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Systems Processes Theory and Sustainability: III. Application of Cycling as a Systems Process to Indoor Environments

I.A.S.

SELECTION OF SYSTEMS PROCESS

My thesis research aims to assess the ability of living plants to enhance the performance of a building by improving indoor air quality. The photosynthesis processes replaces CO_2 with oxygen, improving the quality of air inside the building.

The health effects of poor indoor air quality on human health have been well established. The carbon monoxide, carbon dioxide, nitrous oxides, sulfur oxides, volatile organic compounds, polycyclic aromatic hydrocarbons, metals and particular matter that make up typical air pollution can lead to asthma, strokes, heart attacks and sudden infant death syndrome in the short term and low birth weights, some cancers, cardiovascular disorders, schizophrenia and other mental illnesses in the long term (Burchett 2007). In an indoor area, elevated carbon dioxide levels can produce feelings of stuffiness, loss of concentration and drowsiness, as the brain is essentially becoming oxygen deprived. Studies have also shown that student performance and workplace productivity have an inverse relationship with carbon dioxide levels (Tarran 2007).

APPLICATION TO SUSTAINABILITY

In system theory cycling is a process, which occurs when a system experiences transformation from one state to another, eventually transforming into a previous existing state. Generally cycles are found in anything to which numerical measurements may be assigned at intervals in time. Stages, flow rates, sequences, recycling, population, entrainment, periodicity and initial conditions are all identifying features of cycles that can be implemented into sustainability through nature. By using nature as a model as John T. Lyle, of Cal Poly Pomona's Regenerative Studies Center suggests, we can attempt to design the human ecosystem using nature's ecosystems structure, function and locational patterns.

For my thesis, I will use the natural cycling of a *Pothos* plant to create better indoor air quality as the plants replace CO_2 with oxygen. The chemical equation for photosynthesis:

$$6CO_2 + 6H_20 + \text{Energy} \rightarrow C_6H_{12}O_6 + O_2$$

reveals the process by which plants are able to use carbon dioxide and water to turn sunlight into glucose while releasing oxygen as a byproduct.

This report will show samples of working definitions, identifying features as well as a listing of databases one can search to better understand cycles and their links to sustainability. Cycles in systems will also be exhibited in numerous forms throughout the poster.

IDENTIFYING FEATURES OF A CYCLE

Stages - Stages progress through observable relatively stable entities that are dependent on the previous stage and the complete cycle

Flow rates- each cycle captures matter, energy, and information and moves it through its pathway. Captured flow makes an entity what it is.

Sequence-stages must follow an obligatory sequence in order for the whole cycle to work. Each stage creates conditions and prerequisites for the next stage.

Recycling - The same materials, energy, or information are used over and over again, for example, enzymes and factors in the cell.

Populations - The existence of very large populations of any type of entity are a prerequisite for cycling to occur.

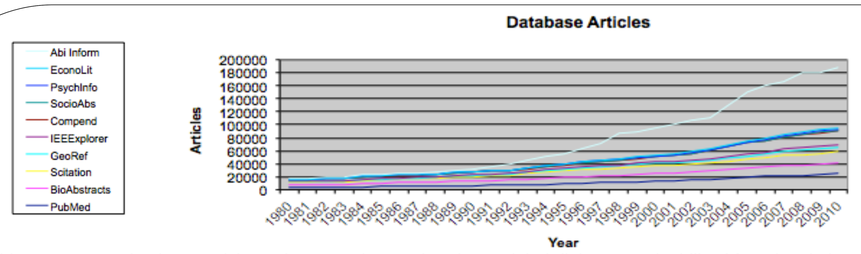
Entrainment - An external force acting on a system that coordinates the populations of entities to act similarly, in this case cyclical behavior.

Periodicity - A system may change from state to state in a fixed, or variable period of time.

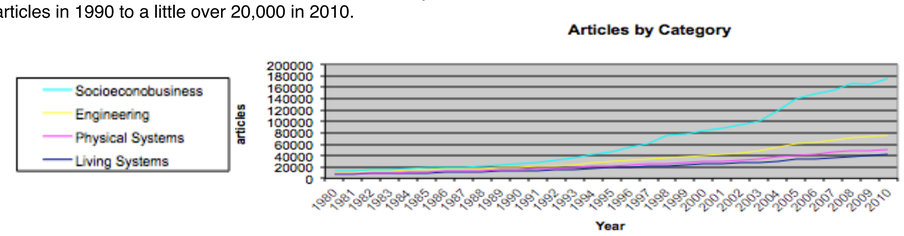
Initial Conditions - Some initial condition may be necessary to begin the progression from stage to stage. Some cycles may return to this initial condition.

TRENDS IN LITERATURE

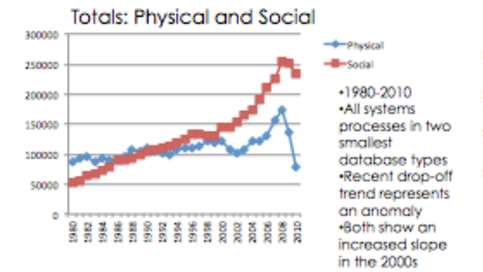
The search parameters used throughout this study were : Cycle* AND Sustainab*

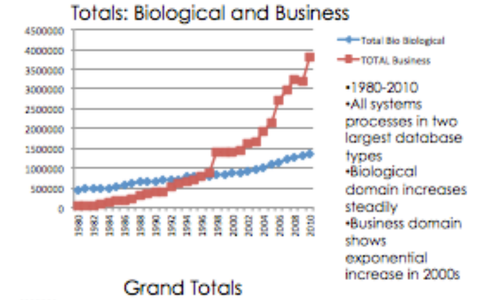


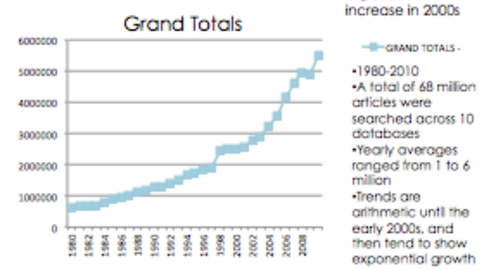
By searching numerous database articles to better understand cycles and their link to sustainability, I found variation of growth from highest to lowest starting with Abi Inform, Econolit, PsychInfo, SocioAbs, Compend, IEEExplorer, GeoRef, Scitation, BioAbstracts to PubMed. The search parameters used were "Cycle* AND Sustainab*" and initially all the articles had between 0-20,000 hits between 1980-1990. Abi Inform had the largest growth as it rose from 30,000 hits in 1990 to 190,000 hits in 2010. PsychInfo and SocioAbs trailed directly behind EconoLit as they rose from 30,000 articles in 1990 to 90,000 articles in 2010. Similarly, IEEExplorer, GeoRef, and Scitation grew closely from 30,000 articles in 1990 to between 60,000 and 70,000 articles in 2010. BioAbstracts grew slowly from 10,000 articles in 1990 to a little over 40,000 in 2010. Lastly, PubMed had the least amount of articles of all with 5,000 articles in 1990 to a little over 20,000 in 2010.



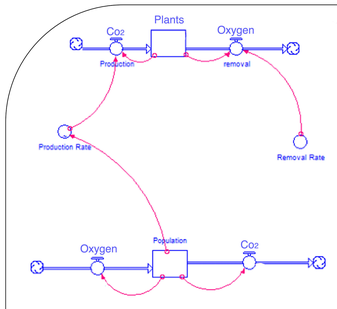
After searching individual articles by database, I compiled the articles by category to obtain a better understand of which category has the most resources. I found variation of growth between the categories of Socioeconobusiness, Engineeing, Physical Systems and Living Systems. The key words used throughout the search were "cycle* AND sustainab*". All four categories remained in a consistent flow between the years 1980-1990 at around 20,000 articles. The largest increase can be found in the Socioeconobusiness category as it rose from 30,000 articles in 1990 to 180,000 in 2010. The second largest growth can be seen in the engineering category as it rose from 30,000 in 1990 to 80,000 in 2010. Physical Systems is followed by Living Systems as Physical Systems grew to 50,000 from 1990 to 2010 and Living Systems grew to 42,000 from 1990 to 2010.







SYSTEMS MODELS

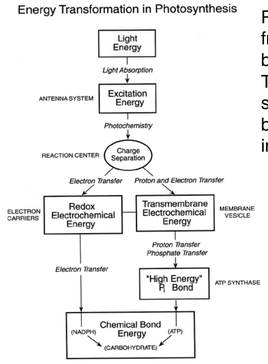


STELLA MODEL

"Any unity including all of the organisms (i.e., the "community") in a given area interacting with the physical environment so that a flow of energy leads to a clearly defined trophic structure, biotic diversity and material cycles (i.e. exchange of materials between living and non living parts) which in the system is an ecological system or ecosystem. " The following formal definition is the one used in the third edition of *Fundamentals of Ecology* (E.P. Odum, 1971)

In this diagram, one can see how the cycle of CO_2 can be exchanged through plants into oxygen and then recycled for respiration.

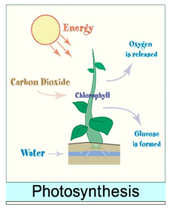
Energy Transformation in Photosynthesis



Adapted from a model by Howard T. Odum.
Odum, H.T. (1971), *Systems ecology: an introduction*. New York, NY: John Wiley & Sons Inc.

Photosynthesis is shown as a series of reactions that transform energy from one form to another. The different forms of energy are shown in boxes and the direction of energy transformation is shown by the arrows. The energy-transforming reaction is shown by italics in the arrows. The site at which the energy is stored is shown in capital letters outside the boxes. The primary photochemical reaction, charge separation, is shown in the oval.

Photosynthesis is a process by which plants are able to use carbon dioxide and water to turn sunlight into glucose while releasing oxygen as a byproduct.



ISSS / INCOSE

INCOSE (the International Council on Systems Engineering) and ISSS (the International Society for Systems Science) have entered into a formal partnership which will facilitate the study of systems science. The cooperation between the two groups will allow a knowledge base to be developed for members of both fields.

Representatives from both organizations have met in Arizona, Canada and England to outline and create these shared learning opportunities. The SSWG (Systems Science Working Group) has chosen four to five official projects to pursue.

This poster serves as an example of a multi-disciplinary project, as several graduate students from systems science, systems engineering, sustainability, and other related fields contributed their unique literature surveys on a variety of systems processes. This cross-boundary cooperation benefits all participants, as well as their respective fields.

CONCLUSION

In conclusion, cycles can not only be found throughout nature but through sustainability design. Regenerative studies aims to mimic nature with a closed loop system, everything is recycled and nothing is wasted. By looking to nature, we are able to not only solve problems using less energy, but create an even healthier environment for ourselves and our planet.

For further research on cycles and sustainability, one might look to the Abi Inform articles or the Socioeconobusiness category where cycles and sustainability had the most resources.