

Data and Information: Effect of Bioinformatics on Traditional Biology

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The Differences between random data and information are examined. The results of a computer simulation are shown, using a two-bit code to represent the ACGT digits of life. It is demonstrated that the probability is vanishingly small that the information contained in living systems is the result of random processes. It is widely acknowledged by investigators who study information that chance has no causative effect and cannot produce information. This will be highlighted in a number of areas such as the search for extraterrestrial intelligence, lotteries, self-replicating programs, and complexity theory. The incredibly complicated digital information that is the focus of Bioinformatics will raise doubts as to the role of chance in evolutionary biology. The validity of several major assumptions will be examined, such as Dawkins' statement that "Each successive change in the gradual evolutionary process was simple enough, relative to its predecessor, to have arisen by chance. (*The Blind Watchmaker*)" Does Bioinformatics support traditional biological views, or will it point in new directions, perhaps proposing other mechanisms for possible testing? Bioinformatics has much to say about the exquisite information in the macromolecules that form life, the repeated patterns, homologues, and gene sequences. What, if anything, does it have to say in regard to biology's unanswered questions?

Traditional Neo-Darwinian Biology

"Each successive change in the gradual evolutionary process was simple enough, relative to its predecessor, to have arisen by chance."¹ (p43)

"We conclude—unexpectedly—that there is little evidence for the neo-Darwinian view: its theoretical foundations and the experimental evidence supporting it are weak."² (p726)

"The failure to observe even one mutation that adds information is more than just a failure to support the theory. It is evidence against the ... neo-Darwinian theory."³ (p 160)

Data Versus Information

Rolling a die 100 times produces a complex pattern with $P = 6^{-100}$ (1.5×10^{-78}) probability for that pattern. But, if any roll is acceptable, the probability is 1^{100} (1). A certainty has no information.

A lottery has "Artificial Information" by chance.

$P = 1/41,416,353$ for CA SuperLotto (5!42!/47!/27)

SETI looks for information in data to detect intelligence^{4,5}.

Detecting Information

Complex, not simple, e.g.—11011100101110111

Could be interpreted:

1 10 11 100 101 110 111 (counting to 7 in binary)

probability is 1 in 131,072

Probability is too low to ensure information is "real".

Chance can't produce complex information⁶⁻⁹.

It can modify existing information, with no net information gain

"None of the papers published in JME (Journal of Molecular Evolution) over the entire course of its life (1971-) as a journal has ever proposed a detailed model by which a complex biochemical system might have been produced in a gradual, step-by-step Darwinian fashion."⁹ (p176)

Encoding Data as Genetic Information

First 98 primes, versus random: **each $P = 4^{-377} = 10^{-227}$**

TAACATTTTCTTGTTTTATTTCTTGCTTGTTCATTGCTTTATCT
GCATTAACCTCTGTCTTCGATGGTTTCAGTGGATTATATGCACT
ACGTGACCGTTTTCTGTGTGGTCGTTGTATTGACGGTGTCCGT
GGGATCAGTGCTGTATGCGCGTTATATGCAGTACGTGATATACC
CGACTTAATCGAATTAACCTTGTACTGTTGGCTGCCTGATTC
TTTCATTACTTACCTAACGTTTGTCCGATGGTCCGGCTGGATGCT
CGCCTGCCGAGTGAGCGAATTTTTACTCGTGGTTATTGCCTAA
TCGCGGCTATTGCATACTGACTTGTCTGGTCTTCCTCATAGTTT
TGCTGCTACTCGTTTCTG

CCGAATGTGTGGAGACTACGGGCTCGTAATGGCATCAGAGCTC
CGGTCGATCGCCATACAATTACAGTAAATCTATCGTGCTGTGTAG
GATTCTGGTAGTAGGGGGGACCTTCCGTAGGTGGGTCAGAACT
CAGAGCGGGAGCCTTATGTGCCAGCTGGAGACCATGTGCTAG
ATGATAAGCCTGTAGGGTTCGAGTTAGGGCGACGTGGAGAGTTC
TTTCGGTCTCAGGGCATAACAGCTACCATAACTTACGTATGGACA
GGCGGGTCTGGCTGATTCTGGACCCATTACTTTCCCTATTGCAC
AACTGACCCTGGAGCATCATGCACGAAACAGCCTAAAGCCCATC
TCGGGGCAAGGGGTTACAGCAGCGAGAA

Probabilities of Life

Law of Probability allows a maximum probability of forming-

a biologically functional amino acid¹⁰: 1 part in 10^{175}

the required enzymes for life¹¹: 1 part in $10^{40,000}$

a living, self-replicating cell¹²: 1 part in $10^{340,000,000,000}$

Life is unfathomably complex¹³⁻¹⁵

"Chemical evolution is broadly regarded as a highly plausible scenario for imagining how life on earth might have begun. ... what has emerged over the last three decades ... is an alternative scenario which is characterized by destruction, and not the synthesis of life. ... The undirected flow of energy through a primordial atmosphere and ocean is at present a woefully inadequate explanation for the incredible complexity associated with even simple living systems"¹⁰ (p. 182 & 186)

"Physics books may be complicated, but . . . the objects and phenomena that a physics book describes are simpler than a single cell in the body of its author. And the author consists of trillions of those cells, many of them different from each other, organized with intricate architecture and precision-engineering into a working machine capable of writing a book. . . . Each nucleus . . . contains a digitally coded database larger, in information content, than all thirty volumes of the Encyclopedia Britannica put together. And this figure is for each cell, not all the cells of the body put together."¹³

"The unexpected levels of complexity revealed at the molecular level have further strained the concept of the random assembly of a self-replicating system."¹⁴

"Two GTPases, one in SRP and one in the SRP receptor (named Ffh and FtsY in bacteria, respectively), form a complex in which both proteins reciprocally activate the GTPase reaction of one another. . . . Surprisingly, even after a stable complex is formed, single mutations in FtsY can block the activation of GTP hydrolysis in both active sites. Thus, activation requires conformational changes across the interface that coordinate the positioning of catalytic residues in both GTPase sites."¹⁵

Computer Simulations

**Dawkins¹⁶ randomly changed:
"WDLTMNLT DTJBK WIRZREZLMQCO P"
to produce on the 43rd try:
"METHINKS IT IS LIKE A WEASEL"**

**Analysis: much shorter than a genome.
knew the goal in advance and stopped mutation if correct.**

**Ludwig¹⁷ Artificial Life contest Winning program: 101 bytes.
P = 256⁻¹⁰¹ = 10⁻²⁴³.**

**If 10⁸ computers try 10⁷/sec: 3X10²² tries/yr = 10²²⁰ years
"Only" 10⁹⁹ years if a 50-byte solution could be possible.**

Programs were intelligently designed for designed platforms.

Bioinformatics Role

Detect - Analyze - Predict

What about information?

-Undirected Natural Source

-Intelligent Source

What FACTs support each?

Natural: mutations modify existing info (no net information gain)

Intelligent: complex info evident with no known natural source

Much "Junk DNA" purpose has been found.¹⁸⁻¹⁹

"Just when scientists thought they had DNA almost figured out, they are discovering in chromosomes two vast, but largely hidden, layers of information that affect inheritance, development and disease."¹⁸ (p48)

"Scientists are puzzling over a collection of mystery DNA segments that seem to be essential to the survival of virtually all vertebrates. But their function is completely unknown.

The segments, dubbed 'ultraconserved elements', lie in the large parts of the genome that do not code for any protein. Their

presence adds to growing evidence that the importance of these areas, often dismissed as junk DNA, could be much more fundamental than anyone suspected."¹⁹

What is the role of Bioinformatics to add enlightened science to the information's source? That life contains complex information is obvious. What criteria can be used to test the veracity of various models, such as self-organization, punctuated equilibrium, cladism, structuralism, neo-Darwinism, or intelligent design? Meyer points out "What natural selection lacks, intelligent selection--purposeful or goal-directed design--provides. Rational agents can arrange both matter and symbols with distant goals in mind. In using language, the human mind routinely "finds" or generates highly improbable linguistic sequences to convey an intended or preconceived idea...The causal powers that natural selection lacks--almost by definition--are associated with the attributes of consciousness and rationality--with purposeful intelligence. Thus, by invoking design to explain the origin of new biological information, contemporary design theorists are not positing an arbitrary explanatory element unmotivated by a consideration of the evidence. Instead, they are positing an entity possessing precisely the attributes and causal powers that the phenomenon in question requires as a condition of its production and explanation."⁶

References

1. Richard Dawkins, The Blind Watchmaker 1986.
2. H. A. Orr & Jerry Coyne, "The Genetics of Adaptation: a Reassessment", American Naturalist, p726, 1992
3. Lee Spetner, Not By Chance, 1996
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5. <http://setiathome.ssl.berkeley.edu/>
6. Stephen Meyer, "The origin of biological information and the higher taxonomic categories" in Proc Biol Soc 117(2):213-239, 2004
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9. Michael Behe., Darwin's Black Box: the biochemical challenge to evolution, 1996.
10. Charles Thaxton, Walter Bradley, and Roger Olsen, The Mystery of Life's Origin 1992.
11. Fred Hoyle, The Intelligent Universe pp. 16-17, 1983.
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13. Richard Dawkins, Climbing Mount Improbable, 1996.
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19. Helen Pearson, "'Junk' DNA reveals vital role", Nature (2004/040503) .

Data vs Information: The Role of Bioinformatics in Biology

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Data Versus Information

Rolling a die 100 times produces a complex pattern with
 $P = 6^{-100}$ (1.5×10^{-78}) probability for that pattern.
But, if any roll is acceptable, the probability is 1^{100} (1).
A certainty has no information.

A lottery has “Artificial Information” by chance.
 $P = 1/41,416,353$ for CA SuperLotto (5!42!/47!/27)

SETI looks for information in data to detect intelligence. (Sag85)

Overview

- Examine random data and information
- Consider probability of information by chance
- Explore SETI, lotteries, & data vs information
- Consider the role of chance in evolutionary biology
- Examine computer simulation results
- Consider self-replicating programs
- Explore new directions for possible testing
- Explore Bioinformatics’ role in regard to biology’s unanswered questions

SETI Statistics (3/19/05)

<http://setiathome.ssl.berkeley.edu/totals.html>

	Total	Last 24 Hours
Users	5380655	550
Results received	1801041134	832843
Total CPU time	2244178.383 years	565.785 years
Floating Point Operations	6.608245e+21	3.248088e+18 (37.59 TeraFLOPs/sec)
Average CPU time per work unit	10 hr 54 min 55.2 sec	5 hr 57 min 03.7 sec

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Probability is too low to ensure information is “real”.

Chance can't produce complex information

Random mutation of existing information has no net information gain, and usually an information loss
(Mey04, Yoc81, Yoc92, Beh96)

Probabilities of Life

Law of Probability allows a maximum probability of forming-

- a typical functional amino acid^a: 1 part in 10^{175}
- the required enzymes for life^b: 1 part in $10^{40,000}$
- a living, self-replicating cell^c: 1 in $10^{340,000,000,000}$
- ^aTha92, ^bHoy83, ^cMor99, ^dDaw96, ^dSwe96
- Life is unfathomably complex^d:
“Functionally effective proteins have a vanishingly small chance of arising spontaneously in a prebiotic environment.”
(Jim04)

Encoding Data as Genetic Information

- First 98 primes, versus random: each $P = 4^{-377} \sim 10^{-227}$
- TAACATTTTCTTGTTTTATTTCCTTGCTGTTTTATTGCTTTATCTG CATTAACTCTCTGTCTTCGATGGTTTTAGTGGATTATATGCACTACGTG ACCGTTTTCTGTGTGGTCGTTGTATTTCGACGGTGTCCGTGGGATCAGT GCTGTATGCGCGTTATATGCAGTACGTGATATACCCGACTTAATCGAA TTAAACTTGTTTACTGTTTGGCTGCCTGATTCTTTCATTACTTACCTAA CGTTTGTCCGTATGGTCGGCTGGATGCTCGCCTGCCCGAGTGAGCGA ATTTTTACTCGTGGTTATTGCCTAATCGCGGCTATTGCATACTGACTT GTTCTGGTCTTCCTCATAGTTTTGTCTGCTACTCGTTTCTG
- CCGAATGTGTGGAGACTACGGGCTCGTAATGGCATCAGAG CTCCGGTCGATCGCCATACAATTCAGTAAATCTATCGTGCTGTGTAGG ATTCTGGTAGTAGGGGGACCTCCGTAGGTGGGTCAGAACTCAGAG CGGGAGCCTTATGTGCCAGCTGGAGACCATGTGCTAGATGATAAGC CTGTAGGGTCGAGTTAGGGCGACGTGGAGAGTTCTTTCGGTCTCAGG GCATACAGCTACCATAACTTACGTATGGACAGGGGCTGGCTGAT TCTGGACCCATTACTTCCCTATTGCACAACCTGACCCTGGAGCATAT GCACGAAACAGCCTAAAGCCCATCTCGGGCAAGGGGTTTACAGCA GCGAGAA
- BLAST best match is 21 nucleotides (mouse DNA)
- Note: A=00, C=01, G=10, T=11(A=01, C=00 for mouse DNA)

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- Analysis: sequence was much shorter than a genome.
- He knew the goal in advance and stopped mutation if correct.

Ludwig (*Lud93*) *Artificial Life* contest Winning program: 101 bytes.

- Chance Probability = $256^{-101} \sim 10^{-243}$.
- If 10^8 computers try 10^7 /sec: 3×10^{22} tries/yr $P_{.5} \sim 10^{220}$ years
- “Only” 10^{99} years if a 50-byte solution could be possible.

Programs were intelligently designed for designed platforms.
Information, not random data caused solutions.

Traditional Neo-Darwinian Biology

“Each successive change in the gradual evolutionary process was simple enough, relative to its predecessor, to have arisen by chance.”
(*Daw86, p43*)

“We conclude—unexpectedly—that there is little evidence for the neo-Darwinian view: its theoretical foundations and the experimental evidence supporting it are weak.” (*Orr92, p726*)

“The failure to observe even one mutation that adds information is more than just a failure to support the theory. It is evidence against the ... neo-Darwinian theory.” (*Spe96, p 160*)

More Interesting Observations

- “Physics books may be complicated, but . . . the objects and phenomena that a physics book describes are simpler than a single cell in the body of its author. And the author consists of trillions of those cells, many of them different from each other, organized with intricate architecture and precision-engineering into a working machine capable of writing a book. . . . Each nucleus . . . contains a digitally coded database larger, in information content, than all thirty volumes of the Encyclopedia Britannica put together. And this figure is for each cell, not all the cells of the body put together.” (*Daw96*)
- “The unexpected levels of complexity revealed at the molecular level have further strained the concept of the random assembly of a self-replicating system.” (*Swe96*)

Interesting Observations

- “None of the papers published in JME (Journal of Molecular Evolution) over the entire course of its life (1971-) as a journal has ever proposed a detailed model by which a complex biochemical system might have been produced in a gradual, step-by-step Darwinian fashion.” (*Beh96,p176*)
- “Chemical evolution is broadly regarded as a highly plausible scenario for imagining how life on earth might have begun. ... what has emerged over the last three decades ... is an alternative scenario which is characterized by destruction, and not the synthesis of life. ... The undirected flow of energy through a primordial atmosphere and ocean is at present a woefully inadequate explanation for the incredible complexity associated with even simple living systems” (*Tha92, p. 182 & 186*)

What About “Junk” DNA?

“Just when scientists thought they had DNA almost figured out, they are discovering in chromosomes two vast, but largely hidden, layers of information that affect inheritance, development, and disease.” (*Gib03*)

“Scientists are puzzling over a collection of mystery DNA segments that seem to be essential to the survival of virtually all vertebrates. But their function is completely unknown. The segments, dubbed 'ultraconserved elements', lie in the large parts of the genome that do not code for any protein. Their presence adds to growing evidence that the importance of these areas, often dismissed as junk DNA, could be much more fundamental than anyone suspected.” (*Pea04*)

Role of Bioinformatics

- Detect exquisite information in the macromolecules that form life.
- Make predictions about properties and structures.
- Does it produce insight as to the source of information?
 - undirected natural source
 - intelligent source
- What facts support each source?
 - natural: mutations do modify information (with no net gain)
 - intelligent: no known mechanism produces complex information
The purpose of much "Junk DNA" has been found.
- What scientific ramifications are there for each source?
 - natural: fits the status quo scientific model (no supernatural)
 - intelligent: intelligent design implies purpose
(lack of understanding does not render something useless)

Summary

- Data is information only if it can be used
- Life is incredibly complex and information rich
- Chance is incapable of producing information
- Naturalistic mechanisms are currently inadequate
- Intelligent source of information is feasible
- ID's implied purpose can stimulate scientific inquiry
- Investigate both natural and intelligent sources

Explanatory Nature of Intelligent Design

"What natural selection lacks, intelligent selection--purposive or goal-directed design--provides. Rational agents can arrange both matter and symbols with distant goals in mind. In using language, the human mind routinely 'finds' or generates highly improbable linguistic sequences to convey an intended or preconceived idea...The causal powers that natural selection lacks--almost by definition--are associated with the attributes of consciousness and rationality--with purposive intelligence. Thus, by invoking design to explain the origin of new biological information, contemporary design theorists are not positing an arbitrary explanatory element unmotivated by a consideration of the evidence. Instead, they are positing an entity possessing precisely the attributes and causal powers that the phenomenon in question requires as a condition of its production and explanation." (Mey04)

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The Source of Information in Living Organisms: Chance or Design?

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Natural Explanations of Life

Biochemical predestination (“directed chance”)

- Matter must “want” to organize into life
- Life is “inevitable” (SETI and probes result)

Prebiotic simulation (Stanley Miller--1953, Harada & Fox--1964):

- amino acid synthesis from methane, ammonia, water, hydrogen
- Chemically pure components were artificially mixed
- Components generated were removed immediately
- No oxygen was permitted (would cause quick decomposition)

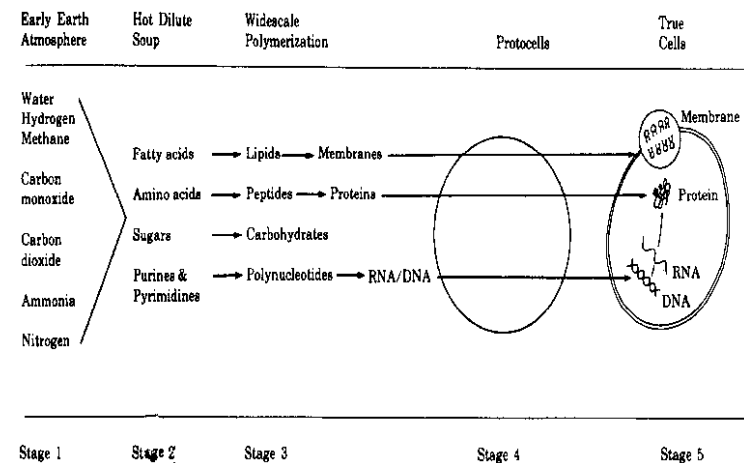
Scientific Law Problems

The source of matter and energy

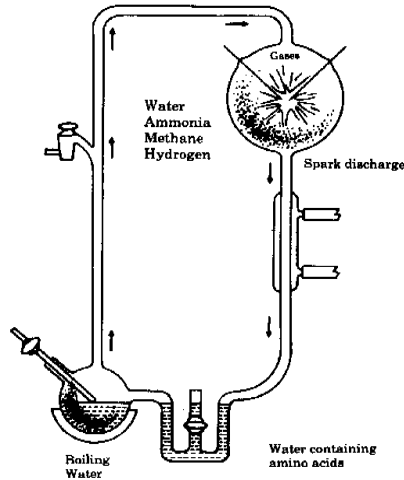
LAW of conservation of mass and energy: $\Delta E + c^2 \Delta M = 0$

- Evolution requires "matter from nothing", or "eternal existence" of matter (Infinitely old universe violates 2nd LAW)
- Second LAW of thermodynamics, entropy (S) always increases, with implications
 - a) Perpetual-motion is impossible
 - b) Directed energy for an isolated entropy decrease
 - c) Living organisms are energy rich (0.27 e.v./at lower ent.)
 - d) Evolution requires decrease in entropy (complexity increase)

Major Stages of Chemical Evolution (Thaxton, Fig.2-1)



Miller Experiment for Amino Acid Formation



“Chemical evolution is broadly regarded as a highly plausible scenario for imagining how life on earth might have begun. ... what has emerged over the last three decades ... is an alternative scenario which is characterized by destruction, and not the synthesis of life. ... The undirected flow of energy through a primordial atmosphere and ocean is at present a woefully inadequate explanation for the incredible complexity associated with even simple living systems” (Thaxton, The Mystery of Life’s Origin: Reassessing Current Theories, p. 182 & 186, 1984)

Evolution in Living Organisms

- Natural Selection: survival of the fittest
- Selective Breeding: artificial manipulation for desired traits
- Both of the above are accepted by designists and evolutionists

Macro Evolution (Speciation)

- Darwinian Evolution: simple to complex by natural selection
- “If it could be demonstrated that any complex organ existed which could not possibly have been formed by numerous, successive, slight modifications, my theory would absolutely break down.” (C. Darwin, Origin of Species, 6th Ed, p 154)

Macro Evolution (Speciation)

- “We conclude—unexpectedly—that there is little evidence for the neo-Darwinian view: its theoretical foundations and the experimental evidence supporting it are weak.” (Orr & Coyne, “The Genetics of Adaptation: a Resessment”, *American Naturalist*, 140, p726, 1992)
- “None of the papers published in JME (*Journal of Molecular Evolution*) over the entire course of its life (1971-) as a journal has ever proposed a detailed model by which a complex biochemical system might have been produced in a gradual, step-by-step Darwinian fashion.” (M. Behe, Darwin’s Black Box, p176, 1996)
Behe discusses “irreducible complexity”

Macro Evolution (Speciation)

- **Neo-Darwinism:** interdisciplinary “evolutionary synthesis”
- Changes are by random (chance) mutations over time.
- “Evolution ...must be gradual when it is being used to explain the coming into existence of complicated, apparently designed objects, like eyes. ... Without gradualness in these cases, we are back to miracle, which is simply a synonym for the total absence of explanation.” (R. Dawkins, River Out of Eden, p83, 1995)

Probabilities Involved With Life

Law of Probability allows a maximum probability of forming:

- a biologically functional protein: 1 part in 10^{175}
- a normal protein of molecular wt 20,000: ½ part in 10^{320}
- the required enzymes for life: 1 part in 10^{40000}
- a living, self-replicating cell: 1 part in $10^{340000000}$

The Role of Chance

- Chance has no causative effect.
- Rolling 6s 10 times in a row results in a 1/6 probability of 6 next.
- 10 sixes in a row has a probability of 1/60466176

The Role of Chance

- Chance can result in data, but not information (specificity).
- Inserting random (chance) data into “My name is Don” might produce “Xmyq anoamvie this MikeJorDon”.
- The chance data reduces/obscures the (meaningful) information.
- Neo-Darwinism holds “Each successive change in the gradual evolutionary process was simple enough, relative to its predecessor, to have arisen by chance.” (R. Dawkins, The Blind Watchmaker, p43, 1986)

Robert Sproul asserts

(Not a Chance, p12-13, 1994)

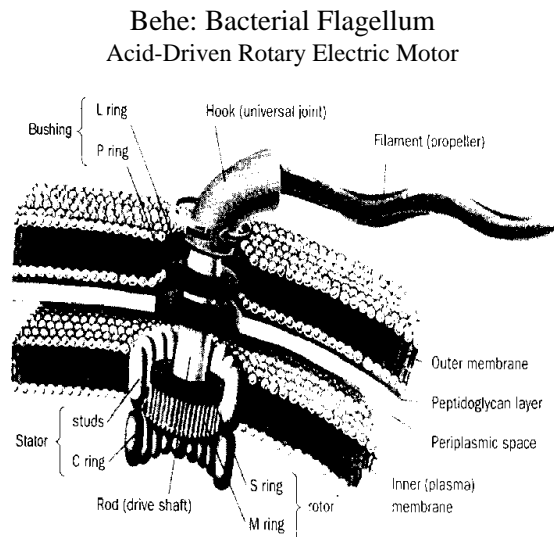
- Chance is not an entity.
- Nonentities have no power because they have no being
- To say that something happens or is caused by chance is to suggest attributing instrumental power to nothing.
- Something caused by nothing is in effect self-created.
- The concept of self-creation is irrational and violates the law of noncontradiction.
- To persist in theories of self-creation one must reject logic and rationality.

Lee Spetner (Not By Chance, 1996)

- Demonstrates how the DNA “machine” carries information.
- Proves mathematically that chance can’t produce information.
- Shows that mutations are the result of information loss.
- Sometimes this results in better survival rates (super-bugs).
- “The failure to observe even one mutation that adds information is more than just a failure to support the theory. It is evidence against the ... neo-Darwinian theory.” (Spetner, p 160)

Intelligent Design is evident in universe and man

- 10^5 (overlapping) genes, each with $> 10^3$ bits of information
- 10^{13} traits by DNA sequence ($>60,000$ bases in 6', 10^{-16} gram chain)
- Even "simplest" organism's DNA has > 5000 nucleotides
- Information in 1 teaspoon of DNA: all people + all books
- Each cell is a complex chemical factory (10^{-13} of Viking's size) (<1 sec to do what scientists can manufacture in weeks)
- Over 10^{15} human brain interconnections,
- Brain performs 10^{15} ops/sec ($>$ all computers in the world)
- 1 sec of optic nerve's data would take >2 Cray hrs to process
- Talking: $>10^5$ neuromuscular events/sec, using >100 muscles (controlling diaphragm, tongue, cheeks, jaw, etc.)



Intelligent Design

- Universe is “fine-tuned” to allow for life on earth
- “An accuracy of one part in 10^{123} ...the precision needed to set the universe on its course.” Penrose in *The Emperor's New Mind*, p.344
- **Designed** complex information-rich structures are empirically detectable (e.g.– AI, SETI, forensics, cryptography, archaeology, etc.)
- Information is a reliable indicator of intelligent design:
- irreducible complexity (Behe), functional complexity (Schützenberger), specified complexity (Dembski): all **empirically** detect design.

Intelligent Design

- ID is **NOT** connected to a particular theology
- Theist may believe in old or young earth, once or multiple designs.
- “God” is not a required belief (but is certainly compatible), e.g.–
- Hoyle states “the intelligence which assembled the enzymes did not itself contain them...which by no means need be God, however.” *Evolution From Space*, p. 139
- **Science** currently restricted to “undirected natural processes”.
- Consideration of intelligence, design, and purpose are not allowed.
- ID makes better science:
- “Vestigial organs” & “junk DNA” have been found to have purpose.
- Complex Specified Information (CSI) **requires** intelligence.
- Dembski set a 500 bit (probability= 10^{-150}) criterion cut-off.

Complex Specified Information (CSI)

- Complex, not simple, e.g.– 11011100101110111 Could be interpreted: 1 10 11 100 101 110 111 (counting to 7 in binary), but this pattern has a probability of 1 in 131,072 (too high to unambiguously indicate an intelligent source)
- Rolling a die 100 times produces a complex pattern with 6^{-100} (1.5×10^{-78}) probability for that pattern
- But, if any roll is acceptable, the probability is 1^{100} (1)
- Specified means it has information content
A certainty contains no information
- When both complexity and information are undeniable, INTELLIGENCE is the unavoidable conclusion
- Life is both complex and information-rich, leading to the inescapable conclusion of Intelligent Design