Molecule/idea code expression in layered networks

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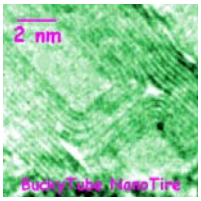
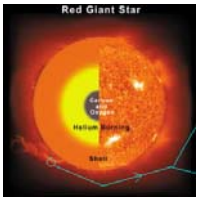
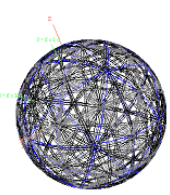
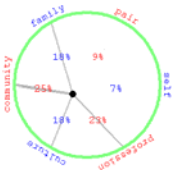
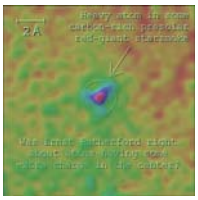










Although I've spent a lot of time doing detective work with electrons e.g. on extraterrestrial materials & semiconductors, this talk is about a long-term side project on complex-system informatics that was inspired in part by interactions with Ed Jaynes.

Outline

- Integrating scales, disciplines, factions?
  thinking on multiple scales
  emerging subsystem correlations
- Physical models of community health
  boundary-directed niche networks
  uniting observation, belief, & consensus
  data acquisition bottleneck

The first part of this talk is about key background ideas, where I'll try to get a sense of your perspective as well. The second is about a simplex model of community health that we've been working on lately.

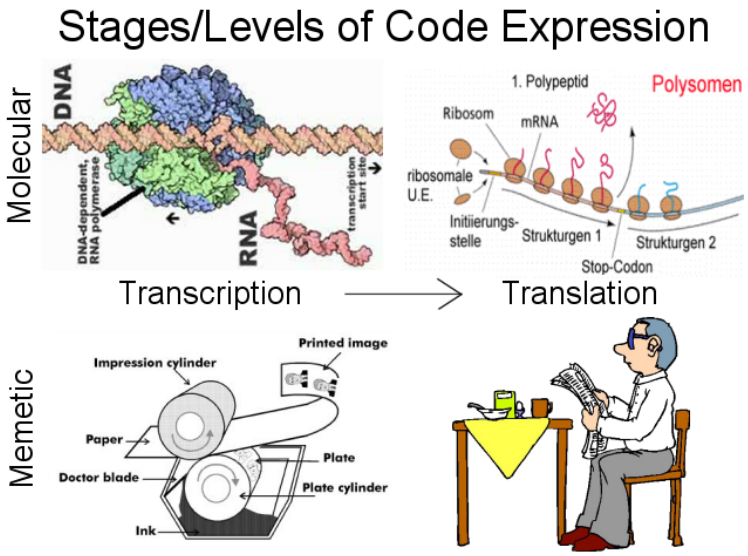
Part 1

- Integrating Scales, Disciplines, and Factions
  - Why work to inform our ideas to multiple levels of space, time, and organization?
  - **Background:** Subsystem correlations as a form of thermodynamic availability, …
  - subsystem boundaries in evolution, & …
  - life-specific correlation boundaries: molecule surface, cell wall, tissue surface, metazoan skin, plus molecule & idea code-pool edges.

Part 1 here is basically to discuss context and fundamentals relevant to Part 2.

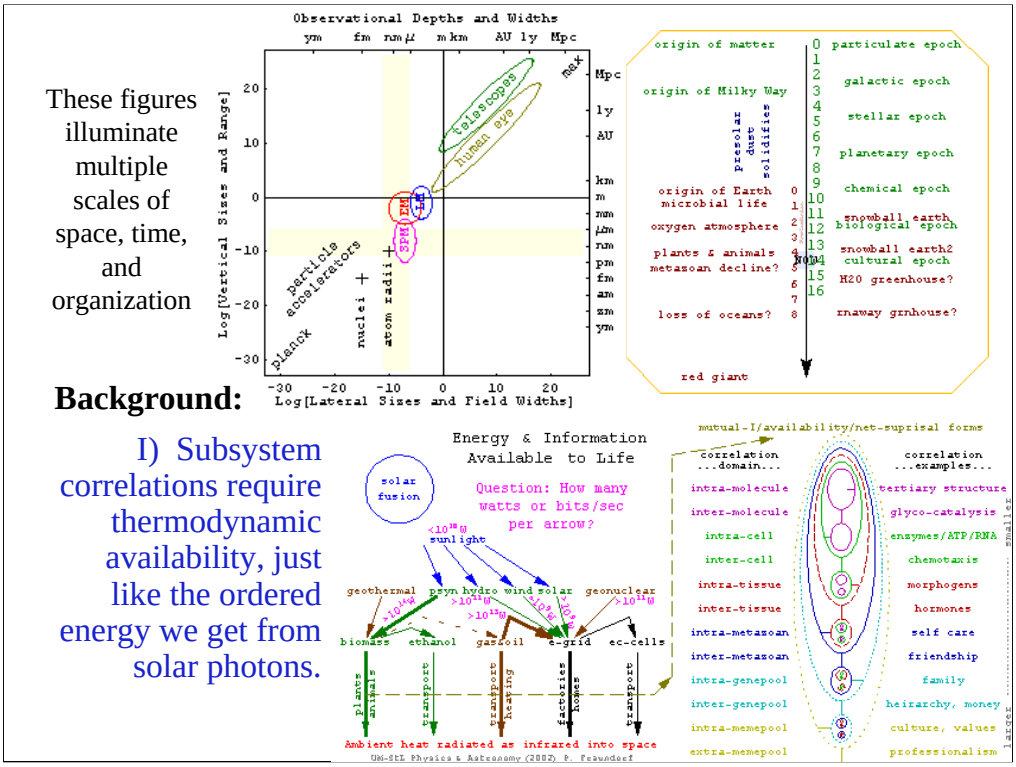
Why inform our ideas to multiple scales of space, time, and organization?

On the level of cells, only eukaryotes can assemble a bobcat from one cell, thanks to the fact that *code expression* is informed to multiple scales of space, time, & organization. What if metazoans did that for idea codes?



This slide illustrates an interesting justification for informing our ideas to multiple scales, namely the magical things (like embryonic development, butterflies, and wikipedia) that emerged after eukaryotic cells figured out how to inform the expression of their molecular codes to processes taking place on multiple scales of organization, size, and time.

These figures illuminate multiple scales of space, time, and organization

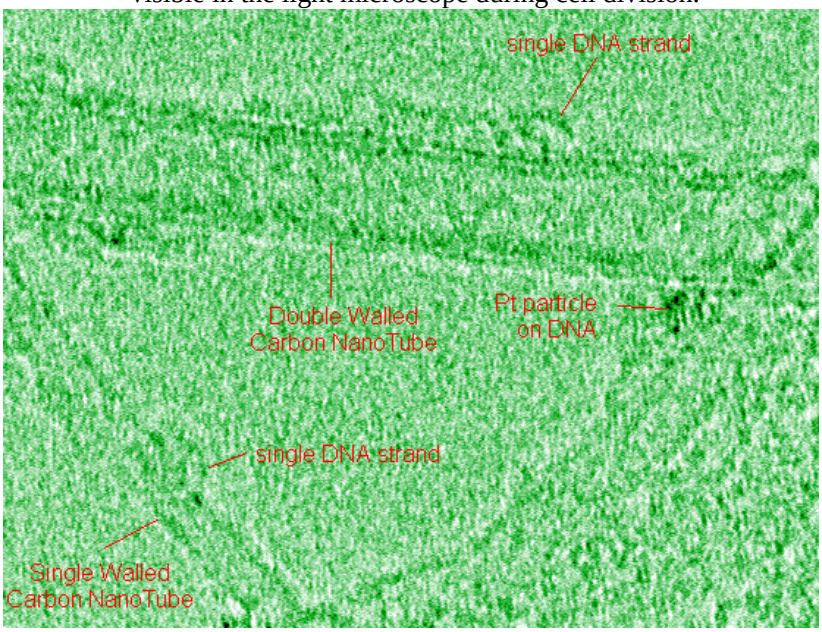


Background:

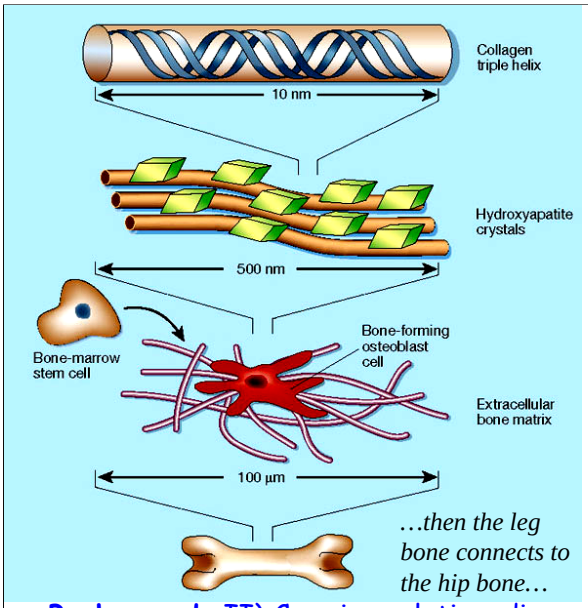
I) Subsystem correlations require thermodynamic availability, just like the ordered energy we get from solar photons.

How many here knew that the 2nd law of thermodynamics requires that creation of sub-system correlations (e.g. correlations between molecules, cells, individuals, or ideas) extracts a price in Gibbsian availability or free energy/kT? (Perhaps a third of the room said yes.) In that context, therefore, subsystem correlations (often in living systems created by reversible thermalization of solar photons) constitute a fundamental measure of order on a given level. By that same token, such order on multiple levels might provide quantitative insight into evolving complexity.

Single strand curls of a DNA molecule, like those wrapped around nanotubes here, go through many levels of folding to create chromosomes visible in the light microscope during cell division.



I couldn't resist showing you this recent picture that I took of single strand DNA curled around carbon nanotubes, mainly because it prompted me to explore briefly the hierarchical way that these single strands are folded, on one level after another, in order to pack one double helix (like a multi-level parachute) into a micron-sized chromosome during cell division. Another example of hierarchical correlation involves bones…

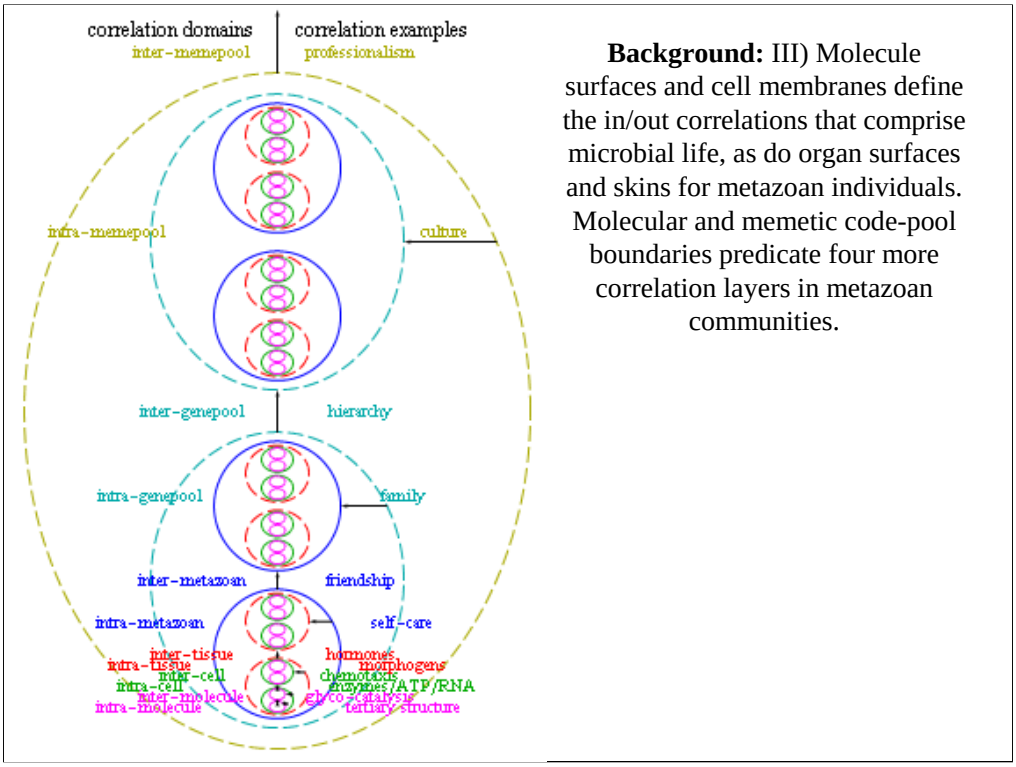


The many scales of organization in natural bone. (credit J. Liu)

Collagen triple helices spontaneously form nanoscale bundles of protein, which act as a template for the crystallization of hydroxyapatite nanocrystals. The collagen matrix is also recognized by undifferentiated bone-marrow stem cells, which become bone-forming osteoblasts after signals from bone-specific proteins in the matrix.

Background: II) Cosmic evolution, discussed e.g. by astrophysicist Eric Chaisson and biologist Ursula Goodenough, generally involves powered formation of a series of subsystem correlations with respect to a hierarchical set of physical gradients and boundaries.

How many are familiar with this concept of order emergence (starting e.g. with the formation of neutral atoms, galaxies, etc.) based on layered subsystem correlations? (Again perhaps a third of the room raised their hands.) The example above, of correlations in bone design looking in/out from molecule, cell, tissue and individual boundaries was also mentioned in Marc Kirshner's talk (Harvard Medical School) earlier in the day when he mentioned growth rates of bone tissue in elk antlers at about ½ centimeter per day in the interest of sexual selection.



Background: III) Molecule surfaces and cell membranes define the in/out correlations that comprise microbial life, as do organ surfaces and skins for metazoan individuals. Molecular and memetic code-pool boundaries predicate four more correlation layers in metazoan communities.

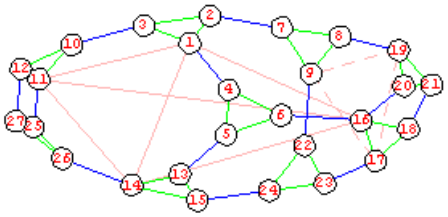
Here we show schematically the hierarchy of correlations looking in/out from a half dozen layered physical boundaries associated with living systems on earth, the last two of which are the molecular and memetic code-pool boundaries of added importance in animal and human communities, respectively. These ideas have also been developing for some time (cf. J. G. Miller's book on *Living Systems* from 1978, or better check with participants in the *Systems Engineering* sessions this week) although we attempt a concise summary here.

Part 2

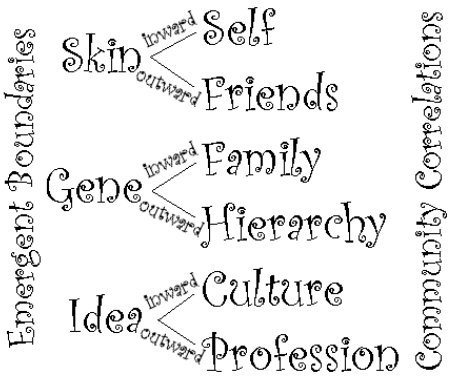
- Physical models of community health
  - Metazoan niche networks with layers directed in/out from skin, family and culture.
  - Counting levels only: Harmonic average niche multiplicity as a quantitative measure of health in metazoan communities.
  - Yields method for *independent* monitoring of respect for observation, belief, consensus, family, friendship, and healthcare.
  - Data acquisition bottleneck: Experts needed.

We now turn from a general review of relevant physical principles to the specific question of niche-correlations maintained by metazoan individuals, including us.

physical boundary-directed niche networks



Layered niche-network inventory
This one shows four scales of correlation: self (#), friends (blue), family (green) & teams (light red).

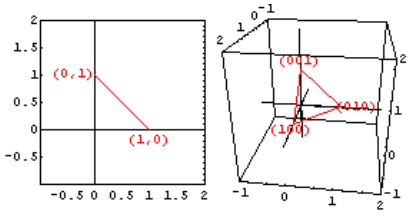


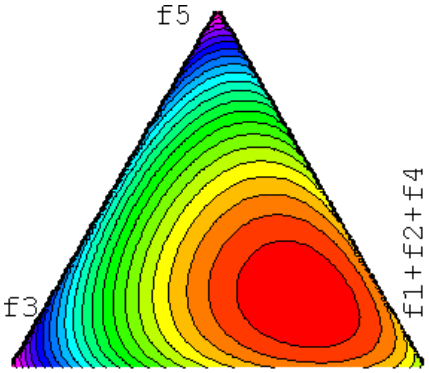
- The right figure takes a clue from the way our species (e.g. Schaik in *Sci Am* 4/2006) conceptualizes its own networks.
- The left column lists three geometically complex physical boundaries: metazoan skin, gene pool, and meme pool.
- At right, find six niche layers that each individual can concurrently occupy.

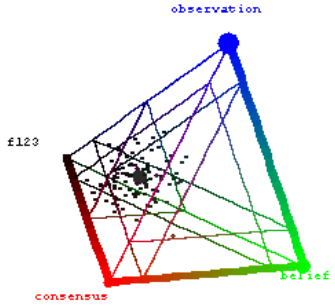
Although the details of layered niche networks (upper left with only 4 layers) are overwhelmingly complicated (not to mention intrusive), the suggestion here is that a simple count of number of levels might be put into very simple form (upper right). In fact from here on we look at what might be done with a simple set of 6 numbers that add to one for each individual, and which are designed to reflect the time, attention, or resource allocation that the individual invests in the development of correlations within each of these six layers. Given these six numbers for each individual, we also propose a simple measure of niche multiplicity for communities by taking the harmonic average of niche multiplicity 2^(Sum[p_j Log_2[1/p_j],j=1,6]) for each individual. This employs the Shannon-Jaynes measure of surprisal in bits employed e.g. in the wide-ranging application areas of Bayesian MaxEnt.

The Attention-Slice Simplex

A one simplex in 2-space, a two simplex in 3-space, and an un-embedded three simplex…



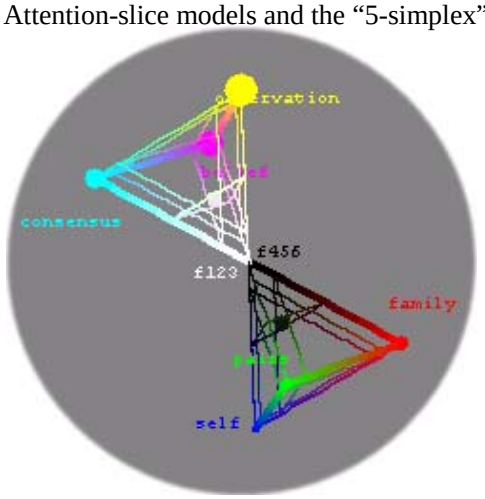




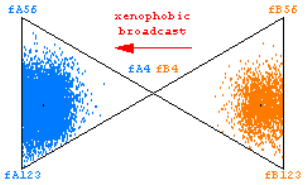
How many are familiar with ternary diagrams as a way to project three values which add to a constant into a 2D triangle? (Again, perhaps 1/3 of the room raised hands.) The same technique works in 5 dimensions for 6 numbers which sum to 1, with the added advantage that sums of these numbers can be projected into an even lower dimensional space as needed.

Inward Focus	Physical Boundary	Outward Focus	Applies To	Correlation Models
Individual	**Metazoan Skin**	Environment/Pairs/Friends	All	Patterns in Space & Time
Family	**Gene Pool**	Consensus Hierarchy	Animals	4-Scale Resource Slicing
Culture/Beliefs	**Meme Pool**	Professional Observation	Idea Sharers	6-Scale Attention Slicing

Attention-slice models and the "5-simplex"

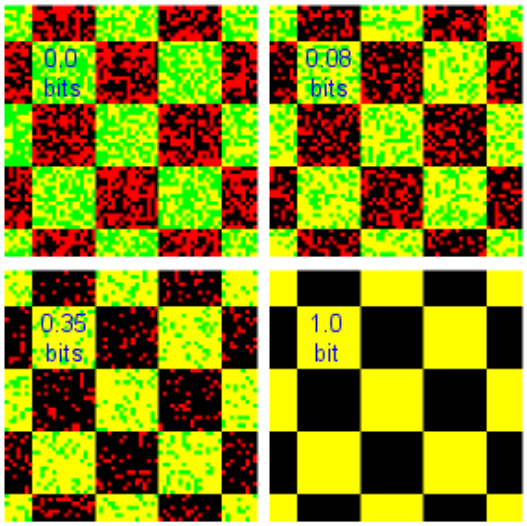


Attention-space tracking (like the opinion-space modeling mentioned by Dr. Levin this morning) might help e.g. us get a handle on the interaction between electronic media and human communities today.



Given one way to visualize these six numbers, what good might having them do? One thing might be to use them in monitoring changes in a community, for example by behavioral ecologists in monitoring environmental stress on animal communities, or by sociologists in monitoring the effect (figure above for shifts from science to politics) of broadcasts that appeal to our baser instincts. Related types of "opinion-space" modeling had been discussed earlier in the day by Simon Levin of Princeton's Department of Ecology and Evolutionary Biology.

Spatial vs attention-slice modeling



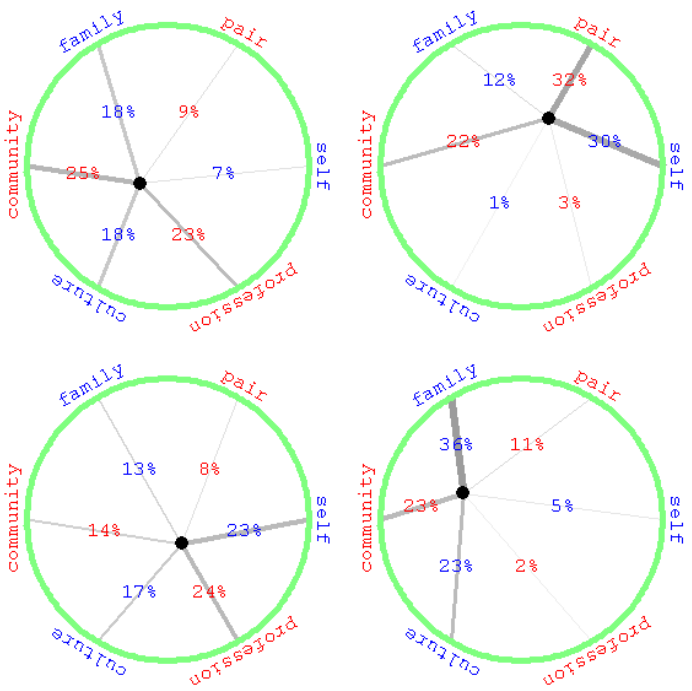
Spatial correlation models (left) are applied in population ecology, e.g. plants & predator/prey modeling. That recent NECSI *Science* paper looks at spatial correlations of violence. Fractional resource/ attention models could extend this beyond skin to all niche layers.

The reference is to M. Lim, R. Metzler and Y. Bar-Yam, Science 317 (2007) 5844. In other words, geographic mapping might be extended beyond spatial correlations of violence (threats to an individual's physical body) to subsystem correlations on other levels. For example, Lorraine Dodd of QinetiQ (who'd given a talk earlier about open-systems thinking in the move from tactical to strategic) noted that the building of physical boundaries between communities might impact community niche multiplicity significantly, even when it does not damage the physical health of individuals directly.

Layered network spiders, for visualizing your connections to the world around.

The color of the numbers in these figures reflects one's emphasis on inward-looking (blue) versus outward-looking (red) objectives.

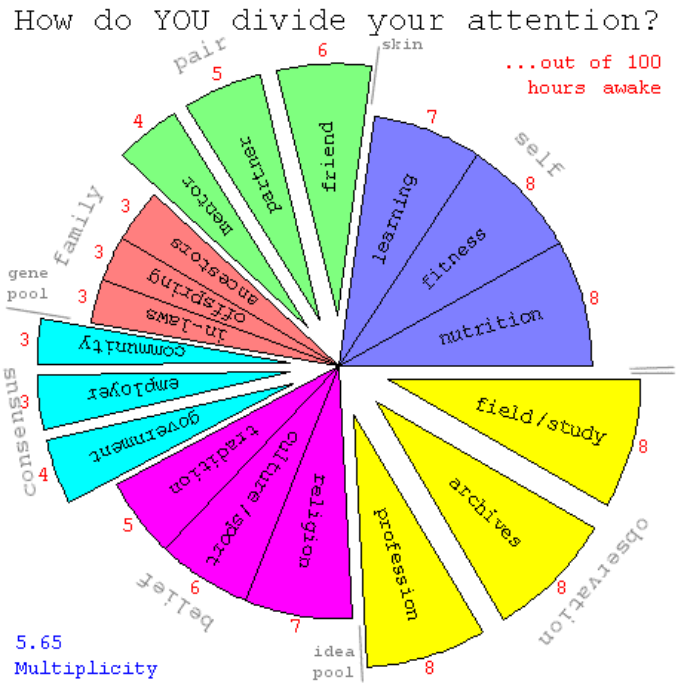
In the modern world, we might like for everyone to be able to connect well in all six ways.



When it comes to acquiring data, one simple and potentially enjoyable format is this spider web visualization of each individual's connections. It also points out something else to me, namely that it's tough for me to do all of these things well and therefore I suspect that I still have some evolving to do.

Monitoring & modeling requires data. Help! *How can we quantify the correlation-focus of individuals in communities?*

Possibilities include:
(i) population surveys at right,
(ii) behavioral observation,
(iii) data on communication focus…



Given that there are interesting things to be done with these 6 numbers in non-human as well as human communities, the bottleneck now is the development and implementation of protocols for acquiring high quality data. In non-human communities behavior observation might help, while in human communities robust issues related to privacy will likely require development of survey instruments (e.g. sociological affect control theory might be an inspiration in this regard) as well as ways to monitor public communication traffic. In the latter context Nicolas Lassabe of *Institut de Recherche en Informatique de Toulouse* mentioned an initiative on the web where this kind of time balance effort is being explored, although I haven't located it yet.

Refined methods for monitoring these correlations might help us ask…

- As with the selfish gene, should the *survival perspective* of ideas be considered in balancing one's options (ala Dr. Zimbardo's fundamental attribution error)?
- Can extremism be linked to perspectives that do not respect care of observation, belief, consensus, family, friends, and self all at once?
- How long have six distinct layers been evident with humans?
- Might measures of correlation standing crop be less monochromatic than e.g. GDP and census?
- Eric Chaisson has argued that complexity correlates with free energy rate density. Will a lower per capita free energy rate mean we can't maintain all six layers?
- Can a theory of correlations in physical systems inspire dialog on scientific, cultural and political grounds among ALL who don't insist on ignoring one layer or another?

arXiv: physics/0603068

I'll close with some other ways that niche-layer multiplicity information might be put to use, as added incentive to you for helping develop and implement reliable data acquisition protocols. The *fundamental attribution error*, of assuming that who and not what is to blame, was discussed earlier in the day by Phillip Zimbardo of Stanford University during his discussion of emergent Human Behavior.