Attributing Function to Molecules?

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Concepts of Life

| DARWIN LIFE

Exhibiting evolution by natural selection | HALDANE LIFE

Exhibiting metabolism and maintenance |
| --- | --- |
| WOESE LIFE

Possessing small subunit rRNA | ARISTOTLE LIFE

Capable of repurposing matter
to perpetuate self |

Mix, LJ (2015) Defending definitions of life.
Astrobiology 15:15-19

Living Thing = Player

Bio-Ontology

No consensus exists on an operational concept of life for astrobiology or origin of life studies. The leading concept for life invokes Darwinian evolution and by extension game theory. In other words, evolutionary concepts of life contain an operational ontology of players with utility functions. The utility functions unambiguously map to fitness, but the players represent a more problematic category. This is the primary obstacle in developing an operational concept of life along evolutionary lines (a.k.a. "Darwin Life").
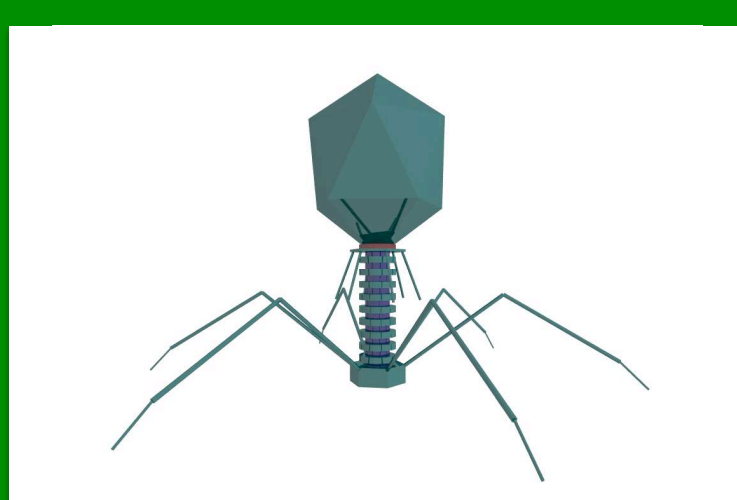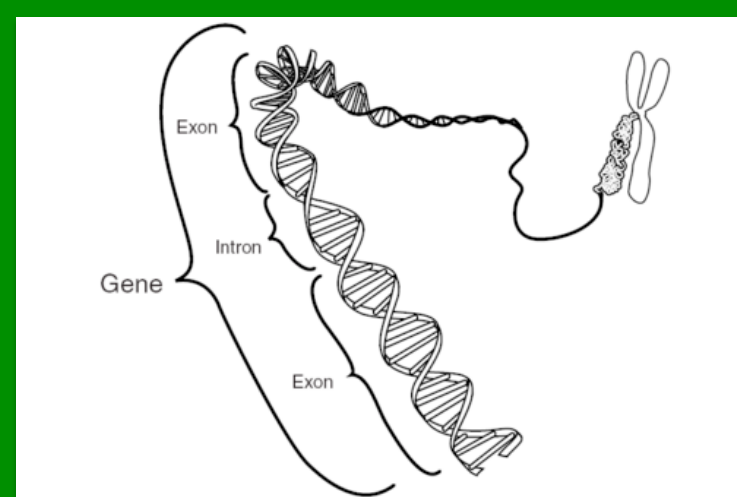
The categories of "individual," "organism," and "replicator" are thought to be intuitively obvious, but misapplication has prevented progress in a number of areas. If the origin-of-life is to be modeled as the origin-of-players, it will be necessary to have a clear concept of player with which to work.
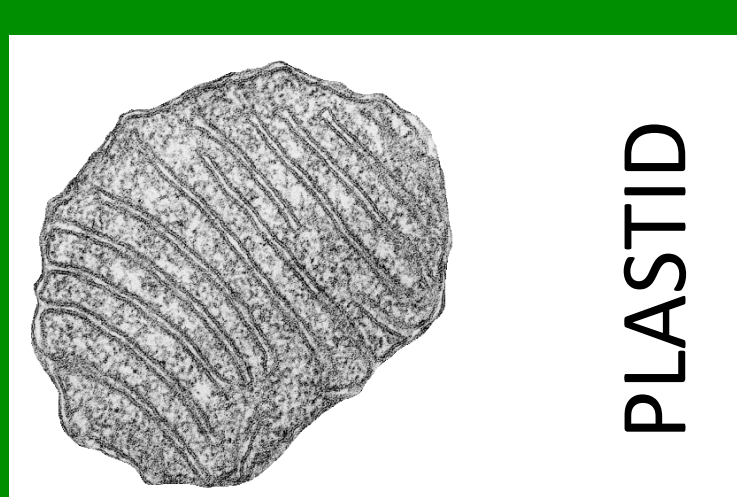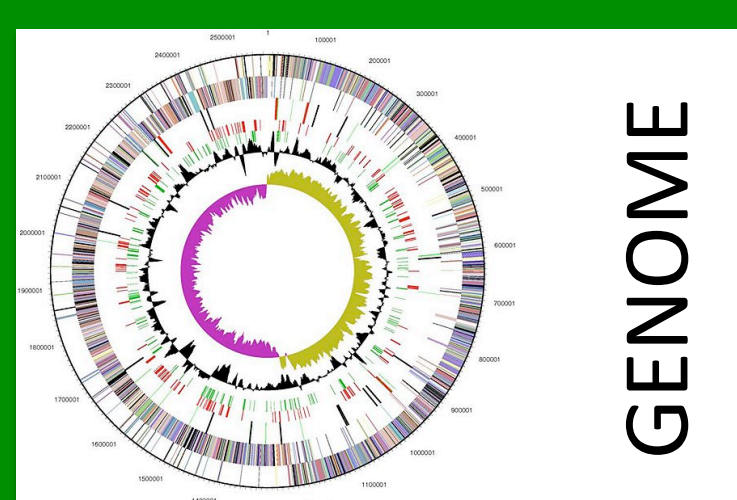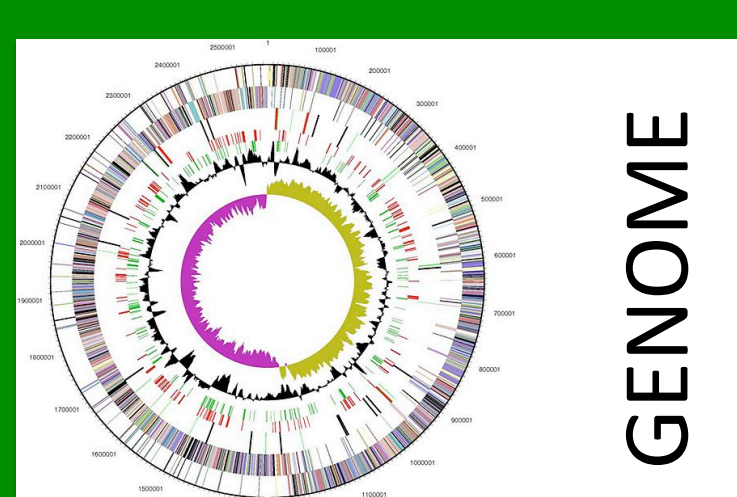

VS

VS

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GENOME

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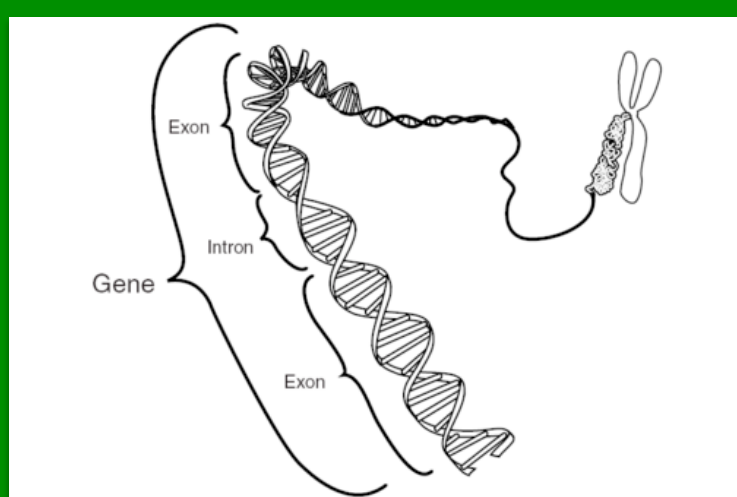
Expansion of "Player"

The replicators of Darwin were clearly individual organisms.

In the 20th century, molecular biologists discovered the molecular machinery behind inheritance and began to understand the virus as an extrinsic genome that hijacked cells. The modern concept of "virus" requires us to admit two biological categories: the genome, which replicates, and the cell/organism, in which it replicates. The cell/organism contains a normative genome and an invasive genome. Restriction enzymes can be said to have evolutionary functions only in light of this conflict; thus proper understanding of restriction enzymes required a biontology capable of dealing with sub-cell-level players (Dussoix 1962).

A similar development occurred, simultaneously, with explanations of biological altruism. Behaviors can be selected, not because they benefit individuals (organisms), or even because they benefit genomes, but because they benefit genes (Hamilton 1963). This spawned the 'selfish gene' school of thought, which privileges genes as players over any other unit. Whether or not other levels-of-selection are accepted, it has become clear that a biontology including genes as replicators will be essential.

A naïve approach to gene-level-selection would relegate the genome, cell, and organism to the status of environment, but this approach has not been taken. Rather these groups are referred to player coalitions (e.g., Leigh (1971) referring to a genome as a 'parliament of genes') or tools in the service of players (e.g., Dawkins (1976) referring to organisms as vehicles). At the very least, they represent an ecosystem or niche, in which replication takes place. Nor would it seem sensible to eliminate the common-sense use of individuals as players, as this informs vast swaths of biology – not to mention public understanding.

More recently, it has become clear that competition occurs across levels and the normative relationships between levels (e.g., nuclear genome defines the cell) are not universal. Maternally and paternally derived genes within the same individual have different interests (Moore and Haig 1991). Restriction enzymes can become addiction systems to the detriment of the nuclear genome (Naito et al. 1995). Nuclei from different sources can compete for long periods within a single celled fungal hypha (Joahnnesson and Stenlid 2004).

We now recognize that cells may compete within an individual (e.g., cancer), genomes may compete within a cell (e.g., viruses, heterokaryotic cells), genes may compete within a genome (e.g., imprinting), genes may compete with genomes (e.g., transposable elements) and organelles with cells (e.g., mitochondrial sex determination). The term 'player' applies to multiple kinds of entities, even within a single game.

References
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Consequences

1) Life requires at least 2 living things.
2) Functional molecules come from players with goals.
3) The first game must have players; therefore, evolution cannot precede players, goals, or functions (in time or explanation).
4) The "origin-of-life" becomes a single point in time – when the game begins.

The Game of Life

Under the Darwin Life model, the origin-of-life occurs when we first recognize objects as players. Likewise, the first 'biological function' will be the first strategic. There may be multiple, non-reconciled game models of life (e.g., competition among alleles in a population and competition of demes in an ecosystem). [I'm not commenting on the merit of the models, only saying they are distinct game models of life.] Nonetheless, all game models should have certain properties.

1. The game (life/evolution) requires at least two players.
2. Players, by definition, have goals. These involve a utility function made up of preferences. They need not be prospective, intentional, coherent, or constant, but they must be consistent enough to be heritable.
   i. Biological function is goal-oriented activity.
   ii. Biological function, including the first biological function, must be relative to a specific player.
   iii. The function may appear in an object other than the player (e.g., protein function relative to the fitness of the host organism or coding gene).
3. The plainest application of the game metaphor equates goal and maximizing fitness for the player. This is an identity statement and not a definition. Neither element explains the other.
   i. Under the Darwin Life model and this plain metaphor, evolution cannot occur without players, nor the players without evolution. They must arise simultaneously; therefore evolution cannot precede the first 'player' or the first 'goal.'
4. Players marshal resources in pursuit of their goals.
   i. Most biological games rely on other games. For example, cells competing for sugar rely on carbon, hydrogen, and oxygen atoms being marshaled as sugar.
   ii. The most fundamental games marshal a few elements (C, H, N, O, P, S) and a few forms of usable energy (visible light, excited electrons, ion gradients).
   iii. Players cannot be identical to resources.
      a. Players must be composed solely out of resources, but fundamental resources (as used in chemistry and physics) cannot have goals; therefore goals arise as relational properties among the marshaled resources.
      b. Thus, players have a 'form' – a pattern of resources or process running on resources – for which elements and energy are necessary, but not sufficient.
      c. 'Form' proves to be the difficult category for modern biology.
   iv. Players need not be discrete, but they must be distinct with regard to the benefit of resources. For example, two genes may overlap on a chromosome, but they can only be said to be players if they receive differential benefit.

Origin of Function

If we subscribe to the Darwin Life concept, then recognizing the first biological function will require a distinct goal, a specific player, and resources. The last is relatively easy and several good candidates have been proposed (most notably nucleotides marshaled by autocatalytic ribozymes). The first two are more problematic. As much as we wish to decompose the "origin-of-life" into a continuous chain of events, Darwin Life thinking requires a magic moment at which the game begins, when the form of life – relative to a goal – first appears.

Living Thing =? Product

One attempt to avoid consequences 3 and 4 changes our definition of living thing from player to product of play. This addresses those issues, but raises another; it makes all fossils, prostheses, technologies, and waste products into life. This seems transparently unhelpful. Note that all waste products are, necessarily, more organized than their surroundings; the useful parts have been removed. Waste is an organized product of evolutionary processes.

Can we live with these consequences to the Darwin Life model?