Bulletins from the Ecological Research Committee
No. 16

ECOSYSTEM APPROACH TO THE BALTIC PROBLEM

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The Energy Circuit Language – Equations (Appendix B)

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APPENDIX B

EQUATIONS

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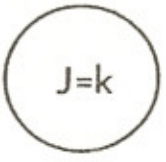
Some of the main symbols and their mathematical translations are also found in B. Patten (ed.) Systems Analysis and Simulation in Ecology, Academic Press, 1972.

Energy source
(Forcing Function)

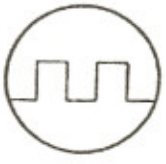
Examples of forcing functions

N = Population force



J = Flux (flow of quantity per unit time)

sine function



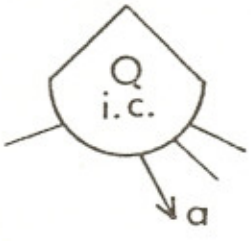
square wave

Heat sink

$\frac{TdS}{dt}$ Where S is entropy and T absolute temperature

Storage
(State variable or Intergrator)

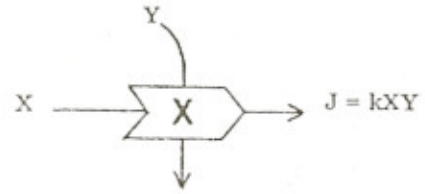
von Bertalanffy growth module)



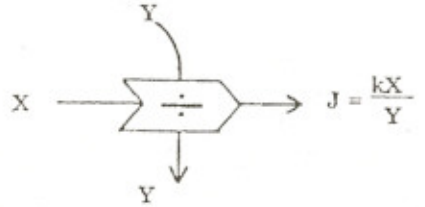
Q (in-out)dt + initial conditions, i.c. where outflow forces = $= \frac{Q}{C} = X$ or $\frac{Q}{C} = N$ and c is capacitance with units of length; note cost of storage (a).

Work Gates

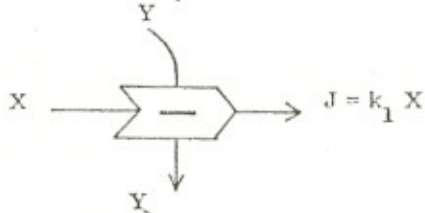
Augmenting conductivity (multiplier)



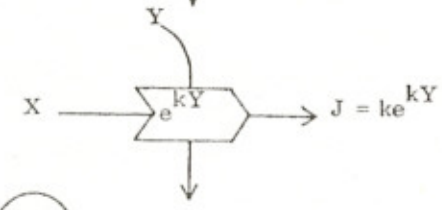
Diluting



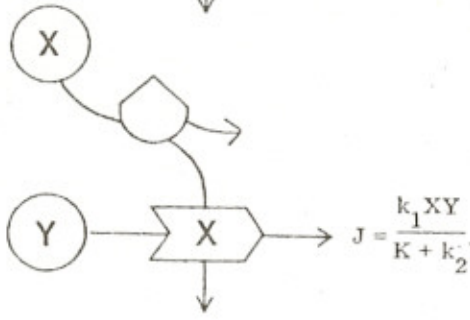
Retarding



Shading and some temperature accelerations

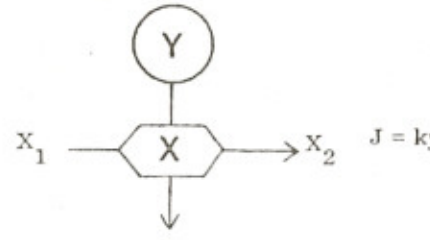


Limiting (X)

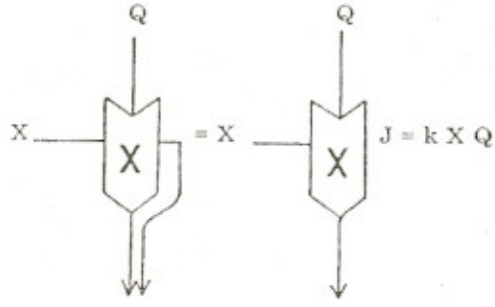


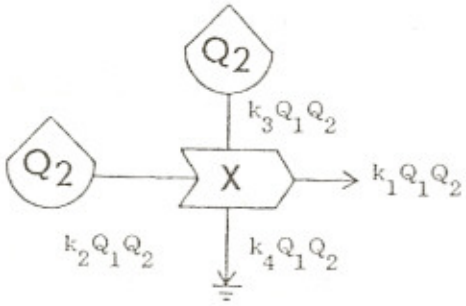
for derivation see "Environment, Power and Society", p. 315.

Pumped diffusion



Stress Gate





Pathways

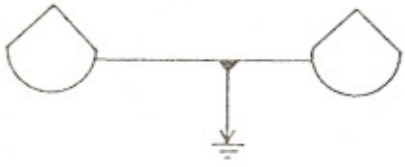
J is rate of flow

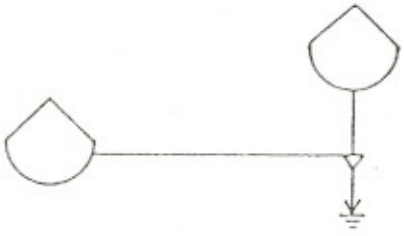
undirected driving force  $J = kQ = LX = L\frac{Q}{C} = \frac{1Q}{RC} = \frac{Q}{\tau}$

opposed driving forces  $J = L(X_1 - X_2)$

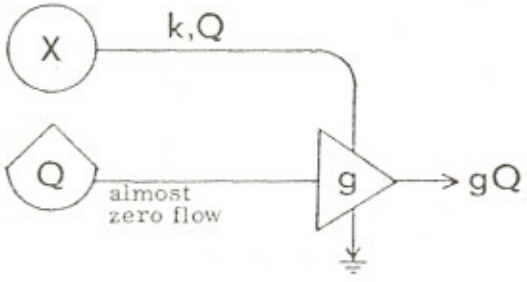
valve, one way flow but 2 way forces  Same but no back flow

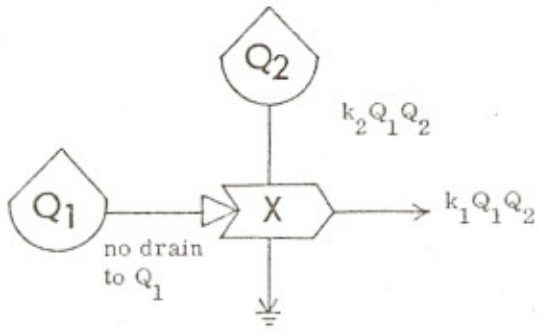
adding energy flow  $J = L(X_1 + X_2)$

heat loss in a frictional pathway 

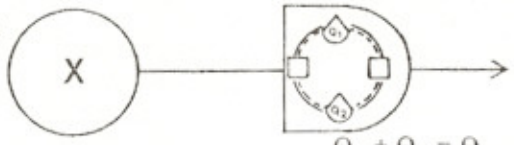
heat loss in a potential generating pathway 

Constant gain amplifier





combined with multiplier

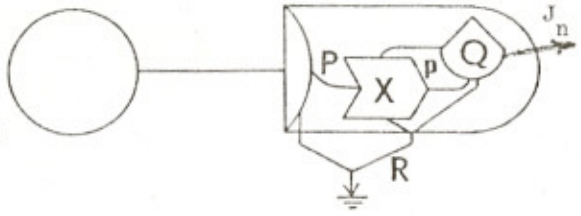


Michaelis-Menton (limiting cycling material)

$$J = \frac{k_1 X Q}{K + k_2 X}$$

$Q_1 + Q_2 = Q_t$

for derivation see page 317 in "Environment, Power, and Society".



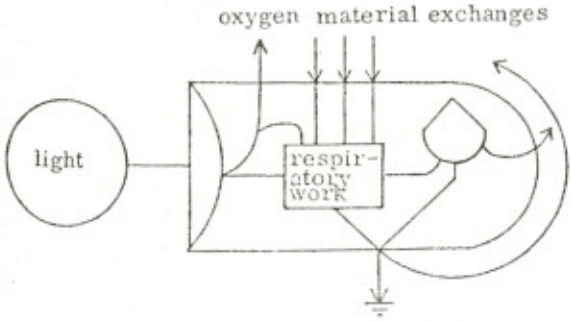
Composite Class Symbols in which inside details are varied

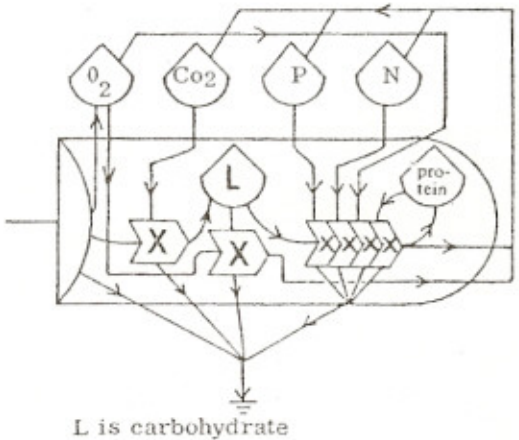
Two meanings for net production: J_n, $\dot{Q}$

gross production is P; sometimes gross production is used for p.

R = respiration

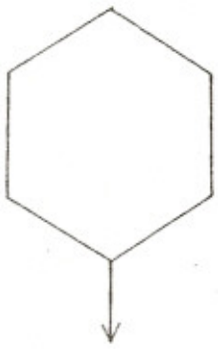
Plant systems



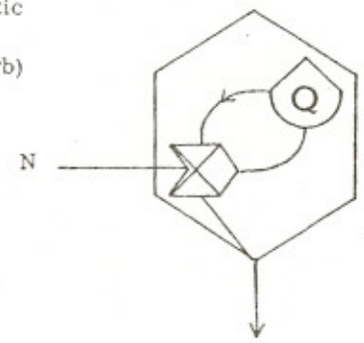


L is carbohydrate

Self-maintaining systems with autocatalytic pathways



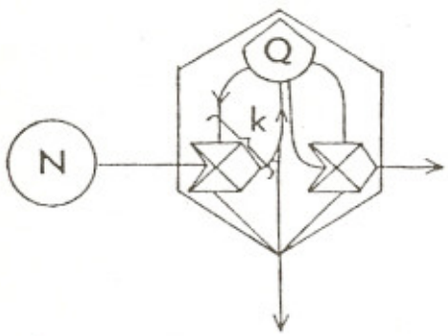
one form of ligistic growth with backforce (no barb)



$kQ\ (N - \frac{Q}{C})$

no intrinsic rate of increase since there is always an outside energy source N

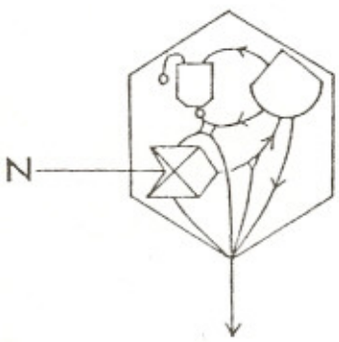
$N = \frac{Q}{C}$ where C is capacitance (volume/surface ratio)



another form of logistic growth

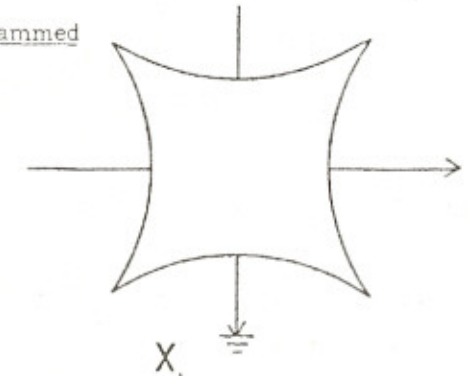
$Q = kNQ - k_2Q^2$

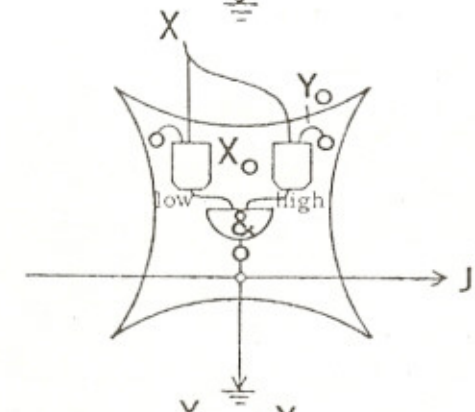
Hunger Switch



Work functions programmed as switching actions

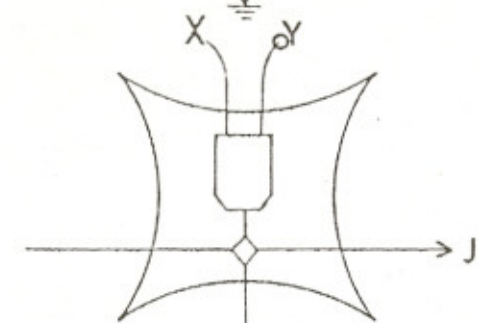
group symbol indicating logic switch actions (work) on the flow



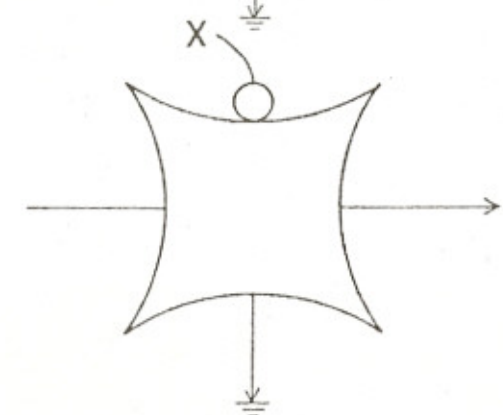


X and Y are simple forces

If X is between X_o and Y_o then flow it off

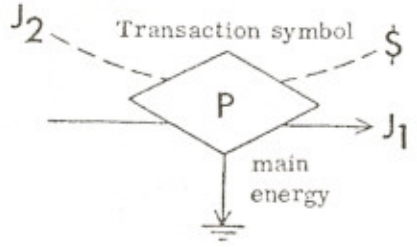


Comparator, if force of X is greater than Y switch is open and J flows

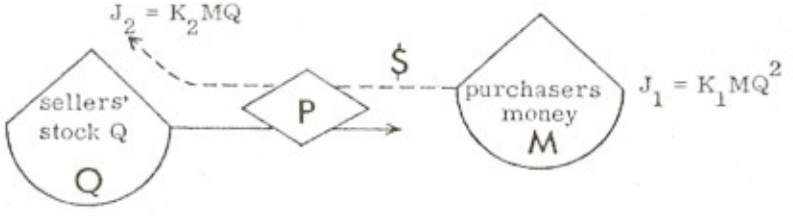


A logic "not" function (the small circle) if X is on, switch is off, if X is off, switch is on.

Price Transactions Involving Money



$P = \frac{J_2}{J_1}$ P is price



Price inverse to stock $P = \frac{K_a}{Q}$

Spending tendency $J_2 = LM$

Purchase tendency inverse to price $L = \frac{K_b}{P}$

$J_2 = K_2MQ$

$J_1 = K_1MQ^2$