

**International Workshop -Advances in  
Cleaner Production**

**22-24 de Maio de 2013**

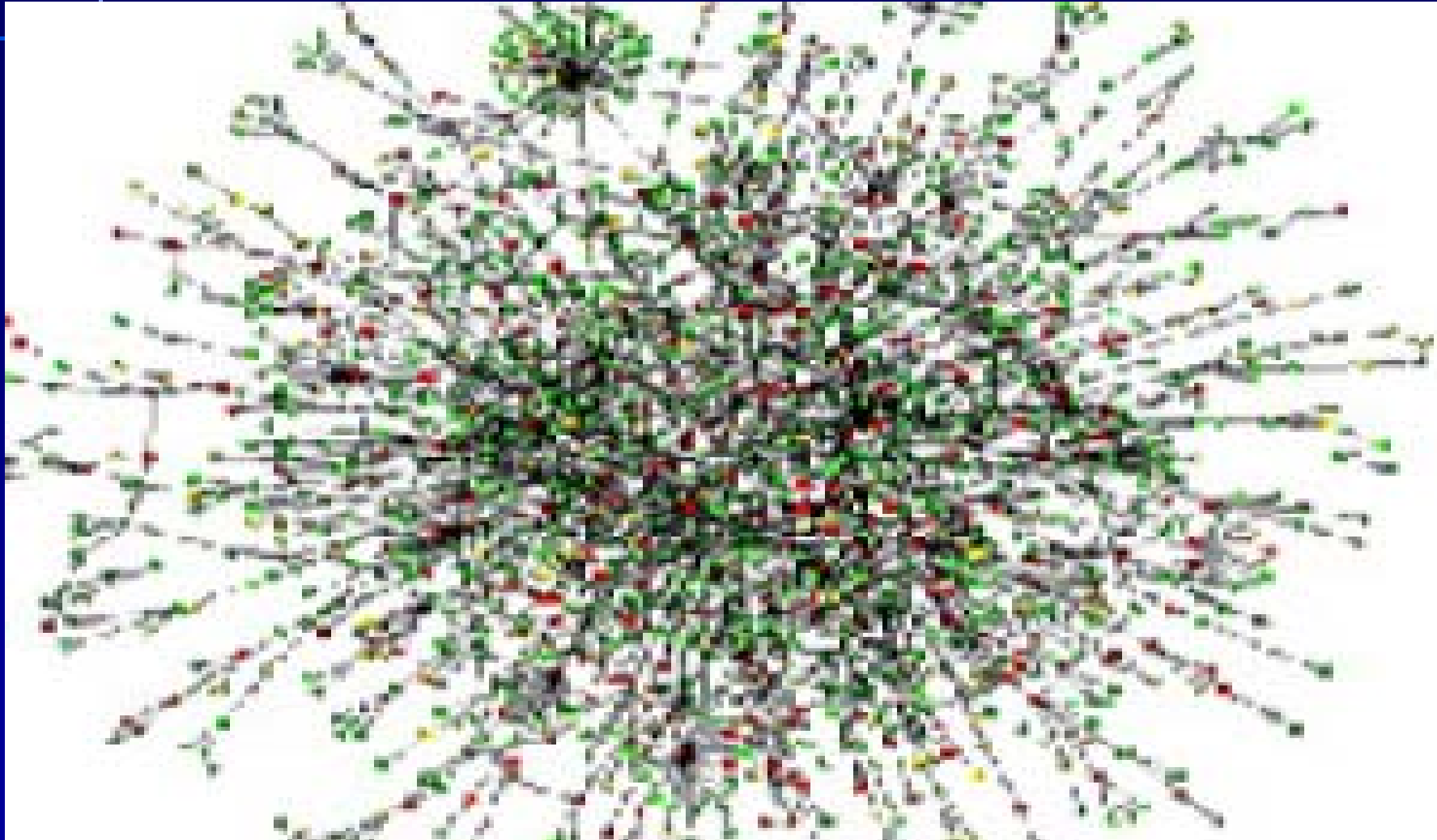
**An introduction to the Nature of Wicked  
Problems- Ecological Challenges as Super  
Wicked Problems**

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# COMPLEXITY WORLD WIDE WEB



# COMMON PROPERTIES OF COMPLEX SYSTEMS

COMPLEXITY-From Latin word  
*plectere*: to weave, entwine

**COMPLEX COLLECTIVE BEHAVIOR** -  
COMPONENTS ( ANTS, B CELLS, NEURONS,  
STOCK BUYERS, WEB -SITE CREATORS, (   
IDEAS CONCEPTS , ? ) , EACH FOLLOWING  
SIMPLES RULES, NO CENTRAL CONTROL OR  
LEADER, GIVE RISE TO HARD-TO-PREDICT  
PATTERNS

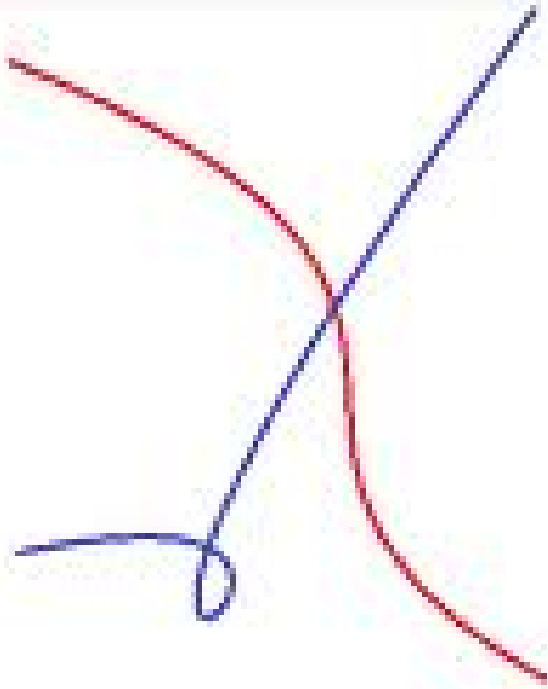
**SIGNALING AND INFORMATION**

PROCESSING- SIGNALING AND EXCHANGE  
OF INFORMATION INTERNAL AND EXTERNAL

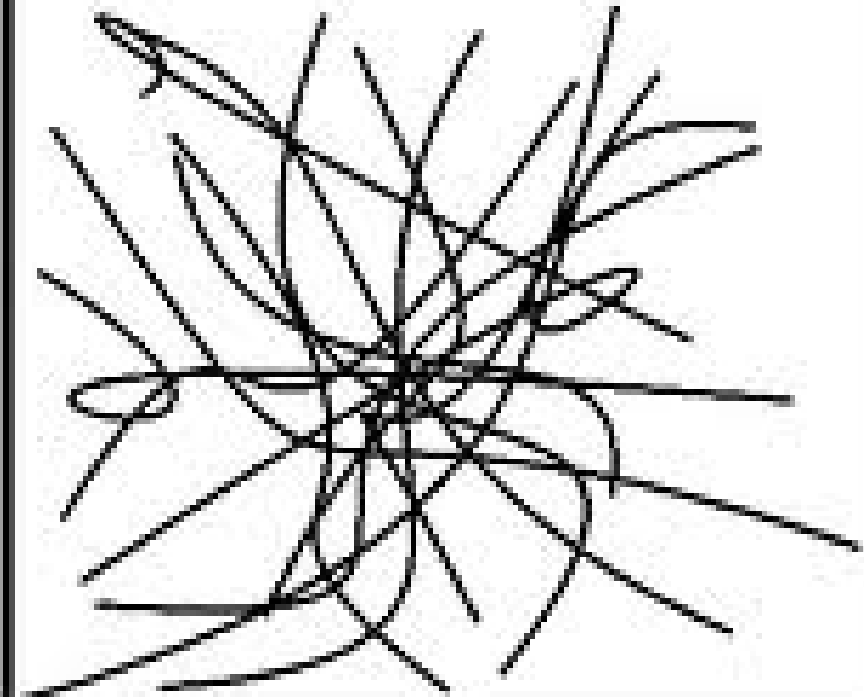
**ADAPTATION**- ALL THOSE SYSTEMS  
ADAPT TO IMPROVE THEIR CHANCE OF  
SUCCESS, THROUGH LEARNING OR  
REVOLUTIONARY PROCESS



# WICKED PROBLEMAS



**Traditional Problem**



**Wicked Problem**

We need to increase our market penetration by at least 27%.

That would be easy, Bob, if your customers didn't hate your products.



DECIDE, v. i. To succumb to the preponderance of one set of influences over another set

Ambrose Bierce, *The Devil's Dictionary*

"On purposeful Systems - An Interdisciplinary Analysis of Individual and Social Behavior as a System of Purposeful Events" Russel L. Ackoff and Fred E. Emery



Some problems are so complex that you have to be highly intelligent and well informed just to be undecided about them."

--Laurence J. Peter

The term "wicked problem" was coined by Horst Rittel, who with colleagues perceived the failure of linear approaches to treat design and planning.

Failing to recognize a problem as "wicked", results in the utilization of inappropriate tools to solve problems in climate change, leading to the use of inadequate methodology and management procedures, restricted to treat "tame problems".

Ecological and Economical issues are considered as "super-wicked" problems, due to its innumerable uncertainties, interdependencies, complexity, and social fragmentation introduced by the stakeholders involved.

"Super complex" too?

Remember WWW

How we perceive and manage this complex economic and ecologic network will affect the future of our planet, and hopefully, correctly orient the decisions on ecological issues, as well as contribute to the effort to implement cleaner production practices. We strongly emphasize that this group of problems -wicked- should be made more familiar to students, early in their careers.

## A Systemic View The New Paradigm

According to theories dominating the scientific world in the last century, the whole could be analyzed by dissecting the system to its ultimate elements. "Every science sought its ultimate elements"(Ackoff, 2013). Complex problems were cut down to smaller, simpler problems. As an example, it was believed that the problem of running a city could be broken down into "running transportation, housing, health, education and so on".

The fascinating evolution in the last 50 years in science led to the study of ecological systems as complex -super-wicked, super-complex (?)-, integrated whole. This view is clearly expressed in the title of the work of James Kay (2000), "Ecosystems as Self-Organizing Holarchic Opens Systems: Narratives and the Second Law of Thermodynamics". James Kay coined the term "SOHO" (Self Organizing, Holarchic, Open Systems), to describe ecological systems. Bittencourt (1999) also ended up with four letters to describe those systems: "OCPI" - meaning systems which are Open, Coherent, Purposive, and Irreversible

Some attributes of wicked problems detailed by Conklin (2005), are:

- You don't understand the problem until you have developed a solution.
- Since there is no definitive 'The Problem', there is also no definitive 'The Solution.' (no stopping rule).
- Solutions to wicked problems are not right or wrong.
- Every wicked problem is essentially unique and novel.
- Every solution to a wicked problem is a 'one-shot operation.'
- Wicked problems have no given alternative solutions.

Examples of a "tame" problem are also given. According to Conklin, a tame problem,

- Has a well-defined and stable problem statement.
- Has a definite stopping point, i.e. when the solution is reached.
- Has a solution which can be objectively evaluated as right or wrong.
- Belongs to a class of similar problems which are all solved in the same similar way.
- Have solutions which can be easily tried and abandoned.
- Comes with a limited set of alternative solutions.



We propose that the *wickedness* of a problem results from the basic characteristics of complex system—as implicit in “complexity theory”, with super-wicked problems corresponding to the highest degrees of complexity, where the variables of the system entangle with intangibles derived from human nature, incorporating the influences of free will, purposiveness, and adaptativeness. The frontier between wickedness and super wickedness of a problem cannot be precisely established, as well as complexity cannot be measured or even defined with precision. Hierarchically, thermodynamics can be ordered in a direction of increasing entanglement, increasing complexity, resulting from the nature of environment-bound (open) systems

# The New scientific paradigm

## Paradigm

“ ..a constellation of achievements -concepts, values, techniques, etc, shared by a scientific community to define legitimate problems and solutions. Occurs in discontinuous ,revolutionary breaks , called paradigms shifts” Thomas Kuhn

**IN THE NEW PARADIGM HOLISM REPLACES  
REDUCTIONISM, TO THE ULTIMATE AND  
HIGHEST LIMIT**

**"I want to know how God created this world. I am not interested in this and that phenomenon, in the spectrum of this or that element. I want to know His thoughts: the rest are details"**

**Albert Einstein**

**( so do I...)**

The new paradigm "...includes a shift in social organization from hierarchies to networks" (Capra, 1997)

I ask: What is left to traditional politicians?

**THEN...WHAT IS LEFT TO  
POLITICIANS ?**



**HOW I GOT HERE: AN HIERARCHICAL VIEW  
OF THERMODYNAMICS LEADING TO  
EMERGENCE OF STRUCTURES  
TEACHING AN INTEGRATED VIEW FROM THE  
BEGINNING**

- **CLASSICAL THERMODYNAMICS** -equilibrium, closed, isolated systems,, and infinitely slow processes
- **LINEAR NON EQUILIBRIUM THERMODYNAMICS** – flows as linear functions of forces, valid in the neighborhood of equilibrium, coupling of fluxes
- **FAR FROM EQUILIBRIUM** – associated with dissipative structures, nonlinear, bifurcations, multiplicity of solutions, spacial and temporal order

# LIVING SYSTEMS



# LIFE AND ECOSYSTEMS

A few comments



# FROM CLASSICAL TO IRREVERSIBLE

- Curricula traditionally emphasizes reversible processes in thermodynamics, linearity and continuity in mathematics, and economy is still dominated by mechanistic models. Reductionism prevails
- "The majority of the phenomena studied in biology, meteorology, astrophysics, and other subjects are irreversible processes which take place outside the equilibrium state", Prigogine
- Classical thermodynamics : "... once the second law is formulated, concentrates on the properties of system which have reached thermodynamic equilibrium ", Glansdorf and Prigogine ,  
"Particularly applicable to closed systems "  
Katchalsky

**VOCABULARY OF THE NEW PARADIGM- ATTRIBUTES OF  
LIVING SYSTEMS (THAT NEED TO BE INTRODUCED TO  
STUDENTS) INVOLVING THERMODYNAMICS, MATH,  
SYSTEMIC VIEW**

**OPEN AND INTERACTIVE WITH THE  
ENVIRONMENT  
IRREVERSIBLE  
DYNAMIC  
NON-LINEAR  
COMPLEX  
COHERENT  
PURPOSIVE  
ENDOWED WITH REPRODUCTION WITH  
INVARIANCE  
ADAPTATIVE**

## MORE VOCABULARY

CHAOS

AUTOMATA

FRACTALS

BIFURCATIONS

ATTRACTORS

ORDER

EMERGENCE

CATASTROPHE

...

...

## FROM CARNOT TO AMOEBEA -LINKING TO LIFE

- SEQUENCE : CLASSICAL , REVERSIBLE → IRREVERSIBLE LINEAR → IRREVERSIBLE NON-LINEAR → PURPOSIVE, ADAPTATIVE, COMPLEX, COHERENT SYSTEMS
- JAMES KAY: Ecological and Human Systems as Self- Organizing ,Holarchic, Open (SOHO), systems\*
- MYSELF : Open, Coherent, Purposive, Irreversible (PICO), systems -Referring human productive systems, and nature

\* James J Kay, *Self-Organization in Living Systems, PhD Thesis, University of Waterloo, 1984*

## PROPERTIES OF COMPLEX SYSTEMS WHEN THINKING ABOUT ECOSYSTEMS (BASED ON MAY, 2000)

- **NON-LINEAR** - BEHAVE AS A WHOLE, IT IS A *SYSTEM* -NOT UNDERSTOOD BY DECOMPOSABLE INTO PIECES
- **HIERARCHICAL - HOLARCHICALLY NESTED** -SYSTEMS WITHIN A SYSTEM -RECIPROCATING CONTROLS
- **INTERNAL CAUSALITY** - NON-NEWTONIAN, NOT A MECHANISM , CHARACTERIZED BY GOALS (PURPOSIVE?) AUTOCATALYSIS, , SELF ORGANIZING, SURPRISES
- **WINDOW OF VITALITY** - A RANGE WITHIN WHICH SELF-ORGANIZATION CAN OCCUR. SYSTEM STRIVES FOR OPTIMUM, NOT MINIMUM OR MAXIMUM
- **MULTIPLE STEADY STATES** - MULTIPLE ATTRACTORS POSSIBLE, SYSTEM STATE A FUNCTION ( ALSO) OF HISTORICAL EVENTS
- **CATASTROPHIC BEHAVIOR** - BIFURCATIONS ( MOMENTS OF UNPREDICTABLE BEHAVIOR);FLIPS ( SUDDEN DISCONTINUITIES , RAPID CHANGE) , SHIFTING STEADY STATES MOSAIC
- **CHAOTIC BEHAVIOR** - WE HAVE LIMITED ABILITY FOR PREDICTION (I. E., WEATHER FORECASTS ) REGARDLESS OF HOW MUCH INFORMATION WE HAVE AND HOW SOPHISTICATED ARE OUR COMPUTERS

## HIERARCHY OF SYSTEMS (BOULDING) GENERAL SYSTEMS THEORY (BERTALANFY)

- **Frameworks:** systems comprising static structures: . atoms in a crystal
- **Clockworks:** simple dynamic systems with predetermined motions, such as the clock and the solar system.
- **Cybernetic systems:** systems capable of self-regulation in terms of some externally prescribed target or criterion: thermostat.
- **Open purposive systems:** capable of self-maintenance based on a throughput of resources from its environment, such as a living cell.
- **Blueprinted-growth systems:** containing preprogrammed instructions for development, the egg-chicken system.
- **Internal-image systems:** systems capable of a detailed awareness of the environment , image or knowledge as a whole: animals
- **Symbol-processing systems:** self-conscious , use language: humans

# PURPOSEFULNESS

"Individual systems are purposive" (Ackoff and Emery), ... "knowledge and understanding of their aims can only be gained by taking into account the mechanisms of social, cultural, and psychological systems".<sup>[2]</sup>

Any human-created systems can be characterized as "purposeful system" when its "members are also purposeful individuals who intentionally and collectively formulate objectives and are parts of larger purposeful systems".<sup>[5]</sup>

"A purposeful system or individual is ideal-seeking if... it chooses another objective that more closely approximates its ideal".<sup>[6]</sup>

"An ideal-seeking system or individual is necessarily one that is purposeful, but not all purposeful entities seek ideals",<sup>[6]</sup> and,

"The capability of seeking ideals may well be a characteristic that distinguishes man from anything he can make, including computers".<sup>[7]</sup>

According to Kirby and Rosenhead (2005), "the fact that these systems were experiencing profound change could be attributed to the end of the "Machine Age" and the onset of the "Systems Age"

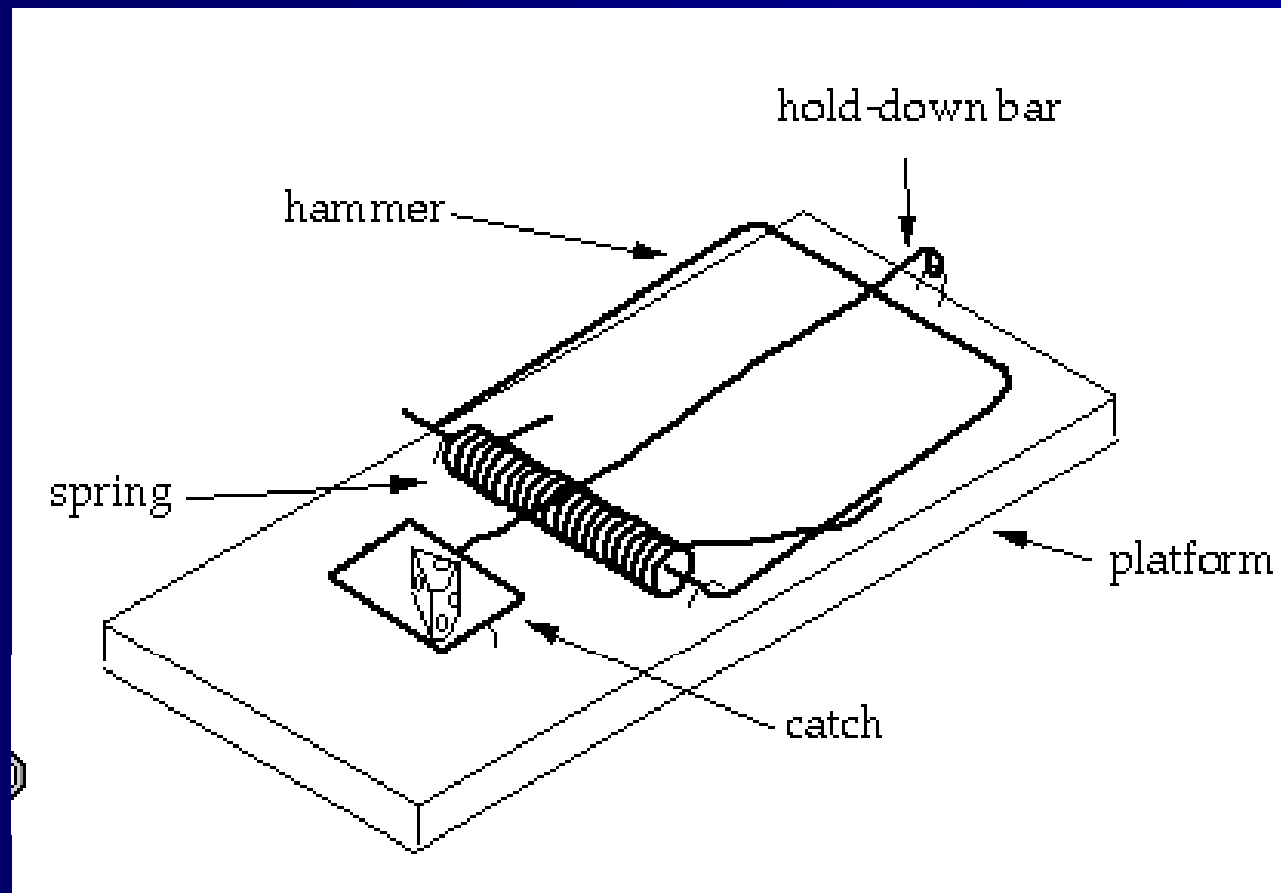


# PURPOSEFUL SYSTEMS

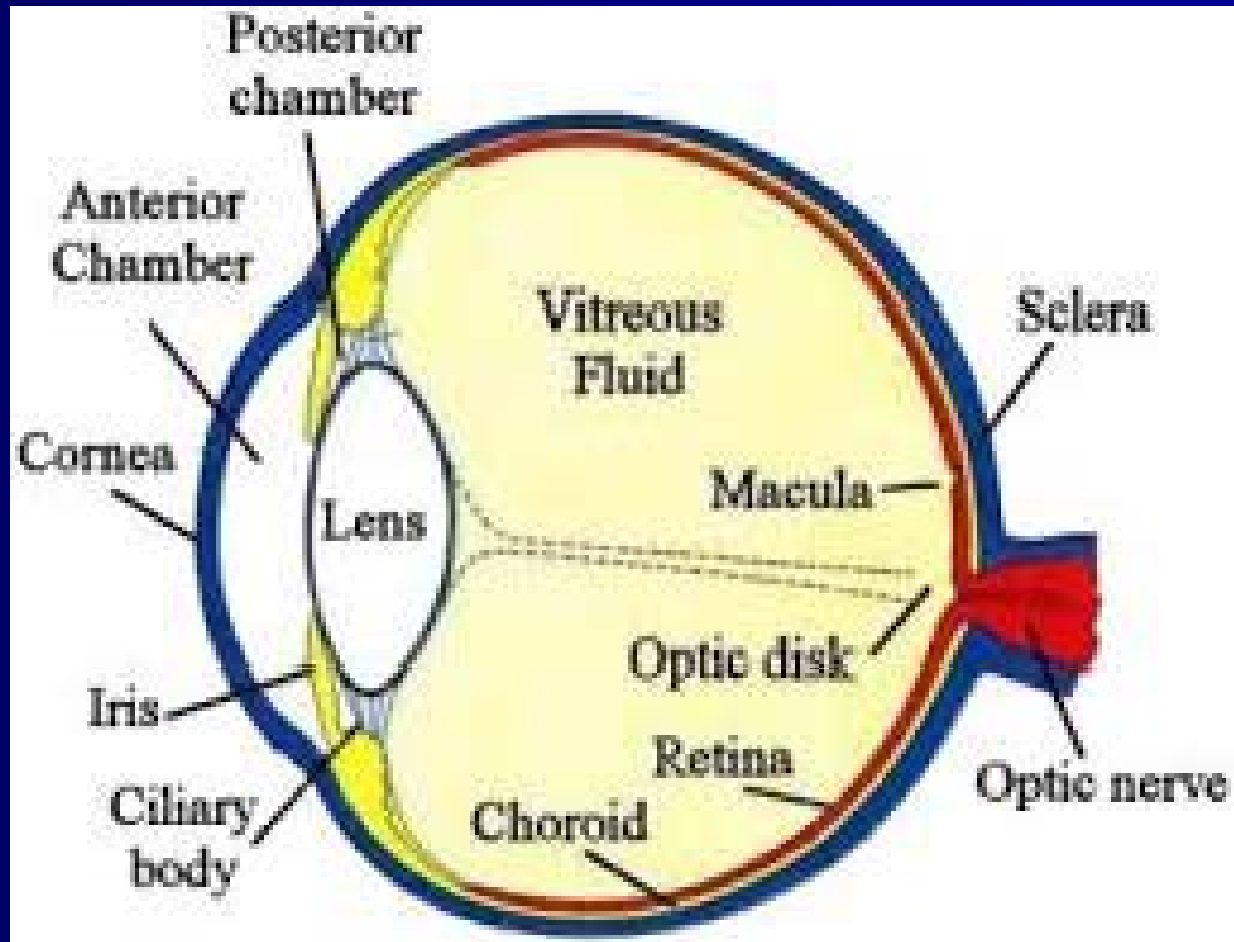


# MOUSETRAP: STRANGE OBJECT (Monod)

RESULTS FROM ARTIFACT PRODUCING ACTIVITY ON  
EARTH



# THE PURPOSEIVE ,STRANGE OBJECT EYE



# PURPOSEFUL OBJECT - CAMERA



# Social Fragmentation In Stakeholder's Group



Fragmentation = wickedness  $\times$   
social complexity



**DIALOG MAPPING... JEFF CONKLIN**

--WICKED PROBLEMS FRAGMENT PROJECT WORK, ESPECIALLY WHEN THE PROBLEM IS SEEN AS TAME

--IF THERES IS NO AGREEMENT ON WHAT THE PROBLEM IS HOW CAN YOU EXPECT A SOLUTION?

--SOCIAL COMPLEXITY : FRAGMENTS TEAM UNITY BY THE DYNAMICS OF COMPETING INTERESTS AND HIDDEN AGENDAS

--ALL THIS ADDS TO TECHNICAL COMPLEXITY

RESULT: BLAMING, FINGERPOINTING

(DIALOGUE MAPPING....JEFF CONKLIN )

CONCLUSIONS ...  
OR, TO BE HONEST..  
TO ABRUPT ENDING





As pointed out by Nancy Cartwright (1983) in "How the Laws of Physics Lie", no system of laws can describe the real world, due to its complexity. This affirmation consists in a strong and impacting limitation that has received even more importance later in time, due to the emergence of the theory of complexity.

Cartwright establishes a firm limitation to our dialogue with nature: there are problems that are rigorously proved to be unsolvable, and there are problems, involving complex systems, that include intangibles, also accepted as unsolvable, even if not rigorously proved unsolvable in a mathematical sense- such as wicked and super-wicked problems

Wicked problems, involving a large amount of variables, including non quantifiable variables, are problems that admit a set of *alternatives* (called "solutions"), that is, decisions will be implemented on how to act upon the problem to "solve" it, but "solving" has to be understood not in a rigorous, mathematical sense. Wicked problems are problems generated by complex systems, dealing with attributes inherent to the theory of complexity - associated with emergent phenomena; non linear dynamic; environment bound (open systems); subject to chaotic behavior, and adaptive.

Ecology involves a network of open, nonlinear dynamic systems, hierarchically structured, adaptive, highly integrated whole.

Ecological systems include living and non-living dissipative structures, entangled with social, cultural, and economic phenomena, constituting wicked and super-wicked problems

Understanding and adequately managing this complex network will positively influence the future of our planet, and contribute to the study of ecological issues as well as to the effort of implementing cleaner production practices.

We strongly emphasize that this class of problems -wicked- should be made more familiar to students, as early as possible in their careers.

**OBRIGADO**  
**POR ME**  
**OUVIRES!**



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