RESEARCH MATRIX: REDUNDANCY IN NATURE

In environments that are ever in flux, it is critical that ecological systems have the ability to rapidly jump between states of temporary stability. Ciro Najle's essay 'Convolutedness' contributes significantly to this point. Najle holds that the key to these quick fire adaptations is self management on many levels.

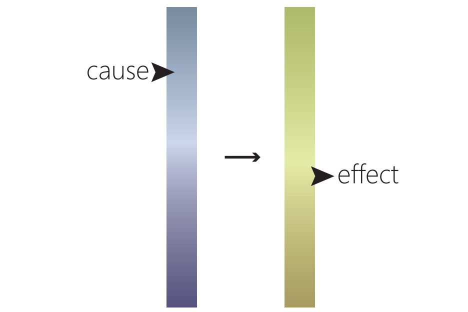
Mediation between self and environment is a fundamental capacity for ecological systems. Focusing on the lowest level of a single exchange, the system produces various qualitative and quantitative response to gradations of external stimuli. This simple cause-effect relationship does not accurately describe natural systems which never exist in isolation or stasis. Stimuli-response relationships exist in unending chains in which every response is the catalyst for additional change.

Intelligent systems function at a higher level of self management as they have the capacity to learn environmental stimuli and are able to alter their response accordingly. In addition intelligence enables ecological systems to sensor the various stimuli acting upon them and establish priorities among them.

> "A convoluted system is a delicate balance of times. Its aesthetics have to do not only with its configuration, not even just with its performance, but also wit its change of performance. It is by offering multiple sides and edges, and by generating richness, that a system becomes capable of changing its function and adapting."
>
> [Ciro Najle, 2003]

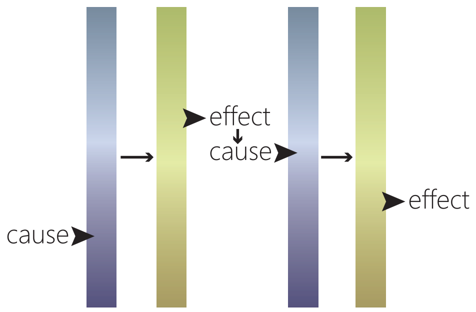
SYSTEMS OF SELF MANAGEMENT

Level 1



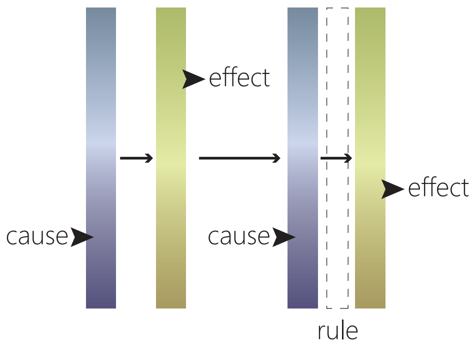
Complex cause/effect relationships allow effects to fluctuate with qualitative and quantitative variations of the cause.

Level 2



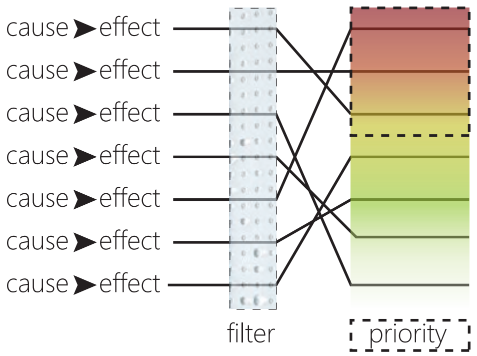
Stimuli can set off chain reactions in which the effects of one stimulus can become the trigger of another reaction.

Level 3

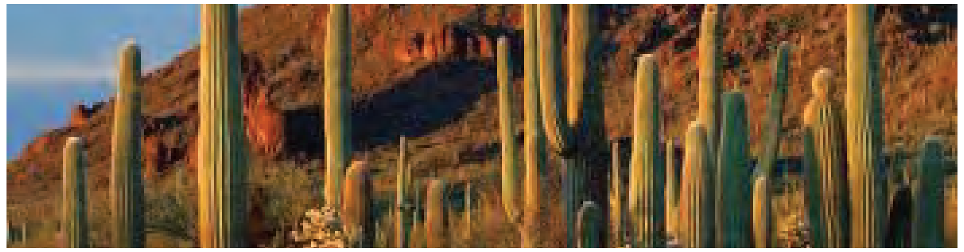


Intelligent systems can create rules that allow them to alter their response to a learned stimulus.

Level 4

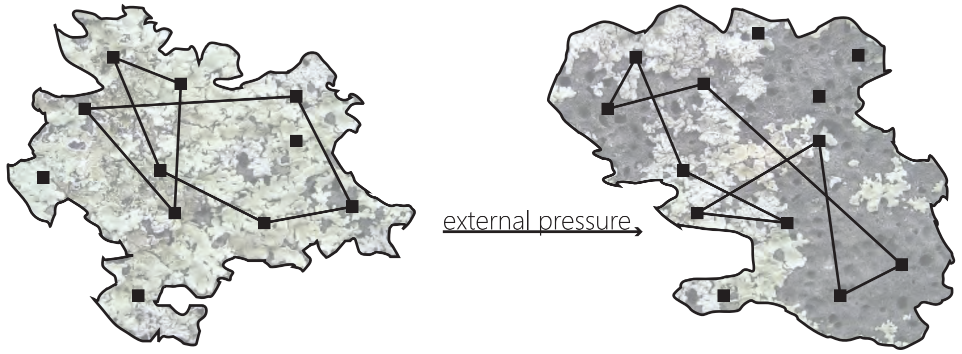


The system can regulate its intelligence by prioritizing its stored information.

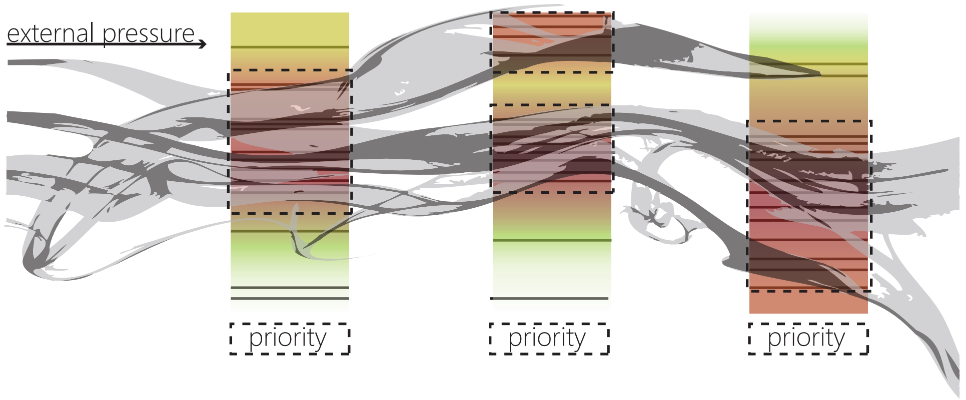


> "This implies that expression has gone beyond the production of information to include its active storage and processing. And this, in turn, implies that when populations of information-storing molecules replicate themselves, and when this replication is biased in one or another direction by the interactions of proteins with each other and with their environment, the expressive capacities of material entities may evolve and expand in a multiplicity of novel ways."
>
> [Manuel DeLanda, 2008]

Level 5



The storing of excess (redundancy) provides the system with robustness and flexibility. Excessive information leaves room for the system to reconfigure and adapt in response to external pressure.



In response to external stimuli, the system can re-prioritize its stored information. An abundance of information allows the system to live both in a between environments, constantly fluctuating and reiterating itself.

The highest level of self management goes beyond simple learning and enters the realm of memory. In order for systems to intelligently respond to stimuli, they must retain vast stores of knowledge beyond the exchange immediately at hand. In other words, it is a redundancy of information that gives the system the flexibility to rapidly adapt to shifting environments. A redundancy of data sets allows a system to constantly reiterate itself and co-evolve with its environment.

It is these complex networks of feedback loops that exist simultaneously in and between environmental stimuli that constitute Najle's notion of convolutedness. In essence a certain amount of messiness, of 'consistent senselessness' is both intelligent and productive in an ecological system.

RESEARCH MATRIX: LOOSE COUPLING

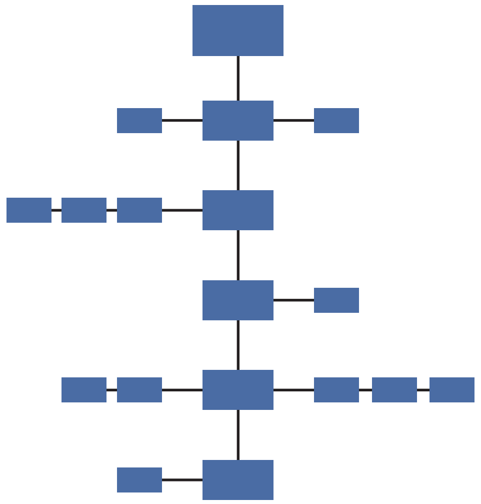
Organizational strategies have a profound impact on the nature of the system. Linear organizations have very little built in flexibility. Because of their hierarchical structure, intelligence is centralized at the top of the chain of command, there is limited room for creativity and deviation from the norm. Innovations within a node remain relatively isolated from the rest of the system. Conversely, failure of a single node is disastrous for the system as a whole, as all the nodes reliant on the weak point are also jeopardized.

Loose coupling is a much more flexible organization. It distributes intelligence throughout the whole, allowing innovations in a single node to benefit the entire system. Rather than relying on a top-down chain of command, loosely coupled systems are composed of relatively autonomous elements; each element is allowed to maintain its unique characteristics, thus increasing the chances of reaching novel solutions. Because elements are relatively well suited to functioning on their own, loosely coupled systems have the added advantage of easily allowing failing nodes to be removed with little harm to the system. Similarly, as circumstances change over time, new nodes can easily be grafted onto the existing structure. Overall this system provides a powerful model of distribution and adaptability.

"In loosely coupled systems where the identity, uniqueness, and separateness of elements is preserved, the system potentially can retain a greater number of mutations and novel solutions than would be the case with a tightly coupled system."

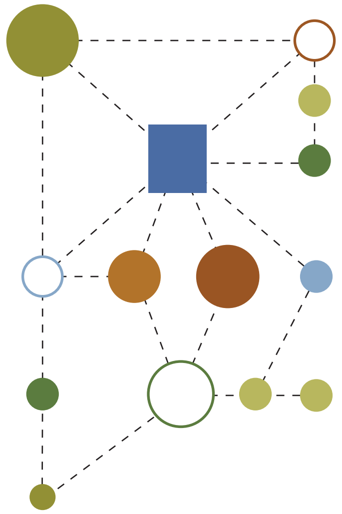
[Karl E. Weick, 2008]

LINEAR ORGANIZATION

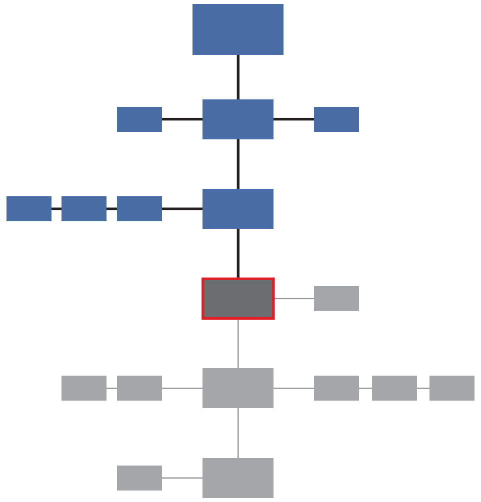


Linear organizational structures are rigid and hierarchical. This structure limits growth and feedback within the system.

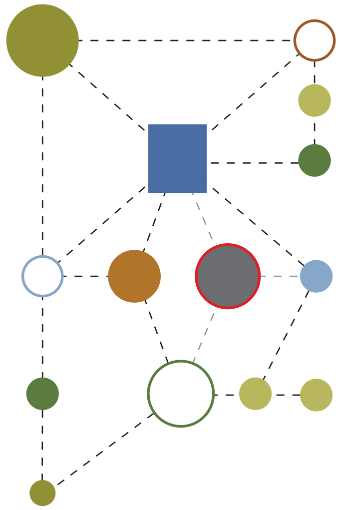
LOOSE COUPLING



Loose coupling promotes distributed intelligence. Innovations in one node can benefit the entire system through the flexible web of connections.



Failure in a single node of a linear organization can be detrimental to the entire system.



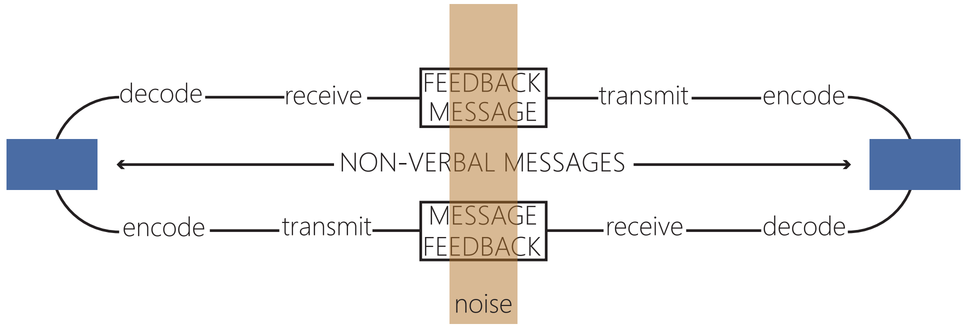
A failing node can be abandoned with a limited effect on the entire system. In a loosely coupled system.

RESEARCH MATRIX: COMMUNICATION MODELS

"[If we] consider the outer world of natural phenomena, we observe at once that this outer world is similarly characterized by redundancy, i.e., that when an observer perceives only certain parts of a sequence or configuration of phenomena, he is...able to guess...at the parts he cannot immediately perceive."

[Gregory Bateson, 1968]

TRANSACTIONAL MODEL OF COMMUNICATION [Barnlund 1970]



Barnlund's Transaction Model of Communication acknowledges the importance of simultaneous sending a receiving of verbal and non-verbal messages by the parties involved. This instantaneous feedback loop system allows for the coevolution of understanding.

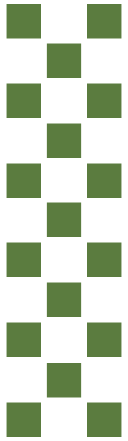
Meaning is understood between systems through mutual languages, patterns, and symbols. While there are distinct differences in complexity between verbal and non-verbal communication, both methods rely on adherence to established rules in order to accurately convey a message. Barnlund's Transactional Model of Communication acknowledges that consistent rules of encoding and decoding must apply in order for meaning between parties to be understood.

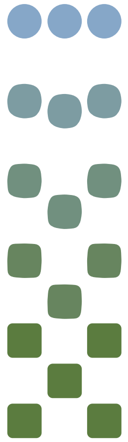
Gregory Bateson, in his essay 'Redundancy and Coding', builds off the power of this simple model. Bateson argues that because communication follows predictable patterns, that is, because there is redundancy in the message, the meaning can be understood from an incomplete portion of the message.

Communication is complicated by systems that are capable of mimicry or deception. Once a system can detect and learn a coded message, it can learn to mimic the pattern to its own advantage.

CYBERNETICS

Based on an understanding of patterning, the meaning of messages can be predicted from incomplete data sets.



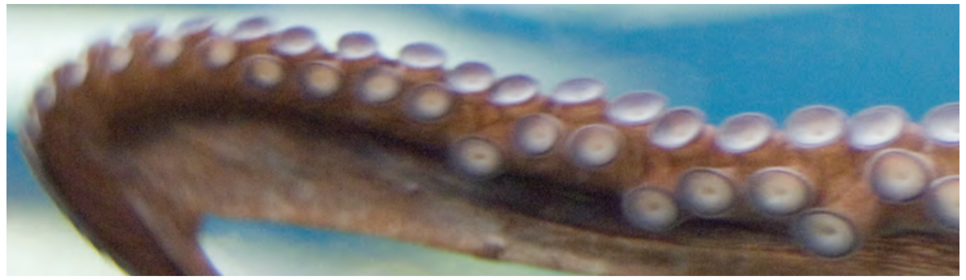


Signals become more complex when species are capable of deciphering code and learning to mimic patterns.

CASE STUDY: OCTOPUS ANATOMY

Octopuses are remarkably intelligent creatures that are well equiped to handle a fluctuating environment. Physically, their bodies are designed accomodate nearly any challenge. Without bones to restrict their movement, they have nearly infinite degrees of flexibility. They can expand to impressive stature, and compress to fit inside impossibly small crevices. the only hard part on their body is their beak, located in the center of their body. This means that their body can squeeze through and opening that their beak fits through, which for the Great Pacific Octopus, can be as small as a quarter. In addition to flexibility, octopuses also have immense strength and sophistocated eyesight that is similar to that of humans.

The octopus' most extraordinary feature is its nervous system. Studies indicate that octopuses have redundant nervous systems. That is, while the body serves as a command center for the octopus, each arm has in addition its own nervous system. This redundancy allows the central nervous system to essentially issue commands while each arm is responsible for determining how that command is carried out. The octopus' high level of coordination can likely be contributed to the fact that each arm can be considered an autonomous unit within the larger system.

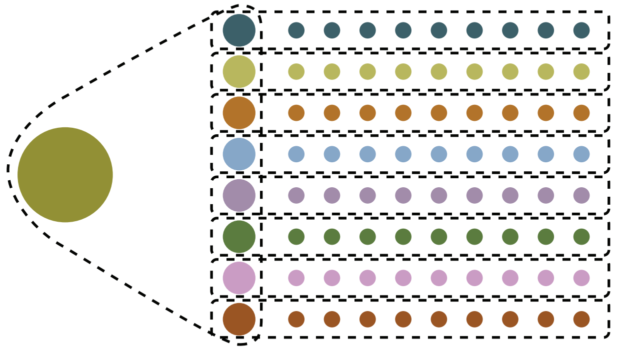


"It displays a high level of organization in order to do things like coordinate all of the chromataphores' color changes. The brain is only part of the story though. Three-fifths of the octopus's nerves are distributed throughout its eight arms."

[Jennifer Horton, 2008]

PERFORMANCE ACROSS SCALES

Body



A central nervous system coordinates the tasks of the octopus's body. Redundant nervous systems control the specific movement of each arm. The arm determines how each task will be carried out and regulates the individual movement of each suction cup on the arm.

Arms

Without bones to limit its motion, the octopus' arms are capable of nearly infinite degrees of rotation. Interestingly, the octopus can also bend its arms in specific point locations, mimicing the jointed consturtion of human arms.

Suction Cups

The octopus can individually manipulate each suction cup along its arms. This allows to assist in the octopus with precise movements, such as detecting small objects and opening closed containers.

"Octopuses have intrigued scientists for years, because they have both long- and short-term memory, they remember solutions to problems, and they can go on to solve the same or similar problems."

[Hillary Mayell, 2005]

Learning

Octopuses are highly intelligent creatures capable of learning visually and through trial and error. Not only are they able to devise solutions to complex problems, they are also capable of remembering these solutions and assessing future problems relationally. Octopuses have been known to open sealed containers, solve puzzles, navigate mazes, and, mysteriously, predict the outcome of soccer matches.

Mimicry

The octopus' high learning capacity makes it well suited for outsmarting predators. One common tactic involves mimicry. Above to the left is a flounder navigating the ocean floor. To the right is an octopus, streamlining its fluid body to mimic the look and pattern of movements of the flounder.

Though they are generally creatures that prefer a secluded life, octopuses also have developed sophistocated systems of visual communication. Octopuses will alter their texture and color to express fear, danger, and mood, among other messages.

The octopus' facinating abilities are only in part due to it's physicality; its cognitive abilites have led some to call them 'the primates of the sea'. Not only can octopuses encounter problems and visualize solutions, they can recognize that there are multiple ways of solving a problem and are able to select the most economic solution.

These capacities make the ctopus well suited for suited for adaptation in a constantly fluctuating environment.

CASE STUDY: RENSSELAER CENTER FOR BIOTECHNOLOGY AND INTERDISCIPLINARY STUDIES

"Our success is built on the faculty, students, and staff, and the innovation that flows from collaboration. CBIS houses biologists, chemists, physicists, chemical engineers, bioengineers, and materials scientists. Laboratories are designed to be large and open, with no artificial boundaries separating disciplines. Therefore, scientists and engineers work side-by-side to understand mysteries of life and exploit biological systems to make products and processes that benefit society."

[Jonathan S. Dordick, Ph.D, Director, CBIS]

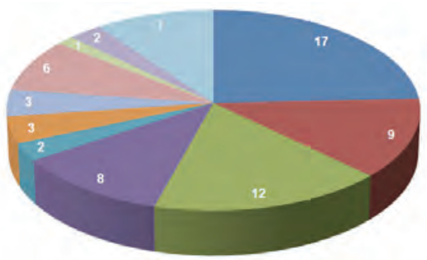
Rensselaer Polytechnic Institute's Center for Biotechnology and Interdisciplinary Studies [CBIS] is a catalyst for collaboration across fields of research. The 219,000 sqft. facility houses both theoretical and experimental research programs in biotechnology and bioengineering. There are nine areas of focus within these fields: Functional Tissue Engineering, Integrative Systems Biology, Biocomputation and Bioinformatics, Biocatalysis and Metabolic Engineering, Biology and Biochemistry, Biochemistry and Biophysics, Nanobiotechnology, Biochips and Microsystems, and Bioimaging and Bioinstrumentation.

Research in the CBIS is carried out in 'constellations': "Constellations are multidisciplinary teams of senior faculty, junior faculty, graduate students, and undergraduates. Each constellation is led by one to three world-class faculty members in a particular research field."

The constant circulation of faculty, visiting researchers, and students promotes fresh ideas and new ways of thinking. This contributes to the 'multilevel, multidisciplinary' nature of the research programs, depicted by the diagram at the right.

THE PEOPLE

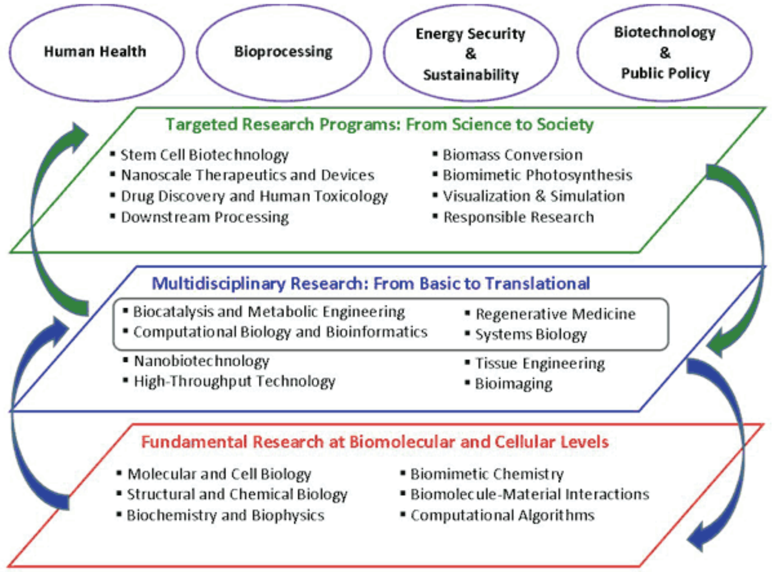
Faculty



- Biology
- Biomedical Engineering
- Chemical and Biological Engineering
- Chemistry and Chemical Biology
- Civil Engineering
- Materials Science and Engineering
- Mathematical Sciences
- Mechanical, Aero. and Nuclear Engineering
- Physics
- Other

The resident faculty of the CBIS provides a cross-section of the research done across the RPI campus. Graduate and undergraduate students are invited to participate in the research process. Bolstered by visiting researchers, these faculty-student teams for the CBIS's research constellations.

Research



THE FACILITY

Laboratory

Conference Space

Open Atruim

The CBIS is a state-of-the-art facility that is 'big enough for world-class research, small enough for meaningful collaboration'.

The CBIS encourages this collaboration through its open design. Laboratories and resources are shared by researchers without physical boundaries between disciplines. Laboratories are clustered in the center of the building. Forming and L around the laboratories is an atrium that invites foot traffic through the core of the building. Forming the outside boundary of the L is a rim of faculty and staff offices. The intermingling of offices is another way in which the facility embodies the interdisciplinary nature of the research within.

Supporting the work done in laboratories and offices, digitally equipped conference rooms are dispersed throughout the building for meeting purposes. The high visibility of these rooms encourages interdisciplinary participation. A 153 seat auditorium provides an arena for the work of researchers to be shared and for knowledge to be spread across campus. In addition to these structured interactive spaces, open lounge spaces are located at the crux of the L on every floor, encouraging casual interaction between researchers.