Pregnancy as a Bifurcating Process

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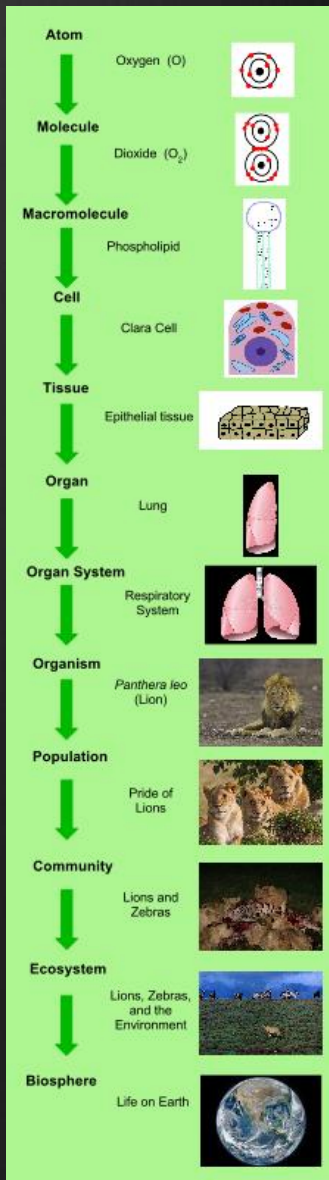
Overview

The common view of pregnancy ("the bun in the oven") is firmly grounded in a thing/substance ontology.

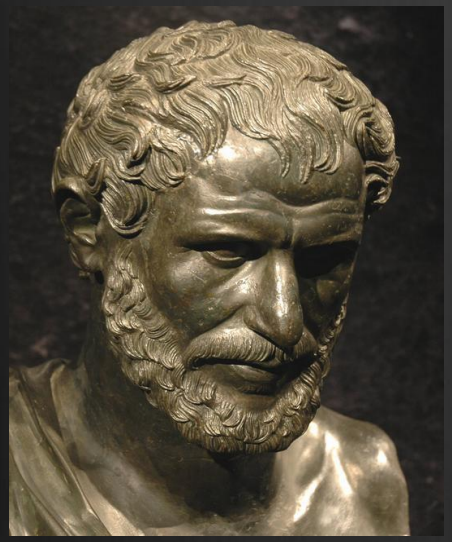
This ontology is inappropriate for living systems and should be replaced by a thoroughgoing process ontology.

This talk aims to explore how we should think of pregnancy from this perspective.

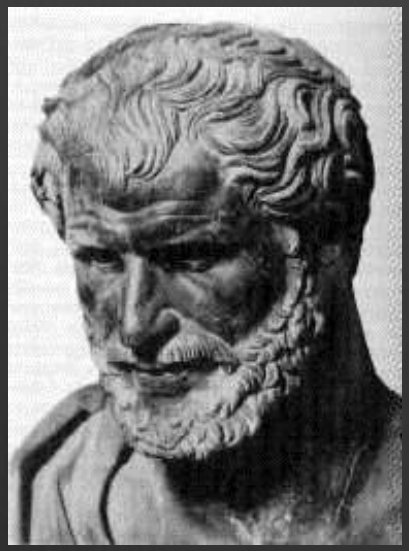


Processes and Things

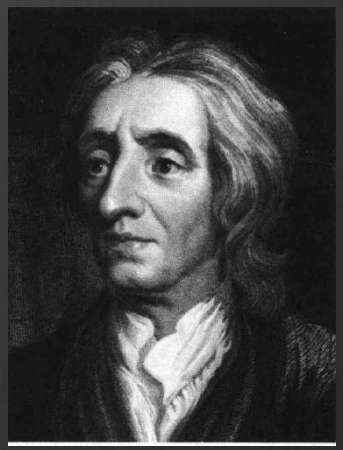
A (Very) Brief History: Processes and Things



Heraclitus: "Nothing endures but change. Change is the only constant."



Democritus: "Nothing exists except atoms and empty space; everything else is opinion"



Robert Boyle: "the Naturalist…in explicating *particular phenomena*, considers onely the *Size, Shape, Motion*, (or *want of it*) *Texture*, and the resulting Qualities and Attributes of the small particles of Matter."

Processes vs. Things

Processes persist through activity, whereas for things the default condition is stasis. For things persistence through change requires explanation; for processes persistence without change is impossible.

"As process ontologists see it, enduring things are never more than patterns of stability in a sea of process" (Rescher, SEP). Or "For process philosophy, what a thing *is* consists in what it *does*."

By 'process' I understand something (some-entity) for which change, or activity, is necessary for it to continue to be the kind of thing it is.

A thing?

A process: dynamic stabilisation; stability of form vs. matter

Biology Is All Process

- Evolution: hours to aeons
- Development: minutes to decades
- What evolve are developmental systems or cycles
- Metabolism: milliseconds to hours
  - Protein building, ~15 amino acids per second
  - Transcription, up to 80 nucleotides per second
  - DNA replication from ~ 50 nucleotides per second in eukaryotes to about 1,000 in bacteria
- Biological ‘things’ —species, organisms, genes, metabolites...are parts of processes stabilised over relevant time scales
- Biological ‘things’ are stabilised both by their internal processes and by the larger processes of which they are parts: life is a hierarchy of mutually stabilising processes.
- Some applications: ageing, cancer, evolution, reproduction…

Questions for a Process Perspective on Pregnancy

Two main questions:

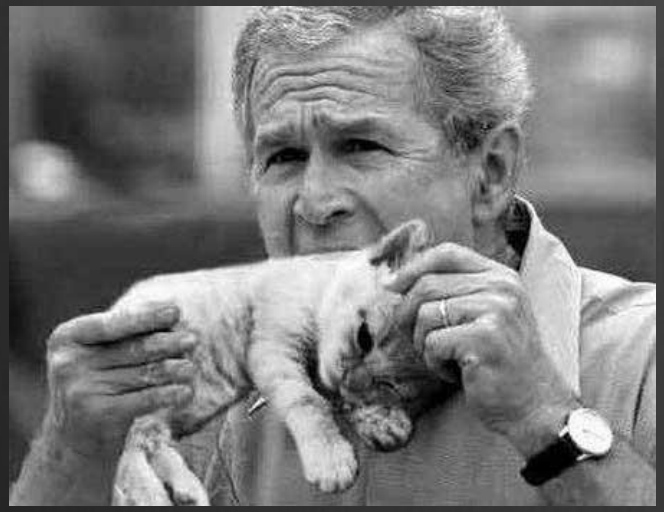
1. Is a pregnant mammal, one process or two. Generally, how do we decide what are the boundaries of a process?

2. When does one process split into two?

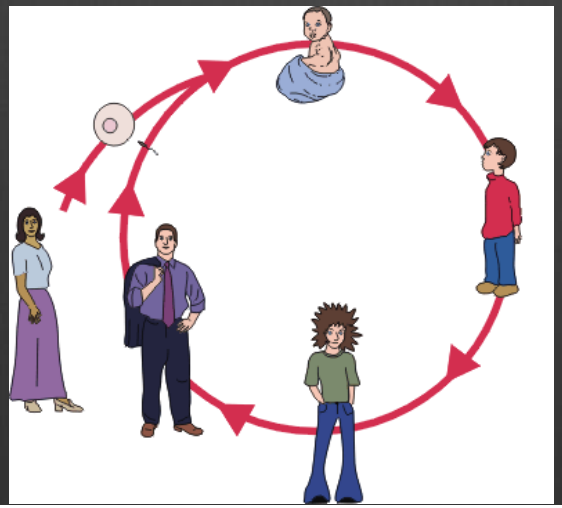
My general thesis is that there are no unequivocal answers to these questions, but that there is little reason to say that a pregnant mammal becomes two distinct processes any time before birth.

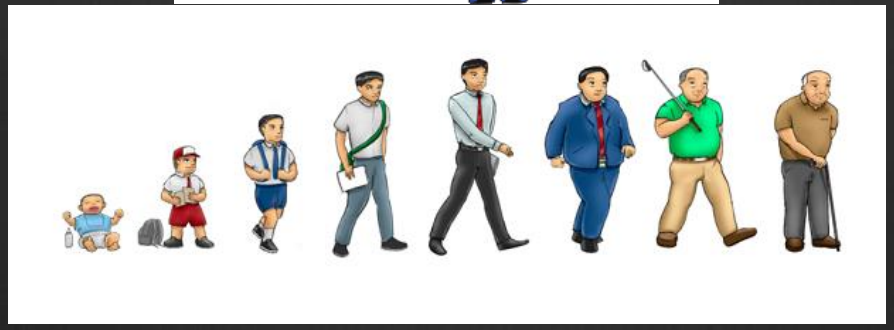
The Boundaries of Processes, or What is an Organism?

What is a Human?



A Process not a Thing





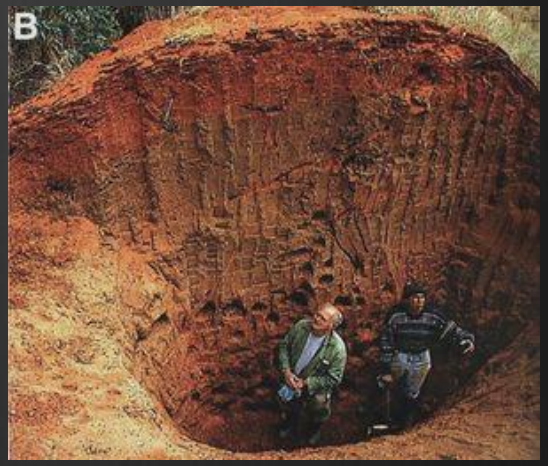
Processes don’t just happen by default, as things may persist. Many interacting factors stabilize living processes in the short term (metabolism, behaviour) and as life cycles (genes, parental care, material and social environment, and more).

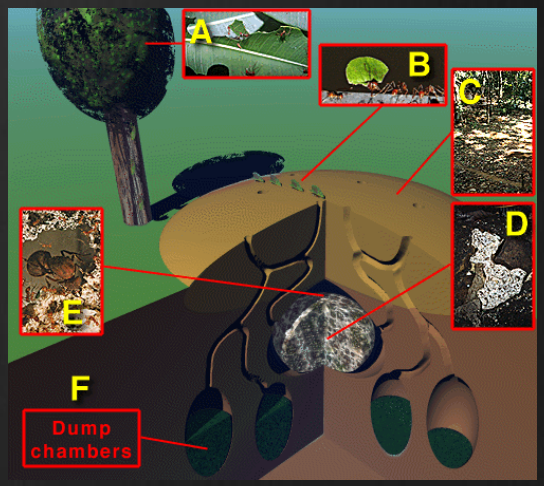
What Kind of Process is an Organism?

- Standard view: an organism is either single-celled or a clone originating from a single cell (e.g. a zygote). In the latter case the process often involves functional differentiation of the cell lineage. (Monogenomic differentiated cell lineage [MDCL]). This view underlies the 'bun in the oven' idea.
- Problem: organisms as just described are seldom autonomous, self-sufficient or *self-stabilising* systems. Almost all of life is in fact obligatorily symbiotic.

Leaf-Cutter Ants: The Multiplicity of Intertwined Lineages, and How Organisms Persist

- Castes and functional divisions of ants (queen, soldiers, foragers, masticators, nurses...)
- Symbiotic fungi (superorganism stomach)
- Microbial consortia in fungus gardens, including digestive and nitrogen-fixing bacteria and antibiotic bacteria on ants working in gardens
- Microbial consortia in waste dumps
- *Wolbachia* (obligate endosymbionts involved in sex ratio determination)
- Viruses...?

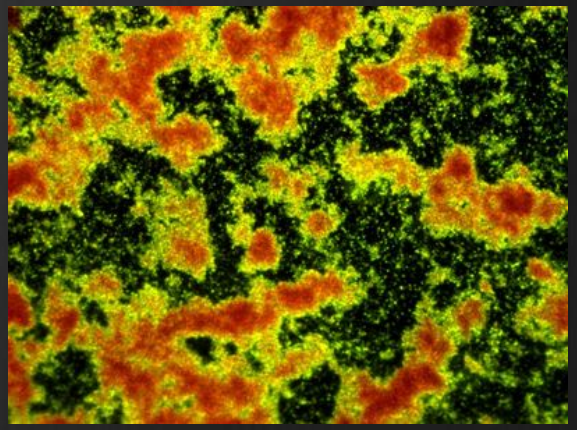




Some Other Living 'Things'

*Asterophora parasitica: (*mushroom that parasitizes mushrooms)

Various pelagic plankton

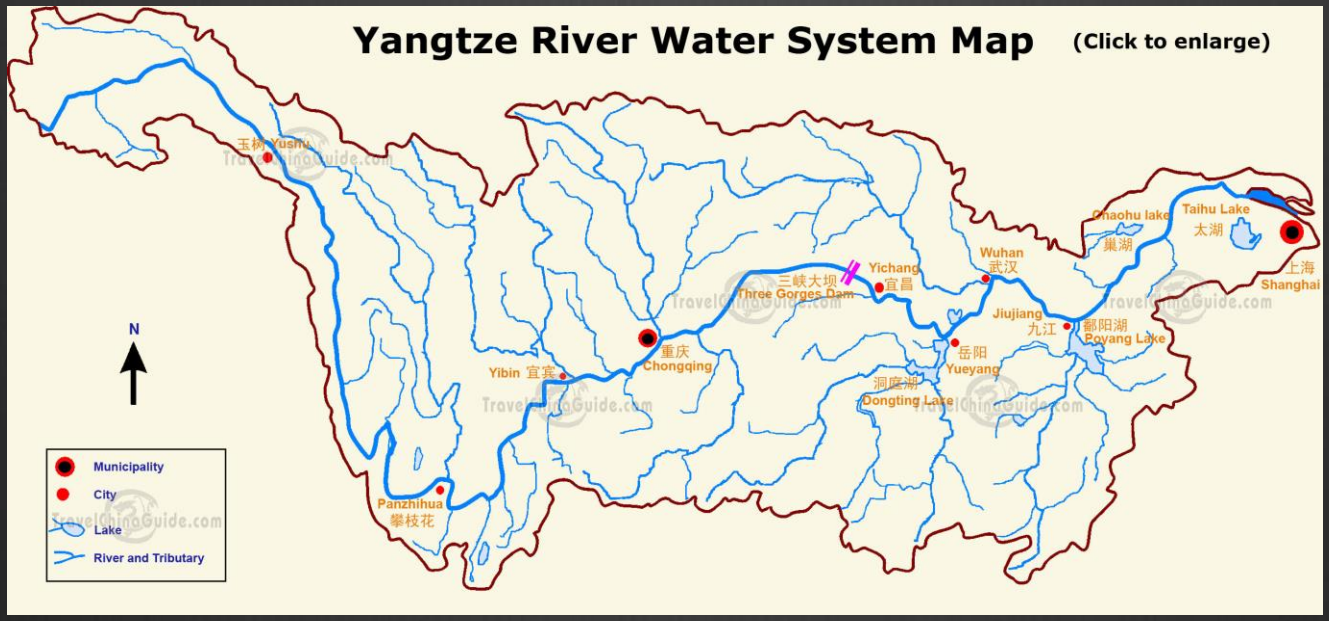


Multispecies biofilm

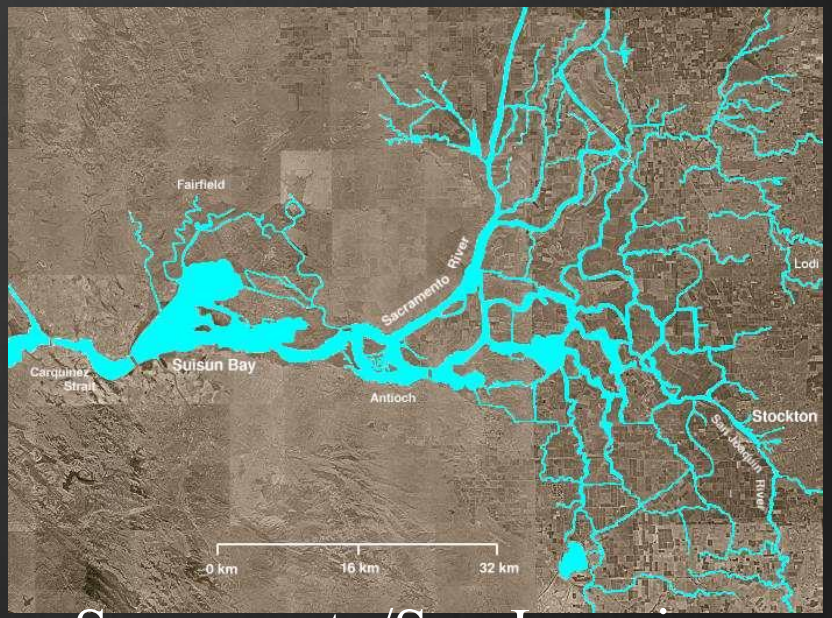
What is an Organism?

- Organism$_1$ as part of a (cell) lineage (unicellular or multicellular (MDCL), vs. organism$_2$ as a living system (interactor)
- Living systems typically involve a complexly intertwined interaction between many organisms$_1$.
- Defining the boundaries of organisms$_2$ is difficult, underdetermined, and interest-relative. However, these are what we generally mean when we refer to organisms.
- Organisms$_1$ are abstractions from the complex, intertwined and mutually stabilising processes that constitute organisms$_2$.
- Problems are not only with symbionts, but also conspecifics. Questions about social insects and "superorganisms" have long been discussed. Humans are massively social animals.

How Do Processes Divide and Merge? (Vs. Things)

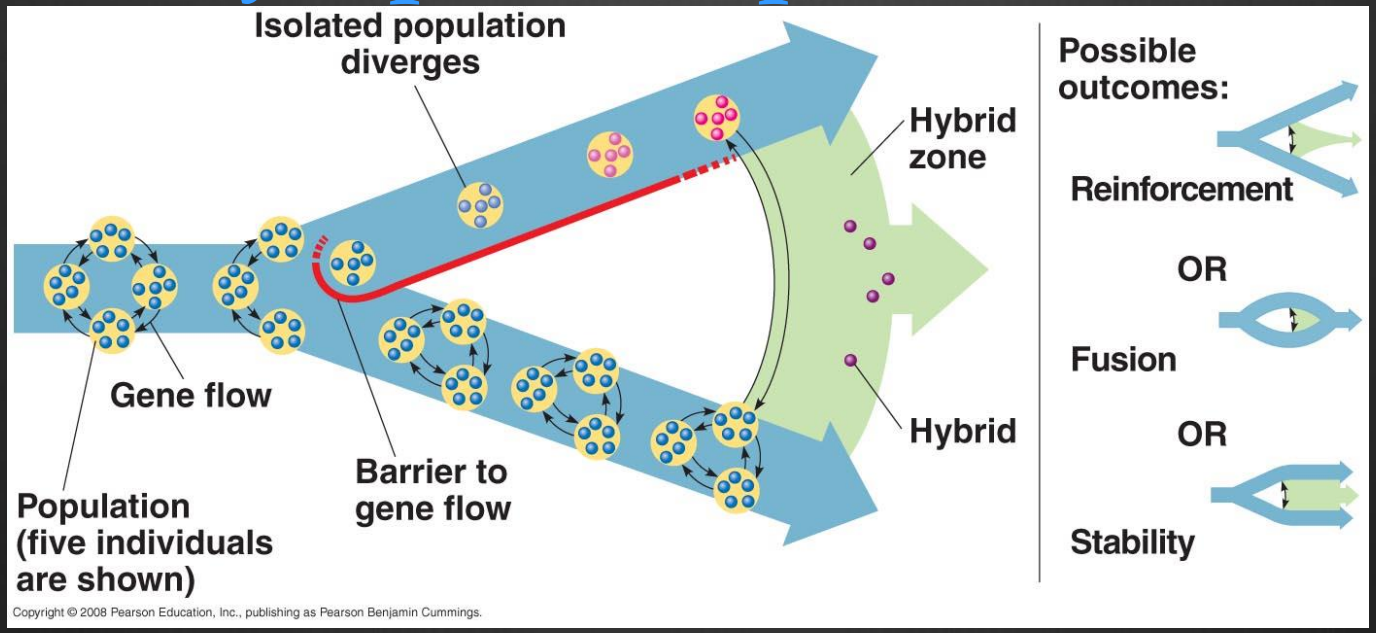


Ganges delta



Sacramento/San Joaquin (inverted) delta

A Biological Example: Sympatric Speciation



Barriers to gene flow can arise in many ways: disruptive selection, assortative mating, homozygote superiority, etc.
Limited gene flow may persist for a long time after the beginning of separation.
The cause of divergence may act long before speciation is established

Reproduction

- Reproduction is the generation of new developmental cycles from old.
- However, not always readily distinguished from growth, especially in plants.
- Reproduction is generally thought of in terms of organisms$_1$ rather than organisms$_2$. The reproduction of organisms$_2$ is often a much more complex process, that may not take place at a particular moment.
- Generally, if the boundaries of organisms are unclear, counting them will be ambiguous, and reproduction will be hard to locate unequivocally.

In plant cases, counting organisms is underdetermined.
Ant colonies, ants, fungus gardens, are countable, but reproductive relations are complex and discontinuous.

Optionally Lichenized Fungi: When a New Kind of Organism Comes into Being by Symbiosis is that Reproduction?

Species of *Stictis* (saprophytic fungi; above) appear to be indistinguishable from species formerly know as *Contrema* (a lichen; below). The lichen grows on living plants of the tree, the unlichenized fungus on decaying parts.

(Wedin et al. *New Phytologist* [2004])

When does a Human Start?

- A common view is that a human life begins with fertilisation of the ovum.
- This is a cause of process-splitting (though a probabilistic one) that may result in 0, 1, or more subsequently distinguished processes. But why identify the beginning of a process with its cause? (Compare speciation example.)
- In fact the processes of mother and child are deeply intertwined during pregnancy, and separate gradually post partum. No reason to suppose there is in general any definite point at which they become fully distinct processes.

Synchronization of Multi-Species System Bifurcation in Humans

- The gut microbiome changes during pregnancy, inducing metabolic changes including reduced insulin sensitivity and fat storage (Koren et al, Cell 2012).
- Diversity is generally reduced in the vaginal microbiome during pregnancy, and increases post partum. Usually dominated by lactobacillus spp.
- Vaginal microbiome is important in initial colonisation of the neonate. (Vaginal and Caesarean births lead to distinctively different microbiomes.)
- Atypical placental microbes associated with premature birth.

Summary

- Recognizing that life consists of a hierarchy of deeply intertwined, mutually stabilising, processes problematizes assumptions about the distinctness of biological 'things'. Indeed, the individualism that has dominated social and economic thought for at least 150 years is arguably based on a profound biological misunderstanding.
- From this perspective it is natural to think of pregnancy as the gradual bifurcation of a process, with no particular point of separation (the newborn infant is still not a wholly autonomous process).

Concluding Thought

J. H. Woodger (1929, p. 330): "*What is required is an enlargement of our concept of 'structure' so as to include and recognize that in the living organism it is not merely a question of spatial structure with an 'activity' as something over against it, but that the concrete organism is a spatio-temporal structure and that this spatiotemporal structure* is *the activity itself*"

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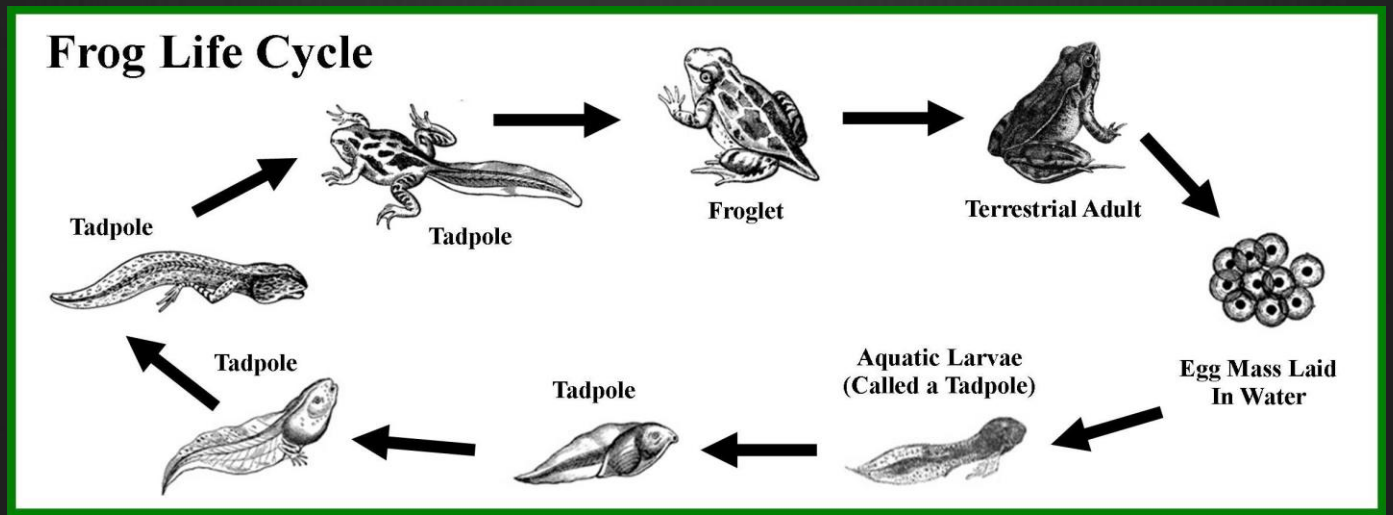
More on Organisms as Processes not Things/Substances

- An organism should not be identified with its morphology at any particular stage, but rather its whole life cycle. Temporal parts of this may be very different. Knowledge of all is required for reliable recognition.
- Persistence of an organism (life cycle) requires a great deal of activity (e.g. metabolism); it is not the default state.
- Evolution consist in a series of overlapping life cycles not a sequence of adult (or any other) stages.



- L. v. Bertalanffy (1941, p. 251): "*The old contrast between 'structure' and 'function' is to be reduced to the relative speed of processes within the organism. Structures are extended, slow processes; functions are transitory, rapid processes*"

- J. S. Haldane (1931, p. 22): "*Structure and functional relation to environment cannot be separated in the serious scientific study of life, since structure expresses the maintenance of function, and function expresses the maintenance of structure*"

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