Design Isomorphs in the Wild

It can now be easily recognized that design isomorphs permeate all levels of biological complexity.

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Isomorph	Tech.	Bio.
Accessory input-output regulators[1]	Manufacturing controllers	'Quorum sensing' and other genetic production regulation
Adhesive	Glues, tape	Gecko's feet
Aggregate and non-aggregate production	Aggregate – wood framing Non-aggregate – interlocking bricks	Aggregate – intron splicing Non-aggregate – Ribosome RNA-AA transcription
Antenna	Radio antenna	Insect antenna
Boolean logic[2]	Logic gates in computer languages	Some gene regulatory regions
Cameras	Video camcorders	Biological Visual systems
Camouflage	Military uniforms	Some animal skins
Centralization	Computer motherboards	Centrosome, Heart-Circulatory system
Circuitry[3]	Tandem control switches and output amplifiers	Genetic networks

[1] Accessory input-output regulators in manufacturing controllers work like 'quorum sensing' genetic production regulation in microorganisms.

[2] Gene regulatory regions function much like Boolean logic gates in computer languages.

Isomorph	Tech.	Bio.
Clamps	Sliding clamps, locking clamps	DNA polymerase sliding clamp[4]
Codes[5]	Human languages[6] and computer codes	Nucleic acids; RNA and DNA
Coil rebounding	Springs	Spasmoneme[7]
Communication signals[8]	Telecommunication devices	Cell signaling including hormones
Compaction	Cable and tube coil-based packing for storage and transport of ropes, wires, cables, etc	DNA coil-based packing for storage and transport (replication)
Compression	Data compression to save computer storage space	Thought to be used by cells to increase efficiency and facilitate replication
Controlled access[9]	Key-access doors	Cell and nuclear gateways, Lock-and-key biomechanisms[10]
Controlled combustion[11]	Combustion engines	Respiration in specific tissues
Coordinate logistics[12]	Zip codes	Fibroblast genetic expression regulators

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[3] Circuitry has some interesting isomorphic features in genetic networks by the use of tandem control switches and output amplifiers. Also see "An Introduction to Systems Biology: Design Principles of Biological Circuits," by Uri Alon.

[4] http://www.biomedcentral.com/1472-6807/6/2

[5] The genetic "code" is inseparably tied to languages and computer codes by an isomorphic conceptual link. Coding in languages and computers, with syntax and semantic data, are found in the genetic "code."

[6] "By applying statistical methods developed by linguists, investigators have found that "junk" parts of the genomes of many organisms may be expressing a language." – Phillip Yam. 1995. "Talking Trash." *Scientific American*, 272, March 1995, p. 24.

[7] Yasushige Moriyama, Shigeo Hiyama, and Hiroshi Asai. 1998. "High-Speed Video Cinematographic Demonstration of Stalk and Zooid Contraction of Vorticella convallaria." *Biophysical Journal* Volume 74 January 1998 pp. 487–491.

[8] Communication signals in the genetic networks are being explored by epigenetics and systems biology.

[9] Controlled access: Key-access door (tech) and cell gateways (bio)

[10] Lock and key, Natalie A. Borg, Kwok S. Wun, et al. 2007. "CD1d–lipid-antigen recognition by the semi-invariant NKT T-cell receptor." *Nature* 448, 44-49, 5 July 2007
– Blogged at ARN

[11] "For example, the discovery by Antoine Laurent Lavoisier, Pierre Simon de Laplace24 and Lazzaro Spallanzani25, that a process akin to combustion occurs in living tissues." -- Biological machines: from mills to molecules.

[12] Zip codes help direct proteins to targets, including regulating gene expression, and fibroblast gene expression programs.

Isomorph	Tech.	Bio.
Data duplication and transfer[13]	File sharing	DNA replication, horizontal gene transfer
Decentralization	Internet	ATP production in prokaryotes
Digital counters	Shift registers, NO operation (NO-OP) instructions	regulation of SRC-3/AIB1[14]
Doors	Household door	Cell gateways
Echolocation	Airport traffic controls, planes	Bats
Electronic countermeasures (ECMs) and Electronic counter-countermeasures (ECCMs)	MIJI (Meaconing, Intrusion, Jamming, and Interference)	Radar-warning and radar-jamming in Tiger moths for bat engagement
Evaporative cooling	Air-conditioners	Animal sweating and panting
Factory	Production facilities and manufacturing plants	Cells
Fiber optics	Fiber optic cables	Müller cells
Finishing rooms; stage-specific production mechanisms	Rooms and mechanisms specifically designed for particular production stages; (i.e. clean rooms for computers, oxygen-free rooms for jet fuel production)	Chaperonin
Flight technologies[15]	Planes, powered flight	Flying animals, gliding plant seeds
Fluid mechanics and dynamics	Engineering principles of liquid motion	Blood flow
Fluid pulse jets	Fire hoses	Bombardier beetles
Force dampeners	Shock absorbers	Spider webs, cartilage

[13] Data transfer processes are used in computers for file sharing, and horizontal gene transfer in organisms involves the sharing of genetic information.

[14] NOP time delays and regulation here: [paper] [press] [blog]

[15] *Leading edge slats*, *airbrakes*, and *biplane wing design* are isomorphs between technology and biology.

Isomorph	Tech.	Bio.
Functional information	Production schemas	Amino acids and polypeptides
Hinges	Door hinge	Joints
Injection mechanisms	Syringe and needle	Secretory systems like the TTSS
Interface transfer	Node-node communication coupling	
LEDs (high-efficiency)	Energy efficient lights invented at MIT	Wing coloration of African swallowtail butterflies
Lens and mirror optics	Mirrors, telescopes, microscopes, and eyeglasses	Spookfish eyes (mirror focus) and mammalian eyes (lens focus)
Lever	Plank-and-fulcrum machines	Joints (i.e. elbow and knee)
Luminescence[16]	Chemiluminescence	Bioluminescence
Materials recycling[17]	Plastic and aluminum recycling	RNases, ubiquitin
Nanotubes	Carbon nanotubes	Microtubules, cilia
Network configurations[18]	Ubiquitous in computational and mechanical systems	Genetic, proteomic, and other biological systems
Outboard motors	Motor boats	Bacterial flagellum
Parallel navigation[19]	Homing missile guidance systems acquiring a moving target	Bats acquiring moving prey

[16] The firefly reaction has the highest known quantum efficiency for luminescent reactions, with a Q_C of 88%.

[17] Materials recycling is an efficient way to make multiple templates from the same materials. This is how mRNA templates are broke down by RNases for recycling the nucleotide materials to be made into other mRNA templates.

[18] Network configurations of living organisms are being mapped by methods of systems biology, which tackles the mapping of biological networks and biological circuits. E.g. Bernhard O. Palsson "Systems Biology: Properties of Reconstructed Networks."

[19] Parallel navigation is a flight-intercept strategy used in advanced missile guidance systems, wherein the missile closes in on a moving target by matching in parallel the velocities and direction of the target and responding with proper vectors to overtake the target. Parallel navigation is utilized by echolocating bats to catch their prey, and this navigation strategy requires an exquisite coordination of the bat's echolocation system, nervous system, reflexes, brain responses, and wing motion.

Isomorph	Tech.	Bio.
Plough	Ploughshare	GINS complex as a strand displacement blade[20]
Production assembly regimes and coded-program control systems[21]	Automated data-management systems	Gene expression
Propeller	Propeller on boat	Helical propeller on bacterial flagella
Pulley	Hoist	Complex joints in the human thumb
Pumps	Bilge pumps	Cell and nucleus pumps[22]
Rack and pinion	Rack railway	Kinesin/tubulin interaction
Redundant robustness	Computer programs and contingency designs	Redundant DNA
Repair schemas	Repair sub-routines in computer coding	DNA repair and error correction mechanisms
Rope-based information storage	Jewelry w/ inlayed or interlaced informatic symbols	DNA
Rotary motors	Racing boats and high-performance cars	Flagellated bacteria
Sensory mechanisms [active and passive]	Motion detectors, light detection	Hatchet fish, active and passive electronic sensing in fish

[20] Takahashi, Wigley, and Walter. 2005. "Pumps, paradoxes and ploughshares: mechanism of the MCM2–7 DNA helicase." *Trends in Biochemical Science* 30: 437–444.

[21] Production assembly regimes and coded-program control systems are working with the protein assembly processes in the cell, including the DNA-RNA-ribosome complex. These processes are conceptually similar to processes that are setup in automated factories, and in automated data-handling systems. A more complex example is the assembly of the bacterial flagellum.

[22] Takahashi, Wigley, and Walter. 2005. "Pumps, paradoxes and ploughshares: mechanism of the MCM2–7 DNA helicase." *Trends in Biochemical Science* 30: 437–444.

Isomorph	Tech.	Bio.
Shutters	Cameras	Biological visual systems, mechanically-sensitive channels named MscS in E. coli bacteria[23]
Signal amplification[24]	Transmission amplification in radio, TV, and many communication signals	RNA interference and reuse of messenger RNA templates
Signal conversion	Analog-Digital (A-D) conversion	Signal transduction[25] in cellular processes, also in the functions of sensory organs
Sonar		
Splicing[26]	Pattern and signal splicing	DNA ligases
Stealth		
Suction cups[27]	Rubber suction cups	suction cups on octopus arms
Symbolic logic and languages	Languages, mathematics, iconography, symbolology	DNA and RNA codes, genetic sequence hypothesis
Template modeling and functionality[28]	Manufacturing molds	mRNA
Template reuse[29]	Industrial and manufacturing processes	DNA-RNA-ribosome functionality

[23] Wang et al. "The Structure of an Open Form of an E. coli Mechanosensitive Channel at 3.45 Angstrom Resolution," Science, 29 August 2008: Vol. 321. no. 5893, pp. 1179-1183, DOI: 10.1126/science.1159262.

[24] Signal amplification from the genetic code can be accomplished by RNA interactions, including alternative splicing as well as the reuse of messenger RNA templates.

[25] Yifei Kong and Martin Karplus. 2007. "The Signaling Pathway of Rhodopsin." *Structure* 15, 611–623, May 2007, Elsevier, p. 611-623.

[26] Jiafeng Gu, Haihui Lu, et al. 2007. "DNA ligase IV can ligate incompatible DNA ends and can ligate across gaps." The EMBO Journal (2007) 26, p. 1010–1023.

[27] PNAS - http://en.wikipedia.org/wiki/Suction_cup - Suction cups are believed to have first been used in the 3rd century, B.C., and were made out of gourds. They were used to suction "bad blood" from internal organs to the surface. Hippocrates is believed to have invented this procedure.[1] The modern suction cup was patented in 1882, and is based on the suction cup-like features on octopus arms.

[28] Templates are an effective means of producing many copies of the same structure, and the transcribed code that is read off the DNA is an mRNA template.

[29] Template reuse is an efficient way to make multiple products from one template. This is how mRNA templates are reused for multiple protein products.

Isomorph	Tech.	Bio.
Text frame-shifting[30]	Intra-textual Caesar ciphers	Genetic ARF's (alternate reading frames) and ORFans (open reading frames)
Transcription and Translation[31]	Automatic translation computer programs	RNA-ribosome-protein translation
Transposition shifting	Transposition ciphers	Nucleosome code
Trial-and-error problem solving	Engineering methods sometimes involve trial-and-error	Darwinian mutation and selection mechanisms
Triangulation	Mapping and positioning systems	Visual systems
Troubleshooting process-schemas	Checksum's, SED-DED's	Processes that initiate DNA repair and error correction mechanisms
Waste disposal systems[32]	Trash disposal	Protein-degradation mechanisms
Wheels, cogs, axles, and rotors	Carts, motors, etc.	Molecular motors, ATPase, wheel spider
Worm gear	Worm wheel speed regulators	Helicase
Zippers[33]	Zippers on clothing	DNA double helix unzips for replication and transcription

[30] Text frame-shifting like 'intra-textual Caesar ciphers' can be found in the genome's alternate reading frames (ARF's).
[31] Transcription and translation functions are used by the cell in using the DNA syntax to render a scripted code of mRNA syntax, and then mRNA is put into the product code of amino acid syntax.
[32] Protein-degradation mechanisms in cells can involve ubiquitin ligase, ubiquitin molecules, and these utilize F-box adapters.
[33] Zippers are conceptually at work in the DNA double helix, which is "unzipped" for replication and transcription.