The Dictionary of Life

Dr. Paul A. Nelson
I would like to personally thank you for watching the Origins program. Origins was a special program, near to the heart of my late husband, Russell Bixler.

I trust that the information in this presentation will be helpful in your study of creation science. Thank you for your prayerful and financial support of Origins... you’re making the television production of this program possible.

Norma Bixler
Electron micrograph of *Mycoplasma*

(from Zinsser 1976, p. 756)
The minimal gene complement ("parts list") of *Mycoplasma genitalium* (Fraser *et al.*, 1995)
Mycoplasma genitalium genes by functional classes

- Cell envelope
- Energy metabolism
- DNA translation
- DNA transcription
- Cellular processes
- DNA replication
- Transport & binding
- Regulatory functions
Bacterial cell-division protein (ftsZ)

(from J. Lowe and L.A. Amos, 1998)
Chaperone (groEL)

(from Z. Xu, A. L. Horwich, and P. B. Sigler, 1997)
Elongation factor Ts (tsf)

(from Y. Wang et al., 1997)
The minimal gene complement ("parts list") of *Mycoplasma genitalium* (Fraser *et al.*, 1995)
A significant question:

How many of these “parts” (that is, genes and their protein products) of *Mycoplasma* can be taken away – and still have a functioning cell?
Global Transposon Mutagenesis and a Minimal Mycoplasma Genome

Clyde A. Hutchison III, Scott C. Peterson, Steven R. Gill, Robin T. Cline, Owen White, Claire M. Fraser, Hamilton O. Smith; J. Craig Venter

Mycoplasma genitalium with 517 genes has the smallest gene complement of any independently replicating cell so far identified. Global transposon mutagenesis was used to identify nonessential genes in an effort to learn whether the naturally occurring gene complement is a true minimal genome under laboratory growth conditions. The positions of 2209 transposon insertions in the completely sequenced genomes of M. genitalium and its close relative M. pneumoniae were determined by sequencing across the junction of the transposon and the genomic DNA. These junctions defined 1354 distinct sites of insertion that were not lethal. The analysis suggests that 265 to 350 of the 480 protein-coding genes of M. genitalium are essential under laboratory growth conditions, including about 100 genes of unknown function.

One important question posed by the availability of complete genomic sequences (1–3) is how many genes are essential for cellular life. We are now in a position to approach this problem by rephrasing the question “What is life?” in genomic terms: “What is a minimal set of essential cellular genes?”

Interest in the minimal cellular genome predates genome sequencing (for a review, see (4)). The smallest known cellular genome (5) is that of Mycoplasma genitalium, which is only 580 kb. This genome has been completely sequenced, and analysis of the sequence revealed 480 protein-coding genes, plus 37 genes for RNA species (2). The fraction of nonminimal genomes that is essential for cell growth and division has been experimentally measured in yeast (12%) and in the bacterium Bacillus subtilis (9%) (6). The indispensable portion of the B. subtilis genome was estimated to be 562 kb, close to the size of the M. genitalium genome. Theoretical approaches to defining a minimal gene set have also been attempted. With the availability of the first two complete genome sequences (Haemophilus influenzae and M. genitalium) and the assumption that genes conserved across large phylogenetic distances are likely to be essential, a minimal gene set of 256 genes was proposed (7).

Mycoplasma pneumoniae is the closest known relative of M. genitalium, with a genome size of 816 kb, 236 kb larger than that of M. genitalium (5). Comparison of the two genomes indicates that M. pneumoniae
Essential Genes of a Minimal Bacterium

transposon (tn4001)

DNA (circular chromosome) of Mycoplasma

The transposon inserted randomly in the bacterial chromosomes, disrupting genes as it did.
transposon (tn4001)

essential gene (e.g., ribosomal protein)
transposon (tn4001)

essential gene (e.g., ribosomal protein)

cell death
transposon (tn4001)

Essential genes are disrupted: the cell dies.
Essential genes are disrupted: the cell dies.
No essential genes are disrupted: the cell lives.
What did Hutchison and his colleagues find in this experiment?

Their analysis suggests that 382 of the 482 protein-coding genes of *M. genitalium* are essential under laboratory growth conditions, including 110 genes of unknown function.

(2006, pp. 425, 429)
What did Hutchison and his colleagues find in this experiment?

“The presence of so many genes of unknown function among the essential genes of the simplest known cell suggests that all the basic molecular mechanisms underlying cellular life may not yet have been described.”

(1999, p. 2168)
“Caulobacter crescentus is a model organism for the integrated circuitry that runs a bacterial cell. Full discovery of its essential genome, including non-coding, regulatory and coding elements, is a prerequisite for understanding the complete regulatory network of a bacterial cell… [W]e determined… 1012 essential genome features: 480 ORFs, 402 regulatory sequences and 130 non-coding elements, including 90 segments of unknown function.”

(2011, 528, emphasis added)
"There were many surprises in the analysis of the essential regions of Caulobacter's genome... For instance, we found 90 essential DNA segments where we have no idea what they do. These may provide clues to lead us to new and completely unknown bacterial functions."

Lucy Shapiro, Stanford University

Science Daily, 30 August 2011
The “essential” parts of these engines are...
“Bottom-up” origin of life scenario

self-replicating RNA molecules within a cell membrane

self-replicating RNA molecule

non-living chemicals
Do “bottom-up” processes, and “top-down” functional requirements, intersect?

minimal complexity analysis

No: a vast complexity gulf separates the two regions.

the interaction of non-living chemicals
For instance, we know of no prebiological (undirected, abiotic) pathway to RNA molecules.
Biotic realm ("living")

Origin of life

Prebiotic realm ("non-living")

"bottom-up approach"
Well...is it possible that life did not arise via natural causes only, but was intelligently designed?
The Rule of Methodological Naturalism

“The statements of science must invoke only natural things and processes.”

National Academy of Sciences (Donald Kennedy et al., 1998)
The disappearance of a possible cause

“The Darwinian revolution was as much concerned with the promotion of a particular view of science as it was with the introduction of a theory on the transmutation of species.”

David Hull, “Darwin and the nature of science” (1983, p. 65)
“Hence the first paradox... to obtain the minimal complexity required of a biological system to start on the path of biological evolution, a system of a far greater complexity, i.e., a highly evolved one, appears to be required. How such a system could evolve, is a puzzle that defeats conventional evolutionary thinking.”
Dr. Paul A. Nelson
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The Dictionary of Life

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