

Dumb design: Evidence for non-optimality or incomplete adaptation in organisms

A list compiled by John R. Hutchinson, Lecturer in Evolutionary Biomechanics, June 13 2008

Many thanks to contributors from the vertebrate paleontology listserver, vrtpaleo@usc.edu

Why the list?

It is easy to get tired of biomechanists, engineers and physicists, as well as nature documentaries and even some biologists, rattling on about how great organisms are. We know they are! We know we're great too-- even the more misanthropic of my colleagues must admit we've done some amazing stuff thanks to our hypertrophied neocortex and such. Adaptation (or optimization) perfuses organisms. It's seemingly everywhere, flashing its rainbow-coloured buttocks at us with an impish grin.

But that's actually rather boring!

What can be more fascinating about nature is where it has gone pear-shaped; gotten it wrong; broken its back under the burden of phylogenetic baggage. Some scientists may miss the boat on pointing such flawed gems of nature's unintelligent design. As experts on life's rich pageant and all its ruffles and runway slips, biologists (including paleontologists) should be able to counter claims of intelligent design and other BS, whether it comes from scientists who should know better, from the public who often doesn't, or from pseudoscientists who should just go away. Yet in informal discussions, we tend to be better equipped to rhapsodize about how great organisms (especially our study taxa) are, and more prone to stammering when we're asked what's not so great about them, except perhaps for vague generalizations (accurate as those may be). So in a spirit of fun-loving (and pedantic?) scholarship, I have compiled this list of sundry examples of nature cocking it up. A bloopers reel for the epic film of "The Empire of Life". Initiate linguo-buccal impaction, dry off your wit, and hit your sarcasm switches if you wish. Enjoy.

[I've tried to give credit where due to individuals that sent ideas, but have also edited some of these and do not have the time to detail all my editing. I also don't have time to go into semantics of what is meant by "dumb design."

I did a lot of cutting and pasting here, and ended up with some poorly designed formatting, but am designed to be too anal-retentive about such things, and chose to more cleanly format this rather than preserve the imperfectitudes.;..]

Good places to look for more examples:

[Stephen Jay Gould](#) and [Richard C. Lewontin](#). "[The Spandrels of San Marco and the Panglossian Paradigm: A Critique of the Adaptationist Programme](#)" *Proc. Roy. Soc. London B* **205** (1979) pp. 581-598

Your Inner Fish, N Shubin

The Blind Watchmaker, R Dawkins (and other books by the same)

The Panda's Thumb, SJ Gould (and other books by the same)

Cat's Paws and Catapults, S Vogel

More web links and lists:

<http://www.theshrubbery.com/udn/>

<http://www.funtrivia.com/en/SciTech/Evolution-10900.html>

http://en.wikipedia.org/wiki/Argument_from_poor_design

http://seedmagazine.com/news/2005/11/the_other_id.php

http://www.pandasthumb.org/archives/2005/12/don_wise_and_in_1.html

<https://notes.utk.edu/bio/greenberg.nsf/0/0765bb50d404455385256f0000680854?OpenDocument&Click=>

Or just Google “unintelligent design” or similar phrases.

General themes for most organisms (but especially those egotistic humans):

Some favorites:

1. Extinction (about as non-optimal as you get).
 2. Vestigial traits and atavisms.
http://www.talkorigins.org/faqs/comdesc/section2.html#morphological_vestiges
http://www.livescience.com/animals/top10_vestigial_organs.html
 3. Defects, diseases/pathologies, allergies, and accidents in organisms.
 4. Jury-rigged, overcomplicated, excessively redundant design throughout organisms.
<http://www.talkorigins.org/faqs/jury-rigged.html>
 5. Junk DNA (yes I know some evidence is emerging that some of this actually plays a regulatory or other role, but cmon, up to 90% of the genome? A lot is probably just junk.)
 6. Essentially all biological processes act at <100% efficiency and hence are suboptimal: e.g., muscles lose 70% of their metabolic energy as heat, and most of that is shed to their environment so it isn't used to keep them warm (for long, anyway).
 7. Variation in populations: if there is one optimal design, then in an optimal world there should be no deviation from that. Sure, environments in reality are stochastic, so variation is good in the real world, but that is not an optimal world.
 8. Natural selection, as a corollary, is decidedly non-optimal even though it is an optimizing process; inevitably some organisms die and the inevitable inefficiency in digesting/decomposing them is inherently wasteful, even though other organisms thrive off the carnage.
 9. Sexual selection: Similarly, some organisms never get to mate; their genitals are thus not so useful.
 10. Phenotypic plasticity: of muscles, connective tissues, immune response, etc; a more optimal design would preclude the time lag involved in responding to
 11. Biological structures aren't stronger, faster, or otherwise just better—e.g. all vertebrate muscle can produce only $\sim 300\text{kNm}^{-2}$ of isometric stress; why not much more?
 12. Invasive species: if rabbits invading Australia (for example) can wreak such havoc, how well designed are the ecosystems that they invade? Not very.
 13. Sleep. Sure, it's helpful and pleasant, but surely a better design would be to not spend 1/3 your life doing it?
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1. Things that are redundant - we don't need 2 kidneys or an appendix
 2. Things that are done better elsewhere in animals - we can't see in UV, or hear infrasound
 3. Things that are genuinely 'bad' (you can imagine a way to do it better)- our retinas are effectively backwards.

--Dave Hone

General organismic nonsense:

Muscles can only pull. This makes it terribly complicated to do some very simple actions, but we're so used to it that we don't really think of the alternatives. I like to tell my students that any designer who was told to build a biological engine and came up with one this limited would probably be fired.—Tristan Stayton

Very few wheels in nature: (ciliary motors perhaps one counterexample, and rolling stomatopods, sowbugs, etc) Well, not many roads in nature, duhh.... I actually had that as a test question many years ago in a paleo class - "why aren't there any wheeled elephants"? The obvious answer is the intermediate stages between legged - to - wheeled animals are pretty nonfunctional. The other one was strength of biological materials available for a wheel, how a pulley-shaped muscle arrangement could possibly work, etc..... The point is an intelligent designer should be able to solve these problems in a variety of outlandish ways and realize greater efficiencies, instead of sticking with one upper limb bone, two lower limb bones, and optional accessories. (various contributors; Vertpaleo listserver discussion of this went off on an amusing tangent but I'll keep this brief)

Ovaries in vertebrates are not confined within the oviducts; hence, occasionally an egg will escape into the body cavity, become fertilized and implanted, and start an ectopic pregnancy. Very painful and probably fatal before modern medicine - I read about one case on the BBC where a woman carried an ectopic fetus to term while it was attached to her liver. Again, bad idea with no apparent benefit.—Tristan Stayton

Other miscellaneous sources:

Green plants reflect green light; inefficient not to use that wavelength- why not black plants?

LGGLO gene in primates: same 3-amino acid deletion leading to loss of vitamin C synthesis capability presumably postdating fruit-eating habits in ancestral primates. Nonfunctional via a different deletion in guinea pigs, etc.

Nipples in male animals including humans as a byproduct of development and late sex determination (embryos start off as female)

Tortuous path of the recurrent laryngeal nerve from the brainstem (vagus nerve) and looping around the aortic arch and through a ligament near the lung before coming back to the larynx.

Pharyngeal gill slits/arches, webbed toes, and other "aquatic adaptations" in embryos/juveniles of non-aquatic chordates.

Gigantic dystrophin gene in animals that seems to have no function except causing muscular dystrophy when damaged.

Constantly-growing teeth in rodents and other animals that grow into the skull if not worn down regularly.

Asexual dandelions that still have sexual organs (true in numerous other species; also parthenogenetic lizards etc).

Humans (and some other primates): oh let me count the ways we suck!

The larynx / epiglottis is a classic one as we are vulnerable to choking unlike other primates, and our eyes are a mess (not great vision compared to many animals, limited spectrum, retinas backwards, retinas detach easily).—Dave Hone

The human larynx being set so far down the throat that we're liable to choke on food (as we now no longer have the pharyngeal seal that keeps esophageal and tracheal flows separated, as in other mammals and newborn humans). Still no good reason for why we evolved this condition. The standard one is so that we could make better vowel sounds with an expanded pharynx. I favor the notion that this allows for voluntary mouth breathings, which became under strong selection when the human common cold virus evolved!---
Christine Janis

The route of the vas deferens which instead of traveling a few inches from origin to source, travels up from the seminal vesicles and loops over the pelvis before descending back to the testicles [because the gonads begin in development up near the liver/kidneys as in other vertebrates; this also leaves us susceptible to hernias].—James Lamb

Hiccups (tortuous path of vagus and phrenic nerves leaving them susceptible to spasms) and sleep apnea (hyper-relaxation of pharyngeal muscles due to speech-related specializations) in humans. Appendix (in humans and other great apes; <http://www.talkorigins.org/faqs/vestigis/appendix.html>); vestigial (no longer used for cellulose fermentation) and problematic [appendicitis] organ (even if it does have a wee bit of immune system tissue left inside, it's pretty lame). Vast number of genes for smell that are turned off in humans [~3% of the genome, ~30% of these genes mutated to inactivity].—James Lamb

Intervertebral disks - never intended to be load-bearing structures (the notochord evolved for a certain amount of bending), thus they often fail in humans and cause all sorts of problems (e.g. scoliosis, sciatica, dislocation) - even worse, they are poorly innervated and vascularized so they often can't tell that they are damaged or heal themselves. Terrible idea for an intelligent designer.—Tristan Stayton

Human orthograde (vertical, bipedal) posture. OK, hands free for all that stuff like using tools or carrying groceries. However, the resultant bad back, hip problems, exposure of the femoral arteries to easy damage, as well as even further exposure of male mammalian gonads (already poorly placed) to an even greater degree. Not to mention what a pain in the arse it makes the massively flexed human skull compared to those of animals that retained a more reasonable pronograde posture!—Stuart Sumida

Miscellaneous sources: varicosities in leg veins due to inadequate adaptation to vertical limb posture; knees with weak medial menisci and collateral ligaments + anterior cruciate ligaments. Inguinal and other hernias caused by weaknesses in the abdominal wall allowing the digestive tract to squeeze out of it, or be carried through with other organs during development. Large baby heads causing problems making it through the pelvic canal during childbirth. Blocked sinuses and headaches.

More hominin vestigial structures: vomeronasal organ, cervical/13th rib (atavism), wisdom teeth, extrinsic ear muscles, subclavius, pyramidalis, plantaris and palmaris muscles, goosebumps (relict piloerection with vestigial fur), body hair, coccyx.

Our hands, when relaxed, have their fingers flexed. This makes sense for an arboreal lifestyle. However, our metacarpals are straight, rather than curved as in most primates.

"... the dreaded hemorrhoid. A uniquely human condition, it was the direct result of our hominid ancestor's fateful decision to stand up and walk on two legs instead of four. In virtually every other mammal, the anus and heart occupy the same horizontal plane. ... Upon assuming an upright stance, a hominid positioned its heart approximately two feet above its anus in a vertical plane. This created a bedeviling hydraulics problem. Arterial blood flow hurries along on its appointed tasks, urged onward by the propulsive force of each systolic heartbeat. Once on the venous side of each capillary, however, the movement of blood slows to a sluggish crawl, since there is no pump propelling it back to the heart. In humans, venous flow returning to the heart from the pelvis must defy the force of gravity, heading straight uphill. As a result, the veins underlying the delicate lining of the distal rectal tract remain permanently engorged, because there is a several-foot-high column of blood pressing down from above. ... Humans are the only animal in all the phyla that must learn at a very early age to maintain tight control over their anal sphincter. ... A physiological side effect of this idiosyncratic human cultural convention is that the human anal sphincter is in a state of near perpetual constriction. The small circular muscle squeezes the veins around it, engorging them further, making them more susceptible to bleeding." - Leonard Shlain, *Time, Sex and Power: How Women's Sexuality Shaped Human Evolution*, pp 33-34

Miscellaneous specific examples of kooky critters:

Whales and snakes with legs - think 65 foot Basilosaurus with a 1 1/2 foot long hind leg. Men have nipples. All mammals have 7 cervicals even though it might make more sense for say, giraffes to achieve the long neck by increasing vertebral number. Dew claws. Any sort of tetrapod with vestiges of digits now reduced from the starting # of ~5. Birds have the genes to make teeth although no living bird has teeth. Blind fish in caves that have eyes. .—James Lamb

Tree kangaroos and many other animals that climb trees, but do it badly because of inadequate adaptation (recent change of habitat/behavior)—Jenny Clack

Snakes: God decreed “things-bigger-than-your-own-head shalt thou eat.” And for proof positive that God is male (and not very nice) - TWO penises, covered in spines.— private email that will be anonymous for now

From Chris Darkin: What about the giant panda? Evolved to eat meat but chooses to eat only one kind of plant - a plant so low in nutrient that it has to eat for 23 hours a day just to stay alive. What's more, the plant only flowers every hundred years. Lives a solitary life, hundreds of miles from other pandas, but its mating season lasts just three days. Gives birth to embryos so premature that it most often ends up squashing them. The giant panda looks like it's a dead cert for extinction.

However, it has one incredibly powerful survival adaptation. It's cute. So cute that wildlife organisations the world over use it to front their advertising campaigns. So cute **that our urge to save it is unstoppable**. The shark (a piece of evolution so perfect that it's dominated through nearly half a billion years without significant change) plummets towards extinction and nobody gives a toss, but the giant panda is the world symbol of conservation. The race does not always go to the swift or the fight to the brave - and I foresee a future in which every animal on earth is evolved from the giant panda because it's the only thing we've bothered to save.---Chris Darkin

Also, you could mention the penguin's bauplan. Its distant ancestors first swam in in the ocean, then walked on land, then flew through the air...and now they're back swimming in the goddamn water again! PICK ONE AND STICK WITH IT, FLIPPER BOY!—Daniel Snyder

Sails on whales are another innovation that could be energetically efficient in some situations-- Brian Bodenbender

Gastropod torsion (during embryonic development) always makes me wonder about design. It sounds so painful...I can't imagine what it would feel like if my GI track was flipped and folded over on itself so that my anus was over my head...—Lee Hall