Evolution by natural selection can create adaptation, that tangible sense of “designed for function”
But it is also an historical process – only works with existing variation, has a characteristic “makeshift” quality

**Homologous** organs, **homologous** genes
“Panda’s thumb”

The late evolutionary biologist Stephen J. Gould loved to dwell on this historical component of design in nature

A favorite example – the “thumb” of the Giant Panda

Wrist bone – radial sesamoid

http://www.athro.com/evo/pthumb.html
“Giant pandas are peculiar bears, members of the order Carnivora. Conventional bears are the most omnivorous representatives of their order, but pandas have restricted this catholicity of taste in the other direction – hey belie the name of their order by subsisting almost entirely on bamboo.

“[Watching the pandas at the Washington zoo] I was amazed by their dexterity and wondered how the scion of a stock adapted for running could use its hands so adroitly. They held the stalks of bamboo in their paws and stripped off the leaves by passing the stalks between an apparently flexible thumb and the remaining fingers…So I counted the panda’s other digits and received an even greater surprise: there were five, not four. Was the “thumb” a separately evolved sixth finger?”

“The pandas “thumb” is not, anatomically, a finger at all. It is constructed from a bone called the radial sesamoid, normally a small component of the wrist. In pandas, the radial sesamoid is greatly enlarged and elongated until it almost equals the metapodial bones of the true digits in length.”

“The sesamoid thumb wins no prize in an engineer’s derby. It is … a contraption, not a lovely contrivance. But it does its job and excites our imagination all the more because it builds on such improbably foundations.”

*From “The Panda’s Thumb” by Stephen Jay Gould*
Kiwi egg

Why would such a little bird have such a big egg?

http://www.kamcom.co.nz/kiwi/index.html
Ratites: Ostrich, cassowary, moa (extinct), rhea, emu, kiwi, tinamou

http://www.camacdonald.com/birding/Sampler1.htm
And now, more

**BIOLOGY**

*In The News!*
New Zealand is fighting to save its symbol
By Rohan Sullivan - Associated Press
KARORI WILDLIFE SANCTUARY, New Zealand — As national symbols go, the kiwi makes up in curiosity value for what it lacks in good looks. The squat, flightless bird appears a bit like a cross between a hamster and an anteater, with furlike plumage, a long, quill-like beak and a grumpy demeanor. But don't let its looks and ungainliness mislead you. This bird is to New Zealanders what the bald eagle is to Americans.

It's on the coins and many product logos. It's in the indigenous Maori creation myth, and it lends its name to the fruit, a New Zealand export. It's even a synonym for the currency — as well as for a New Zealander, as in "I'm a kiwi, mate, and proud of it."

The only kiwis in short supply are the creatures themselves. They're an endangered species, now being nursed back to healthy numbers by an innovative conservation effort not far from the bustle of Wellington, the capital.

"When we talk about the kiwi — that's our identity," said Raewyn Empson, conservation manager at the Karori Wildlife Sanctuary. "When all of a sudden you're talking about kiwi becoming extinct in our lifetime, it's a bit scary really."
Rugged and wind-swept, New Zealand is so remote that many of its animals had few enemies and never developed strong defense mechanisms. Then, 750 years ago, man began arriving — Polynesians first, with rats in their canoes. Much later, Europeans came, bringing cats, dogs, stoats, ferrets, possums, rabbits and weasels. The islands were a predator's paradise, and the newcomers ran riot, eating the local wildlife or stealing its lunch.

Now New Zealand has one of the world's biodiversity depletion records. More than 30 percent — at least 51 species — of native birds are thought to have died out, along with frogs, lizards, fish and plants. Among them were the giant flightless moa, which the Polynesians hunted to extinction for food. Haast's eagle, dependent on moa for food, died out about 1400. The eagle could weigh more than 30 pounds and was the world's largest.
As farmers cleared forest, depriving native species of habitat, the newly arrived mammals raided nests and burrows for eggs and munched their way through countless unique beasts, pushing them toward extinction — the kakapo, the world's only flightless parrot; the tuatara, an ancient footlong reptile, and a cricket whose Maori name, wetapunga, connotes a god of ugly things.
The kiwi virtually disappeared from New Zealand's mainland, and it could only be seen on smaller, less inhabited islands.

But nature-loving New Zealand prides itself on being greener than other places, and communities and people have rushed to the rescue. More than two dozen privately run sanctuaries have sprouted. And thousands of volunteers trap, kill or chase away non-native predators. "It has been a major change in the way conservation is done in New Zealand," says Bruce Burns, a biologist who helps run a loose network called Sanctuaries in New Zealand. "Communities are taking the matter into their own hands."

In 2000, little spotted kiwi — the smallest and rarest of the six species — were released into Karori, returning the bird to the wild on the mainland for the first time in a century. Within a year a chick was born and named Frodo after the hero hobbit of the Lord of the Rings fantasy novel and movies, which were filmed in New Zealand. The park expects to count about 40 of the birds by next year.
George C. Williams’ favorite example

“Animal gonads, including those of vertebrates, are generally internal organs, although their products, at least those of males, can function only outside the body. So the internal gonads must always have associated tubing that gets gametes or partly developed offspring to the outside… [In] male mammals… normal body temperature is too high to permit normal sperm production. For this reason they move from the ancestrally normal (internal) position to a special structure, the scrotum, where they will be separated from the outside by only a thin layer of tissue.”

“This is merely the final episode of a complex story of shifts in organ positions in the abdominal cavity. The caudad [toward tail] shift of the testis … brought is closer to the point where the semen is discharged. This should mean, one might think, that ever shorter tubing would be needed. In fact … it went dorsal [behind] the ureter, which drains the kidney [resulting in] a longer, not a shorter sperm duct (fig. 6.1).”

“As an analogy I suggest picturing yourself using a garden hose to water some plantings scattered over a lawn. You might move in a rational manner, so as to minimize…the obstructions that the hose might catch…or you can be as short-sighted as natural selection …[and] end up using far more than the needed length, looped in a complex pattern around obstructions on the lawn.”

- From “Historicity and Constraint” by G.C. Williams
The Vasectomy song
by Larry Heagle

Well, I went to see my Doctor,
I said, "Doc, I can't pay my bills!
The rent's all spent,
The truck's got a dent,
And I think I'm gettin' the chills
From being forced to sleep alone,
You see this house just ain't no home,
I can't afford no kids,
My life is on the skids,
'Cause my woman says "Leave me alone,

Unless you get a vasectomy!
You ought to get a vasectomy!
Just one little male alteration
Can keep us from another altercation!
Get a vasectomy!
You ought to get a vasectomy!
Oh what a vas deferens there could be!

Well, the next thing I know,
I'm laying on a table
With a light shinin' in my eyes!
They strapped my wrists,
They strapped my ankles,
And they double-strapped my thighs!
The nurses were a gigglin'
And I was a wigglin',
Most uncomfortably,
When the Doc walked in,
With a perverted grin,
And here's what he said to me:

"It only hurts for a little while,
That's what they tell me, that's what they say!"
Well, it's two weeks later,  
And I feel a little better,  
My mind is more at ease.  
The rent's still spent,  
The truck's got a dent,  
But my woman's no longer a tease!  
And even down at the office,  
There is a lot more interest in me,  
The girls all grin when I walk in!  
And brother, they mean to please

A man with a vasectomy,  
You ought to get a vasectomy!  
Like a Sunkist orange,  
I've been squeezed,  
'Cause its all juice and there's no seed!

Well, a vasectomy!  
You ought to get a vasectomy!  
Oh what a vas deferens!  
It's beginnin' to make a little sense!  
Oh what a vas deferens there could...

Here is the part that I like the most,  
It takes the danger out of bein' close!  
Oh what a vas deferens there could..

They snip those little suckers right in two  
And clamp 'em off with super-glue!  
Oh what a vas deferens there could be!
My favorite example – why is the slime green??
Recall that much of the energy in sunlight is in the blue-green portion of the visible spectrum.

Does plant greenness relate to the use of this energy?
Light energy is obtained by the absorption of photons (light “particles”) by PIGMENTS.

Photosynthetic pigment molecules include:
- Chlorophyll a, b, c
- Carotenoids
- Phycobilins
Each pigment has its own **ABSORPTION SPECTRUM**

The rate of photosynthesis is also a function of wavelength as a result of the pigments – **ACTION SPECTRUM**
So, plants use light in the visible range where most energy is, but there is a dip in absorption in the green-yellow range. So that’s why plants are green – that light is not absorbed, so it is reflected (so we see it).

Ok, but this means lots of energy is going to waste – why don’t plants use it?
Maybe – a mistake? Historical accident? Some cyanobacteria (photosynthetic bacteria) have phycobilins.

If plants were fully utilizing sunlight, what color would they be? So, why the slime is green is still a mystery.
So design by natural selection has a distinctive historical “signature”

While many details of organisms in nature seem beautifully, exquisitely adapted for survival, they also need to be given a history - how did it get there?

In fact, many details really don’t seem to make much “sense” without that history.
“The generation of diversity by cladogenesis [the tree of life] furnishes every population with a unique set of historical legacies. In this sense an organism is a living record of its own history. In addition to whatever other values it may have, it has the same value as any other historical document. The loss of the Stellar sea cow and the Adam-and-Eve orchid were the same kind of loss to historical scholarship as the burning of the library at Alexandria. The current wholesale extinction of organisms is especially tragic and ironic because we are only now learning to read history in molecular structure, where the writing may well prove clearer and more detailed than in morphology and other phenotypic end states. To the aesthetic and economic arguments for the conservation of taxa, we should add the argument that the white rhinoceros and the blue whale must be immensely informative books that we have not yet had the skill or the time to read.”

-from “Historicity and constraint” by G.C. Williams
Extinction – loss of species
– speciation increases diversity, extinction reduces it

The fossil record documents the existence of many species that no longer exist
Occasionally, a species known first from fossils has been found still existing.

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Coelacanth

Ginkgo

http://www.dinofish.com/

http://www.xs4all.nl/~kwanten/
Tree of life has many aborted branches

Canidae – dogs: many more extinct than extant

Extinction rates have been variable over time, with occasional “mass” extinctions. Often climate change is suspected. Despite this, there have been long term increases in measures of diversity.
Adaptive Radiation

Speciation rates are variable as well, especially within groups

Adaptive radiation – “rapid” production of descendant species

What might cause this?

Probably a result of new adaptive “opportunity”

1. Colonization of new place (e.g. new island)
2. Mass extinction
3. Adaptive innovation
Adaptive radiation

Classic island examples

Galapagos finches

http://www.rit.edu/~rhrsbi/GalapagosPages/DarwinFinch.html
Sato et al. 2001
Hawaiian honeycreepers

Fleischer et al 1998
Hawaiian Silverswords

California Tarweed
Mass extinctions followed by major biotic shifts

1. **Permian** extinction (250 MYA)

Before - amphibians and ferns  
After – reptiles and gymnosperms

2. **Cretaceous** extinction (65 MYA)

Before – reptiles and gymnosperms  
After – mammals and angiosperms

Adaptive radiation

http://www.dinosaursinart.com/

http://gpc.edu/~pgore/images/mastodon.gif
National Science Foundation Press Release March 4, 2010
Revisiting Chicxulub: A broad look at the evidence for a dinosaur-killing impact

For decades, scientists have accumulated ever-larger datasets that suggest an enormous space rock crashed into the ocean off the Yucatan Peninsula more than 65 million years ago, resulting in the Cretaceous-Paleogene (K-Pg) extinction.

Recent research, supported in part by the National Science Foundation (NSF), suggested that the impact could have occurred 300,000 years prior to the K-Pg extinction, and that another cause--perhaps a second impact, or the long-lasting volcanic activity at the Deccan Traps in what is now India--drove numerous plant and animal species to their end.
Now, an interdisciplinary team of 41 scientists from 12 nations, also supported in part by NSF, has prepared a paper to specifically counter the volcanic and dual-impact alternatives, a comprehensive review of the multiple, global lines of evidence linking a single impact near what is now Chicxulub, Mexico, to the timing and breadth of the K-Pg extinction.

The researchers, led by Peter Schulte of the University of Erlangen-Nuremburg, present their findings in the March 5, 2010, issue of Science. "We felt it important to present the wealth of data now available about the remarkable and exact correlation between the impact in the Yucatan and the extinction event at the K-Pg boundary," said University of Texas geophysicist Sean Gulick, one of the authors on the paper.

One factor that is not in dispute: the end of the Cretaceous 65.5 million years ago was marked by one of the most devastating extinctions our planet has faced. The most famous victims were the dinosaurs (their avian relatives notwithstanding), but the event also saw the loss of all flying reptiles, most marine reptiles, more than half of land plants and insects, and hosts of other terrestrial and marine organisms--50 to 70 percent of all species on Earth.
Read more:

See video discussion:
Adaptive radiation

Adaptive innovations

Large category, most important traits probably qualify (e.g., photosynthesis, nucleus, multicellularity, flowers…)

“Cambrian explosion” – innovation?

By 543 MYA – all extant animal phyla
38 body plans from 3 in 20MY
Adaptive radiation

Whales (Cetacea)

Since <30 MYA
Whales (Cetacea)

Tremendous diversification in a short time

Where did they come from?
Whales are mammals most closely related to the Hippopotamus, in the Artiodactyls, the even-toed ungulates. Horses and rhinos are Perissodactyls, odd-toed ungulates.

What are the Archaeocetes?
Archaeocetes

Ambulocetidae 50 MYA

Pakicetidae 50 MYA

Protocetidae

Remingtonocetidae 45 MYA

http://www.sci.tamu.edu/~wcrc/cetaceans/extinct/archaeocetes.html
Possible transitional whale fossil Basilosaurus 35 MYA
Morphological reconstruction of the Cetacea phylogeny (no DNA for extinct taxa)

http://palaeo.gly.bris.ac.uk/Palaeofiles/whales/archaeoceti.htm
Whales are a striking example of how evolution can, relatively quickly, result not only in dramatic radiation, but extreme changes in phenotype.

Consider: Camels are more closely related to whales than to horses.

What was the “force” that caused this?
End