

## **INFORMATION IN COMPLEX SYSTEMS: SEMANTICS, SELF-REFERENCE AND CAUSALITY."**

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## **WHAT I HOPE TO ACCOMPLISH**

- **DESCRIBE A NEW FORM OF INFORMATION WHICH CAN BE USEFUL IN THE STUDY OF BIOLOGICAL COMPLEXITY**
- **RELATE THIS FORM OF INFORMATION TO THE FORMALISM CALLED "RELATIONAL BIOLOGY"**
- **REVIEW THE APPLICATION OF THIS FORMALISM TO THE DISTINCTION BETWEEN ORGANISMS AND SIMPLE MECHANISMS OR MACHINES**

## **OUR DEFINITION OF COMPLEXITY**

**Complexity is the property of a real world system that is manifest in the inability of any one formalism being adequate to capture all its properties. It requires that we find distinctly different ways of interacting with systems. Distinctly different in**

**the sense that when we make successful models, the formal systems needed to describe each distinct aspect are NOT derivable from each other**

## **THE MODELING RELATION: A MODEL OF HOW WE MAKE MODELS**

## **COMPLEX SYSTEMS VS SIMPLE MECHANISMS**

- **COMPLEX**
- **NO LARGEST MODEL**
- **WHOLE MORE THAN SUM OF PARTS**
- **CAUSAL RELATIONS RICH AND INTERTWINED**
- **GENERIC**

- ANALYTIC ≠ SYNTHETIC
- NON-FRAGMENTABLE
- NON-COMPUTABLE
- REAL WORLD
- SIMPLE
- LARGEST MODEL
- WHOLE IS SUM OF PARTS
  
- CAUSAL RELATIONS DISTINCT
- NON-GENERIC
- ANALYTIC = SYNTHETIC
- FRAGMENTABLE
- COMPUTABLE
- FORMAL SYSTEM

## WHAT IS INFORMATION?

- THERE IS A DIFFERENCE BETWEEN SYNTACTIC AND SEMANTIC INFORMATION
- SYNTACTIC INFORMATION IS THE SUBJECT OF “INFORMATION THEORY” IN SCIENCE AND ENGINEERING
- SEMANTIC INFORMATION HAS A VERY DIFFERENT NATURE

## SEMANTIC INFORMATION

- ANSWERS AN INTERROGATIVE (?)
- HAS NO LOGICAL STATUS
- THE ANSWER IS USUALLY AN ADJECTIVE THAT COMES TO MODIFY A NOUN
- THE NOUN IS WHAT THE INFORMATION IS ABOUT...WHAT IS REFERRED TO

## ENTAILMENT SYSTEMS: ARISE FROM THE INTERROGATIVE

- WHY?
- WHY X?
- WHAT ENTAILS X?

## THE RELATIONAL DEFINITION OF

# INFORMATION

- SCIENCE HAS ASKED “HOW?” AND AS A RESULT HAD A MECHANISTIC DEFINITION OF INFORMATION
- THIS HAS INHERENT PROBLEMS SINCE IT CAN NOT DEAL WITH SEMANTICS AND SELF-REFERENCE
- WE ASK “WHY?” AND ARE IMMEDIATELY FORCED TO DEAL WITH CAUSAL ENTAILMENT
- THE RESULT IS PROFOUND IN THAT WE NOW DEAL WITH THE ESSENCE OF THAT “SOMETHING” THAT MAKES THE WHOLE MORE THAN THE SUM OF ITS PARTS-THE MISSING LINK IN REDUCTIONISM
- WE NOW ARE FORCED TO DEAL WITH CLOSED LOOPS OF CAUSALITY AND OTHER IMPREDICATIVITIES (SORRY RUSSEL)

# THE FOUR BECAUSES: WHY A HOUSE?

- MATERIAL: THE STUFF IT’S MADE OF
- EFFICIENT: IT NEEDED A BUILDER
- FORMAL: THERE WAS A BLUEPRINT
- FINAL: IT HAS A PURPOSE

# THE RELATIONAL APPROACH TO A COMPLEX REALITY

- FOCUS ON THE ORGANIZATION
- DEVELOP A SET OF FUNCTIONAL COMPONENTS WHICH CAPTURE THAT ORGANIZATION
- UTILIZE THE CAUSAL RELATIONS RESULTING FROM ANSWERING “WHY?”

# FUNCTIONAL COMPONENTS

- MUST POSSESS ENOUGH IDENTITY TO BE CONSIDERED A “THING”
- MUST BE ABLE TO ACQUIRE PROPERTIES FROM LARGER SYSTEMS TO WHICH IT MAY BELONG
- ITS FORMAL IMAGE IS A MAPPING  $f: A \rightarrow B$
- THIS INTRODUCES A NEW KIND OF “DYNAMICS” :  
RELATIONAL

# METABOLISM/REPAIR SYSTEMS

- BASED ON INPUT/OUTPUT REPRESENTATIONS OF SYSTEMS

- MORE ABSTRACT
- ALLOW CAUSALITY TO BE REPRESENTED
- LEAD TO NEW INFORMATION
- ARE BASED ON RECOGNITION THAT BUILDING UP AND TEARING DOWN ARE PART OF THE LIFE PROCESS

INPUT/OUTPUT REPRESENTATION OF A SYSTEM

## THE RELATIONAL REPRESENTATION

- INVOLVES MAPPINGS
- METABOLISM IS  $f: A \rightarrow B$
- A REPRESENTS METABOLITES WHICH CAN ALSO EXCHANGE WITH THE ENVIRONMENT
- B REPRESENTS THE RESULTS OF METABOLISM
- $f$  IS A MAPPING FROM A TO B

## THE CAUSAL RELATIONSHIPS

- A IS THE MATERIAL CAUSE OF B (DOTTED ARROW)
- $f$  IS THE EFFICIENT CAUSE OF B
- OTHER COMPONENTS FOR REPAIR AND REPLICATION COME IN BECAUSE THESE COMPONENTS HAVE A FINITE LIFETIME: CATABOLISM AND ANABOLISM OR "TURNOVER"

## ROSEN'S RELATIONAL MODEL OF THE ORGANISM: METABOLISM

METABOLISM HAS A FINITE LIFETIME. IT CAN BE EXTENDED BY THE REPAIR OF THE FUNCTIONAL COMPONENT  $f$

- THE REPAIR OF  $f$  MUST BE ENTAILED
- THE MATERIAL CAUSE OF  $f$  IS IN THE PRODUCTS OF METABOLISM, B
- THE EFFICIENT CAUSE OF  $f$  WE WILL CALL  $\phi$

METABOLISM HAS A FINITE LIFETIME. IT CAN BE EXTENDED BY THE REPAIR OF THE FUNCTIONAL COMPONENT  $f$

THE REPAIR FUNCTION CAN BE SHOWN TO BE CLOSELY RELATED TO A REPLICATION OF FUNCTION IF WE REQUIRE THAT  $\phi$  ALSO BE REPAIRED OR REPLACED

- THE MATERIAL CAUSE OF  $\phi$  IS  $f$ . (IT COMES FROM AMONG THOSE THINGS THAT ENTAIL METABOLISM).
- CALL THE EFFICIENT CAUSE OF  $\phi$   $\beta$

## **PROVIDING FOR REPAIR OF THE REPAIRER**

THE END OF A POTENTIAL INFINITE  
REGRESSION

## **ROSEN'S RELATIONAL MODEL OF THE ORGANISM**

### **ORGANISMS**

- ARE COMPLEX SYSTEMS
- ARE CLOSED TO EFFICIENT CAUSE
- ARE AUTOPOIETIC UNITIES

### **ROSEN AS BIOLOGY'S NEWTON**

- NEWTON WAS ABLE TO CLOSE AN INFINITE REGRESSION BY FORMULATING  $F = MA$
- OVER 300 YEARS OF SCIENCE ARE BUILT ON THIS
- ROSEN'S CLOSURE OF THE RELATIONAL DIAGRAM SHOWING THAT ORGANISMS DIFFER FROM MACHINES BY BEING CLOSED TO EFFICIENT CAUSE IS AT LEAST AS IMPORTANT