

## Complexity?

- What we've covered so far might seem adequate for explaining the origins of relatively modest changes—new species, and such...
- But can natural selection explain major changes—such as the origins of new organs, new major functions, new features?



"To suppose that the eye with all its inimitable contrivances for adjusting the focus to different distances, for admitting different amounts of light, and for the correction of spherical and chromatic aberration, could have been formed by natural selection, seems, I freely confess, absurd in the highest degree." -- Origin of Species, Chapter 6



What bugs me is that none of these Websites ever quote Darwin's rebuttal *in the next sentence of the darn book*!

"Yet reason tells me, that if numerous gradations from a perfect and complex eye to one very imperfect and simple, each grade being useful to its possessor, can be shown to exist; if further, the eye does vary ever so slightly, and the variations be inherited, which is certainly the case; and if any variation or modification in the organ be ever useful to an animal under changing conditions of life, then the difficulty of believing that a perfect and complex eye could be formed by natural selection, though insuperable by our imagination, can hardly be considered real." *– Origin of Species*, Chapter 6



The usual argument goes that it's not possible for eyes to evolve, because "half an eye" is useless and could never be favored by natural selection.

"The human eye could not have evolved over long periods of time, because it is absolutely useless unless complete. The lens, which focuses light, would be useless without the retina, which senses light. And all the light received would serve no purpose without the nerve fibers which carry signals to the brain."

-- Some creationist website or other

#### Evolution of eyes

- Computer simulations of the process of eye evolution were carried out in 1994 by D. E. Nilsson and S. Pelger
  - Start with a computer model of a simple, three-layered, light-sensitive spot
  - Allow the properties of each layer (curvature, refractive index, etc.) to vary randomly by up to 1% per generation
  - Create random "eyes" in the next generation, and select those with greatest efficiency
  - Repeat as necessary. . .

There's the starting point, in cross-section—a round spot with a clear layer, a pigment layer, and a nerve layer....



After about another 800 simulated generations, the eyespot has developed a lens and a cornea, and looks suspiciously like our own...







# What's interesting is that Darwin basically foresaw this kind of experiment. . .

"If we must compare the eye to an optical instrument, we ought in imagination to take a thick layer of transparent tissue, with a nerve sensitive to light beneath, and then suppose every part of this layer to be continually changing slowly in density, so as to separate into layers of different densities and thicknesses, placed at different distances from each other, and with the surfaces of each layer slowly changing in form. Further we must suppose that there is a power always intently watching each slight accidental alteration in the transparent layers; and carefully selecting each alteration which, under varied circumstances, may in any way, or in any degree, tend to produce a distincter image." *-- Origin of Species*, Chapter 6



#### Take-Home Message

- Sometimes you don't need to explain the origin of complexity as anything other than good ol' natural selection on natural variation
  - An artificial analogue: Art Samuel's checkersplaying computer program. . .
  - Evolutionary algorithms in computer programming, drug design, industrial design, etc.

## Exaptation and Tinkering

- Jacques Monod referred to the evolutionary process as a *bricoleur*, a French word translated more or less as "tinkerer".
- Stephen Jay Gould and Elisabeth Vrba coined the term *exaptation*...
  - Many major evolutionary changes don't involve creating anything *new*...
  - What happens is that old structures get "reused" and modified in different ways
  - This used to be called "pre-adaptation", but this isn't accurate—evolution can't "foresee" what's going to happen and "prepare" accordingly.

#### Spandrels

- Gould and Richard Lewontin wrote one of the best-known papers in evolution, "The spandrels of San Marcos: A critique of the Panglossian paradigm"
- When you support a circular dome on top of arches—as is common in Byzantine and Renaissance church architecture—you end up with four curved triangular walls between the arches.
  - Technically, an architect would call these *pendentives*, but a pendentive is a three-dimensional variant of a spandrel (which is anything left over when you punch an arch through a wall)







#### Spandrels

- Spandrels (or pendentives, or what-*evarrr*) are often beautifully decorated in old churches
- Yet spandrels were not selected by the architect for the purpose of decoration.
- In fact, they weren't "selected" at all—they exist out of necessity; if you're going to support a dome on top of arches, something has to be left over
- Gould and Lewontin argued that many features of organisms are not adaptations and were not selected for—they result from the same sort of necessity



Some snail species (like this one, *Solariella*) are *umbilical brooders*—they lay their eggs inside the umbilicus and protect them there until hatching.



But snails didn't evolve coiled shells because having an umbilicus was useful for egg brooding! They evolved coiling for some other reason, and the umbilicus exists because, geometrically speaking, it has to.



Gould's point is that natural selection does not cause each piece of an organism to adapt, directly and perfectly, to its environment—it's not the only explanation for why living things are as they are!



Too often, the adaptationist programme gave us an evolutionary biology of parts and genes, but not of organisms. .... A pluralistic view could put organisms, with all their recalcitrant yet intelligible complexity, back into evolutionary theory.

http://ethomas.web.wesleyan.edu/wescourses/2004s/ees227/01/spandrels.html

To clarify the terminology: The umbilicus would be a *spandrel*: it exists out of geometrical necessity. The use of the umbilicus as an egg chamber is *exaptation*.



#### Example: Croatian Lizards

- In 1971, five pairs of wall lizards (*Podarcis sicula*) were introduced from the Croatian island of Pod Kopiste to the nearby island of Pod Mrcaru, which had no lizards at the time
- The Pod Kopiste lizards fed mostly on insects, but Pod Mrcaru has a wide range of plant foods available
- By 2004, the Pod Mrcaru lizards' diet consisted of up to 60% plants, compared with less than 10% on Pod Kopiste....

In just 35 years, the Pod Mrcaru lizards had evolved larger jaws and heads, and could exert greater bite force. They'd ceased to be territorial, evidently because their food supply was more even and dependable. . .



