

Chapter Five

DARWIN AND COMMON DESCENT

When on board H.M.S 'Beagle,' as naturalist, I was much struck with certain facts in the distribution of the organic beings inhabiting South America, and in the geological relations of the present to past inhabitants of that continent. These facts, as will be seen in the latter chapters of this volume, seemed to throw some light on the origin of species--that mystery of mysteries, as it has been called by one of our greatest philosophers.

Charles Darwin

MAKING SENSE OF WHAT IS ALREADY KNOWN

The story of Semmelweis is one of the scientist confronting a mystery and systematically going out and gathering new data that helped him solve the mystery. The story of Darwin is very different. *Origin of Species*, Darwin's four hundred plus page "abstract," is one of the best argued works in the history of science. He makes a powerful case for, what we shall see, are two monumental theories. Although he was an excellent field biologist and geologist, and although that his experiences on the Beagle were clearly formative, the evidence he presented in *Origin of Species* was not original, nor even cutting edge discoveries. Darwin's genius was seeing, I would say explaining, known facts in original and insightful ways.

The history of science is full of examples where the revolutionary breakthrough comes, not in the laboratory, but

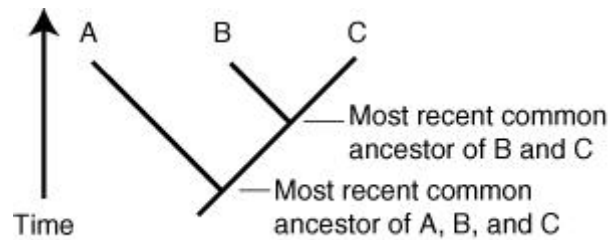
in the theorist's study. This is hardly surprising, since when you are trying to make sense of the myriad of facts and results that comprise any of the natural sciences, the level of generality and abstraction required for the grand overarching theories will seldom, if ever, come from one nicely designed experiment. Darwin was able to articulate general principles that have unified biology for over a century and a half. And, most remarkably, fit perfectly with biological discoveries that Darwin himself could never imagined.

THE TWO THEORIES

The "theory of evolution," what Darwin called, a "theory of descent with modification by natural selection," is really three distinct theories, two of which owe a great deal to Darwin.¹ We can translate the term "evolution" as simply meaning "biological change." The biological world we see today, including the species now in existence, is different from the biological world at different historical periods. Many theorists before Darwin, including his own grandfather, Erasmus Darwin, had proposed theories of biological change. The problem was that, although (as we shall see directly) these theories nicely explained many known facts, no one before Darwin had any good ideas as to the causes of this change.

Descent with modification, or equivalently, ***common descent***, is Darwin's theory about the patterns and history of this biological change. Darwin cannot really be given credit for originating the theory of descent with modification, but one of the great achievements of *Origin of Species*, is that he so powerfully laid out the evidence for this theory, that within less than a generation, almost every biologist accepted the truth of this view of biological history.

The following very simple graphic gives us the heart of descent with modification.



The vertical axis represents time, and the horizontal axis represents the present or past picture of biological diversity. So in this little snippet we learn about the history of three related species, A, B, and C. That they are related is indicated by the common ancestor at the bottom (i.e., earlier in history). We also learn that Species B is a more recent evolutionary arrival than Species A, since the common ancestor that begins its history is higher (later). Descent with modification says that current species are related to one another through a series of ever narrowing common ancestors (thus, common descent). The logical extension of this line of reasoning is, as Darwin saw, that all life can be traced back to a single common ancestor.

I cannot doubt that the theory of descent with modification embraces all the members of the same great class or kingdom. I believe that animals are descended from at most only four or five progenitors, and plants from an equal or lesser number.

Analogy would lead me one step further, namely, in the belief that all animals and plants are descended from some one prototype.²

Darwin worried that "analogy may be a deceitful guide," but contemporary facts about the molecular structure of DNA make his speculation look even stronger.

If the history of life is as descent with modification outlines, the obvious question is what brings about all of this change? If new species arise from ancestors, what is the

origin of species? Darwin stroke of genius was an original answer to this question. Breeders "select" in order to improve the stock. Nature, by analogy, also selects, but not consciously, nor with a purpose. **Natural selection** is the engine that drives biological history. More individuals in every generation are born than will survive, so there is a "struggle for existence." Some individuals are lucky enough to be born with slight advantages in this struggle, and these advantages improve their chances of surviving and passing along these advantages to their offspring. So over time, there is inevitable change within the species, and given enough time these changes accumulate to result in the start of a new species.

RIVAL EXPLANATIONS TO COMMON DESCENT

In the rest of this chapter we will focus on the least scientifically controversial of Darwin's two theories, but the one that is clearly the most controversial in the popular culture -- descent with modification. I want to try to convince you that evidence Darwin presented for this view of biological history is quite overwhelming. More recent additional evidence has only further strengthened his original argument.

We should candidly address the sources of this cultural controversy. The primary source, of course, is that Darwin is widely believed to be anti-religious. The theory of descent is seen by many as denying, not only the literal truth of the Old Testament, but flat out denying the existence of God. This latter interpretation is surprising in light of the fact that many contemporary scientists see themselves as conventional religious believers, yet accept the scientific truth of common descent and natural selection. My students are constantly surprised to hear that Darwin nowhere denies the existence of God. Nor does *Origin of Species* say anything about the creation of the universe, or the origins of

life. Many sincere theists have seen complete consistency between what traditional religion teaches us and what our best natural sciences, including biology, teaches.

The second source of controversy regards the place of our own species in Darwin's picture. Although he tried to soft-peddle it in *Origin*, it was perfectly obvious to his contemporaries, both opponents and supporters, that humans were just as much a part of descent with modification and natural selection as every other part of the biological world. This is troubling to many, I realize. I personally think explains a lot of what I know about myself, my friends, and the social world I live in.

Before *Origin of Species* the most widely accepted rival account of biological history assumed that species were permanent, unchanging, and the individual products of divine creation. This view was not just a religious one, but a scientific one as well. The theory of ***special creation*** should be interpreted in our context as a rival explanation for the facts that Darwin offered in support of descent with modification. It will helpful to distinguish two versions of special creation. One accepted the Book of Genesis as literal history -- all of the earth's species, as well as everything else, were individually created by God over the course of six, twenty-four hour days.

t₁. Fundamentalist special creation

A second version of special creation that enjoyed more support among Darwin's contemporaries in the scientific community might be termed ***relaxed*** special creation. It conceded some of the data about biological change and allowed that divine creation of individual species took place at different times of the history of the earth and life.

t₂. Relaxed special creation

THE EXPANDED AGE OF THE EARTH

The first part of Darwin's case for descent with modification consisted of a review of, indeed a powerful sub-argument for, the relatively new estimates of the age of the earth.

- e₁. The earth is much older than had been previously believed -- thousands of millions of years.

This was essential to his theory, for a great deal of time was required for the sort of biological change he was postulating. It's doubtful that any theory like common descent could have come before the discovery of "geologic time."

We should pause here to notice something general about inference to the best explanation. You will remember that in Chapter One we treated the premises in an argument as data, and the theory being defended as an explanation of this data. That is actually a bit of an oversimplification. Often times important facts will be included in the premises that are not explained by the conclusion, but are relevant to that conclusion being an adequate explanation of those data that are being accounted for. Charlie's being a poor writer was not explained by his being a cheater, but was still relevant for this explaining the identical exams. Descent with modification does not explain a much more ancient earth than previous generations had believed, but it is required for descent with modification to work.

THE FOSSIL RECORD

Let us now look at the mutual affinities of extinct and living species. All fall into a few grand classes; and this fact is at once explained on the principle of descent. The more ancient any form is, the more, as a general rule, it differs from living forms.³

Darwin spends a great deal of time discussing fossils, and well he might. Whatever else it tells us, it virtually screams out change. We see species that once thrived and are now extinct. We see progressions like the changes in the American horse. His emphasis on fossils shows us that he saw this as a particularly strong bit of evidence.

e₂. The fossil record

The fossil record, particularly in Darwin's time, was a bit of a two edge sword. Critics complained that if descent with modification was true there should be a fossil record of these "transitional forms." Darwin wisely conceded the force of this objection, but also offered a very sophisticated explanation of how difficult it is for fossils to form, and why gaps in the record were inevitable.

THE *SCALA NATURAE* OR THE NATURAL SYSTEM

From the most remote period in the history of the world organic beings have been found to resemble each other in descending degrees, so that they can be classed in groups under groups. This classification is not arbitrary like the grouping of stars in constellations.⁴

A widely held view in the century before Darwin postulated a very different kind of order to the biological world. According to the *scala naturae* (scale of nature), life was static, but hierarchical. There was an observable and classifiable ***progression*** from the simplest and most primitive forms of life to the most complex and advanced.

This view had been pretty thoroughly rejected by the time Darwin began his work. But a remnant of it remained at the heart of biology. Even if the structure wasn't hierarchical, there was a structured order to life, nonetheless.

Any intelligent four year old can go to the zoo and recognize that the different feline species in the cages are all cats, just like Boots at home. Feline species around the world are "related" to each other, and they are more "closely related" to each other than they are to canine species living in the same environment with them. Nature seems to sort itself out into one giant *natural system*.

The obvious question is what do we observe the following?

e₃. The Natural System

Darwin's answer was unequivocal.

The real affinities of all organic beings, in contradistinction to their adaptive resemblances, are due to inheritance of community of descent. The Natural System is a genealogical arrangement, with acquired grades of difference, marked by the terms, varieties, species, genera, families, etc.; and we have to discover the lines of descent by the most permanent characters whatever they may be and of however slight vital importance.⁵

PATTERNS OF GEOGRAPHICAL DISTRIBUTION

Darwin was fascinated by the connection between life and where that life was found on this earth. Before Darwin the only viable explanation of this connection was that God chose to put it there. Darwin is the founder of modern, causal biogeography.⁶ And biogeographical facts are, perhaps, the most widely used evidence in *Origin of Specis*.

e4. Patterns of geographical distribution.

Let's start with a macro question. If an omniscient and all-loving God deliberately created each species to fit perfectly with its environment, why do we see such diversity in virtually identical climates between the Old and New Worlds?

if we travel over the vast American continent, from the central parts of the United States to its extreme districts, arid deserts, lofty mountains, grassy plains, forests, marshes, lakes, and great rivers, under almost every temperature. There is hardly a climate or condition in the Old World which cannot be paralleled in the New—at least as closely as same species generally require. ... Notwithstanding this general parallelism in conditions of the Old and New Worlds, how widely different are their living productions!⁷

From continents separated by whole oceans, to islands separated by a few miles of ocean, the micro questions of biogeographical distribution are just as puzzling on the theory of special creation.

The same law which has determined the relationship between the inhabitants of islands and the nearest mainland, is sometimes displayed on a small scale, but in a most interesting manner, within the limits of the same archipelago. Thus each separate island of the Galapagos Archipelago is tenanted, and the fact is a marvelous one, by many distinct species; but these species are related to each other in a much closer manner than to inhabitants of the American continent, or any other quarter of the world.⁸

Descent with modification, of course, beautifully answers both questions. The flora and fauna in the Old and New Worlds are generally different because they spring from very different lines of descent. Species in the Galapagos (think of his famous finches) all descend from a common ancestor on

the South American mainland, but have different histories of descent on the individual islands.

MORPHOLOGICAL FACTS

Morphology is the science of shape and form, hence the computer notion of an image "morphing." Consider the four tetrapods pictured below. Why the common four "leg" structure? The frog hops, the lion runs, the particular dinosaur swam, and the bird flies. If you were engineering a hopping machine, a running machine, a swimming machine, and a flying machine, would you automatically use the same overall design?



Darwin saw morphology as fundamental to his defense of descent with modification.

We have seen that the members of the same class, independently of their habits of life, resemble each other in the general plan of their organization. This

resemblance is often expressed by the term "unity of type" ... The whole subject is included under the general name of Morphology. This is the most interesting department of natural history, and may be said to be its very soul.⁹

Immediately following this quote, Darwin articulates as a question, the data regarding the forelimbs in mammals that is perhaps, for my students, at least, the most convincing as evidence of common descent.

What can be more curious than that the hand of a man, formed for grasping, that of a mole for digging, the leg of a horse, the paddle of the porpoise, and the wing of a bat, should all be constructed on the same pattern, and should include the same bones in the same relative positions?¹⁰

Pretty darn curious, wouldn't you agree?

e₅. Morphological commonalities

EMBRYOLOGICAL FACTS

As Darwin remarks several times in his discussion of embryos, just as the remarkable similarity in the bones in the forelimbs of mammals require an explanation, curious features of embryos also must be accounted for.

How, then, can we explain these several facts in embryology,--namely the very general, but not universal difference in structure between the embryo and the adult;--of parts of the same individual embryo, which ultimately become very unlike and serve for diverse purposes, being at this early period of growth alike;--of embryos of different species within the same class, generally, but not universally, resembling each other;--of the structure of the embryo not being closely related to its conditions of existence, except when the embryo becomes at any period of life active and has to provide for itself;--of the embryo apparently having sometimes a

higher organization than the mature animal, into which it is developed. I believe all these facts, as follows, on the view of descent with modification.¹¹

Give me a common ancestor, Darwin seems to say, and I can explain the circuitous route, with many detours, from egg to adult in animal development, why young baleen whales develop teeth, why land-living vertebrates (including ourselves) go through a gill-arch stage, and why higher vertebrates have a notochord.

There is no obvious reason why, for instance, the wing of a bat, or the fin of a porpoise, should not have been sketched out with all the parts in proper proportions, as soon as any structure became visible in the embryo.¹²

e₆. Embryological oddities

I must tell you, here, that were you to google “Darwin, embryology” you would find that some of the sites are highly critical of Darwin, and argue that his appeals to embryology have been discredited in modern biology. This isn’t really true, but we can make sense of these, I believe, sincere criticisms. Part of the problem Darwin faced in his section on embryology was that centuries of thought had tied embryonic development to the static, *Scala naturae*, that we discussed earlier. These scientists believed that each stage in embryonic development represented an earlier, non-changing, stage in the hierarchy of life. Darwin, of course, completely rejected this view, but it remained part of the common (mis)/understanding within embryology.

Even more problematic, though, was that many scientists sympathetic to biological change believed that there was a very strong correlation between the different stages of the history of life – its phylogenetic structure, and the different stages of an individual’s embryonic development. Thus, one of Darwin’s contemporaries, Ernst Haeckel, claimed:

Ontogeny is a concise and compressed recapitulation of phylogeny, conditioned by the laws of heredity and adaptation.¹³

We now know that the recapitulation theory is mistaken, and that embryonic development is much more complicated than either Darwin or Haeckel could have ever imagined. Darwin conceived of descent with modification as applying to individuals exemplifying a species – that species's **phenotype** (its appearance and behavior). Modern biology, though, also includes the descent with modification of its **genotype** (the genetic instructions for building the phenotype), and if that were not complicated enough, it also must include the descent with modification of the underlying biochemical processes that take the information in the genotype and physically develops the individual. We are really only getting a handle on that in the 21st Century.¹⁴

DARWIN'S EVIDENCE FOR DESCENT WITH MODIFICATION

The evidence can now be schematized.

- e₁. The earth is much older than had been previously believed -- thousands of millions of years.
- e₂. The fossil record
- e₃. The Natural System
- e₄. Patterns of geographical distribution
- e₅. Morphological commonalities
- e₆. Embryological oddities
- t₀. Descent with modification

The central question in inference to the best explanation is always the same – is t_0 the **best** explanation? We've already discussed the two serious rival explanations in Darwin's time.

t_1 . Fundamentalist special creation

t_2 . Relaxed special creation

Within in ten years or so of the publication of *Origin of Species*, say 1870, up to this first decade of the twenty-first century, there has been clear, overwhelming consensus in the broad scientific community that descent with modification – evolution – does such a manifestly better job of explaining all of this uncontroversial data that the evidence is so strong, we can talk of common descent as a scientific **fact**. You, of course, must rank order the explanations for yourself. Some of you will insist on a different ranking, and I maintain that is your moral and intellectual right. My job as a philosopher and a teacher is accomplished if you can simply see why Darwin, his contemporaries, and his scientific descendants all thought the evidence was so powerful. I do want to remind you, however, that many traditional theists have seen complete consistency between mainstream religious doctrine, and evolution. Consider the words of Richard Swineburne, for many years the Nolloth Professor of the Philosophy of the Christian Religion at the University of Oxford, beginning his book, *The Evolution of the Soul*.

Men evolved from apes, and apes from more primitive animals, and the primitive animals evolved from the soup of inanimate atoms which consolidated to form the Earth some four thousand million years ago. Although there is much uncertainty about the exact stages and mechanisms involved, the fact of evolution is evident.¹⁵

NATURAL SELECTION

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. Nevertheless, such a conclusion, even if well founded, would be unsatisfactory, until it could be shown how the innumerable species inhabiting this world have been modified, so as to acquire that perfection of structure and coadaptation which most justly excites our admiration.¹⁶

Why do we see such change in biological history? Why does this change so often seem exactly what is required for changing circumstances? What is the engine that drives descent with modification? One of my teachers called natural selection an algorithm, and Ernst Mayr, who I will be borrowing heavily from in this section, calls the theory "very logical."¹⁷ All of this could be taken to mean that natural selection is *automatic*, or that the inference is deductive. The argument, though, is explanatory, just like the argument for common descent. I will follow Mayr, indeed I will use his wording, and treat Darwin's reasoning as "three inferences based on five facts."¹⁸

Three of these facts provide evidence for what he called the "struggle for existence."

A struggle for existence inevitable follows from the high rate at which all organic beings tend to increase. Every being which during its natural lifetime produces several eggs or seeds, must suffer destruction during some period of its life, and during some season or occasional year, otherwise, on the principle of geometrical increase, its numbers would quickly become so inordinately great that no country could support the product. Hence, as more individuals are produced than can possibly survive,

there must be in every case a struggle for existence, either one individual with another of the same species, or with distinct species, or with the physical conditions of life.¹⁹

e₇. All species have such great potential fertility that their population size would increase exponentially ... if all that are born would again reproduce successfully.²⁰

e₈. Except for minor annual fluctuations and occasional major fluctuations, populations normally display stability.²¹

e₉. Natural resources are limited. In a stable environment they remain relatively constant.²²

t₀¹. There is a fierce struggle for existence among individuals of a population, resulting in the survival of only a part, often a very small part, of the progeny of each generation.²³

The game of life is unfair – not all compete in this struggle for existence equally. Darwin, who was a pigeon breeder, and recognized its relevance to his argument, saw that some individuals in any species would have slight advantages (and other, slight disadvantages) in surviving long enough to reproduce. Nature, itself, would be selecting.

Owing to this struggle for life, any variation, however slight and from whatever cause proceeding, if it be in any degree profitable to an individual of any species, in its infinitely complex relations to other organic beings and to external nature, will tend to the preservation of that individual, and will generally be inherited by its offspring. The offspring, also, will thus have a better

chance of surviving, for, of the many individuals of any species which are periodically born, but a small number can survive. I have called this principle, by which each slight variation, if useful, is preserved, by the term of Natural Selection, in order to mark its relation to man's power of selection.²⁴

e₁₀. No two individuals are exactly the same; rather, every population displays enormous variation.²⁵

e₁₁. Much of this variation is heritable.²⁶

t₀². Survival in the struggle for existence is not random but depends in part on the heredity constitution of the surviving individuals. This unequal survival constitutes a process of natural selection.²⁷

From t₀² Darwin makes one more inference that gives him the title for his book, and the explanation of descent with modification.

t₀³. Over generations this process of natural selection will lead to a continuing gradual change of populations, that is, to evolution and to the production of new species.²⁸

ONE LONG ARGUMENT

Darwin called *Origin of Species* "one long argument." I have stressed that he actually defended two, quite distinct theories, but at the same time, it's easy to see the truth in the one long argument characterization. Having clearly presented the evidence for descent with modification, he then (actually this is not the progression in the book) lays out the case for natural selection.

e₁. The earth is much older than had been previously believed -- thousands of millions of years

e₂. The fossil record

e₃. The Natural System

e₄. Patterns of geographical distribution

e₅. Morphological commonalities

e₆. Embryological oddities

t₀. Descent with modification

e₇. All species have great potential fertility

e₈. Populations normally display stability

e₉. Natural resources are limited

t₀¹. Fierce struggle for – more are born than will reproduce

e₁₀. No two individuals are exactly the same

e₁₁. Much of this variation is heritable

t₀². Survival in the struggle for existence is not completely random – natural selection.

t₀³. Over generations this process of natural selection will lead to evolution and to the production of new species.

As always, rival explanations are possible. Almost every biologist now accepts t_0 , t^1_0 , t^2_0 , as the best explanations. Some controversy remains, however, regarding t^3_0 . Most grant that natural selection does result in species change, but some question whether it is the primary cause. This kind of controversy, rather than calling evolution into question, is precisely what healthy science is all about. There do remain questions, not about the overall theory, but about the details. Darwin wrote *Origin of Species* in ignorance of genetics, population biology, and molecular biology. It is quite remarkable that these revolutions, rather than undercutting his theories, actually over time came to add further support.

¹ Reference to Mayr and Darwin.

² Darwin (1900), pp. 298-9.

³ *Ibid*, pp. 106-7.

⁴ *Ibid*, p. 202.

⁵ Darwin (1991), p. 398.

⁶ Mayr, p. 446.

⁷ Darwin (1991), p. 301.

⁸ *Ibid*, p. 338.

⁹ Darwin (1964), p. 434.

¹⁰ *Ibid*.

¹¹ *Ibid*, pp. 442-3.

¹² *Ibid*, p. 442.

¹³ Quoted in Mayr, *op. cit.*, p. 474.

¹⁴ See, *Shaping Life: Genes, Embryos, and Evolution*, by John Maynard Smith (New Haven: Yale University Press, 1998).

¹⁵ Richard Swinburne, *The Evolution of the Soul* (Oxford: Oxford University Press, 1997), p. 1.

¹⁶ Darwin, *op. cit.*, p. 3.

¹⁷ Note to Dennett and Mayr

¹⁸ Mayr, *op. cit.*, p. 479.

¹⁹ Darwin, *op. cit.*, p. 63.

²⁰ I take the wording, indeed the structuring of Darwin's argument from Mayr, *op. cit.*, p. 479.

²¹ *Ibid*, p. 480.

²² *Ibid*.

²³ *Ibid*, p. 62.

²⁴ *Ibid*, p. 61

²⁵ *Ibid*, p. 480.

²⁶ *Ibid*.

²⁷ *Ibid*.

²⁸ *Ibid*.