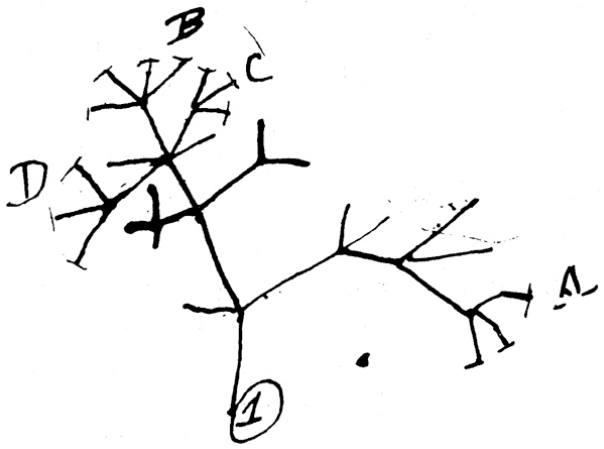
. . .rounded Africa, sailed up the Atlantic, and returned to England on October 2, 1836.

Down House, near London, where Darwin lived from 1842 until his death in 1882

Diagram from one of Darwin's early notebooks (p. 36, "Notebook B", 1837), showing how old species might branch and divide into new species over time. . . .



Back in England. . . .

Darwin's discoveries on the *Beagle* had made him famous among the naturalists of his day. He had his hands full, writing up his discoveries and collaborating with various experts. But he still found time to think about the possibility that species could change. . .

He started reading—not just biology, but economics, history, sociology. . . . including the works of these two gentlemen, which had a powerful effect on his thinking.

Thomas Malthus

Adam Smith

Adam Smith

(1723-1790)

- Author of *Wealth of Nations* (1776)
- Argued that free, unregulated economic competition would maximize profits, boost quality and innovation, create division of labor, and make prices reasonable.
- Referred to competition as "an invisible hand," which kept the economy stable and orderly, without the need for any external "designers". . .

Thomas Malthus

(1766-1834)

- Author of *Essay on the Principles of Population* (1798)
- Argued that the food supply increased in a linear fashion, while population increased "geometrically" (exponentially)
- Malthus's conclusion: There will always be social inequality, poverty, and want: share-the-wealth liberalism doesn't work

Darwin on Malthus

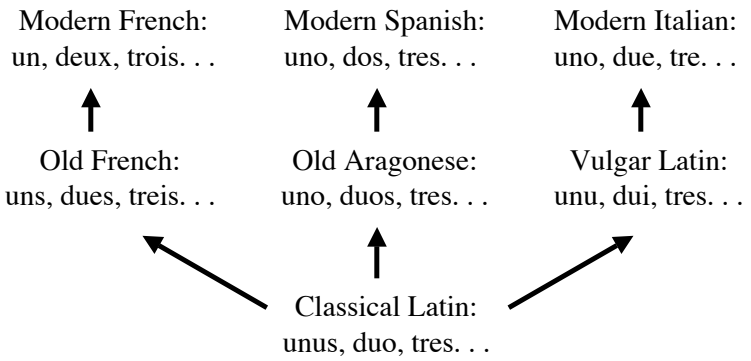
In October 1838. . . I happened to read for amusement Malthus on *Population*, and being well prepared to appreciate the struggle for existence which everywhere goes on . . . it at once struck me that under these circumstances favourable variations would tend to be preserved, and unfavourable ones to be destroyed. The results of this would be the formation of a new species. Here, then, I had at last got a theory by which to work.

—Charles Darwin, *Autobiography*

Darwin also looked at *linguistics*. . .

- In 1786, a British judge in India, William Jones, had been studying the ancient Sanskrit language of India.
- He noticed a large number of words that were very similar to words in most of the other languages of Europe—very basic words for numbers, body parts, family members, etc.
- Languages could evolve—and the *Indo-European* languages had evolved from a common ancestor!

It was already known that languages could evolve. Latin, for example, gave rise to French, Spanish, Italian, Portuguese, Romanian. . . This has been traced through written documents and inscriptions—easy as 1, 2, 3. . .



English:	*one*	*two*	*three*
Latin:	*unus*	*duo*	*tres*
Ancient Greek:	*heis*	*dyo*	*treis*
Sanskrit:	*eka*	*dwau*	*traeyas*
Persian:	*yak*	*do*	*trayas*
Russian:	*odin*	*dva*	*tri*
Irish:	*aon*	*doe*	*trae*
Lithuanian:	*viens*	*divi*	*tris*
Proto-IE	**oinos*	**duwo*	**treies*

But even where we don't have direct evidence of language evolution, we can still trace patterns of similarity—and infer that groups of languages evolved from common ancestors! (Here's more. . .)

English:	*brother*	*mother*	*[I] bear*
Latin:	*frater*	*mater*	*fero*
Ancient Greek:	*phrater*	*mētēr*	*phero*
Sanskrit:	*bhrátár*	*matar*	*bharami*
Persian:	*bratar*	*madar*	*baraimi*
Russian:	*brat'*	*mat'*	*berju*
Irish:	*bráthair*	*máthair*	*beirim*
Lithuanian:	*brolis*	*motyna*	*bérnas*
Proto-IE	**bratar*	**māter*	**bher-*

"a stronger affinity ... than could possibly have been produced by accident; so strong, indeed, that no philologer could examine them all without believing them to have sprung from some common source, which, perhaps, no longer exists". —William Jones, 1786

Putting all of this together, Darwin got his grand idea. . .

". . . I determined to collect blindly every sort of fact, which could bear any way on what are species. . . . I am almost convinced (quite contrary to opinion I started with) that species are not (it is like confessing a murder) immutable."

—Letter to botanist J. D. Hooker, January 11, 1844

Natural Selection, I:

- Any species is theoretically capable of increasing its population exponentially and indefinitely.
- But we don't see this indefinite increase; populations tend to hold roughly constant, or at least to stay within certain limits.
- Conclusion: Not all offspring produced can survive.
- Conclusion: There is a metaphorical "*struggle for existence*" constantly going on in any species.

Natural Selection, II:

- Individuals in any species vary.
- Some individuals vary in ways that help them to survive and reproduce; others vary in ways that decrease their chances
- Variation is inherited—individuals somehow transmit their variation to any offspring they have.
- Conclusion: A species will change over time, producing new and different varieties.

Natural Selection, III:

- It is often difficult to tell the difference between a variety and a species—the two blend into each other.
- There has been lots of time for change to happen, and environments have changed over that length of time.
- Conclusion: Over time, the process of natural selection has created countless new species.

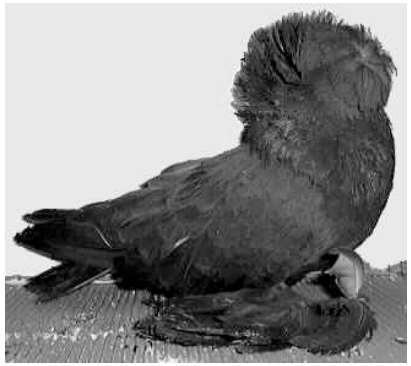
Darwin used artificial selection, practiced by animal breeders, as an analogue for natural selection. He ended up raising fancy pigeons. . .

"Believing that it is always best to study some special group, I have, after deliberation, taken up domestic pigeons. I have kept every breed which I could purchase or obtain. . . . The diversity of the breeds is something astonishing." -- *Origin of Species*, ch. 1

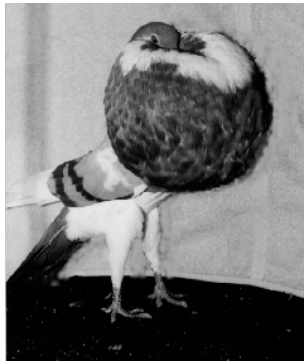
From the wild rock pigeon. . .

. . . breeders had produced a huge variety of very different pigeon breeds—by selecting individuals with traits they liked and letting them breed.

This still goes on today. . .



Bokhara



Pouter

And on. . .

Trumpeter

Frillback

And on, and on, and on, and on. . . .

Fantail

Nun

Mookee

Swallow

So what?

- Darwin argued that natural processes did exactly what breeders did: exert control over which varieties of animal or plant reproduced. Given millions of years, natural selection could create the enormous diversity of life from a few simple predecessors.
- The usual objection at this stage is to say, "Wait a minute! Selection can generate new breeds of pigeon, but it can't create anything really new — it can't create new *kinds* of living things!"
- But what, exactly, is a "kind"?

Consider these similar species. . .

Rock pigeon
Columbia livia
Europe and western Asia;
introduced to Americas

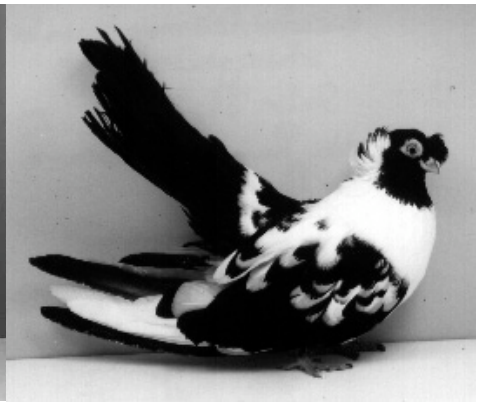
Pink-necked fruit dove
Ptilinopus porphyreus
Indonesia

These two birds are classified as different species. . .

. . . but which are more different from each other : these two wild species. . .

. . . or these two breeds of fancy pigeon, produced by artificial selection?

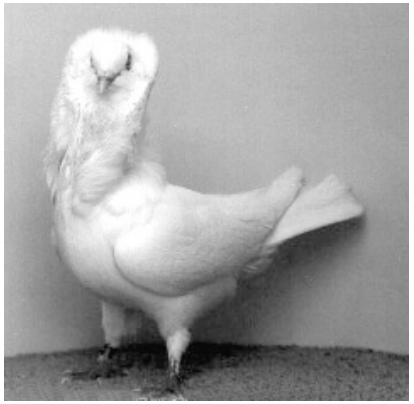
Yellow Brunner Pouter



Akermann Tumbler

. . . with *these* two fancy pigeons! All fancy pigeons are descended from the common rock pigeon—there are written records of this—but it sure can be hard to tell just by looking. . .

Black Fantail



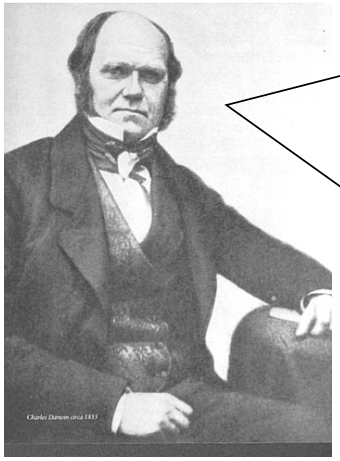
Old Dutch Capuchine

Try it again: compare these two wild species, *Columba livia* the rock pigeon (left) and *Gallicolumba luzonica*, the endangered bleeding-heart pigeon from the Philippine Islands (right). . .

And that's Darwin's point: there's *no* real difference between a "natural" species and an "artificial" variety.

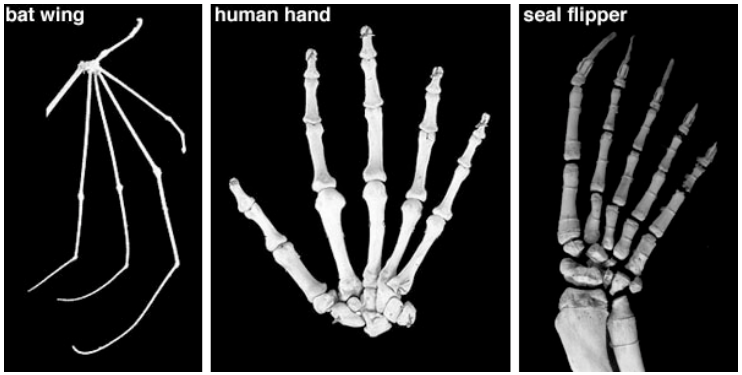
Altogether at least a score of pigeons might be chosen, which if shown to an ornithologist, and he were told that they were wild birds, would certainly, I think, be ranked by him as well-defined species. Moreover, I do not believe that any ornithologist would place the English carrier, the short-faced tumbler, the runt, the barb, pouter, and fantail in the same genus. . .
—*Origin of Species*, Chapter 1.

Evolution by natural selection seemed to explain a lot of *other* biological facts as well!



In considering the Origin of Species, it is quite conceivable that a naturalist, reflecting on the mutual affinities of organic beings, on their embryological relations, their geographical distribution, geological succession, and other such facts, might come to the conclusion that each species had not been independently created, but had descended, like varieties, from other species.
—*Origin of Species*, Introduction

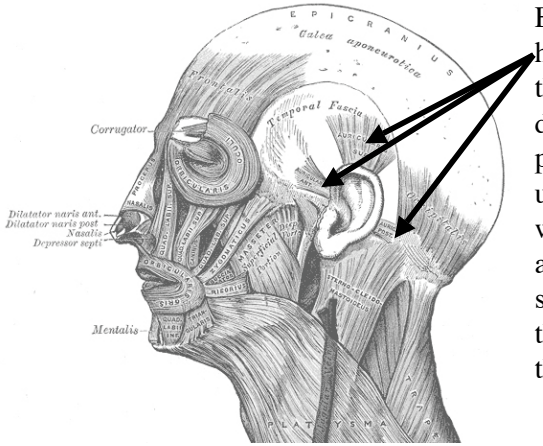
Comparative Anatomy



Why should structures as different in function as a bat's wing, a human hand, and a seal flipper be built using identical arrangements of bones?

The anatomist Richard Owen (1804-1892) had already written that all vertebrates were variations on one "archetype" or common plan, because they all shared the same basic structural plan (although it might be highly modified for different functions). Owen coined the word *homology* to mean this kind of deep similarity of structure. But how to explain it?

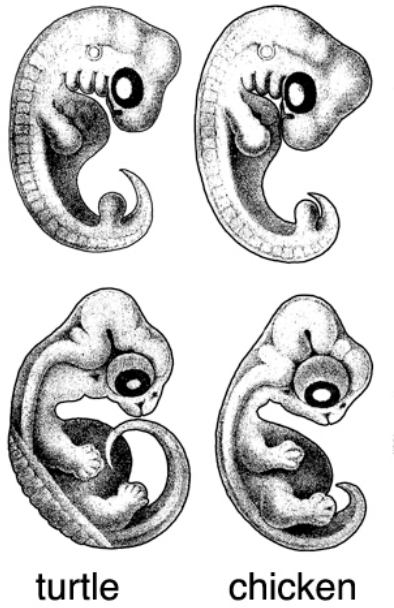
Vestigial Structures



Example: Mammals have muscles that move their external ears. You do, too, but most people never learn to use them, and ear-wiggling doesn't make any difference to your survival. . . so what are the muscles doing there?

Biogeography

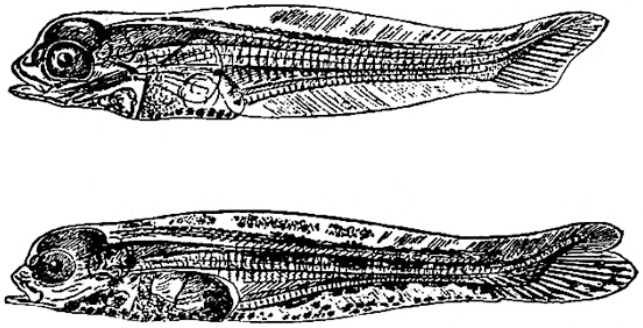
Why should young islands such as the Galápagos have so many species unique to themselves—but at the same time similar to those of the mainland?



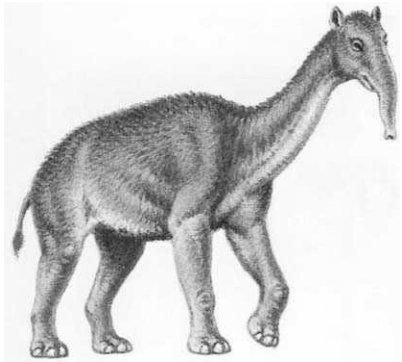
Embryology

Scientists like Karl von Baer and Louis Agassiz had already pointed out similarities between the embryos of species that looked very different as adults. In some cases, embryos of "more advanced" species had features that looked like those of adults of "less advanced" species. Why should these similarities exist in the first place?

Agassiz had shown that embryonic fish go from a stage with an asymmetrical, *heterocercal* tail (top), to a stage with a symmetrical *homocercal* tail (bottom). This matches the fossil order: heterocercal fish (such as sharks and sturgeons) appeared before homocercal fish (most modern bony fish). But *why?*



Paleontology



Darwin had already noted that some fossils, such as this South American beast *Macrauchenia*, seemed to blend characters of what would be considered very separate groups today. And fossils sometimes bore an odd resemblance to the living forms in the same place. . . how to explain all that?

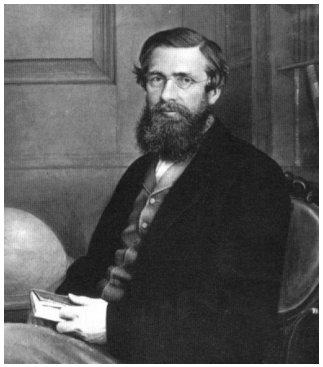
Darwin didn't go public right away. . .

- Dominant philosophy of science at the time placed most value on gathering facts, not on hypothesizing
- Conservative political and religious climate meant that Darwin was risking a lot. . .

Fact-gathering. . .

Darwin spent over twenty years gathering facts that might have some bearing on how species originated. He wrote two manuscripts laying out his theory of "descent with modification" (in 1842 and in 1844), but they were not published in his lifetime.

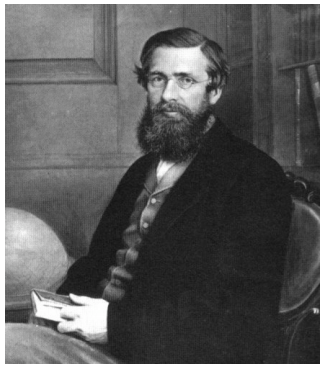
And then came the rude awakening. . .



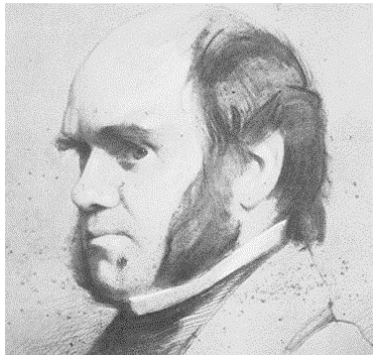
In 1858, puttering away at the manuscript for a giant book that would have explained all this in full detail, Darwin got a letter from this man—who had come up with the same idea independently (while recuperating from a tropical fever).

Alfred Russel Wallace

(1823-1913)

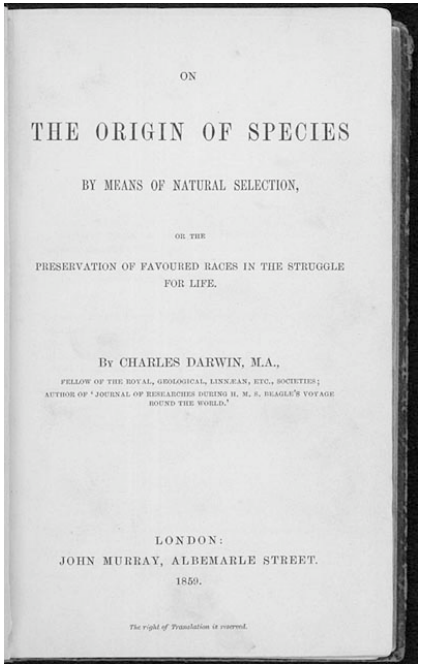


- Professional collector from a poor background
- Hit upon ideas identical to Darwin's while collecting beetles in Malaysia
- Wrote a famous letter to Darwin in 1858—which devastated Darwin, who thought he was about to be "scooped."



"I never saw a more striking coincidence. If Wallace had my M.S. *[manuscript]* sketch written out in 1842 he could not have made a better short abstract! Even his terms now stand as heads of my Chapters. . . So all my originality, whatever it may amount to, will be smashed."

—Letter from Darwin to Charles Lyell, June 18, 1858



ON

THE ORIGIN OF SPECIES

BY MEANS OF NATURAL SELECTION,

OR THE

PRESERVATION OF FAVOURED RACES IN THE STRUGGLE FOR LIFE.

By CHARLES DARWIN, M.A.,

FELLOW OF THE ROYAL, GEOLOGICAL, LINNEAN, ETC., SOCIETIES;
AUTHOR OF 'JOURNAL OF RESEARCHES DURING H. M. S. BEAGLE'S VOYAGE ROUND THE WORLD.'

LONDON:
JOHN MURRAY, ALBEMARLE STREET.
1859.

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. . . and *On The Origin of Species By Means of Natural Selection* was published in December 1859, and rapidly became a best-seller.

The Origin of Species

- Darwin's friends, including Lyell, brokered a compromise with Wallace.
  - Some modern writers have argued that Darwin and friends conspired to cheat Wallace out of his share of the credit. But Darwin had been working on evolution since 1837, and his friends knew it.
- Both men presented outlines of their ideas in a jointly written paper published 1858.
- Darwin then cut down the huge book he'd been writing to a more manageable length. . .