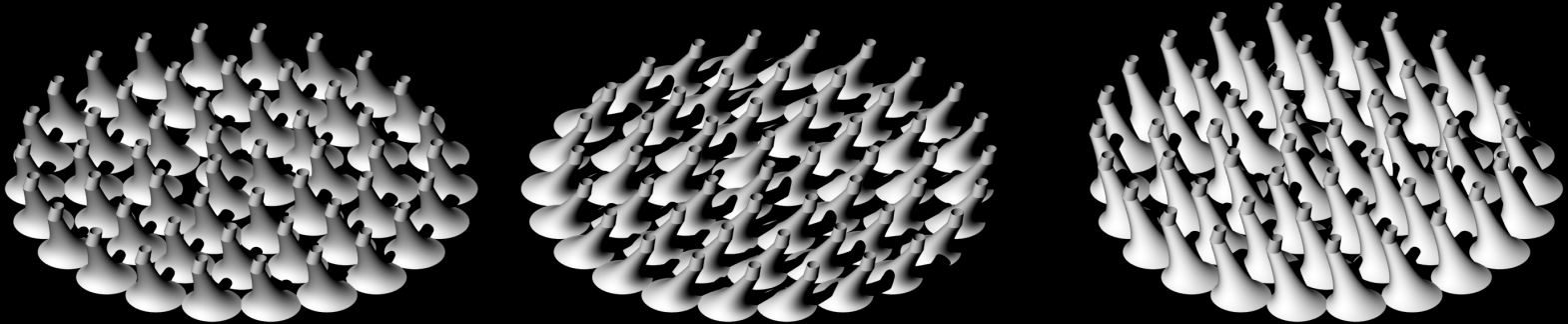
Using Natural Forms and Qualitative Features to Offer Substantive Representations for Offloading Existing and New Knowledge



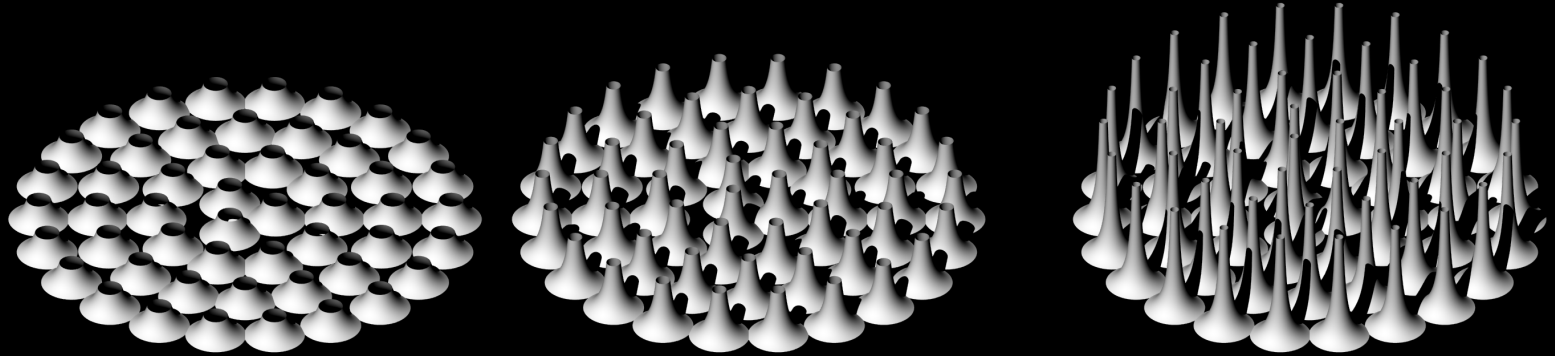


# Parametric Modeling Quantitatively Maps Single Cell Protein Levels to Individual Qualitative Components

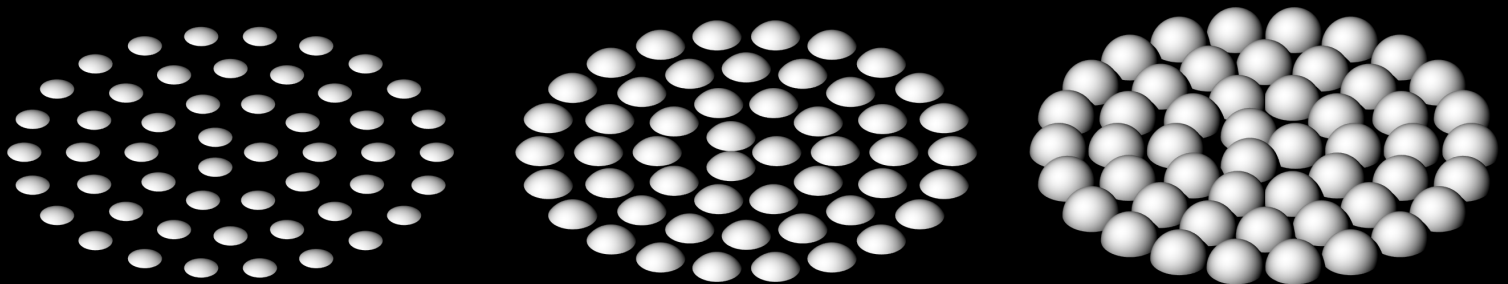
Component  
and Behavior  
for Protein 1



Component  
and Behavior  
for Protein 2



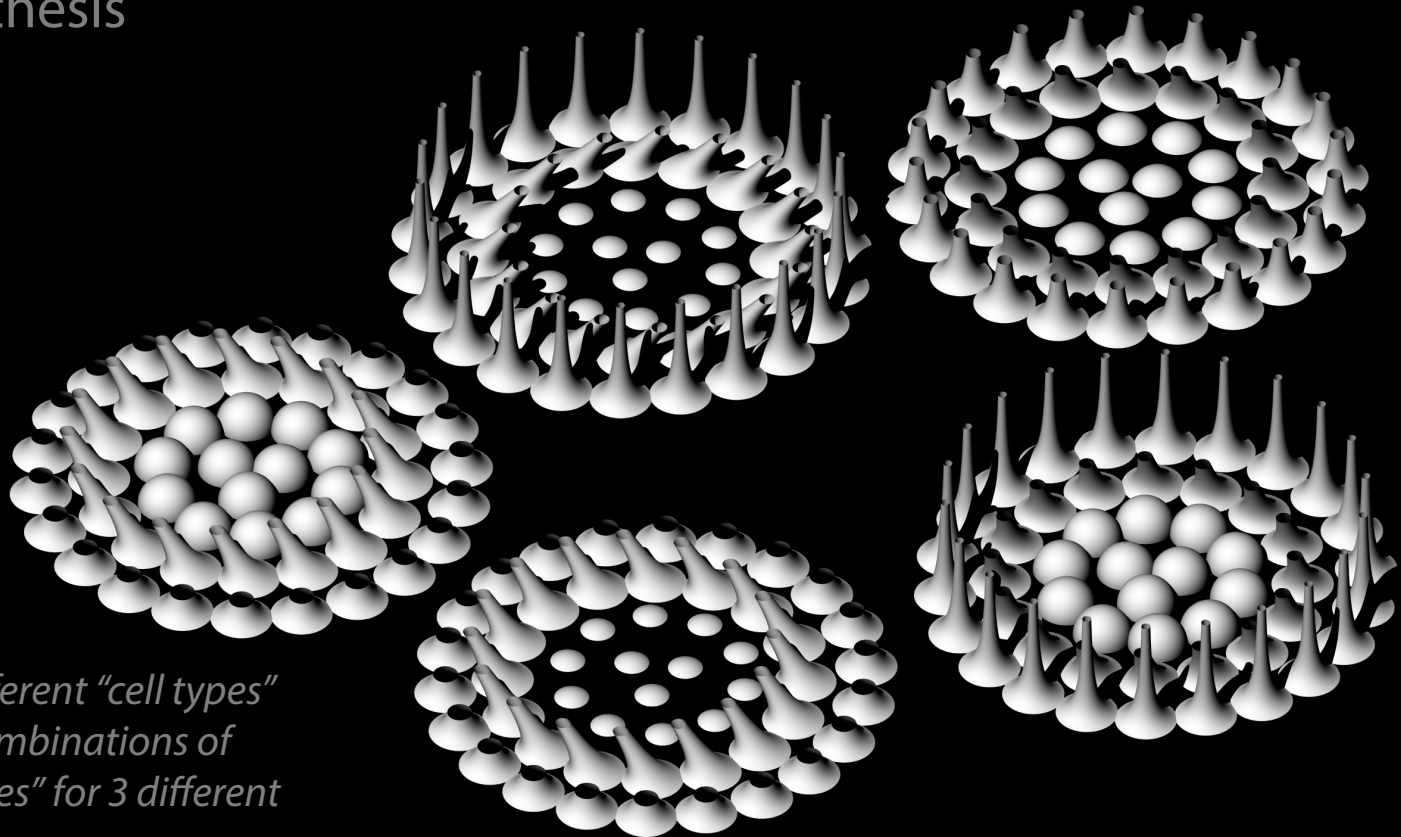
Component  
and Behavior  
for Protein 3



# Designing Qualitative Multi-Scalar Data Architectures

## Considerations To Be Addressed:

- Selecting Appropriate Representations Per Protein
- Maintaining Contextual Organization at Various Scales
- Maintaining Data Structure within Architectural Relationships
- Bottom-Up Emergent Representations Across Scales
- Total Synthesis



*Example of 5 different "cell types" with different combinations of "protein responses" for 3 different proteins.*

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	1500	1600	1700
	<i>Saintgermain</i>	<i>Coke</i>	<i>P. King</i>
<i>Lynwool</i>	<i>Fitzherbert</i>	<i>Brissonius</i>	<i>Hale Holt Poster</i>
	<i>Amir</i>	<i>Yahia Cowel</i>	<i>Atkins Talbot</i>
	<i>Littleton</i>	<i>Cyprian Pancirollus</i>	<i>Bryne Somers Viner</i>
	<i>Fortescue</i>	<i>Alciat</i>	<i>Fabrot Hardwicke</i>
<i>igne</i>	<i>H. Boetius</i>	<i>Hotman</i>	<i>Greaves Montfaucon</i>
	<i>P. Comines</i>	<i>Cujacius</i>	<i>Abulghazi Hearne</i>
	<i>Khondamir</i>	<i>Dayila Maimburg</i>	
<i>in</i>	<i>Mirkhond</i>	<i>Baronius Mezerau Belsuet</i>	<i>Cantemir</i>
	<i>Machiavel</i>	<i>Thuanus Herbelot</i>	
	<i>Eln Sbonah</i>	<i>Buchanan</i>	<i>Marsham Barnage</i>
	<i>Pontanus</i>	<i>Stow</i>	<i>Dugdale Dupin</i>
	<i>Jovius</i>	<i>Usher</i>	<i>Rapin</i>
<i>Blondus</i>	<i>Cranzius</i>	<i>Mariana</i>	<i>Burnet</i>
<i>rtine</i>	<i>Guiciardin</i>	<i>Fa. Paul</i>	<i>Verlot</i>
	<i>Bembo</i>	<i>Speed Heylin Cave</i>	
	<i>Platina</i>	<i>Steidan</i>	<i>Petavius Echard</i>
		<i>Olaus M. Camden</i>	<i>Vaillant</i>
	<i>M. Ducas</i>	<i>Leland Cotton</i>	<i>Strype</i>
<i>o: Wals:</i>	<i>Pol: Virgil</i>	<i>Spelman</i>	<i>Prideaux</i>
<i>a</i>	<i>Merula</i>	<i>Busbequius</i>	<i>Ashmole</i>
	<i>M. Marullus</i>	<i>Lambinus</i>	<i>Kercher Perizonius</i>
	<i>Musurus</i>	<i>Lipsius</i>	<i>Rochebault Simon</i>
<i>Philadelphus</i>	<i>Camerarius</i>	<i>Birese</i>	<i>Hardouin</i>
	<i>Budaeus</i>	<i>Cervantes</i>	<i>Morhoff Masclef</i>
	<i>Chalchondites</i>	<i>On: Panvinius</i>	<i>Bochart Spencer Le Sage</i>
	<i>Argyropylos</i>	<i>P. Aretine Bodinus</i>	<i>Freinshemius Petter</i>
	<i>Lascaris</i>	<i>Sigonius</i>	<i>Salmasius Fabricius</i>
<i>Trapezuntius</i>	<i>P. Manutius</i>	<i>Qataker Faber Kuster</i>	
<i>Tbeod: Gaza</i>	<i>R. Stephens</i>	<i>I. G. Vassius</i>	<i>Rollin</i>
<i>as</i>	<i>A. Manutius</i>	<i>H. Stephens</i>	<i>Du Fresnoe Hucl</i>
	<i>Reuchlin</i>	<i>J. Scaliger</i>	<i>Hottinger Richardson</i>
<i>oggio Fl.</i>	<i>J. C. Scaliger</i>	<i>Scoppius</i>	<i>Barnes</i>
<i>L. Valla</i>	<i>L. Vives</i>	<i>Casaubon Golius Spanheim</i>	
<i>ylus</i>	<i>Wassettus</i>	<i>Rabelais</i>	<i>Oruter</i>
	<i>Politian</i>	<i>Turnebus</i>	<i>Meursius I. Gronovius</i>
<i>Nhethamsted</i>	<i>Alexander A.</i>	<i>Drusius</i>	<i>Temple Fielding</i>
	<i>Grocyn</i>	<i>Montaigne</i>	<i>Quivedo Ducier</i>
	<i>H. Barbarus</i>	<i>Cheke</i>	<i>Buxtorf Sen: G. Hicks</i>
<i>Agricola R.</i>	<i>Aucham</i>	<i>Selden</i>	<i>Bentley</i>
	<i>W. Lilly</i>	<i>P. Sydney</i>	<i>Pococke Hudson</i>

HISTORIANS and ANTIQUARIES  
LAWYERS  
ORATORS and CRITICS &c

# Early Modern Historical Data is Heterogeneous, Multi-dimensional, and Incomplete

We are attempting to understand the intellectual communities that made up the “Republic of Letters” through case studies spanning three centuries, based on **hundreds of thousands of documents** (mostly letters) and biographical data on **tens of thousands of individuals.**

Joseph Priestley’s Chart of Biography, 1765



# The Information Context: Biographical + Correspondence



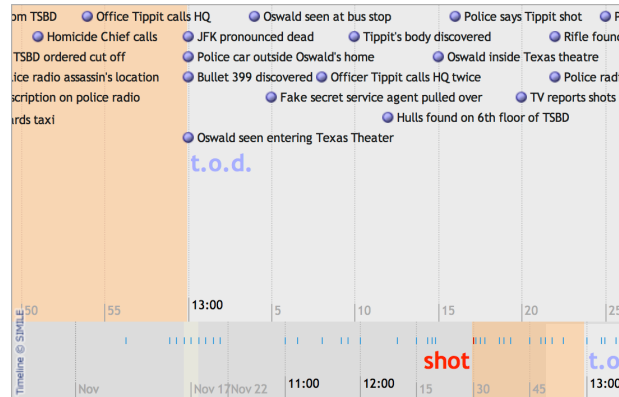


# Current Visualizations Do Not Accommodate Incomplete and Imprecise Data

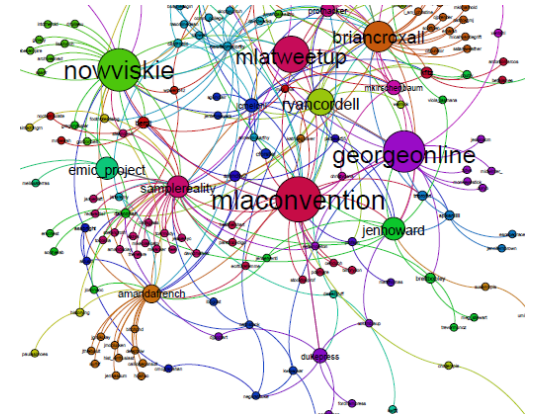
## Flight Pattern Maps



## Timelines



## Network Graphs



# Spatial-Temporal-Relational Dynamics

Letters ▾

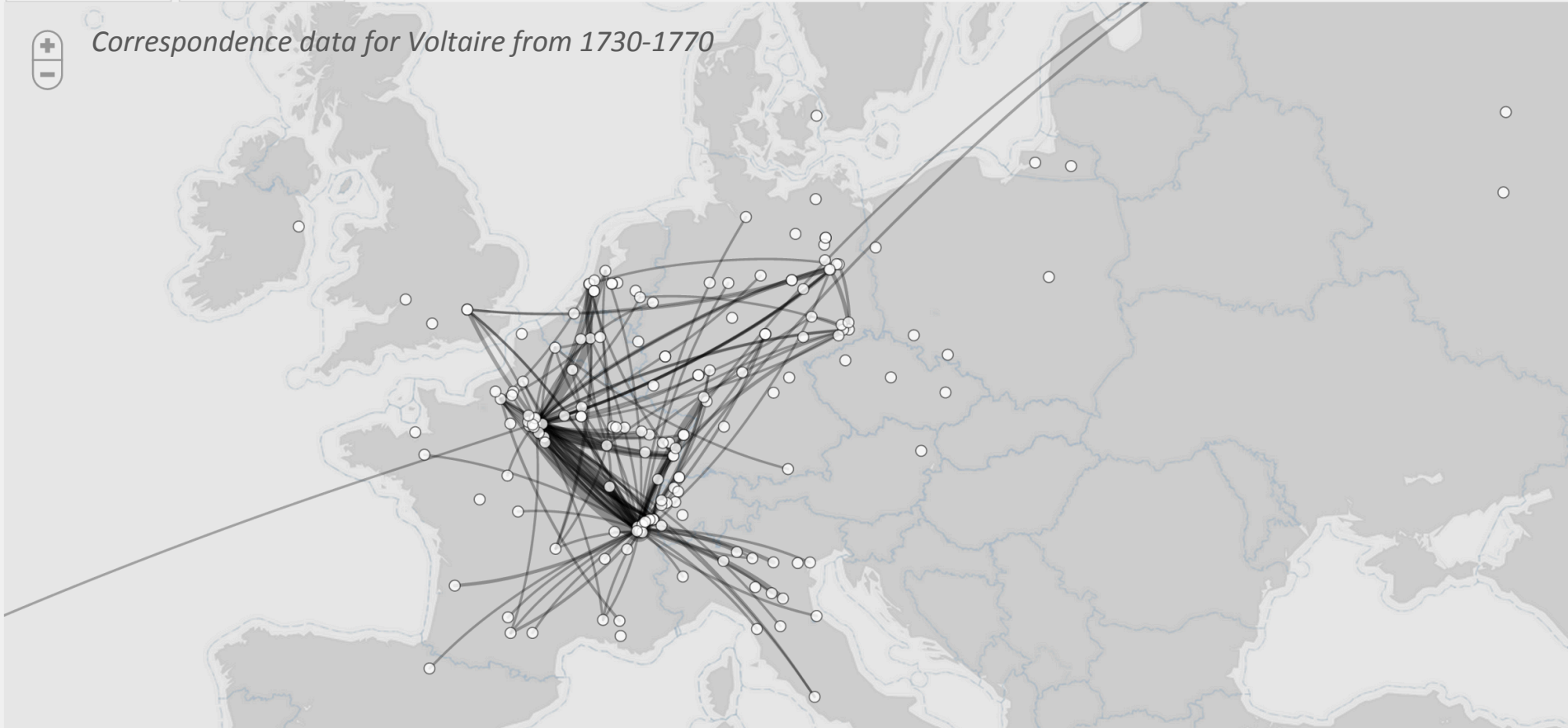
1720

1770

Go

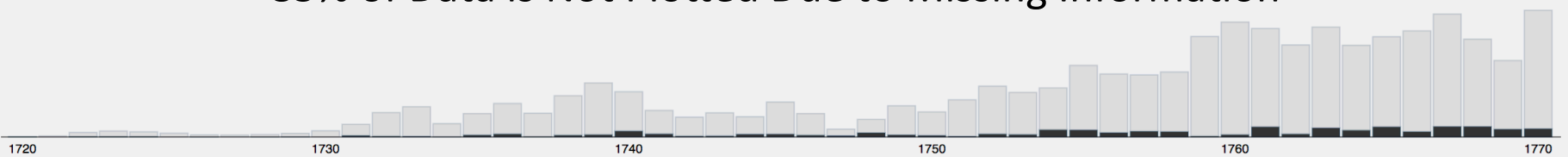


*Correspondence data for Voltaire from 1730-1770*

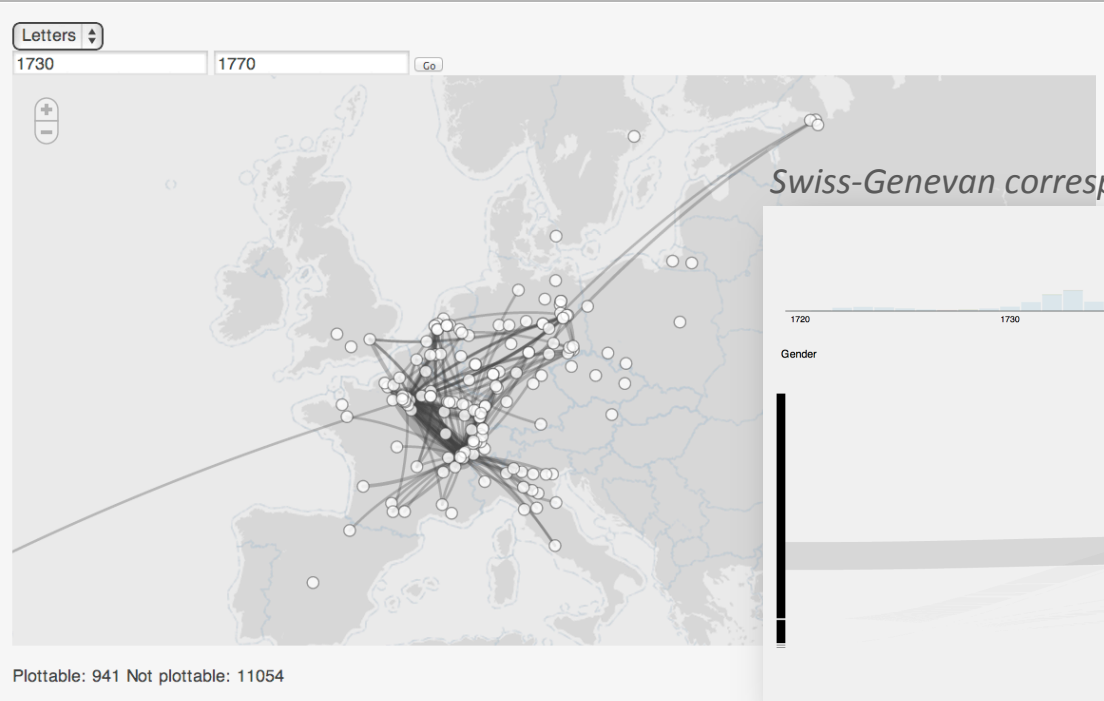


Plottable: 957 Not plottable: 11238

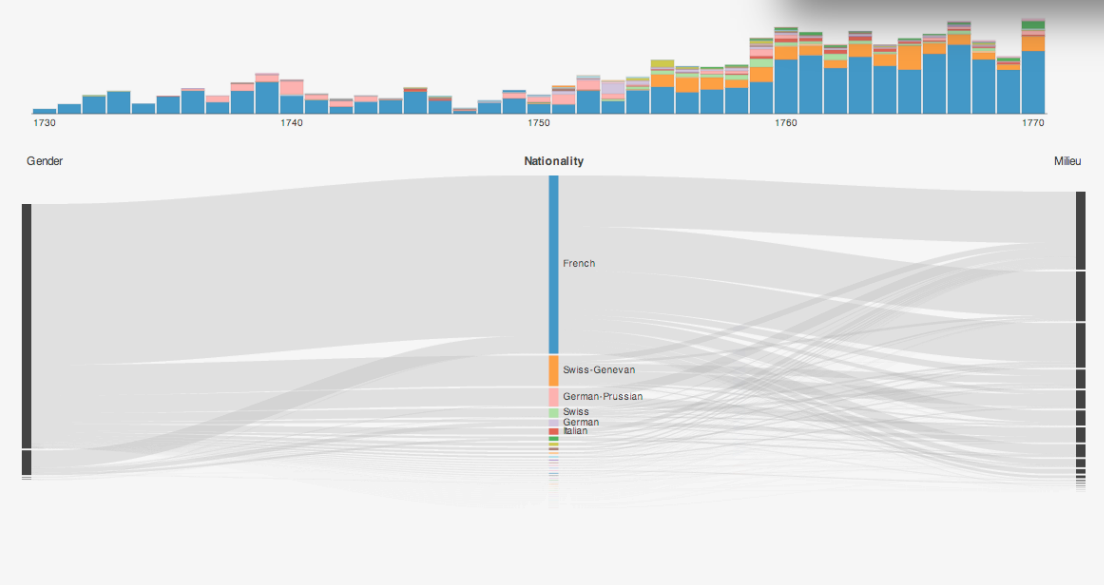
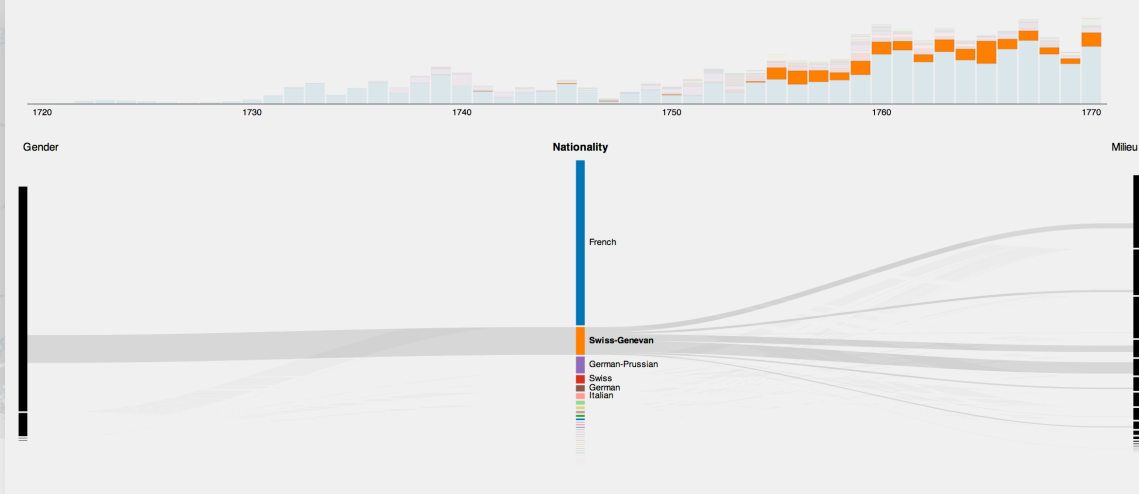
85% of Data is Not Plotted Due to Missing Information



# Interactivity with User-Defined Attributes



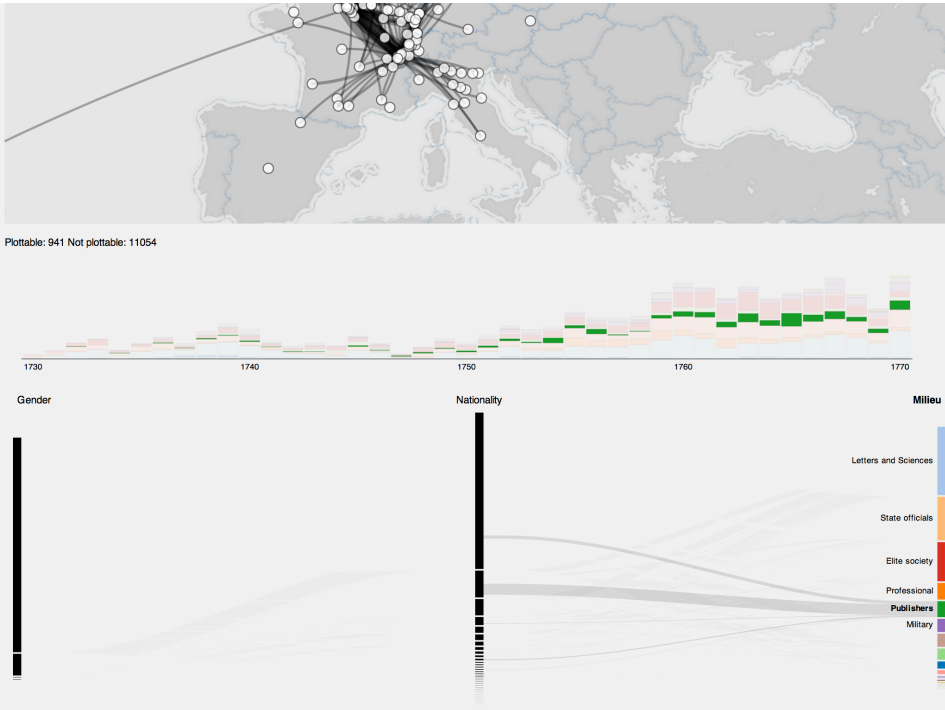
Swiss-Genevan correspondence in orange, after Voltaire's move to Geneva



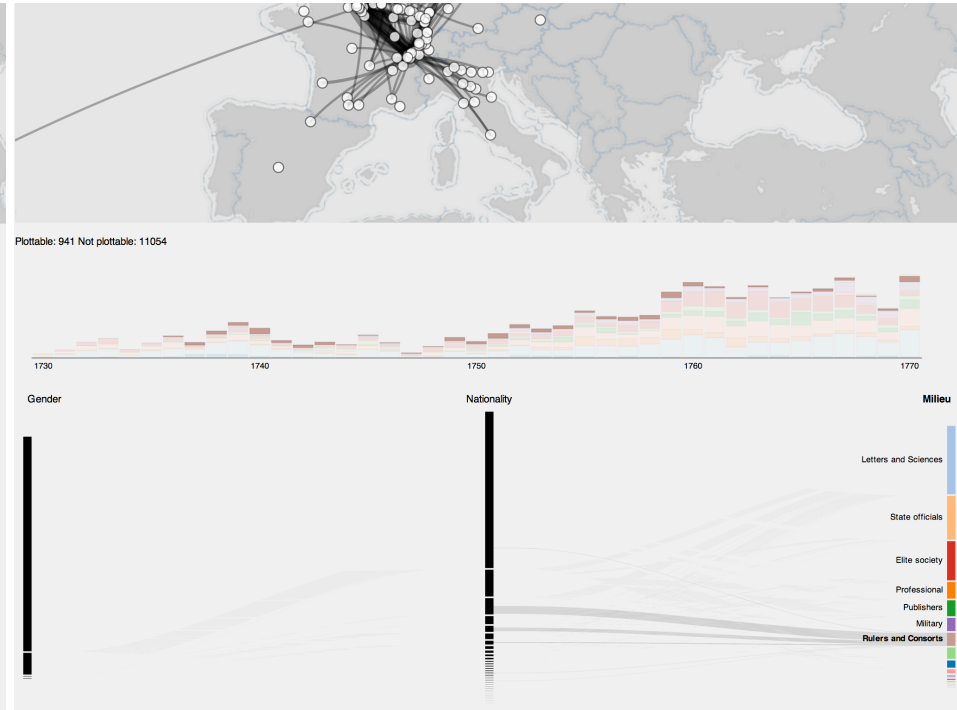
User-Defined Attributes  
+  
Interactivity with  
Parallel Visualizations  
Help with Multi-Dimensional  
Data Exploration

# User-Defined Schema for Categorization by Social Group

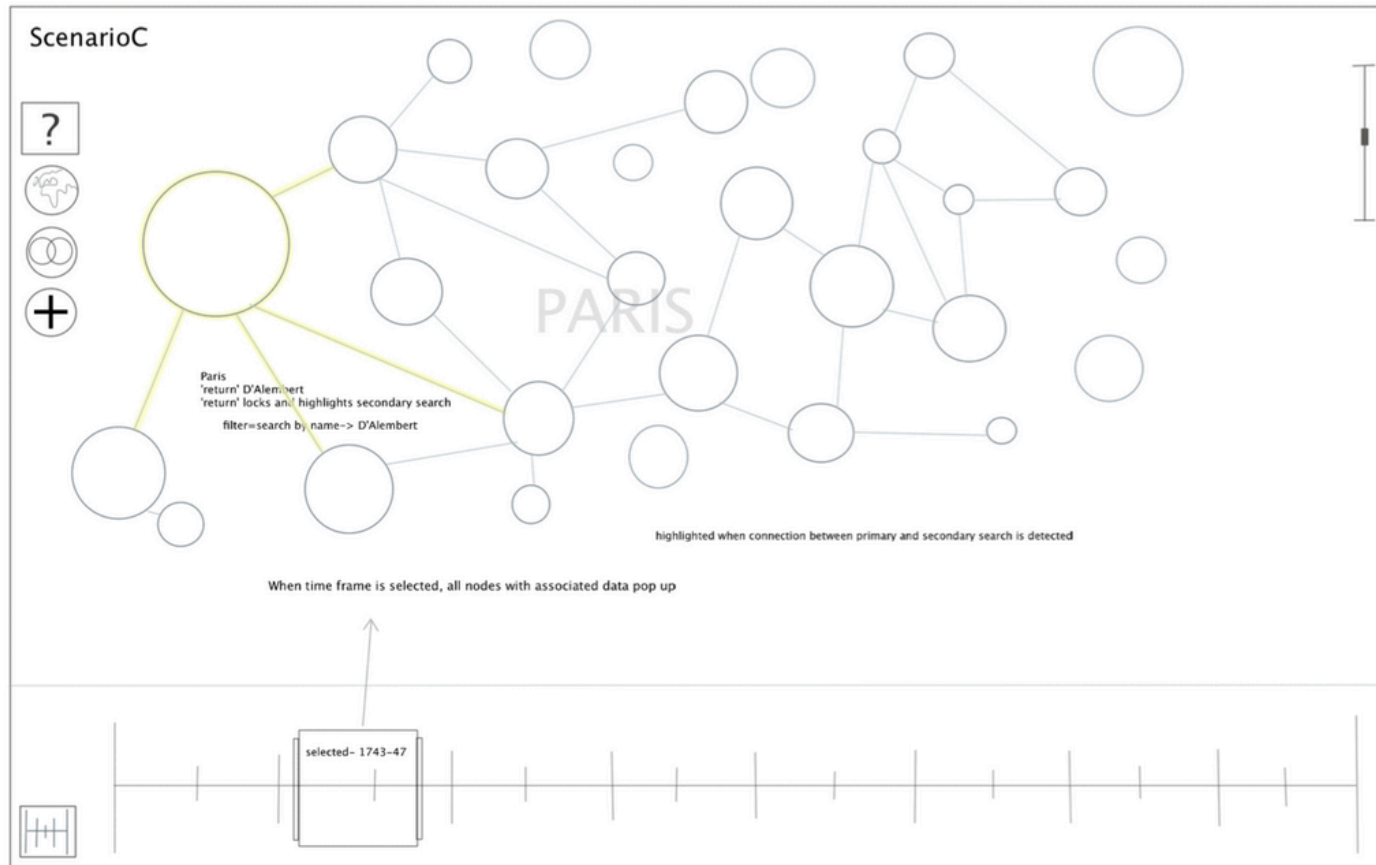
*Correspondence with rulers consistent throughout period*



*Correspondence with publishers increases in later years*



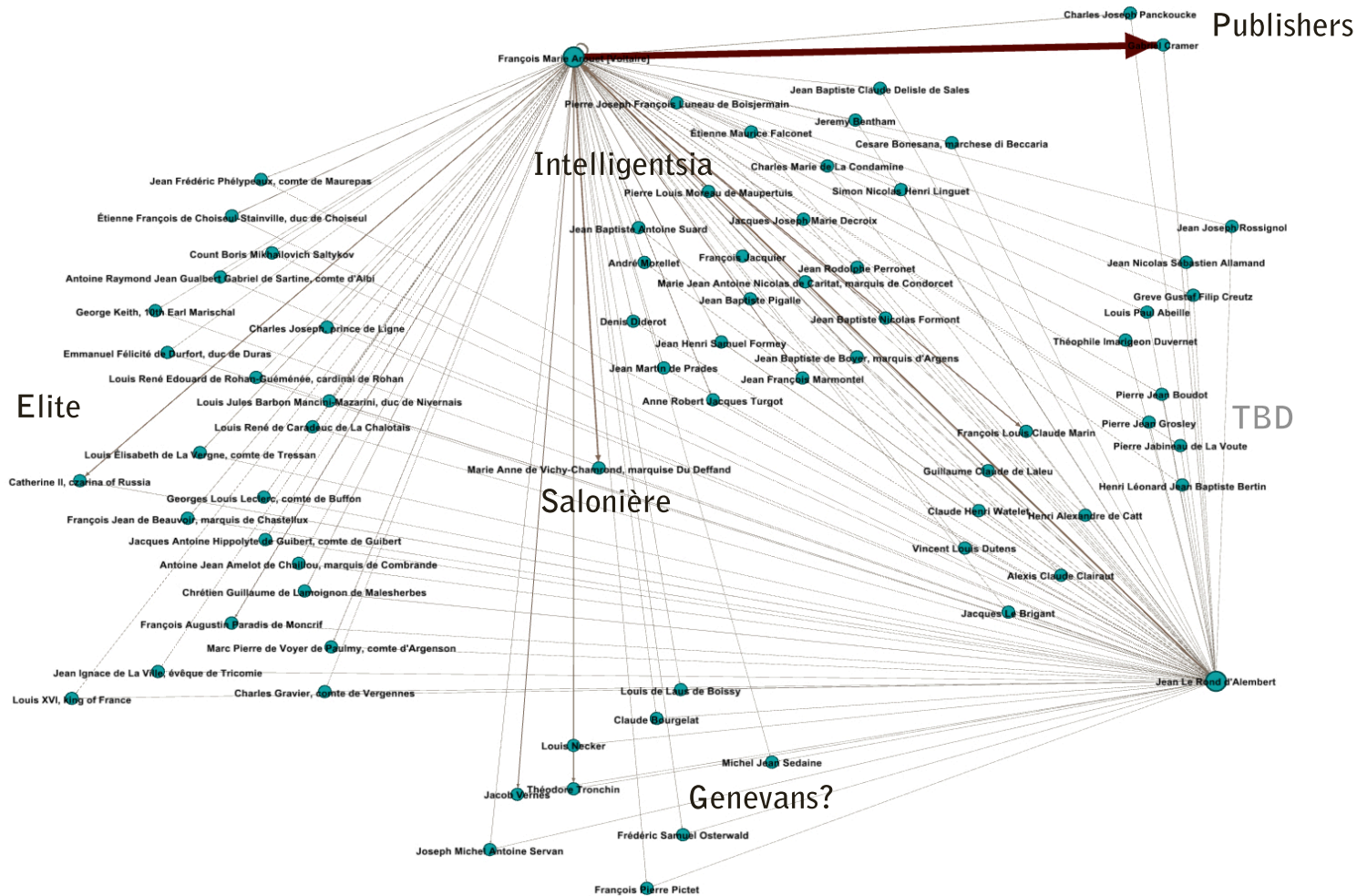
# Spatial-Temporal-Relational Dynamics



We think in terms of possible networks, loosely defined based on affiliation, shared location, or other non-explicit types of relationship.



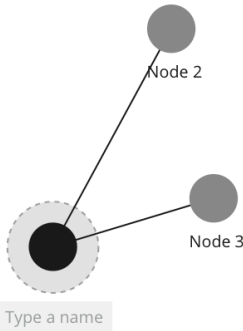
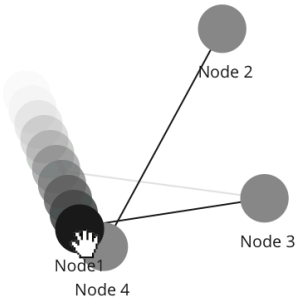
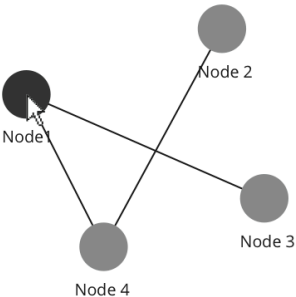
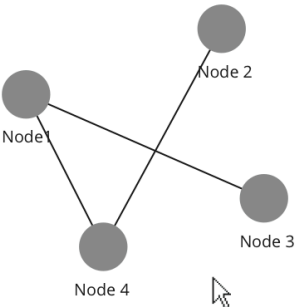
# Freedom to Construct Our Own Organizational Scheme is Part of the Knowledge Production Process



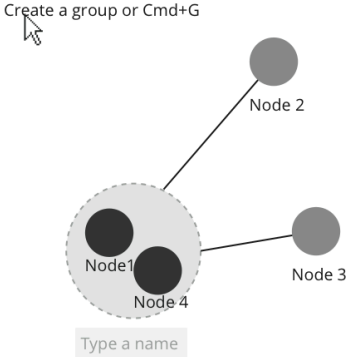
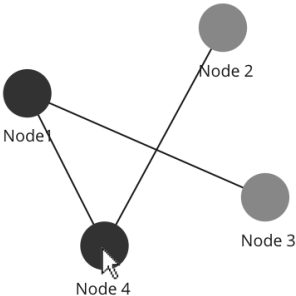
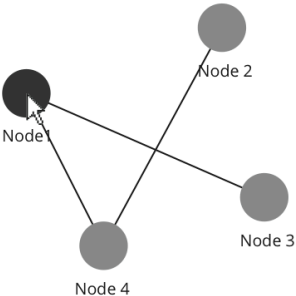
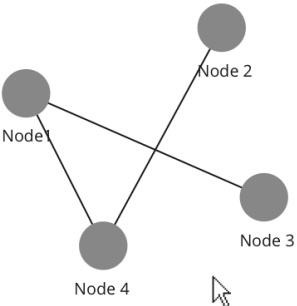
Correspondents Common to Voltaire and D'Alembert  
based on letters authored by Voltaire and D'Alembert only

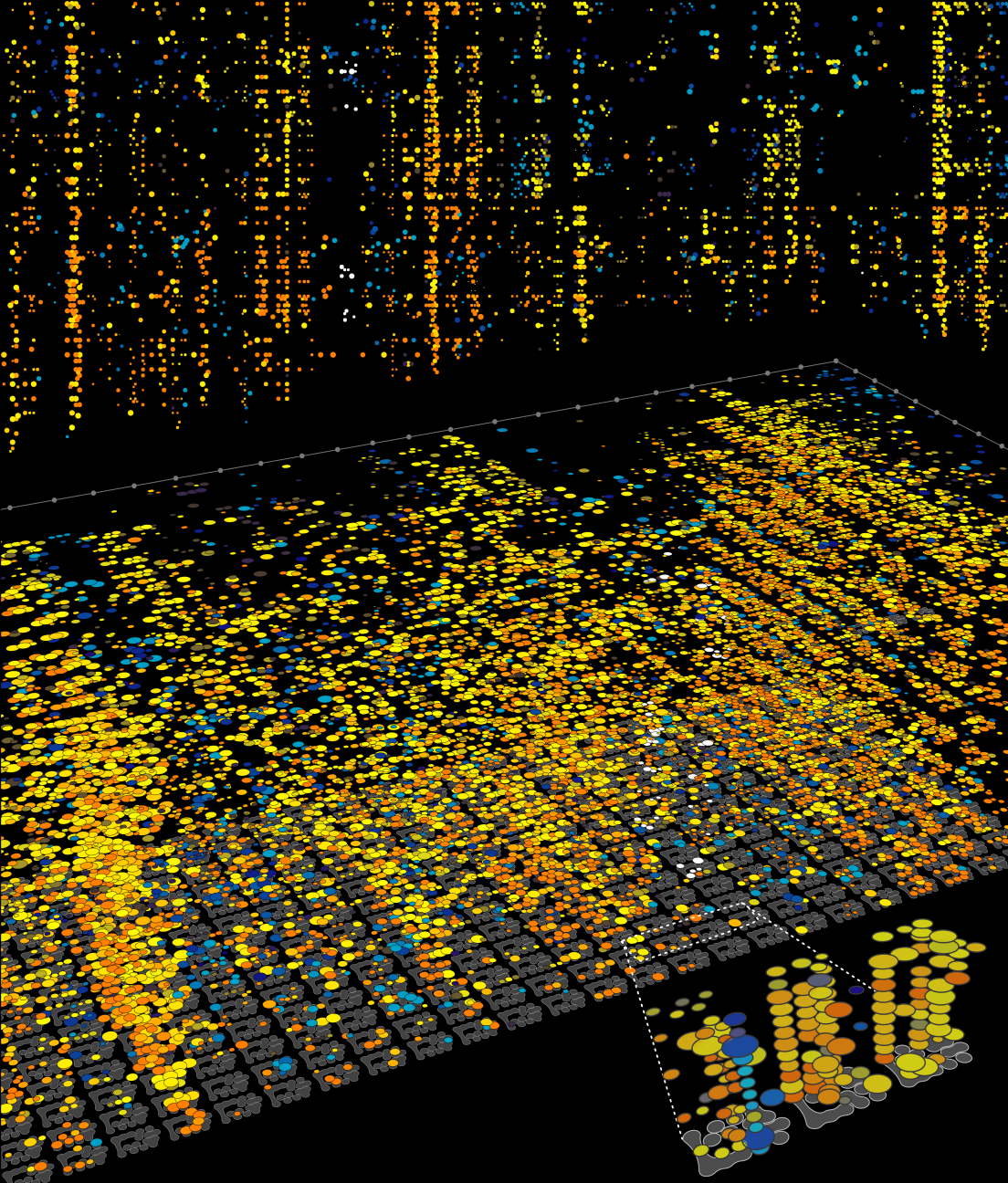
# New Direction: Building Schema Directly, Contextually, Through the Visual Interface

## Treat more nodes as one



## Create a group of nodes





# Common Design Strategies for Exploring Signaling Networks in Biology and Intellectual Geographies in History

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