The Theory of Options

A New Theory of the Evolution of Human Behavior

Sean Gould

The Theory of Options: A New Theory of The Evolution of Behavior

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"I have just finished reading all of the text in your *Theory of Options* website, as well as the new book *Nonzero* by Robert Wright. I have also recently read several other related books such as the following: *Vision* by Machio Kaku, *River From Eden* by Richard Dawkins, and *Consilience* by Edward O. Wilson. When your book is published, I believe it will … serve to enrich and clarify the messages contained in each of the other books noted above, as well as stand alone as a defining milestone for our understanding of the past and hope for the future."

Pat McDonald
(Pat is an independent reviewer who lives in Birmingham, AL.)

"There are aspects of evolutionary theory that do not yet explain certain human behaviors all that well. The ideas expressed in the book are timely, and will increase our knowledge of the human condition, and the processes that operate in the universe; something in which we all seem so interested. I was impressed."

Roger McEvilly
(Roger is a contributor to the evolution debate, and is a top 1,000 reviewer on Amazon.)

“I found this theory very exciting ... an evolutionary theory that emphasizes the significance of options, yet provides a secular basis for morality!"

George Boeree
(George is a lecturer in psychology at Shippensburg University.)

Why is the human brain so large, if pre-humans survived with a much smaller brain? Why if fitness favors individuals, did humans evolve morality, which favors groups? If individuals evolved to be fit, why do some people commit suicide, or abjure procreative sex? Why, all through history, have people felt that each action was being judged morally, when nature would have no reason to select such a feeling? How can people reconcile a biological drive to be fit, with complex emotions that we experience every day?

This book tries to provide some insights…

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"We are nature's unique experiment to make the rational intelligence sounder than reflex" **Jacob Bronowski**

Seeking Explanations…

"Some problems continue to baffle the modern mind… People have thought about these problems for millennia but have made no progress solving them".

Thus, wrote Steven Pinker in the final chapter of his excellent book, *How the Mind Works*. If anything, lack of a theory of human uniqueness is a paradox of the human condition. There are many inspirational views of human nature, and theories of how humans are motivated. And there is a theory that humans, as with all other organisms, evolved by favored individuals passing on more DNA than less fit rivals. Even so, knowing how humans evolved only deepens the enigma, because human behavior often seems to lack a deep genetic motive. Or while some drives are genetic, much of human behavior can be explained by other principles, based on culture or psychology. For this reason a theory reconciling how humans evolved with how they behave has not been possible.

This book uses a different approach, called the *Theory of Options*, that might provide some insights. So, what is this approach?

Well, one difficulty of this topic is that there is no current theory of human behavior that will easily integrate with current models of human evolution. So the argument begins from updated theories of both human behavior and evolution, that will better work together.

The first theory concerns behavior. It is based on a principle that as individuals, humans feel motivated to *maximize options* in life. Broadly, when facing complex situations, humans try to evaluate their options, and enact actions that will maximize options for future behavior, from that point forward. Of course, part of the theory is that not all humans learn to maximize options. Personal failure or social frustration restricts options, so conflicts arise. The theory is then extended as a method for handling conflicts, by uncovering the sources of frustration. Once the problems are known it is possible to find viable options that an individual, or a group, could enact from that point forward.

This way, the idea of maximizing options is not just a description of behavior, but is intended as a workable theory. This is one of the debates. Often a researcher insists that a theory of behavior is correct because it is based on evolution. However, evolutionary precepts are hard to establish for humans, and human behavior is so varied that it ends up being just whatever people do. So any theory of behavior needs to be plausible on its own. If humans truly do feel motivated to maximize options, a priest should be able to counsel an individual on how to increase options in life, even if neither person believes in evolution.

Ultimately though, the argument comes back to evolution, and this leads to the second theory. It is true that populations modify by favored individuals passing on DNA, but this only explains the mechanisms of how populations modify, not why they do. Processes of selection and adaptation apply to all populations, but other factors will cause one population to evolve into butterflies, and another into polar bears. Factors constraining a population to evolve in a particular direction can be called a fitness *pathway*. Humans say, evolved along a pathway maximizing adaptation to bipedal life on the plains of Africa. And although they do not call it that, researchers such as Steven Pinker use a 'plains of Africa' or 'hunter and forager' pathway, as a model of human evolution.

The limitation with this local pathway model is that though humans evolved for life in Africa, they were able with little modification to also live in mountains or the Arctic. Or humans whose ancestors evolved for primitive life, within a short time developed art, poetry, and culture. The same minds that evolved to be good hunters and foragers, also invented string theory. The same hands that evolved to pick berries were delicate enough to perform brain surgery. So, the pathway along which humans evolved seemed to adapt them for more than just the local conditions of struggle. The challenge is to discover what that pathway was.

Testing for pathways that might account for the human uniqueness, leads to an unusual principle. Humans appeared to evolve along a fitness pathway that *maximized the options of behavior* for the least cost to adapt. People might see evolution as species 'striving' towards a goal. Yet adaptation is always along available pathways, and change incurs costs. For humans, each attribute that changed, whether the body covering, hand, or posture, was fit if it gained enhanced flexibility of behavior for a minimum cost to evolve. The human male say, grows a beard. It is not clear why growing a beard maximizes the options of behavior for a cost to evolve, so cases such as this will challenge the theory to explain them. Even so, there are other conundrums of human evolution, such as why the brain is so large, or the hand so delicate, or why it was fit to have morals. Examining such conundrums by asking how it would maximize options, often provides fresh insights.

Also, from a principle that humans evolved to maximize the options of behavior, it is easier to derive a theory of modern behavior. A thesis about how in business or politics one can maximize the spread of one’s DNA does not make sense. Yet, people strive to maximize their options. Leaders in a crisis state that they will keep their options open. People trapped in awkward situations will examine "other options". One great challenge to any theory is explaining suicide, but people commit suicide when all the normal options in life are closed off. In prehistory the DNA of individuals born with flexible attributes of behavior spread. So, it is the consequence of selection in prehistory, not selection itself, that drives modern human behavior.

From carefully working through these concepts, testing each idea, insights can be found into not just how human behavior evolved, but why morals, or feelings of religious awe might have arisen. (Everybody tries to explain this, but to be fair, nobody has really explained why religious or moral feelings have arisen in 2,500 years of secular debate.) Still, none of this is easy to explain in any theory, so critics will certainly find alternative explanations to those given here. Hopefully though, as the debate progresses, those who failed to agree over human behavior before might find that the arguments here are not so unfamiliar. They allow that genes and evolution do shape behavior, in testable ways. But they also allow that humans should have viable options, which can be achieved through self-directed effort.

Even so, there is one further challenge to formulating any model of how human behavior evolved, concerning evolutionary theory itself. The standard theory is that genes are selfish and manipulative, which is how they spread. Nobody suggests that genes are this way with intent, but scientists need a measure of how organisms adapt. The spread of DNA provides this. If people sight a male bird feeding ten hatchlings, he looks like a fit parent. Yet, if scientists measure the DNA and discover that the hatchlings are not his, another male is fitter biologically, and DNA of the rival will spread. The fact that species such as birds modify behavior by such mechanisms causes a dilemma explaining human behavior. One can certainly explain human behavior by psychological or ethical principles, but how does one explain it in terms of the real mechanisms by which individuals are fit, and DNA spreads?

Well, in the following chapters, evolution of each human attribute, including the large brain, emotions, or morals, is explained as individual fitness, or by acceptable mechanisms. If anything, the effect of options works so well explaining human evolution that one is challenged to ask why. One suggestion offered here, and critics are encouraged to dispute it, is that the standard theory of DNA selfishness is not itself consistent. There are anomalies in it, such as why sex evolved (only 50% of an individual's DNA is passed on), why renegade DNA cannot spread as fast as the calculations show, or why steady change in DNA produces a punctuated pattern of how life evolves. These difficulties require patches to orthodox theory, such that genes can also be cooperative or even 'parliamentary', or other *ad hoc* explanations.

This book proposes a more consistent model of gene selfishness, one that better correlates with the idea of a fitness pathway. If genes truly did try to replicate their copies selfishly, then they would attempt not just to copy in great numbers, but keep the copies exact over time. Again, genes do not try with intent, but some genes are forced to alter less over time to adapt into a variety of organisms. If anything, as life evolves many core genes become perfected at expressing new organisms for little alteration to themselves. Evolution from the first cell into more advanced cell types required most genes in primitive genomes to change, which took billions of years. Yet, humans evolved in five million years, because a mere 1-2% of genes in hominids had to change.[1] This tendency of genes to allow rapid evolution in certain directions results in genetic fitness pathways, in addition to environmental ones. Only again, while it is easy to say this in words, this is not how the equations quite work. The issues are discussed, briefly, and an alternative model of how genes spread over large scales is proposed in the section on evolution.

These then, are some of the many controversies that the theory faces. On one hand, it uses an unusual model of DNA selfishness. On the other, it is a theory about how ordinary humans think, feel, and behave every day, by common observation. It is a theory that can provide insights into how the mind works and how the brain evolved. It offers a plausible explanation of morality. The theory can also be used as a hypothesis of not just how human behavior evolved, but how the hand, face, or posture evolved. Yet despite its evolutionary underpinnings, the concepts work as general psychology, without any reference to evolution.

Finally, the argument is that knowledge increases options**.** The more that we know about a thing, including our own human nature, the more clearly each of us can delineate the real choices in life, that humans have the options to make.

Layout of the Book….

There is no optimal layout for a book like this.

Humans evolving to maximize options might appear as a plausible argument that can be smoothly developed. However, any theory of how human behavior evolved faces ensconced difficulties, such as explaining fitness, or why morals evolved. Each difficulty will be examined, but only with considerable digression. Chapters were also not written in the order that they now appear, and over the few years that the book was written, this has resulted in a slightly disjointed style.

Another difficulty is that the first aim of the book is to show how the options effect is broadly applicable; to evolution, behavior, psychology, and culture. The book discusses why a large brain, morals, or a flexible psychology would maximize options, and the fitness reasons why these evolved. But other details of why particular human novelties evolved are left to further research. This has given some critics, whose focus is on evolution, an impression that the argument is circular. (Be convinced of

[1] This figure is much quoted in this book. Genes vary about 1.5% from chimp genes, but within any human individual, there can be a 0-5% variation of alleles at many loci.

the theory first, then research the details needed to support the theory.) To be fair, the theory is intended as an overall framework to research fresh approaches, but there should be sufficient detail to explain human evolution. Just that the explanations of human evolution tend to be distributed over various sections. One section, say, deals with general evolution, and another with evolution of the brain. The origins of culture, ethics, and religion are in another section. With hindsight, this could have been arranged differently. But for now, readers will have to follow the threads of the argument in the order in which they appear, depending on each reader's particular focus.

Section 1 provides a background to the issues, including a brief survey of the debate over human nature.

Section 2 explains the current evolution debate. Chapter 2.4 gives an outline of the model used to explain how genes spread. Chapter 2.5 explains human evolution in this context.

Section 3 explains the theory about options. Chapter 3.1 outlines the theory of behavior. This is given in just six pages, but the argument can be expanded from this. Chapter 3.2 is a theory of human evolution, in a condensed form. Chapters 3.3 and 3.4 introduce theories of knowledge and morality. These topics are extended in later chapters.

Section 4 contains several original essays on mind, evolution of the brain, abstraction, and artificial intelligence.

Section 5 is on origins of culture, morality, ethics and religion. The final three essays are in a slightly earlier style, but are among the most forceful in the book, especially the essay on religion.

Section 6 is a rounding off. This was originally three chapters, but it has been reduced to just one chapter summarizing the main points.

Appendix I provides some technical details not in the main text.

Appendix II is a suggested compendium of further reading.

Appendix III is a short Table of Authorities.

This first edition was largely a self-published effort, and invariably small errors in the arguments and presentation have crept in. Any oversights or deficiencies in the following pages will be gratefully acknowledged by the author, and corrected in future editions.

To the Reader …

This initial exposition of this book is slightly condensed. This is a controversial theory. Each point requires detailed discussion. Yet readers will also want to see the arguments outlined in as few words as possible. The early draft of the book was a bountiful 400 pages, but this has now been cut down to the present 200 page edition. Five chapters on philosophical and social implications of the theory, plus some discussion and examples, have been cut from the book. If this leaves the style too abrupt this material will be reinstated in later editions.

The book contains some technical details and some equations. None of this is essential, but if the reader is curious about a source, such as a famous equation, it is given if appropriate. There is some technical background, such as how to use large numbers, given in the appendix. The reader, however, can skip technical details on a first reading. Although the essays criticize facets of evolutionary theory, sources are drawn only from authoritative texts, though I explain details my own way. (One authoritative text is *Evolution* by Strickberger, but there are many others.) Always defer back to authoritative texts for further explanation.

Please read the quotations at the start of each chapter…

This book provides insights, but within the context of a debate which is ongoing, and draws from many sources. The quotations at the start of each chapter provide views of the many contributors to the debate. Readers are strongly urged to read the quoted sources in their original texts. If anything, the book will be enjoyed most by those who are already familiar with the issues, who are seeking fresher perspectives. A brief compendium of suggested reading is listed in the Appendix.

The remainder of each chapter excluding the quotes, is always the author's own, original arguments.

Sources and Acknowledgements….

A book like this draws on many sources. The primary one is other books, and these are listed in *Further Reading* in the appendix. I have restricted the list to volumes in my personal library, and have not listed general texts, or materials from periodicals or the Internet. Oversights of important references will be added in later editions.

The start of each chapter lists several quotes. These are from widely published sources, and are intended to be publicly stated views. Even so, this author has attempted to contact many of the persons quoted to check the suitability of the quote, but this was not always possible.

Most diagrams used are the author's, but some details were redrawn from widely available sources. Readers are cautioned that some materials (such as a tree of hominid evolution) can fall out of date quickly, and are encouraged to always check details against the latest findings.

A book like this requires careful review. It is fine to have ideas, but details from a range of topics; evolution, neurology, psychology, and the physical sciences, must be carefully checked. However, the speed with which this book was prepared for print, the diversity of topics, plus the lack of easy access to authorities at the time of writing did not always allow this. Pat McDonald, Roger McEvilly, and George Boeree provided some encouraging early reviews. John Wilkins of Melbourne University reviewed the work, and helped eliminate unclear definitions and poor use of terms. David Ussery of the Technical University of Denmark provided invaluable criticism. Chris Lucas of the Complexity Organization helped. Julian Poulter of Mahaiodol University in Bangkok helped with the equations. I exchanged emails with several biologists and mathematicians on technical points. Lee Altenberg of the University of Hawaii was most helpful. Many persons, quite unknown to me, contacted me over the Internet with kind suggestions to improve the book. The author gratefully acknowledges all these inputs, but accepts that this does not constitute a detailed review of a complex theory. Because several of the arguments are in non-standard terms, errors could easily have been overlooked by the reviewers, struggling with the concepts as a whole. Evolutionary theory also consumed a disproportionate amount of the review effort. So, the chapters on psychology or behavior were not as thoroughly reviewed as these topics deserve.

The author alone is responsible for these gaps in the review process. Any errors or omissions in the book will be corrected in future editions, but are my mistakes alone.

0.1 Introduction

"The main conclusion here arrived at... is that man is descended from some less highly organized form. The grounds upon which this conclusion rests will never be shaken, for the close similarity between man and the lower animals in embryonic development, as well as in innumerable points of structure and constitution, both of high and of the most trifling importance,- the rudiments which he retains, and the abnormal reversions to which he is occasionally liable,- are facts which cannot be disputed." **Darwin**

"But nature -that is, biological evolution - has not fitted man to any specific environment. On the contrary, ... he has a rather crude survival kit; and yet -this is the paradox of the human condition - one that fits him to all environments. Among the multitude of animals which scamper, fly, burrow and swim around us, man is the only one who is not locked into his environment. His imagination, his reason, his emotional subtlety and toughness, make it possible for him not to accept the environment but to change it." **Jacob Bronowski**

"The replicators which survived were the ones that built *survival machines* for themselves to live in... Now they swarm in huge colonies, safe inside gigantic lumbering robots... They are in you and me; they created us, body and mind; and their preservation is the ultimate rationale for our existence. They have come a long way those replicators. Now they go by the name of genes, and we are their survival machines." **Richard Dawkins**

"What distinguishes our species is thought. The cerebral cortex is a liberation. We need no longer be trapped in the genetically inherited behavior patterns of lizards and baboons." **Carl Sagan**

"But as much as we would like to take a unified view of nature, we keep encountering a stubborn duality in the role of intelligent life in the universe, as both subject and student. We see this even at the deepest level of modern physics." **Steven Weinberg**

0.1.1 How the Debate Started

This book examines an important modern debate, concerning how evolution accounts for human behavior. It approaches the issue, which causes bitter disputes, with a theory that at first appears simple.[2] This is the *Theory of Options.* It proposes that of all things that humans do, they most try to *maximize* their options.

So, what is the theory about?

Well, although about evolution, the argument arose from an ancient concern. Since antiquity there has raged a bitter dispute about whether human behavior is fashioned by *nurture* (upbringing) or *nature* (biology). Arguments vary, but some thirty years ago the 'nature' side gained fresh impetus from discoveries in genetic theory. This led, among claims, to famed biologist Richard Dawkins stating that organisms were survival machines of their genes, which were the true motivators of behavior. Implications were that humans too must be survival machines, so human behavior was motivated by the gene's desire to propagate.

Still, calling humans survival machines oversimplified the issue, and Dawkins and others faced such strong criticism that they modified their stance. Yet, behavior does arise from biology, and biology is a product of genes. So, if humans are not survival machines, what are they? While some scientists claimed that human behavior was determined by genes, others said that biology sets humans free. Popular views were those of Jacob Bronowski and Carl Sagan (see quotes). Sagan stated explicitly that humans were not trapped into the behavior patterns of genes. To fly humans did not need to evolve wings, but could go from earthbound to landing on the moon within a century by cultural evolution.

A better analogy than Sagan's (Sagan and Bronowski are both dead) concerns body covering. Humans evolved in a period when temperatures were falling, and one way to protect against cold is by growing body fur. Yet during this period humans shed body fur, so why was this? Well, while temperatures fell, they also fluctuated. If humans had other means to keep warm shedding fur offers the most *options*. If the environment stayed cold humans could wear coverings of fur skinned from animals, but if it warmed again they could abandon the furs and go naked. The detailed reason that humans shed body fur could have been for running in hot climates, yet enhancing options for whatever reason is consistent in human evolution. Other organisms might be survival machines, but evolution seemed to select humans to be an "option-creating" machine, adapted to survive in all environments.

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[2] This is a somewhat earlier essay than the arguments in the main text, but it gives the idea. Always defer to later chapters for detailed explanations. Claiming to explain how humans evolved understates the problem, as nobody has enough data to know for certain.

Even so, for a "survival machine", survivors get to reproduce, which is how species modify. So, while a species that hedged options would do well, the modification process must still be explained. Fitness confers not to species, but individuals. This requires explaining how individuals with versatile adaptations were selected ahead of individuals with specialized adaptations. Some mechanisms in human evolution allow for this. One is sexual selection, emphasized by Darwin. Another possible mechanism is a tendency of large groups to split. These then compete group against group. The following chapters discuss how a combination of several mechanisms could result in the options effect.

0.1.2 The Evolution of Behavior

Even so, explaining how a species can maximize options does not explain other drives, such as for morality. This is controversial because evolutionary theory explains natural behavior that appears moral as just another survival mechanism of individual fitness. However, as opposed to animals, morality often seems against the individual and for the good of the group. The reason again is that maximizing options requires that behavior can be easily changed. Perennial constraints of survival or food cannot be changed easily, but morality, as mental impression or cultural code it is easy to modify. It is like the human skin devoid of fur being the *maximum* option of available skin coverings, because this includes the option of going naked. Having morality as the primary constraint yields maximum options, because morality is an easy attribute to change, or even abandon. This does not totally explain the advantage of morality, which is further discussed in the book.

Moreover, maximization of any attribute drives to an end condition. The end condition of shedding body fur for a supplemental covering is a skin devoid of natural fur. If biological adaptation is slow, and cultural adaptation is fast, then maximum rate of adaptation is where biological modification becomes unnecessary, and adaptation is cultural. If morality is the easiest constraint to change, the end condition of increasing options is to make the primary constraints moral. It is similar to when mammals entered the sea to become whales and dolphins. They could not reach a stable condition of being 'half-adapted' for sea life. All the mammal species that tried this move either maximally adapted for life in the ocean or perished as unsuccessful intermediate varieties.

If we had visited middle Africa 2.5 myrs ago we would see several hominid sub-species adapting to life on the plains. Yet there cannot exist stable evolution of many partially adapted plain dwellers all competing for shrinking resources. Once one variety obtains a slight advantage it will *maximally* adapt, and others will be eliminated. Species modify as individuals, but large changes occur when small groups split from parent species. In human evolution many groups split, until one dominant variety (humans) was left. Even then, millions of years previously, other species had maximally adapted to life on the plains, just as over millions of years various species occupied the seas, forests, and mountains, until every niche was filled. Successful hominid species were not maximizing adaptation to the plains, but to change in all environments.

0.1.3 Human Motivation

Still, the effect of options can help explain no just evolution, but also human motivation and behavior. Biological theory explains evolution, but this leads to theories that human behavior is a survival mechanism of genes. Yet while some behaviors are genetic, the prime human motive is psychological. Still, using mechanical theories to explain the body, but a higher motive to explain human behavior began centuries ago. Descartes (1596 -1650) began a philosophy known as dualism. It meant not only studying mind separate from the body, but that the human mind cannot be part of the thing it studies. This "stubborn duality" to human behavior affects all our science, philosophy, and culture, to an extent that some philosophers despair that we might never solve it.

Yet, dualism *maximizes* the options of acquiring knowledge. Only instead of splitting the mind from the body, nature split the learning of the higher cortex from a more primitive neurology of reflex. One of the few commanding truths known is that to maximize knowledge requires a mind imaginatively free to consider all hypotheses, but at the same time facts must be verified against evidence of the senses. Nature evolved the human functions to maximize learning in the same manner.

Moreover, the debate over human nature has always been that people do not know to which extent behavior is determined by either *nature* or *nurture* anyway. What we really need to know though, is which qualities will maximize human potential, regardless of how the qualities arise. If human motivation comes from the survival needs of genes, not much can follow about how to use this in everyday situations. Seeking to maximize options however, explains how human motivation evolved in response to change, and the deepest human satisfaction comes from a feeling that one can control events. As a result, a human motive that arises from evolution is not merely to survive and procreate. It is to do it in a changing environment, and to do it with more flexibility and options than any species had achieved before.

In Summary…

Arguments here then, offer an unusual approach to complex issues. For studying the mind, morality, or human nature, science is making progress in detail, but traditional problems of dualism, human purpose, or mind studying mind remain. The suggestion here is to examine the issues not with ready answers, but a fresh way to ask questions. If we study an attribute of human physiology or behavior and ask 'why did it evolve this way?' one might ask that question forever. But if we turn that question around, and ask 'how would evolving this way maximize options?' we see old problems from a fresh perspective.

Finally, the real purpose to knowledge is to increase options. Today humanity, which has overcome many trials, now faces perilous options of its success. Self-knowledge of what we are and how we came to be the species that we are, provides our surest path forward. Here the approach offers its final flexibility. The theory can provide fresh insights into how human behavior evolved, but can also be used to analyze behavior in everyday situations. In business, society, personal relations, and morality, people constantly face change and challenge. We *confront* our options. This is how our species raised itself.

Confronting the options in life that humans create is the challenge that everyone must face.

1.0 THE BACKGROUND ISSUES

1.1 Our Place in the Universe

"The large-scale homogeneity of the universe makes it very difficult to believe that the structure of the universe is determined by anything so peripheral as some complicated molecular structure on a minor planet orbiting a very average star in the outer suburbs of a fairly typical galaxy." **Stephen Hawking**

"The argument of this book is that we, and all other animals, are machines created by our genes. Like successful Chicago gangsters, our genes have survived, in some cases for millions of years, in a highly competitive world. This entitles us to expect certain qualities of our genes. I shall argue that the predominate quality to be expected in a successful gene is ruthless selfishness." **Richard Dawkins**

"Insofar as it makes for the survival of one's descendents and near relations, altruistic behavior is a kind of Darwinian fitness, and may be expected to spread as a result of natural selection." **J. B. S. Haldane**

"It is nature's intention also to erect a physical difference between the body of the freeman and that of the slave, giving the latter strength for the menial duties of life, but making the former upright in carriage and useful for the various purposes of civic life... It is thus clear that just as some are by nature free, so others are by nature slaves, and for these latter the condition of slavery is both beneficial and just." **Aristotle**.

"A devil, born a devil, on whose *nature Nurture* can never stick; on whom my pains, Humanely taken, are all lost, quite lost." **Shakespeare**

"Nature hath made men so equal in the faculties of the body and mind; as that though there be found one man sometimes manifestly stronger in body, or of quicker mind than another. Yet when all is reckoned together, the difference between man and man, is not so considerable, as that one man can thereupon claim to himself any benefit, to which another may not pretend, as well as he." **Thomas Hobbes**

"What is the direct evidence for genetic control of specific human social behavior? At the moment the answer is none whatever... Sociobiologists must therefore advance indirect arguments based on plausibility." **Steven Gould**

"In time, much knowledge concerning the genetic foundation of social behavior will accumulate, and techniques may become available for altering gene complexes by molecular engineering and rapid selection through cloning. At the very least, slow evolutionary change will be feasible through conventional eugenics." **E O Wilson**

1.1.1 Two Great Mysteries

Of all intellectual activities none provoke more interest than the discoveries of science. Humans love to imagine, fantasize and compose, but the deepest need is to know, and know for certain. In the modern era science has captured the authority of unimpeachable knowledge, which lends its discoveries a fascination above all others. For instance, humans are curious about life on other worlds, so stories abound about visits by alien beings. People even claim to have met aliens. Yet fascinating as such encounters would be if true, they do not fire the imagination the same way as a discovery of science, even if science only verified the existence of a single cell of once-living matter from another world.

Still, science has not yet confirmed the existence of recognizable life elsewhere, which remains a great discovery unrealized. Yet as humanity enters the Third Millennium science is closing on solutions to two other mysteries of our existence, which at one time seemed impenetrable to the sober strictures of scientific analysis. So, what are these?

The first riddle concerns evolution of the universe itself. All through history, humans have wondered about the universe. Where did it come from? What existed in the beginning? What will happen to the universe in the end? There have been many attempts to answer this by myth or religion, but these cannot satisfy our curiosity in a scientific way. If anything, the evolution of the universe was traditionally once such a colossal conundrum that science too could not make any start on it. Then in 1925 Einstein applied his newly developed theories of general relativity to the universe. To his amazement the equations showed that the universe was expanding. Einstein refused to believe his results, but in 1931 the astronomer Edwin Hubbell experimentally confirmed that the universe was expanding. Hubbell could extrapolate the rate of expansion to a time when all the matter of the universe was concentrated at a single point; the 'beginning' of time. From that felicitous marriage of theory and observation the improbable science of *cosmology* was born.

Since then cosmology made enormous progress. Scientists now recognize that the universe began with a cataclysmic explosion of space-time called the Big Bang, some fifteen billion years ago. As the universe expands, at any time t it has gross properties fitting an equation;

$$E = mR^2(t)\ [1/2\ H^2\ (t) - 4/3\ \pi\rho(t)\ G]$$

However, while π is fixed, terms such as the gravitational constant G or the Hubble value H must be measured. This leads to something curious. For any values of E, m, R, ρ, G or H, the model is valid mathematically. However, while some of these values are not known precisely (G is) they must nevertheless be adjusted to allow at least one thing - us! A tenable model of the universe must allow fifteen billion years after the Big Bang, on a planet circling a Type II Star, that there arise a race of carbon-based life forms intelligent enough to ask why the universe evolved. This is exciting, because ever since Copernicus science has been steadily dethroning man's importance in the cosmos. Now humans might have a role, as cosmic witnesses to the universe that evolved.

Still, although understanding the origins of the universe is exciting, some scientists believe it is not the greatest challenge. Instead, a more perilous challenge is evolution of man himself, and why people behave the way that they do. If there are two great mysteries for which science seeks answers, evolution of the universe is one, but understanding of humanity is the second great scientific endeavor of our age.

1.1.2 Explaining Human Nature

As with trying to understand the universe, humans have also tried to understand what people are. First, there were myths and legends. Then came religion. Myth and religion helped explain the ethical nature of man, but it never formed a systematic study. This came from philosophy, which discovered certain logical truths about thinking. However, the drawback of all earlier philosophy was that it did not have any scientific understanding of how humans came to be, so that aspect of the study was reduced to mere conjecture.

Then in 1859 Darwin published his great theory explaining how all living creatures evolved. Since then there has been much progress. Initially, there was skepticism about humans evolving from lower life forms, because of a "missing link" between apes and humans, and other gaps in the record. Today though, the lineage of not only humans, but much of the anthropoid taxa (which includes humans, chimpanzees and gorillas) has been uncovered in detail. There has been discovered not one but many "missing links" in the anthropoid record, and an approximate sequence can be noted here.

Human evolution began five million years (myrs) ago in the Great Rift Valley in Kenya. Earlier this area had been a continuous belt of forestry, but by five myrs ago the forests had shrunk to a mosaic of woodland and grassland. With increased population pressure only some primates could stay in the remaining forest. So, common ancestors to chimps and humans split into forest dwellers, which would evolve into modern chimps, and a species of bipedal walking chimp called *Ramidus*, the first "missing link".[3] Ramidus did not last long or migrate far, but 4.5 myrs ago it was replaced by a newer species, *Australopithecus* (southern ape) which spread over tracts of middle Africa. Three myrs ago global

[3] It is now questioned if Ramidus was a main-line ancestor. This genealogy was correct at the time it was written, but interested readers should always check against latest findings.

temperatures plunged, and the Rift Valley became drier again. So the *Australopithecus* species split and a new species evolved, Homo *habilis* (handy man), more human than ape-like, who began using tools. 1.5 myrs ago another species evolved, Homo *erectus* (upright man) who displaced Homo *habilis* and remaining *Australopithecus* subspecies, and also migrated from Africa to Asia to become the famous Peking Man. Finally, 500,000 years ago Africa produced its last anthropoid variation. This was Homo *sapiens* (wise man) who migrated over Earth, displacing Homo *erectus* (and Neanderthal man) to become, about 35,000 years ago, modern man. So, human ancestors walked upright before they developed a large brain. And although ape-like ancestors walked over 4-5 myrs ago, modern Homo *sapiens* with a highly evolved brain only emerged in the last few hundred thousand years.

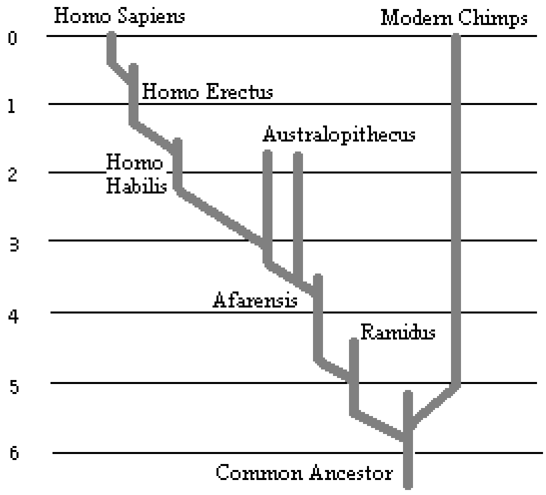

Fig 1.1.1 Human evolution involved many branches over 5 myrs.

Even so, unraveling how humans evolved is not the real dispute. The second great theory is not how humans evolved but how evolution makes humans the beings that they are today. It is like when the average person wants to know about the universe. It often not a technical issue such as how stars evolve, but a fundamental one such as how the universe started and how will it end. When people ask about humanity it is mostly not a detail, such as whether humans evolved in Africa or Asia. It is usually a deeper question, such as why do humans have religions, or where do morals come from, or why do humans fight wars.

Can science answer such questions?

Well, three quarters of a century ago science could not explain the origin of the universe, but since then it has made immeasurable progress.

Even so, applying evolution to explain human behavior has encountered ensconced difficulties. One puzzle is that of *altruism* (Italian - *altrui* – for others). Darwin's theory is about a ruthless struggle between individuals, and there is plenty of that among humans. However, human behavior is also replete with acts of welfare, or self-sacrifice as in war, so where did this come from? For decades Darwinists were stumped. Then a theory arose that the struggle between individuals resulted from a deeper rivalry, between the true transmitters of heritable characteristics, the genes. While an individual had 100% of his own genes, his children and siblings each share 50% of his genes, his first nephews and grandchildren 25% and so on. So there would be calculable cases of genetic advantage for self-sacrifice, such as saving three siblings for a net gain of 50% after 100% self-sacrifice. Yet if the explanation was interesting it was hard to prove. If a bird in a flock spots a hawk and gives an alarm is it warning its siblings to save them, or trying to scatter the flock in confusion to save itself? Even biologists were divided about this.

Then came a breakthrough. The reader might be aware of the strange breeding habits of ant and bee colonies, with a queen and sterile workers. These insects breed by a system of *haplodiploidy*, in which fertilized eggs produce only females, while unfertilized eggs produce males. As a result sisters have a closer genetic kinship, near 75%, than mothers to daughters of only 50%. When many experiments were applied to such colonies, it proved that it was the survival of the genes, not individuals, which determined the insect behaviors. This was an amazing discovery. Since then a range of genetically determined social behaviors has been recorded among wild species, from slavery in ant colonies to prostitution in humming birds, and rape among mallard ducks. So, if genes explained social behaviors among others species might genes not also explain incorrigible behaviors in the human species as well? Many scientists felt that it was at least worth investigating.

In the 1970s two books brought the scientific, but also the social controversies to the public. One was *Sociobiology; The New Synthesis* by Harvard biologist E O Wilson, plus his later book *On Human Nature*. The other book was *The Selfish Gene*, by famed Oxford biologist Richard Dawkins, mentioned already. Since then the authors have modified their views, plus the debate moved on. While these books were a milestone at the time though, the grand synthesis of human nature begun by the ideas never bore fruition. If anything, everyone, including the two original authors, is now more circumspect about how much evolutionary theory can explain human behavior. So, what went wrong?

1.1.3 The Counter-Arguments

The first difficulty trying to biologically code human behavior is that the concept has a tainted reputation, scientifically and politically. Anyone not aware will quickly learn that debates over whether human behavior is determined by *nurture* (upbringing) or *nature* (biology) have raged since antiquity. The term 'nature-nurture debate' comes from Shakespeare's line in *The Tempest*, but the debate began with Aristotle (384-322 BC), who stated the Nature view in order to defend slavery. The counter views for Nurture also began in antiquity, but were forcefully stated during the European enlightenment by men like Thomas Hobbes (1588-1679). (See quotes.) Since Darwin's time a pejoratively defined view known as Social Darwinism became associated with extreme Right wing, racist outlooks. During the 1930s and 40s these views became affiliated with Nazism; politics of the racial state, and hideous nazi extermination programs. Proponents of the newer theories tried to distance themselves from older ideas. However, impolitic enthusiasm by advocates, including E. O. Wilson, to enhance the genetic fitness of the species by cloning or eugenics rekindled bitter memories.

Next, psychology-based theories were already ensconced. Prior to Darwin, philosophers such as Hobbes taught that humans had an equal set of attributes, so it is how people think which differentiates them. This idea is so established that we hardly notice it. If we see people behaving oddly we try to understand what is happening inside their minds, not what genes might be telling them from long ago. This view is also more practical. When the debate began social critics worried that the new theories would be used to justify social exploitation. Yet the practical thrust of behavioral theory in this period concerned management and motivational psychology, not theories about genes. Besides, apart from treating genetic defects medically, not much can be done to alter the make-up of the entire species, other than by eugenics. Especially, genes that determined behaviors to that extent were never isolated, so little was known factually about what to deal with anyway.

Practical concerns over behavior led finally to the scientific issues. Just that here too the new theories did not do so well. For example, it is interesting that the genes of some ants cause them to embark on slaver raids to procure slaves for the ant colony. Yet what relevant conclusions might we draw from this about human behavior, if we observe no similar slaver genes in human kin species such as great apes, or any mammal species at all? Even for universal drives such as aggression, a group of humans wiping out rivals like in war is not how evolution works either. Individuals compete more within a species as individuals than across species for the group. In human society individuals who are aggressive or violent are as likely to perish and not procure offspring as a quiet family man. Dawkins exalted the life of Chicago gangsters, but many of them end up dead too! Some humans do lead violent lives, but most decide that there are less risky ways to achieve like gains.

There was a similar debate because one species of duck, the Mallard, engages in a behavior that appears like rape. But there are several issues here. For a start, sexual selection evolved because it offered huge fitness gains over brute mating. However, not just for mallard ducks, but in any random population there will be a statistical minority of cheats at many things. Plus within biota (all species) there will be a statistical minority of species in which the norm might be something odd, like rape, not the norm in most species. This oddity in an unrelated species (a bird, not a mammal) must now be related to human behavior. Without getting into morals, the first observation is that the human female's ovulation is concealed. Even the male mallard takes risks to commit rape, so even for this species not all males rape. But if procreation is the aim, rape for a human male is a lot of risk (if other males are around) for an act with no guarantee of conception. And unlike for the female mallard, without a partner a lone human female might not survive childbirth, which further diminishes fitness. So when humans, or individuals in most species cheat about sex, it is "fitter" (less risk for like gain) to use adultery. However, while this act is morally decried for humans, biologically it is still sexual selection, not rape. So, while nobody doubts the benefits of rape to the fitness of the male mallard, it does not explain rape or sexual violence in human society, even in those self-same terms.

The other problem is the number of behaviors that can be inherited. One controversy was that it became too easy imputing behaviors to genes. There are 20-25,000 genes[4] to express the human brain, no more than in a chimp brain, yet humans have these extra behaviors that chimps do not. There is a simple explanation of this. Human and chimp brains are expressed by the same number of genes, but the human brain is larger because 75-85% of it is wired after birth by learning, whereas only 35-45% of the chimp brain is (roughly). By these simple ratios humans learn about six times (by brain bulk) more than chimps, though it is more like eight times. Humans have a less diverse genome than chimps, but if they end up as individuals with more diverse behaviors, it is easy to see why. Humans simply learn more after they are born.

However, advocates of the new theories did not focus on the likely explanations first. Instead, they imputed every preference and peccadillo to a gene, going to absurd lengths. If somebody did not like spinach there was a gene for that. If someone liked a different sexual position there was a gene for that too. Dawkins recalls suggesting how to test scientifically for a gene for tying shoelaces, and was surprised when the lecture hall erupted into outcry. So once the theory reduced to a gene for everything, from being controversial already, it lost all credibility.

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[4] Early estimates were 80,000 genes for the human genome, and 50,000 for the brain. Recent studies indicate only 30-40,000 genes for the genome.

1.1.4 The Current Situation

Was then, the new synthesis of human behavior a failure?

Apart from the social controversies, the inescapable problems were scientific. In retrospect, colonies such as ants and bees do select on a basis of *social + biology*, so calling this study sociobiology filled a need. For large animals, however, those parts of sociobiology that were true explained nothing different from conventional theory, and this had not been able to explain human motive all along. Even selfish gene theory was divergent with sociobiology over human behavior. Dawkins instead proposed that culturally evolving 'memes' took the place of genes to account for human sociology. And although the memes idea gained a limited if avid following, Dawkins was to later distance himself from the concept, as did the scientific mainstream. For all the talk of a new synthesis, there was only conventional theory explained in slightly bolder terms. And that could not explain human complexity all along.

This is roughly where things stand today.

Science is making steady progress, and is learning why the theories first proposed cannot work. While behavioral genes are proving hard to isolate, science is learning more about hereditary disease, and genetic counseling is now part of medicine. However, big debates over *nature* or *nurture*, or the biological basis of morality, reached as little consensus at the end of the scientific century as they did at the start. Just everyone is now more cautious. Rebuttal of theories of evolutionary behavior has not stopped people writing books about it, only these now end on a sardonic note. After taking a whole book to explain that genes determine behavior, today an author will concede that few of us are likely to believe it. The main point is true (few of us will believe it) but an unintentional point is also true: human action ends in choice, including choices over which things to believe or which theories of behavior to take seriously. So, until theories which claim that genes determine behavior can explain how genes provide us choice over things to believe, we will always remain in these quandaries and debates.

Yet why cannot evolution explain human behavior?

Humans are a product of biology, and an evolutionary past. While it is now accepted that not all human behavior can be attributed to genes, humans still retain indelible biological drives, so what is the true role of genes in behavior? Only after explaining how, despite the claims, genes cannot determine human behavior to an extent first proposed can we question what role the genes actually do play.

1.2 Genes and Behavior

"The initial configuration of the universe may have been chosen by God, or it may have been determined by the laws of science. In either case, it would seem that everything in the universe would then be determined by evolution according to the laws of science, so it is difficult to see how we can be masters of our fate." **Stephen Hawking**

"If our genes are inherited, and our environment is a train of physical events set in motion before we were born, how can there be a truly independent agent within the brain? The agent itself is created by the interaction of the genes and the environment. It would appear that our freedom is only a self delusion." **E O Wilson**

"Complex organisms are not the sum of their genes, nor do genes alone build particular items of anatomy or behavior by themselves. Most genes influence several aspects of anatomy and behavior - as they operate through complex interactions with other genes and their products, and with environmental factors both within and outside the developing organism. We fall into deep error, not just harmless oversimplification, when we speak of genes "for" particular parts or behaviors." **Stephen Jay Gould**

"A society based simply on the gene's law of universal ruthless selfishness would be a very nasty society in which to live. But unfortunately, however much we deplore something, it does not stop it from being true." **Richard Dawkins**

"Minuscule samples, uncontrolled experiments, exquisite analysis of heterogeneous data, and unsupported speculations in place of measurements are all common features of biological determinist literature. Paper after paper published in the leading journals of human and behavioral genetics... commit the most elementary errors... which would never be tolerated in, say, the Agronomy Journal or Animal Science. To write about human beings gives one a license not extended to the study of corn!" **Rose, Kamin and Lewontin**

1.2.1 Forces Determining Behavior

Do humans have free will? Or is our behavior determined by unseen forces beyond human control?

For thousands of years philosophers debated this, but now we need to know. War, nuclear weapons, overpopulation, climate change, poverty and tyranny, as humanity enters its seventh millennium of civilized existence, but its first as a technological society, the species faces tough choices. It is crucial to know if we control our options or if other forces drive us in ways that we cannot foresee. The founder of sociobiology, E. O. Wilson (see quote) believed that the answer is in the genes. Applying game theory to analyze behavior seemed to prove that it was.

For example, while animals copulate promiscuously humans restrain themselves through moral qualities such as love. Still, we are curious as to why if animals are without morals bonding should occur in many species. In *The Selfish Gene* Richard Dawkins shows how it works for a colony of birds. There are two female types, *coy* and *fast*, and two male types, *faithful* and *philanderer*. Despite different sexual temperaments, all any bird wants is to assure that its offspring, and hence its genes, survive and propagate. However, for choosing mates adults must be careful. The female needs a faithful partner for nesting and raising young, so she must ensure she gets a loyal mate. The male, who does not lay eggs does not invest much in procreation, so he can hedge bets by sowing wild oats with other females, providing at least one female nurtures young for whom he is certain that he is the biological father. Dawkins shows that far from morals being involved it is the evolutionary benefit of each female to be *coy*, providing that by being so she can force all other females to be *coy*, and all other males to be *faithful*.

Still, bird colonies suffer an instability not unfamiliar to humans; not all individuals are honest -some cheat! Once all females are *coy*, males will be *faithful* because apart from rape, they have no choice. Even so, some females might have trouble getting partners, so it will benefit these to become *fast*, and snatch *faithful* males away from *coy* females. (As in the story of Eden in tales told by men the female is the troublemaker!) Except if too many females become *fast* males will cease being *faithful*. Then it would benefit some females to play *coy* to uncover which males are most *faithful*. Now this can cycle several times, but it can be proven that after the *coy, fast, faithful* and *philanderer* strategies have been tried the model stabilizes, and in a recognizable way. The majority of females remain coy (a few do not) while most males remain faithful to coy females, but still philander on opportunity. Without reference to love or morals, scientists can create a model of sexual dynamics that people might consider markedly similar to how humans behave.

If such techniques can model human-like behavior, does it follow human behavior is constrained along such lines?

Well, humans are products of biology, and the only factors affecting permanent biological change are genes. An early theory said that giraffes obtained long necks because individuals stretched their necks to reach high leaves. Now the first giraffes did stretch their necks, but this did not directly alter genes. Rather, although early giraffes stretched their necks, some individuals were randomly born with slightly longer necks. The giraffes with longer necks competed more successfully, so they passed on more genes. After many generations the long-neck producing gene came to predominate throughout the giraffe gene pool.

Processes similar to those that gave giraffes their long necks led to humans. Humans evolved over millions of years, in which time many sub-branches evolved to be the one successful species, Homo *sapiens*, or were wiped out. There is debate over why human ancestors evolved so rapidly or why near-human sub-species were wiped out completely. Later chapters discuss it. Other species may have been inferior at survival, but perhaps the others were a gentler species and more aggressive humans simply killed them. Whatever it was, in prehistory the genes of Homo *sapiens* gave them better adaptation for those times. Humans are not a chosen species, but they survived when others perished. We inherit the genes of that survival, so we need to know how well genes that guided our survival in primitive times affect our behavior today.

Consider the disappearance of a near-kin species, the Neanderthals. 40,000 years ago in Europe humans and Neanderthals were competing for food, mainly meat from wild herds. There is conjecture that the more resourceful humans made camps on hill-tops where they could observe herds better, while less adventurous Neanderthals stuck to the low-lands, and ultimately perished. But it might not have been about hill tops at all. In history, humans often massacred groups perceived as rivals. So there is a chance that humans simply fought with the Neanderthals, and wiped them out that way. (Or for that matter, what happened to all the other sub-species that went extinct?) Dawkins stated that organisms are the "lumbering robots" of genes, whose sole instinct is to survive. But if massacring rival groups was a survival strategy, what would that make humans? E. O. Wilson reiterated that "war is a straightforward example of a hypertrophied biological predisposition".

1.2.2 How Genes Act

Inference like those from E. O. Wilson come with good intentions, warning that if we want world peace we must work doubly hard for it, because our genes mostly work against us. Such warnings come with admonitions that one also must face the facts of science

Still, getting facts right is the debate. There has been a Left-leaning *nurture* view of behavior and a Right-leaning *nature* view since Greek times. In recent years this split has been overlaid by "Creationist" attacks on Darwinism, so any evolutionary explanation of behavior should be welcomed. Yet the new theories incensed the *nurturist* camp by reducing human behavior to the raw needs of biology. Even if opposed to religion, if one's political agenda is for a morally concerned society, theories that morality is an illusion of gene selfishness does not further that goal. So, *nurturist* scientists bitterly counter-attacked. They accused opponents of everything from dangerous ideology to bad or poorly correlated science. Left-leaning biologists such as Stephen Gould even came up with a rival theory of stepped evolutionary change, and the arguments became very heated. Seminars by E. O. Wilson were disrupted by rowdy students, and Stephen Gould's theory was labeled "evolution by jerks".

Today, each side concedes that they do not have all the answers. One problem was an inference that all genetic characteristics are Mendelian; in that each attribute is expressed by a single gene. For some hereditary diseases this is so. Sickle cell disorder results from mutation of a single allele. So does cystic fibrosis. If there is a mutation rate, μ, and lethality, s, of an allele mutating $p \rightarrow q$, geneticists can quantify its probability of spread by (several variations to) the simple equation;

$$(p + q)^2 = p^2 + q^2 + 2pq \quad \text{(This is the Hardy-Weinberg Equation.)}$$

Still, to model via the same equations the spread of a gene for "rape" or "aggression", would require a *p* allele for "rape" and a *q* allele for "non-rape", a mutation rate μ and a selection value s for the act. Yet, unlike for cystic fibrosis, there is no data on how to quantify the selective value, s, of rape among humans, while it is debated if such genes even exist as p, q alleles, or exist in any form at all.

Instead, the effect of these alleged behavioral genes is only inferred.[5] If individuals behave a certain way it must be from enacting behaviors that were fit in the past, so it should be possible to infer what the fit moves were. The controversy is isolating the behavior in the first place. From a gamut of human behaviors, which ones are analyzed seems to depend only on the interest of the sociobiologist. One behavior E. O. Wilson made much of was female infanticide in India. In most societies that do it, the female is "sold" into marriage, but in India the family has to "pay" the man to marry a daughter. With no analysis of these peculiar conditions, Wilson suggested that female infanticide in poverty-stricken India had a genetic origin. Or having observed that some wild animals kill the offspring of rival males, sociobiologists became obsessed by infanticide in history, like Herod's killing of the children of Bethlehem.

[5] There is detailed research on insects and lower animals with precise models. The issue is why do we insist on precise models for lower animals, yet allow problematic inference for models about humans? See previous quote by Rose, Kamin, etc.

Sociobiologist literature is crammed with tales of violence, infanticide, adultery, or bizarre sexual practices in isolated human cultures, without any analysis into the social conditions that cause these.

Still, one argument was valid. Ever since the French Enlightenment, Western intellectuals often saw primitive or tribal life as culturally pure, only tainted by Western values. The new studies have documented that there are no cultures without their share of violence, rape, murder, greed, and cheating. Also, despite that they are one species, human groups adapt racially, and the smaller or more isolated a group, the faster it will adapt biologically to the temperament of its conditions of struggle. However, the fact that the smaller, more isolated groups alter most, makes it harder to extrapolate a temperament among an isolated peoples against the gross human population. Especially, any human from any tribe seems able to adapt into civilized behavior, if social conditions change.

The other complication is that genes for an alleged characteristic still have to fix. The $(p + q)^2$ equation tells us that in dispersed but randomly mating populations it is hard for unique genes to completely dominate or delete from gene pools. This would apply to an alleged aggressive gene that makes humans warlike. For an 'aggressor' gene to spread, aggressive humans would have to kill pacifist humans, or mate more successfully. Yet organizing a tribe for combat is not the same fitness requirements, or the same reward, as for a bull seal getting a harem. Tribal peoples do not fight other tribes as individuals, nor does the whole tribe fight.[6] Plus while say, only European ancestors might have killed the Neanderthals, humans are one species, which scattered over the Earth 50,000 years ago. So, whatever early groups did in isolation, today humans interbreed as a family, and inherit a mix of behaviors. By whatever means humans competed with other groups there was a gene for aggression, one for caution, one for climbing mountains and one for lowlands. However, the genes that made a difference were ones which gave humans multifarious behaviors, to meet any circumstance.

1.2.3 The Current Debate

So, while modeling of behaviors has produced startling inferences, it is not the same calculation of medical genetics. It is instead, as with sex in birds, a calculation of game theory and metaphorical genes. The best game-theory model can only demonstrate that aggression, like infidelity, is a gamble of opportunities against risks. In the wild that gamble is resolved by success to reproduce. In human behavior, it is not certain if this any longer applies. Only 1-2% of genes are unique to humans not shared with other species. Differences between individuals are mainly in

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[6] Less aggressive members can care for the wounded and organize supplies, a division of labor making the human fighting machine efficient. This needs research.

alleles or non-coded DNA. This gives individuals character, but not in ways affecting the modern human gene mix expressible by the $(p + q)^2$ equation. And for all their racial diversity, the human gene mix is more homogeneous than say, for chimps. Moreover, equations only explain how alleles such as for *coy* or *fast* distribute in a stable population. They do not explain why in the history of life it became fit for complex emotions such as love, loyalty, or jealously to evolve at all.

Also, genes are only part of the issue. Evolution theory has been attacked for several failures of explanation, one being human behavior. It is not that genes shape behavior, but that mechanisms of how they shape it which work for birds or insects might not work for higher animals, or do not work for humans. 20-30% of human behavior can be explained by genes, and one should take account of this. However, the genetic motive does not account for the 70-80% of behaviors that are learned, or driven by culture. Nor does it expiate criticism of the theory of evolution that it can only explain part of human behavior, but not all of it.

Still, good ideas can come from bad theories. While a synthesis of behavior is not possible, a more practical goal is to map genes causing heritable diseases. Nobody wants to give children hereditary defects, so couples mostly accept genetic counseling. Here, the old *eugenics* idea of preventing breeding among the unfit does have a voluntary offshoot. And this is how we often expect things to turn out. One starts with a grand scheme for isolating alleged bad behavioral genes and improving the species through cloning or eugenics. When this collides with scientific and social reality, the scheme gets scaled into something practical, such as tracing genes that cause heritable disease, and providing counseling to couples at risk. Even so, while genes causing hereditary defects are often mutant or parasitic, genes determining behavior are part of life's variety. Genetic variability of any species is never expressed among the majority population, but is available if conditions change.[7] So while scientists can isolate "bad" genes medically, for behavior or intelligence they are for now use inferred genetics and metaphorical genes. The inferences are along ideological lines of the *nature-nurture* debate, rather than facts which science has been able to prove in a lab.

So, is human behavior free or determined after all? Well, whatever one thinks it might be, genes are just one issue of the debate. It is time to examine how this issue applies in more general terms.

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[7] Humans breed out characteristics not useful to them from domestic stocks. But if domestic strains were exposed to the wild they might not have the variability to survive.

1.3 The Human Geodesic

"An intelligence knowing at a given instance of time, all forces acting in nature, as well as the momentary positions of all things of which the universe consists, would be able to comprehend the motions of the largest bodies of the world and those of the of the smallest atoms in one single formula... To it, nothing would be uncertain, both future and past would be present before its eyes." **Simon De Laplace**

"The problems of determinism have been discussed over the centuries. The discussion was somewhat academic, however, as we were far from a complete knowledge of the laws of science, and we didn't know how the initial state of the universe was determined. The problems are more urgent now because there is the possibility that we may find a complete unified theory in as little as twenty years. And we realize that the initial state may itself have been determined by the laws of science." **Steven Hawking**

"But radical contingency is a fractal principle, prevailing at all scales with great force. At any of the hundred thousand steps in the particular sequence that actually led to modern humans, a tiny and perfectly plausible variation would have produced a different outcome, making history cascade down a pathway that could never have led to Homo sapiens, or to any self-conscious creature." **Stephen Jay Gould**

"Here then is Darwin's dangerous idea: the algorithmic level is the level which best accounts for the speed of the antelope, the wing of the eagle ... and all the other occasions for wonder in the world of nature. It is hard to believe that something as mindless and mechanical as an algorithm could produce such wonderful things. No matter how impressive the products of an algorithm, the underlying process always consists of nothing but a set of individually mindless steps succeeding each other without the help of any intelligent supervision..." **Daniel Dennett**

"You have written this huge book on the system of the world without once mentioning the author of the universe." **Napoleon**

"Sire, I had no need of that hypothesis." **Simon De Laplace**

1.3.1 The Forever Road

Imagine a road through the universe; the Forever Road. Cars can drive along this road forever, but they always go in one direction, at a constant speed. On the Forever Road is a way station with an observer. He notes the time each car passed and the speed it was traveling. From noting just these it is possible to know the past and future travel of any car. If a car arrived at the way station at 10.00 a.m. going 100 km/h, at 8.00 a.m. the car was 200 km. before the way station. If the next way station is 500 km. further, the car will reach it at 3.00 p.m.

Physically, a Forever Road cannot exist. The universe does not exist "forever", and there could never be a road across it a car could drive on. Not long ago, however, people did believe that the universe was infinite in time and space, and that particles moved through it according to Newton's Laws. At the time of Napoleon, the great French scientist-mathematician Simon de Laplace (1749-1827) set out to investigate how a particle would move in such a universe. Incredibly, he discovered that every particle did move along a "Forever Road"! So if one measured motion of the particle at any point it could be calculated out for all time. (Laplace’s theory was for forces, not constant speeds.) This theory had enormous impact. Space exploration, aeronautics, or electronics would not be possible without the pioneering ideas of Laplace. But although his theory was mathematical, Laplace boldly postulated its implications for culture and morality. So, what did his theory say really?

Without getting too deep, Newton’s Laws provided a method of calculating the attraction between two particles such as;

$F = G\, m_1 m_2 / d^2$ (m_1 and m_2 are particle masses)

Yet, this is just for two particles, at a single instant of time, but there are billions of objects in the universe. If scientists send a rocket to the moon how can they be sure that gravity of all the stars and planets will not pull it off course? Newton did not know how to solve this (not for rockets, but many objects) so he assumed that if any corrections were needed "God" would make them.[8] Laplace used a different method.[9] Instead of trying to solve for each particle, he derived a general solution. He found that over the whole universe all the adjustments would cancel to zero, so the whole system reduced to a simple term;

$\nabla^2 f = 0$ (Laplace’s Equation: “Del squared f equals zero”.)

[8] This led to the famous exchange (see quotes) where Laplace claimed he did not need the hypothesis about God. On hearing this, his colleague LaGrange commented "Ah, but that is such a magnificent hypothesis, it explains so much."

[9] Using calculus; see references to Newton in Chapter 2.1

What does this equation tell us?

Firstly, it states that many physical systems will be *constrained* to follow parameters in the $\nabla^2 f$ part of the equation, because extraneous effects will cancel to zero. So if scientists send a spacecraft to the moon, providing there are no glitches it will go where it was sent, and not veer erratically due to minor perturbations. Some systems, like the weather, the stock market, or insect populations do not do this. Perturbations can send such systems into chaos, so they are not constrained by $\nabla^2 f = 0$. If anything, there are two types of systems.

System	Laplacian	Non-Laplacian
Parameters	Constrained	Unconstrained
Equation	$\nabla^2 f = 0$	???
Outcome	Determined	Chaotic

Still, as knowledge advances new techniques are found to model chaotic processes (such as the weather) into deterministic ones. So, the question arises; will science one day acquire techniques to model human qualities such as free will as deterministic? Laplace's view was that all forces were ultimately determinate, and philosophers have been debating his proposition ever since.

In this chapter any path that an object is constrained to follow will be called a *geodesic*. Strictly, this term applies to an object moving freely though space under gravity, like a planet or an asteroid. Also a *geodesic* is a calculated path, for which one assumes all extraneous effects cancel to zero. Yet loosely, if somebody always eats Corn Flakes for breakfast that person might claim "that is my geodesic" if this term becomes fashionable. Of course, the premise here is that frivolities such as what people have for breakfast are not *geodesics* at all, they are options. But one can also use this term in its general sense.

So, what is the human *geodesic*? What paths are humans constrained to follow, through behavioral space-time?

Well, to try to discover how six billion individual humans will act is like trying to calculate the fate of the universe one particle at a time. Still, one can make general inferences, and the first one is that humans inherit a past. In Laplace’s system the past is rigidly determined by the present, like cars on the forever road. One can replace this rigid determinism with a chaotic system, but events are still deterministically constrained by time, the speed of light, and the expansion of the universe. The ∇ symbol contains any number of dimensions, but objects cannot move as freely in time, even mathematically, as Laplace might have supposed because the universe is expanding in the direction in which time flows.[10] And because objects cannot travel faster than the speed of light, this constrains where anything can have come from. This is shown on a light cone diagram. Even in a chaotic universe, one can only visit places in the forward cone, or could have come from somewhere in the past. In an infinite, static, timeless universe, our past could lie anywhere. In the actual universe the past can only lie within other constraints.

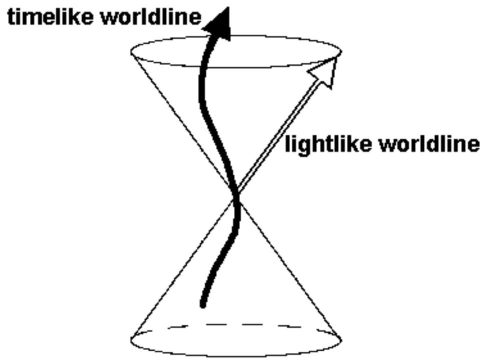

Fig 1.3.1 Even in a chaotic universe, our future can only lie in the top cone, and our past must come from somewhere in the bottom cone. We cannot have come from 'elsewhere', except in a sense that our past is unknown.

1.3.2 Our Human Possibilities

This limitation to where we might have come from is the challenge of evolutionary history. If one can calculate a *geodesic* by which humans traveled through their evolutionary past, this will determine where it will take us in future. Or, by understanding how the *geodesic* constrained us in the past, we can know how it constrains us today.

Is such a calculation possible?

The previous chapter showed an example of sex life among birds. Except such calculations are limited to organisms that display behaviors (they would not apply to plants or fungi). Learned behavior is not so structured that one could not train an animal to act contrary to a behavior that a calculation predicts. Lion cubs raised in captivity must be taught to re-kill in the wild, so observing domestic lion cubs would not give a

[10] A two-dimensional analogy is an ant on an expanding balloon. If the ant lived forever and the balloon did not expand the ant could eventually visit every 'coordinate' on the balloon's surface. But because the balloon is expanding all the time, some coordinates he can never reach. If you have never visited Hawaii you might make it before you die. But if you wanted to visit before turning 25 and you are already 26, you will never make it.

correct understanding of its evolutionary origins. A horse that nearly drowned as a foal can be afraid of water, despite that evolution favored horses that were good swimmers. So, instead of just one calculation for inanimate matter and one for behavior, there could be many calculations. Before transferring a calculation that works for birds or insects to human behavior one should check some assumptions. While say, the ∇ symbol can be used for many dimensions, Laplace's equation presumes that the number of dimensions does not increase. Still, this is only in a geometric sense. Laplacian geodesics apply to inanimate objects, but these tend towards increasing disorder, as per the Second Law. However, living organisms have *metabolism,* which increases order, so it has an energy-complexity dimension, which would be different.

This difference between geodesics of living and inanimate objects becomes striking when organisms move with consciousness. The natural geodesic of objects is to fall downhill, but living organisms can move uphill, directing effort against the natural geodesic. If a meteorite entered the Solar System one could calculate where it had come from. However, if the object were a piloted rocket ship one could not assume that its present trajectory had always been maintained. This applies to observing the path through behavioral space. One can calculate a path an organism would take through behavioral space by assuming selection constrains its behavioral freedom to certain paths. But morality imposes an additional constraint, forcing humans to break from a Darwinian *geodesic*, and explore paths not dictated by Darwinian needs. For example, the natural geodesic of water is to flow downhill, but if engineers encase water in a pipe, they can force it to flow uphill. Similarly, when human behavior is encased in the pipe of moral choice it is constrained to move in directions outside its Darwinian geodesic. Because humans ultimately control the direction of the morality 'dimension' though, morality itself becomes the mechanism by which humans obtain greater options of movement in three-dimensional behavioral space-time.

Everything in the universe is constrained by physical laws to follow a path, but organizational complexity utilizes constraints to move objects in different ways. The Second Law constrains inanimate objects to move towards disorder, but *metabolism* constrains living objects to move in paths seemingly against the increase in disorder.[11] At the next level metabolism constrains DNA strings to replicate blindly, but *behavior* constrains complex organisms to adopt survival strategies beyond blind replication. Finally, at the human level, intelligence, social, and moral strictures force humans away from basic evolutionary survival strategies, into more complex paths of constraint. Even so, however an organism is constrained to behave, constraints will go if complexity breaks down.

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[11] There is much confusion over this. See Appendix I.

- If the pipe forcing water to flow uphill bursts the water will revert to its primitive geodesic and flow downhill again.
- If a rocket loses its controls, its course reverts to a natural geodesic
- When an organism dies, it ceases to exhibit metabolism and the remains will revert to decay and increase of disorder in time.
- If humans destroy the moral fabric of society, primitive behavior of embedded reflex will take over.

1.3.3 Types of Universes

Yet, suppose one could calculate human behaviors, including moral choices, what type of universe does that mean humans live in? Would it be a modified universe of Laplace in which all paths of all objects can be calculated out for all time? Is there say, a potential single *geodesic* for the entire universe, from the instant of the Big Bang, even down to such trivialities as what people do eat for breakfast?

Roughly, there are three types of universes:

1. A **fully constrained**, or *Laplacian* Universe in which all events can be calculated out.
2. A **fully unconstrained**, fortuitous universe, in which few events could be predicted to have happened by a calculable method.
3. A **partially constrained** universe, which is the most likely one.

There is no way to be certain which type of universe we live in. Just that there are difficulties with Universes 1 and 2. In the fully constrained, *Laplacian Universe*, there will be problems with the mathematical tools, in that there will be at least one equation that enforces its own creation. Nobody is certain that such an equation can exist. On the other hand, while an *unconstrained*, fortuitous universe allows many possibilities, the only universe that humans can learn something useful about is one that contains certain regularities of time and space. So, while several types of universe could exist, humans can only make sense from a *partially constrained* universe. In this universe some actions are forced on us by the laws of existence, and cannot be altered by anything that humans do. However, other actions are random, and they might be influenced by the actions that humans take.

Because humans already live in a *partially constrained* universe, we can expect that any universe constructed from the same basic physics, would exhibit similar features to our universe. Such a universe would compose of atoms, stars, and galaxies. It would begin as a 'Big Bang' explosion of space-time about 15 billion years before reaching its present size, and as the universe expanded it would evolve elements containing up to 92 protons. What happens after that, though, is much debated. In the universe which we occupy, 15 billion years after the 'Big Bang' there appeared intelligent, carbon-based, oxygen breathing life on at least one planet, orbiting a medium size Type II sun. And while one could create a mathematical model of a universe in which intelligent life did not evolve, one could never create a scientific model of it, because without evolution of intelligent life there is no way to verify if the model is correct.[12]

Yet even if the universe in which we live is *partially constrained*, there is another property that we can assume about it. Life evolved over billions of years, and is incredibly delicate. So while variation produces life, life also depends on properties exhibiting regularity, repeatability, and symmetry over long periods. Because of this regularity, we can assume that although our universe is only partially constrained humans can learn what the constraints are. From this they can also learn which properties of the universe are unconstrained, that humans have options to change. The argument of this book is that while there are only a limited range of options within a partially constrained universe, humans feel motivated to *maximize* those options.

The need to maximize options has to do with the randomness of the universe. If the universe were fully constrained, evolution would have an easier task, because nature would find change easier to adapt to.[13] If the universe were fully *unconstrained,* there would be little pay back to evolutionary effort, as extinction would be too random to invest guarding against. In a *partially constrained* universe, though, organisms have a chance of adapting to change. Just that for evolution to work the period of random fluctuation must not overwhelm the repeatability and order that the mechanisms rely on.

This book is not about *geodesics* as such, just as it is not about genes or the *nature-nurture* debate. It is about the extent to which humans have real choices. Understanding constraints increases options by showing us in which direction we should concentrate volitional effort. We need to understand constraints because we do not wish to waste effort, but to use that information to act out wisely our viable choices.

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[12] In other words, many universes are possible mathematically, but the only universe that scientists could be certain is a true model, is one allowing evolution of intelligent life.

[13] Still, a *fully constrained* universe could be so "smoothed out" that life might not encounter the variability to arise!

2.0 THE THEORY OF EVOLUTION

2.1 The Evolution Debate

"The theory of natural selection is so elegant and powerful as to inspire a kind of faith in it--not *blind* faith ... But faith nonetheless; there is a point after which one no longer entertains the possibility of encountering some fact that would call the whole theory into question. I must admit to having reached this point. Natural selection has now been shown to plausibly account for so much about life in general and the human mind in particular that I have little doubt that it can account for the rest." **Sewall Wright**

"Today, Darwin's theory is coming under increasing attack from inside and outside the scientific community... There is no doubt such attacks are going to increase in the years ahead, and eventually they will triumph, leaving Darwin a lifeless corps, a distant memory of a bygone era." **Jeremy Rifkin**

"Let me lay my cards on the table. If I were to give an award for the single best idea anyone ever had, I'd give it to Darwin, ahead of even Newton or Einstein and everyone else. In a single stroke, the idea of evolution by natural selection unifies the realm of life, meaning and purpose with the realm of space and time, cause and effect, mechanism and physical law". **Daniel Dennett**

"Expecting DNA to form spontaneously from basic organic chemicals is like expecting a whirlwind to blow through a junkyard and assemble a working Boeing 747." **Sir Fredrick Hoyle**

"But multitudinous atoms, swept along in multitudinous courses through infinite time by mutual clashes of their own weight, have come together in every possible way and realized everything that could be formed by their combinations. So it comes about in a voyage of immense duration in which they have experienced every variety and movement of conjunction, has brought together those whose sudden encounter normally forms the starting point of substantial fabrics - earth and sea and sky and the races of living creatures." **Lucretius.**

"The facts show - so they claim - that the greatest and finest things in the world are the products of ... neither intelligent planning, nor a deity, nor art, but nature and chance. All this, my friends, is the theme of experts ... who assume that the kind of gods the laws tell them to believe in do not exist. This is why we get treasonable efforts to convert people to the 'true natural life', which is nothing but a life of conquest over others..." **Plato**

2.1.1 Background to the Debate

One purpose of this book is to explain human behavior by evolution. This is crucial. A misconception about evolution is that it is for the good of species, so qualities such as morality evolved to benefit groups. Yet fitness confers to individuals, not species. If humans are moral, it can only be because individuals with moral attributes passed on more of their DNA via surviving offspring than rivals. Still, behaviors among many animals that appear moral have been proven to be nothing other than disguised forms of individual selfishness.

A brutal conclusion is that if human behavior arose from evolution it must also be selfish, and mostly it is. However, even if human behavior is morally selfish, which is disputed, it is not biologically selfish, with a singular aim of procuring more offspring. (Selfish people can have small families or no offspring.) This anomaly between how humans behave as a fact, and how evolution seems to work, causes grave difficulties when explaining how human behavior evolved. So while the next few chapters will overview evolution theory, they also explain some mechanisms of it that better account for attributes such as human behavior.

But can evolution explain human behavior at all?

The question sounds paradoxical, because every day researchers find new ways that it can. For example, many observations of higher primate behavior about sex, parenting, or sociality, show remarkable analogies to how humans behave. Or responses that affect human physiology, such as increased heart rate or adrenaline rush, evolved for a selective advantage, and feelings of anger or mistrust can be analyzed in those terms. Yet despite this, even ardent evolutionists such as Richard Dawkins or Daniel Dennett fail to explain human behavior by genes and DNA.[14] Or while theories such as evolutionary psychology allegedly can explain human motive, such theories are always disputed, and science is nowhere near a method of therapy or counseling based on evolution.

If anything, attempts at evolutionary explanations of human behavior often only polarize the larger debate. Many processes mold life, such as inherent complexity, interplay of the environment, or chance and drift. Yet selfish gene or sociobiology theories focus on ruthless competition as the sole molder of life. When such theories are applied to human motive, it often seems that explaining behavior is not the only intent. To critics, it seems that the intent of these arguments is to bind all evolutionary theory to a model of it that Plato, long ago, might have characterized as "nothing but a life of conquest over others".

So, objections to such models of evolution have concerned not just human behavior. Ever since the rediscovery (in 1890's) of Mendel's laws

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[14] They rely instead on contrived devices such as 'memes'. See other references.

of hereditary, evolution theory became divided between an observational and genetic approach. By the 1950's, this was overcome by what is called the new synthesis, that combined mathematical laws of hereditary with the observational record. But during the 1970's, just as sociobiology and selfish gene theories extolled the new synthesis, fresh divisions occurred. Harvard biologist Stephen Gould challenged the synthesis with a theory that evolution was not smooth, but that species enjoyed long periods of minimal change "punctuated" by evolution of new types in short times. (A theory called Punctuated Equilibrium.)[15] Lynne Margulis produced a further theory of early cell formation, that life was not just selfish, but symbiotic and cooperative.[16] The Japanese scientist Motoo Kimura (and others) also produced a theory, now accepted, that much of molecular evolution was non-adaptive in expressed effect. (It is called the neutral theory.) Plus there was a growth in complexity theory. Like the neutral theory, this showed that there are other reasons that life expresses some of the properties it does, apart from Darwinian selection.

Moreover, once alternatives to Darwinian orthodoxy appeared, the criticism spread. The birth of the environmental movement also brought a reaction against so-called 'reductionist' science, for which the Newton-Darwin model was seen as a paradigm, and many academics took this up. As a result, anti-evolution books could now quote scientific authorities allegedly disputing Darwin. Such quotes (including ones by Darwin) are often out of context, or from a pool of religiously inspired anti-evolution critics. But there arose a general awareness that there were difficulties with the theory, or that arguments used to justify the theory were often oversimplified, or needed updating.

2.1.2 The Main Disputes

The best-known dispute over evolution concerns the fossil record. We are told that evolution works by incremental change; Darwin had expected a complete fossil record to exhibit continuous improvement. Supporters argue that Darwin was not expecting this, yet regardless of expectations the pattern of change is not smooth. Since Darwin's day scientists have found fossil evidence back to life's earliest forms, 3.8 billion years ago. Even the Silurian *radiation* 440 myrs ago mentioned by Darwin is preceded by an earlier Cambrian *radiation* 530 myrs ago. The reason that fossils do not appear before that is not because of geology, as Darwin supposed, but prior to the Cambrian period creatures lacked bony parts and were fossilized less. Also, scientists now better understand why new species appear suddenly even if not separately created. Despite this,

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[15] Stephen Gould and his colleagues are paleontologists. They study fossils, where stepped effects are more noticed. Evolutionary biologists study highly active systems like host-parasites, where change is continuous, and the stepped effect is rarely observed.
[16] Concerning evolution of prokaryotic to eukaryotic cells. See Appendix I.

the current model of evolution is of gradual change. Whereas the fossil record shows stepped patterns of long quiescence, "punctuated" by large, relatively rapid evolution of new species in short times.

The next dispute concerns the origin of new species. Every organism has a *genome*, its genetic code, and a *phenotype*, the expressed attributes of the grown individual. Now, the *phenotype* to *genome* distance of every species is in correspondence. Horses are like zebras, but not like fish, so the genome distance is short between horses and zebras, but it is far from fish. The explanation is that species evolved by successive divergence from a progenitor, as Darwin supposed. Yet though species evolved by divergence, it does not explain why they did, because it takes strong pressure to cause speciation. While humans have altered their domestic stocks, they have not been able to breed a new species (wheat perhaps). Speciation among wild species has been observed, but other forces act to retain species within a limit of their genome variability.

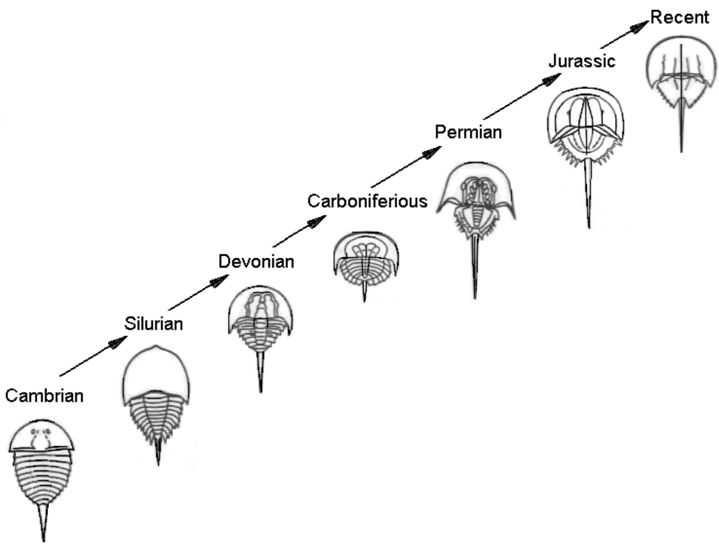

Fig 2.1.1 *Anagenesis* for horseshoe crabs, over 500 myrs. It is hard to quantify if this is a series of species evolving one into the next, or if it is the same species slightly adapting over time. (Redrawn from Strickberger, adapted from Newel.)

When genetic distance evolves with temporal (time) separation from the genome of the ancestral species, it is *anagenesis*. Still, anagenesis is hard to observe because of the long times, and because it must compare a modern individual with one from the past, about which there is less data.[17] There are claims of observing anagenesis but these are disputed,

[17] One test of a species is if it could breed with a member of the parent species. But how could one test if a modern individual could breed with an ancestor of a million years ago?

not that it occurred, but what it represents. Examples are modification of domestic stocks by artificial selection, cited by Darwin, or change in the appearance of peppered moths by natural selection. In both cases the morphology of the species adapted over time, but this is not proof that a new species evolved where a different species existed before. If domestic dogs can breed with wolves, dogs are an adaptation of the wolf type but not proof of anagenesis under domestication. Controversially, Darwin expected that most evolution would be by anagenesis and this is mostly how scientists model evolution mathematically. However, it is now much debated if anagenesis leading to new species can occur at all.

More easy to measure is *cladistic* distance, or separation between modern species, termed *cladogenesis,* which has been observed.

- New species evolved in the plant genus Tragopogon in 50-60 years.
- Modern wheat evolved from a wild type, within the last few thousand years.
- Today, many plants, insects, bacteria and fish species exist at such short distances apart that they must have recently split into separate species.
- Some snakes are adapting rapidly to life in the deep ocean in recent times, including the adaptation of live birth in a reptile.

Still, these changes are over short distances, but the past saw changes over huge distances. This is explained as the longer the time, the greater the distance. Except many large changes occurred in short times. Among different orders of mammals such as carnivores or ungulates the 'distance' say, is greater between the orders than within them. Yet, these major orders arose suddenly 55-60 myrs ago, with no new orders since. Or most modern phyla emerged in a 160 myrs burst of the Cambrian Explosion, but no new phyla have evolved since.

So, although new species evolve genetic and morphological distance from ancestors, the transformation is not linear in time. Occasionally, huge forces pushed species large distances in short times. At other times, forces that should act all the time appear strangely quiescent.

2.1.3 Natural Selection

The next focus of the debate is the applicability of natural selection. This is a broad concern. Many people wonder how properties as intricate as life, the eye, or emotions could arise by so-called blind chance, but some criticism is astonishingly misinformed. Any event has a probability of either 1 (certain), 0 (never) or a statistical outcome that fits a curve (say, a 95% chance it will be between 0.8 and 0.9). However, to make the objections look scientific, critics calculate huge numbers against the chance of evolution occurring. They illustrate these with quips about monkeys typing Hamlet, or quote the astronomer Sir Fred Hoyle about whirlwinds, junkyards, and 747s. Still, quips are not arguments. Hoyle once ridiculed Big Bang theory as "a party girl jumping out of a birthday cake", but Big Bang theory turned out to be correct. And while nobody has made a computer type Hamlet, computers can type simple sentences using natural selection. Nor have odds against an organ such as the eye evolving, once thought huge, proven as great as first supposed. Eyes evolved about forty times and there are many examples of intermediate or partly perfected eyes. Evolution of focusing systems by natural selection has also been easily simulated on a computer.

Once it starts, the rate at which species modify by natural selection is modulated. Natural selection works equally on lungfish and humans, yet humans evolved markedly in five myrs, while lungfish barely altered in 350 myrs. However, despite that evolution must work via many physical principles, people such as Daniel Dennett become *ultra*-Darwinist. They elevate natural selection 'beyond' biology, into a principle that "unifies the realm of life, meaning, and purpose with ... mechanism and physical law". Yet there is no evidence of natural selection outside of life. The eye evolved by natural selection, but only once life first existed. Computer programs simulate natural selection only after these are written by living beings. There is not pre-biotic natural selection, nor is it post-biotic. One can use a metaphor that history or the economy is Darwinian, and the inference is understood. Yet while genes are biological units of selection there is no evidence of so-called memes as post-biotic units, selected the way genes are. A small academic industry has grown around the study of so-called memes, but it is doubtful if the sum total of human knowledge has increased one iota from this effort.

The other key debate, of course, concerns the applicability of natural selection to human behavior. Even in the *Origin* Darwin addressed the difficult issue of how selection shapes behavior. Darwin's example was how selection would guide the honeybee to fashion the hexagons of the honeycomb; another concerned slavery in ants. But the challenge Darwin hinted at was explaining instinct in humans. However, most theorists try to go beyond instinct, to claim that all human behavior is selective. There were early theories of Social Darwinism or evolutionary ethics, followed with kin selection theories with Haldane in the 1930’s. This was revived as Naked Ape (Desmond Morris) and genetic kinship theories (Hamilton and others) in the 1960s. In the 1970s impetus came from sociobiology and selfish gene or meme theories. Today, it is the theme of evolutionary psychology, or older views with fresher examples, such as the peacock's tail theory or the Red Queen effect, explained later.

But while all these theories provide insights, it is still noted that the advocates of these views are the same upholders of a rigid orthodoxy in general theory. And it is not just its explanation of human behavior, but the orthodoxy itself that is often in dispute.

2.1.4 The Current Criticism

How, in the light of these broader debates over evolution, should the arguments of this book proceed?

Well, the thesis used here already works within the current theory. If one claims that sharks evolved along the fitness pathway for an optimal, large marine predator, it just means that shark evolution will be examined from that perspective. If one claims that humans evolved along a fitness pathway that maximized the options of behavior, it might not be obvious why it was that pathway, but that does not prevent analysis of human evolution within that premise. Or even within that premise, one still must explain why, via customary evolutionary mechanisms, individuals that maximized options of behavior passed on more DNA than rivals.

The next problem though, is to explain why the fitness pathway to maximize the options of behavior existed for humans. To claim that there is an optimal fitness path for a large marine predator is never questioned. Predation is a basic survival mechanism, and large predators have been optimized not just to the sea, but plains, forests, or tundra. Other animals have adapted into those environments too, not to maximize predation, or foraging, but maybe to maximize the options of behavior.[18] The effect has simply not been studied using this approach. Yet regardless of how other organisms adapt, the claim is that humans evolved to maximize the options of behavior in all environments. This never happened before in the history of life, so it needs to be explained.

The unique fitness pathway of human evolution will be explained by an effect called *saturation*. Generally, saturation means that other fitness pathways available within a biota or niche are already occupied, so new pathways had to open up for life to further adapt into new forms. Chapter 2.3 provides a model of saturation called *phylogenic* evolution. Broadly species evolve around core designs that we can call phylogenies. (Say, a four-chamber heart is a *phylogeny*.) Species are continuously variable, and never saturate their possibilities for further adaptation. Phylogenies however, can saturate how far they can evolve for a given cost. (Say, a six-chamber heart is too costly to evolve.) The pathway of maximizing the options of behavior seemed to arise then, because when hominid evolution began, primate, or all large animal phylogenies, had saturated their possibilities for further rapid adaptation.

Even so, saturation, options, or fitness pathways, are never the real issues of the evolution of human behavior, which in the end comes down to genes and DNA. Yet even here, evolution theory has always been able to produce viable mechanisms to explain instinctive behaviors, such as aggression, sexual displays, or sibling conflict. The basic mechanism is that any mutation has to only express a slightly fitter behavior, such as

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[18] Maybe, that is what an octopus does in the sea, or a primate does in the forest.

more cunning, for its gene to spread rapidly through the population. This mechanism has been tested many times, by both computer modeling and observations of real populations. For both practical and ethical reasons, it is harder to test this model among human populations. Yet despite this, there is no reason to suppose that instinctive behaviors in humans have evolved by any other way.

The problem though, is that only 10-20% (by brain mass) of human behavior is instinctive. The rest is learned. (The distinction is never that sharp.) So the issue is whether the learned behaviors are selected by the same mechanisms as the instinctive ones, but the issue is complicated. Physically, the neural circuits for both learned and instinctive behaviors are expressed by genes, and all genes are selected via similar processes, even if many genes were selected deep in the past. The real distinction is in how the different types of genes spread. One might say, crudely, that genes for instinctive behaviors spread by being selected. But genes for learned behaviors are already selected by previous events, and learning allows them to spread more widely. However, while in language the words "selected" and "spread" can mean different things, in an equation these tend to be modeled as the same processes. Chapter 2.4 discusses equations that might distinguish between how genes are selected against how they spread, but it is very contentious.

The following chapters then, stay within standard theory to argue the main thesis, but move beyond standard ideas to explain other effects. As discussed, the basic model of evolution is that genes spread as units of selection competing for fitness. Yet if genes as isolated units ever existed and replicated this way, they quickly evolved more efficacious ways to spread. Billions of years ago genes consolidated into chromosomes, then chromosomes grouped into cells.[19] Simple cells formed from basic types into new species, then single-celled species evolved into multi-cellular types. So, although genes might be 'selfish', some selective force yields a great advantage for small units, whether of genes, cells, or individuals, to group together into higher units of organization and complexity.

Humans too are tremendously complex, in their biology, their brain, behavior and culture. So the dispute, really, is whether all this complexity can be understood just from a model based on how single genes spread. Here it is argued that we need to understand more.

Firstly, we need to understand why, from single replicating units, new levels of higher organization form over the history of life.

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[19] Some researchers contend that the cell evolved first.

2.2 Easy and Hard Changes

"When we look at an organism, we are struck by the way its parts cooperate to ensure the survival of the whole. This implies that the many thousands of genes in its genome have been programmed by natural selection to cooperate: in current jargon, they are 'co-adapted'. Until relatively recently, this result was taken for granted..." **John Maynard Smith**

"Science is a search for ever sharper images of physical reality. We need to know what kinds of things populate the material universe... Ultra-Darwinists restrict their lists pretty much to genes, organisms, and populations - acknowledging that species, social systems and ecosystems exist, but not as direct players in the evolutionary arena. In contrast, I see such large-scale systems as absolutely crucial to understanding how the evolutionary process actually works." **Niles Eldredge**

"If a group of atoms in the presence of energy falls into a stable pattern it will tend to stay that way. The earliest form of natural selection was simply a selection of stable forms and rejection of unstable ones. There is no mystery about this. It had to happen by definition" **Richard Dawkins**

"We need only prove that there exists a continuous series of small steps leading from an insect, say a stage beetle, to a mammal, say a stag. By this I mean that starting with the beetle, we could lay out a sequence of hypothetical animals, each one as similar to the previous member as a pair of brothers might be, and the sequence would culminate in a red deer stag." **Richard Dawkins**

"Local varieties will not spread into other and distant regions until they are considerably modified and improved; and when they do spread ... they will appear as if suddenly created there." **Darwin**

"Modern biology has come to occupy an extreme position in the spectrum of science, dominated by historical explanations in terms of the evolutionary adventures of genes. Physics on the other hand, has developed explanations of different levels of reality, microscopic and macroscopic, in terms of theories appropriate to these levels..." **Brian Goodwin**

2.2.1 Selfishness and Cooperation

The previous chapter explained that one difficulty in evolutionary theory concerns why complexity and higher organization evolve. If the gene is taken as the core unit of life, then a fit gene is one that spreads more than rivals. But once a gene combines in a chromosome, cell, or an organism, an individual gene can only spread by the same amount as rival genes. This leads to a puzzle of why the gene would join together in the first place. It is even harder to explain this in terms of sex, which involves two sets of genes, or explain it as social behaviors that require cooperation among many genes in different organisms.

This is now a dispute. It is easy to say that "selfish" behavior at the gene level causes "selfish" behavior at say, the human level. But while it is debatable for human behavior, it still does not explain how cooperation evolves at the gene level either. It is simply assumed that genes cooperate to gain a mutual, or *symmetric* benefit. (If via unity the chromosome gets to copy more, all the genes on it get to copy more.)

This book is unusual then, in that it supports a 'moral' view of human behavior, but it uses an *asymmetric* cooperator model, in which genes are consistently "selfish", and the benefits of cooperation are one-sided. The difference is that standard models all assume that the only goal of genes is the total numbers of copy. This is true, but the gene also requires that however many copies it makes, the copies should retain sequence fidelity over time. The goal is to spread the sequence, but if the sequence keeps altering the point to spreading it will be lost. This results in a form of intragenomic (within the genome) conflict, in which genes cooperate to copy by the same amount, but they compete so that each gene tries to alter least. Evolution is about adaptation, which requires change, but not all genes alter equally for like gains to the chromosome. A weak gene will join a strong gene because it gives the weak gene a better chance to survive. But the strong gene has its "selfish" reason to cooperate too. By uniting with a weak gene, the strong gene can adapt into new forms of life, but retain its own sequence unaltered if it can force the weaker gene to do the altering, and bear the cost of change.

This is how life appears to work. Core genes that express basic body plans or cell types are widely distributed, but are also highly conserved.[20] More recently evolved genes are faster mutating, but are less widely distributed as the same sequence.[21] And this pattern of some genes not altering, but forcing other genes to bear the cost of change, repeats throughout the organization of life. Humans say, evolved rapidly, and

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[20] As an example, the gene for H4 histone is 100% distributed throughout all eukaryotic life, but it is one of the most highly conserved genes, altering one bp per billion years.

[21] The effect is inherent. Suppose two genes α and β from the first life descended into all modern types. If α did not alter, it would be 100% distributed as α. If β mutated to β_1, β_2, etc, there would be more total copies of α, than of β_1, β_2, etc.

changed greatly in appearance and behavior from chimp-like ancestors. But only 1-2% of genes altered for human evolution. Mammals too have become incredibly diverse, but about 70% of genes are shared unaltered among all mammals. Genes such as hox (homeobox) genes, that express basic body plans, are barely altered throughout all animal life. In this way sex too, or the chromosome, is method of adaptation that does not require core genes to alter. Each generation the DNA can vary, but mostly by reshuffling core genes, rather than altering them.

This pattern to how genes try to avoid alteration helps explain why humans have flexible behavior. Each neural circuit used for reflex needs different DNA to express it. But 'learning neurology' is the same design, modified by experience after birth. So learning capable organisms can adapt rapidly to change, but genes that express learning are not forced to alter. This is why humans have ephemeral constraints such as morals. Attributes such as language, learning, cultural adaptation, or moral inhibition depend on cooperation to work, which is a puzzle of why "selfish" genes allow such attributes to evolve. Yet such attributes make organisms adaptable for little change to core genes. By adapting through culture and leaning, say, humans have been able to multiply in great numbers and settle every continent on Earth, for very slight change to essential genes that code for the human type.

2.2.2 Coding Change

Yet, why should genes try to conserve sequence?

Some viral or parasitic fragments do not try to conserve sequence, but mutate opportunistically, to spread however they can. So, why do not all genes behave that way? Why should life not be a soup of Malthusian, isolated, competing genes, without higher organization? A need of genes to conserve sequence might lead to higher organization, or ultimately to higher attributes such as learning or emotion. But it still does not explain why genes try to conserve sequence at all.

Richard Dawkins (see quote) has said that the need of early genes to replicate their pattern is the need of all entities for stability, and that the original survival of the fittest was the "survival of the stable" (Dawkins). The idea is useful, and successful genes, conserved throughout the widest number of organisms, are inherently the most stable. Even so, Dawkins is treating stability of the gene (first genes were probably RNA) as the *cause* itself. Yet however life began, modern DNA is not "life" itself, but a code of information about life. Part of that code is easily reshuffled every replication. But part of the code is 'hardened' into genes, some of which barely alter sequence in billions of years.

The reason that DNA as code is easy to alter, but DNA encoded as specific genes can be exceptionally stable, is that DNA itself evolved as the preeminent code because it reflected life's real properties. And in life and the universe, some properties are easier to alter than others. As basic physics, it takes huge energy to alter the structure of matter, but small energy to bind existing matter into new forms. It is easier to rearrange elements as molecules, than transform one element into another. These properties give direction to change, and this carries into life. Chemistry is the basis of life, but the elements of life; water, amino acids, or RNA and DNA molecules, all exhibit strong, hard-to-alter bonds on one molecular axis, but weak, easy-to-alter bonds along another.

When life begins the easy and hard to alter physical properties of life become the backdrop in which organisms compete for fitness. Organisms that can adapt by altering easily changed attributes first, will adapt at less cost of resources, so their type will spread. The new types that already have found low cost ways to adapt then compete again, for even further refinement of adaptation. But entities that live also die, so ways must be evolved to pass proven adaptations on in an incorruptible form.[22] Genes do this by encoding the protein structure of each attribute. But genes also encode, less precisely, another piece of information. This is the viability of the attribute that the gene expresses, and the cost to alter it. Broadly, genes that passed down through billions of selective events unaltered, did so because they expressed crucial attributes vital to each organism, that it would be fatal to alter.[23] Genes that altered slightly into a broad family of types did so because attributes that they expressed could be adapted to each species. On the other hand, genes that alter all the time can only do so because they no longer express useful attributes, but multiply by any means as junk or parasitic gene fragments.

So, genes do not in a volitional sense 'want' to retain copy fidelity, any more than they 'want' to copy in great numbers. Genes simply exist, in ways that pass on successful adaptations to the next generation. The most successful adaptations, the genetic designs that are recyclable into a huge variety of types unaltered, are inherently expressed by genes that are most stable, and so on down a scale. In conserving some sequences while allowing alteration of others, genes carry forward, from earliest life, the tenet of existence that some properties are always easier to alter than others. But genes carry that principle into modern life, not just as the primal properties of existence.

Instead, the need of genes to conserve copy, interacting against the environment in which life evolves, become available fitness 'pathways' along which all populations are constrained to adapt.

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[22] We presume that the first replicating unit passed on its entire self. But as units became more complex, it became efficient just to pass on the code of how to replicate one's self.

[23] The effect is self-reinforcing. Mutations to crucial sequences abort in the fetus, which inherently conserves the sequences of genes that survive. But selectively too, it will not be fit to waste reproductive resources on mutations that will not be viable anyway.

2.2.3 Trajectories and Pathways

To claim that humans evolved along a certain fitness pathway should not be that unusual. All species evolve along some pathway. It might be a pathway for a large jungle predator, or foraging in the desert. Humans evolved along a pathway that initially say, adapted to bipedal life on the plains. However, apart from pathways formed via the environment or competition, populations evolve along genetic pathways too. Humans evolved along certain environmental pathways, but they also evolved along a narrow genetic pathway, with a slight alteration of genes against radical transformations of behavior and appearance. If the genes had altered more humans might have transformed more, but the genes did not allow this, so we need to understand why.

As explained, genes try to retain an original sequence, which we can call a *trajectory*.[24] But as also explained, genes do not 'want' with volition to retain sequence. It just happens. Correctly, the hominid line that was successful was the one able to best adapt for a small change to its genes. So, the real question is why, for human evolution, was it fit for individual hominids not to alter genes too much to adapt?

Well, genes do alter, but at a rate optimized to the conditions of life. If there were radical transformations to the biota of life in the five myrs when humans evolved, radical genetic transformation might have been viable. However, organisms only have to be slightly fitter than rivals, and change mostly brings disruption. This sets a 'time' genetic pathway on how fast any species can adapt for the needs of the era. Radical new body plans or phyla did not evolve in the era of human evolution. So during that period genes expressing learning, appearance, behavior, or brain size could alter the most, for the smallest risk of disruption. (Or correctly, the genes only altered slightly, but the attributes that they expressed altered a great deal for small changes of DNA.)

Also, genes resist change for a reason. Genetically, large mutations of proven designs are often fatal.[25] Yet the 'message' of this, from early life, is simply that some properties of life are easier to alter than others, with the effect encoded into life by genes. Populations that adapt at little alteration to core genes simply adapt the easiest alterations first. This is why evolution contains so much *homology*, or adaptation of basic body plans. Limbs can be adapted into wing, legs, arms, or flippers, or even atrophy as vestigial growths as in snakes. But the four-limb body plan

[24] For example, the RNA sequence AUCACCUC exists in all archaea, and in 91% of all eubacteria. AUCACCUC is the *trajectory* of that sequence. Or, the H4 histone varies one amino acid in 105 between yeast and mice. Because yeast evolved before mice, the yeast gene has the original H4 *trajectory*, from which the mice sequence diverged (slightly).

[25] See Appendix I, but the 3rd letter in DNA can often alter without changing the amino acid. It would be more one change in the 1st or 2nd letter, or two changes in the 3rd letter that would cause a fatal disruption. Details of how it all works are very intricate.

evolved once only, and is fixed for present life on Earth. Adapting limbs into new forms is an easy evolutionary change. Evolving the vertebrate body plan was a hard to enact, once only change.

This is also why evolution of new species, classes or phyla seems an order-of-magnitude more difficult than adaptation of existing species. There has been huge adaptive variation among orders of mammals in the last 55 myrs. But the existing orders (carnivores, ungulates, etc.) evolved within a short period 55-65 myrs ago, and no new orders have evolved since. Adaptive variations on a basic body plan do not require radical change to proven genetic designs. Evolution of totally new body plans or underlying functions requires costly and disruptive changes to the genetic structures of life, which is very hard to enact.

2.2.4 The Cost of Evolution

In life, just as some changes are harder to adapt than others, some extract a larger cost than others to implement. Yet what determines the "cost" of evolutionary change?

Energy is involved, but organisms use DNA "information" and over time this accumulates, so good designs can beget better ones.[26] Behind the first appearance of eukaryotic life lay two billion years of prokaryotic accumulation.[27] Behind the sudden appearance of the Cambrian forms lay half a billion years of eukaryotic accumulation.[28] Circumstances arise in which organisms are prepared to "pay" a higher cost to evolve than under stable competition. The equilibrium state of evolution is when organisms are evolving in a state of none paying too much cost to alter. But a large geological or climate change can disrupt equilibrium, or after countless iterations a species might strike a step improvement. Ranges in which species compete at low cost might become *saturated*, so other species are pushed into peripheries of harsher adaptation. This throws up statistically hard-to-alter changes, because high-cost windows of forced alteration do not occur all the time.

Moreover, if the initial cost of alteration was high, no organism in rivalry can afford the cost to evolve the trait again. Feathers are complex materials, so pterosaurs could not evolve feathers for flight in the time that a rival pterosaur could streamline its shape or increase its wingspan. Yet once birds evolved feathers away from the open sky, then took to the air, the material was so efficient at flight that no creature could afford the

[26] Like wealth initially tallies possessions or labor, and knowledge is passed on by custom. But once humans have money and writing, wealth and knowledge can build over time, take new forms, and move from place to place. Today it would be prohibitively expensive to colonize the planets, but wealth and knowledge for such a project will accumulate, so what is prohibitive today will be possible tomorrow.

[27] There is a brief explanation of prokaryotic and eukaryotic life in Appendix I.

[28] Just as behind the sudden industrialization of the last two centuries lay thousands of years of accumulation of human wealth and wisdom.

cost to evolve feathers again, in rivalry to the initial cost to birds. (There exist feather look-a-likes, but bona fide material has only evolved once.) Similarly, there was a high cost to evolve the first vertebrate body plan. But once it did evolve, life adapted into millions of vertebrate varieties. Except now, no creature not already a vertebrate could afford the fitness cost to evolve vertebrae again in competition with organisms already vertebrates, that could adapt more quickly. In an invertebrate world, the pathway for a creature to evolve into a vertebrate is open. But once the first creature does so, the pathway closes because of fitness, competition, and the cost of further change.

In the history of life on Earth, the "opportunity" pathway to evolve a new type of eye, wing, diet, or shape, opened many times. Yet the "opportunity" pathway to evolve other traits, such as vertebrae, limbs, or feathers opened only once, then closed for present life on Earth. We call traits that encounter many opportunities to evolve easy-to-alter, and traits that only encountered unique pathways hard-to-alter.

Changes being easy or hard to enact are ultimately why humans are mostly motivated by psychology. Over billions of years, of ages of fish, reptiles, and mammals, evolution "searches out" the easy ways by which organisms can adapt. Fitness refines adaptation to where biology adapts at the maximum rate. Once life evolves to advanced primates, the only way to adapt faster is by culture and learning. So humans are motivated by psychology, because in a universe of easy and hard to alter properties it is easier, and ultimately fitter, to adapt behavior by altering psychology rather than altering hard biology.

In summary, many physical properties of the universe are easier to alter than others, and the effect carries into life. Genes encode the designs of life, precisely, in ways that can efficiently pass from one generation to the next. But genes also encode, less precisely, the "cost" or difficulty to perfect any design. Loosely, this correlates as the resistance to alteration of any gene, such that crucial designs are hard to alter from an original sequence, or *trajectory*, for many reasons. Even so, genetic *trajectories* only act within the other conditions of life. And these confine evolving populations not to a trajectory dictated by solely genes, but a fitness pathway in which genes, with all the other forces of life, mold adaptation within all the other available constraints.

But sometimes in life, all the available pathways become *saturated*. When this occurs, radical new pathways must be forced to open, if life is to further evolve and adapt its multitudinous forms.

2.3 Phylogenic Evolution

"Thus, from the war of nature, from famine and death, the most exalted object of which we are capable of conceiving, namely, the production of higher animals, directly follows." **Darwin**

"This of course is nonsense. Evolution is something that happens to organisms. It is a directionless process that sometimes makes an animal's descendants more complicated, sometimes simpler, and sometimes changes them not at all. We are so steeped in notions of progress and self-improvement that we find it strangely hard to accept this." **Matt Ridley**

"In a universe of blind physical forces and genetic replication, some people are going to get hurt, other people are going to get lucky, and you won't find any rhyme or reason in it, nor any justice. The universe we observe has precisely the properties we should expect if there is, at bottom, no design, no purpose, no evil and no good, nothing but blind, pitiless indifference." **Richard Dawkins**

"We are ... a relatively minor phenomenon that arises only as a side consequence of a physically constrained starting point... The most salient feature of life is the stability of its bacterial mode, so this is truly the age of bacteria". **Stephen Jay Gould**

"I very, very strongly object to the idea that living creatures can be arranged on a ladder, a kind of phylogenetic scale, with humans at the top. Not only should we not treat humans as being on the top, we should not see the animal kingdom as being layered as we often do". **Richard Dawkins**

"Nature works by steps. The cells make up first of all simple animals, and then the sophisticated ones, climbing step by step. ...Evolution is the climbing of a ladder from simple to complex by steps, each of which is stable in itself." **Jacob Bronowski**

"A slow sort of country!" said the Queen. "Now here, you see, it takes all the running you can do, to keep in the same place. If you want to get somewhere else, you must run as least twice as fast as that." **The Red Queen**

"During early periods of the earth's history, when the forms of life were probably fewer and simpler, the rate of change was probably slower;" **Darwin**

2.3.1 Species and Phylogenies

One reason that humans evolved, was that many available fitness pathways of life at that time became *saturated*. Yet, while this is easy to state, saturation is hard to explain. Species are continuously variable, in that the attributes of organisms; size, shape, color, or behavior, never saturate their possibilities. Still, some people argue that species are only a logical grouping of living things, not a natural one. This might not be so, but humans can group parts of nature any way they choose, if it aids understanding. To better explain saturation, we might group attributes of life into *phylogenies*. Large-scale effects of evolution such as saturation can be better understood not as a history of *species* evolution, but as a history of *phylogenic* evolution.

But what is a phylogeny?

Well, a phylogeny can be treated as attributes that organisms share as a *homology*. One might say that each *species* has an **inclusive** set of attributes, which include every feature of that species, distinguishing it from any other species. But *phylogenies* are an **exclusive** set of attributes shared in common among individuals, multiple species, or biota.

- Large brain, upright stance, speech and hairless body is an exclusive *phylogeny* of humans, within the broader primate phylogeny.
- Opposed thumb and stereoscopic vision is part of the human phylogeny, but one that humans share with apes. A phylogeny exclusive to primates is a nerve connection of each digit in the hand directly to the spine.
- Primates are mammals. They share a phylogeny of body fur, four-chamber heart, and suckling, with other mammals, but not with fish or birds.
- Birds, mammals and reptiles are tetrapods, sharing a phylogeny of limbs, heart, and lungs. Fish are not tetrapods, but share a phylogeny of vertebrae, brain, and respiratory and circulatory systems with all other vertebrates.

By defining a *phylogeny* as an exclusive set of attributes, we can make a phylogeny as broad as we like, or stretch it as far back in time as we like. Still, sharing must be by unbroken descent to the last common ancestor (LCA). Birds have wings, but so do pterosaurs. Yet the LCA of pterosaurs and birds did not have wings, so while wings are separate phylogenies of birds or pterosaurs, they are not a *homologous* attribute like vertebrae. Sharks and porpoises share an *analogous* appearance, but one is a fish, which existed for 350 myrs, the other is a mammal, which adapted to sea life within the last 50 myrs. Sharks and porpoises share a phylogeny only of the LCA of fish and reptiles, 400 myrs ago.

For life on Earth all phylogenies relate to deeper ones, because life evolved from a single phylogeny, or a dominant phylogeny that displaced the rest. When we look at the surface attributes of organisms, how they appear, we see the continuously changing qualities. But when we study phylogenies, we see underlying changes. The following diagram shows the phylogenic evolution of a shark, ichthyosaur, and porpoise. In 350 myrs the phylogeny leading to the modern shark did not evolve much, but the phylogeny leading to the porpoise underwent huge changes.

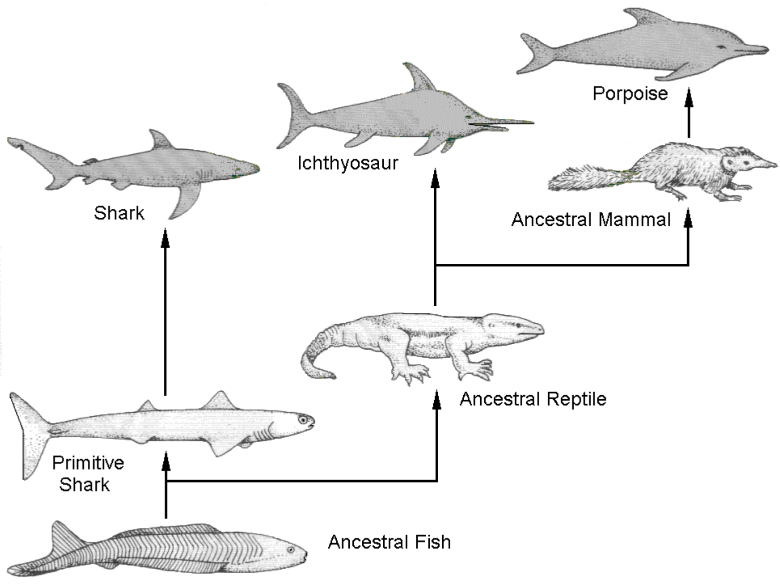

Fig 2.3.1 Phylogenic evolution is of the underlying structures that organisms share. The shared phylogeny of a shark, ichthyosaur, and porpoise is of an ancestral fish. (Redrawn from Strickberger. Similarity of marine shape is ‘convergent evolution’.)

2.3.2 Large Scale Changes

Something happened on Planet Earth, deep in the past. In relatively short periods new phyla, classes, and orders, came into existence for the very first time. Often, the sudden appearance was an effect. Mammals radiated suddenly 65 myrs ago, but mammal ancestors had evolved slowly for 200 myrs. Plus mammal radiation might have been fortuitous. An asteroid *might* have killed the dinosaurs, so mammals expanded into the depopulated niches left behind.

However, two new classes evolved, birds and mammals. Both had complex new behaviors and attributes. Both types were warm-blooded, both strongly used sexual selection. On average both had smaller litter or clutch sizes, and new materials; feathers on birds and fur on mammals, that had not existed previously. The differences are not so dramatic for birds, which branched from dinosaurs only 150 myrs ago. Compared to reptiles though, mammals had a leap of intelligence, genome complexity, metabolic rate, and intricacy of the reproductive systems.

Evolution of birds and mammals was *monophyletic*.[29] Mammals and dinosaurs evolved for 200 myrs, and over that period dinosaurs spread widely into thousands of species on every continent. But at the end of 200 myrs they were still reptile-like. Mammals evolved in a narrower line with smaller radiation. After 200 myrs mammals were not widely distributed, but they had evolved far from their ancestors, and were more advanced than dinosaurs. For a similar effort dinosaur evolution was broad and distended, whereas mammal evolution was narrow, focused, and directional. We would find similar focus for the evolution of birds, though it was over a far shorter period.

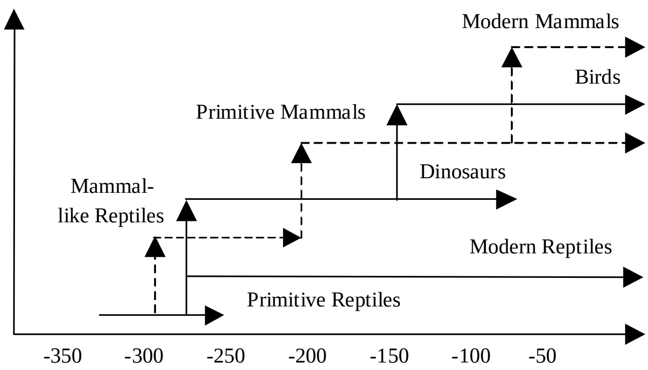

Fig 2.3.2 Mammals (dotted line) did not evolve from dinosaurs, but evolved in parallel from a primitive reptilian ancestor. This sequence is highly simplified.

Large-scale, focused, *monophyletic* evolution occurred many times. The evolution of eukaryotic life was *monophyletic*. So was the evolution of sex. There was an 'explosion' of complexity in the Cambrian period, which must have been preceded by a slow accumulation that allowed sudden radiation. Evolution of the first amphibians, or before that of the first vertebrates, was also *monophyletic*, as were other changes. Stephen Gould has called this type of evolution *orthoselection*. Small adaptive changes are also termed *microevolution,* while supra-species change is often called *macroevolution*. Still, this concerns the scale of change. Here it is asserted that large, focused, *monophyletic* change is not just an effect of scale, but a result of several of factors.

How these factors operate is the theory of *phylogenic* evolution. It concerns evolution of *homologous* attributes that species share. Such

[29] Strictly, this means that as a classification, we can trace all descendents to a single ancestor. Here, if bird evolution was *monophyletic*, it means that there was only one ancestral bird type, so feathers evolved only once. If mammal evolution was *monophyletic*, it means fur or mammary glands evolved only once, but there are disputes over which other mammal attributes evolved one time only in a single species.

attributes evolve fastest when the line carrying the changes forward is focussed as a single, or narrow group of species. It is similar to how small populations can evolve faster than large ones, due to less dispersal. Dinosaurs radiated 250 myrs ago, and could not evolve much further after that because their *homology* became 'frozen' at that level. This happened to mammals too once they radiated. Yet prior to radiation, mammals were evolving in a narrow line, at times a single species. So, every step of evolution in this single, focused line advanced the entire *phylogeny* of mammals. Comparing mammals and dinosaurs over 200 myrs, the external appearance of both changed, but internally in mammals over that period there were huge structural changes, while dinosaurs evolved little internally at all. (This is disputed.)

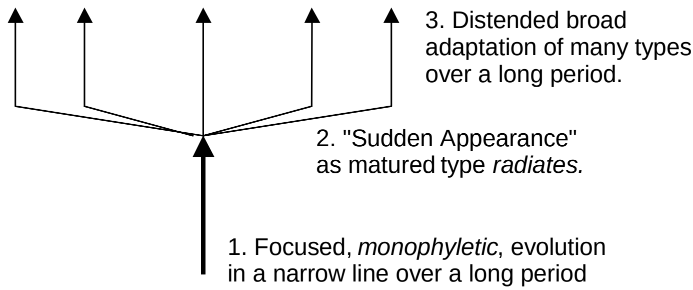

Fig 2.3.3 The theory of *phylogenic* evolution is that significant evolution occurs as a focused **stem** (step 1) leading to *radiation* (step 2) then sub-adaptation (step 3).

2.3.3 Concatenation and Radiation

Generally, phylogenic evolution of totally new types and materials occurs under the following conditions;

1. During intense *saturation* among existing types.
2. In harsh, hostile, or peripheral conditions.
3. Against a loss of absolute genome copy fitness.
4. Only a limited number of times in the history of life.

This is why there are stepped changes. Most theories explain this by a 'dam-burst'. (Rain falls and the river rises steadily, but when the dam bursts there is a step upset.) But there is one more dam; a form of fitness barrier. All change bears a cost, but some changes are less costly. New phylogenies evolve from hard-to-enact changes, but at any point there is an existing phylogeny that can be exploited. Early *thermophilic* organism ate sulfur, directly converting heat to energy. This allowed many types, but it limited life to the heat and sulfur sources. Cyanobacteria were a phylogeny that could move away from the heat sources by converting sunlight to energy, releasing oxygen. This too allowed many types. As the oxygen built up, a phylogeny evolved that allowed some organisms to use oxygen as a rich energy source. Just at each step there is a pause. Each new phylogeny allowed a fresh radiation of types adaptable around a basic design. Because there is a cost to evolving new phylogenies, most organisms will not pay when they can adapt to an existing phylogeny by quick, fitness rich changes.

When every phylogeny of a biota within an environmental *range* has saturated its low cost fitness adaptations, there will be no fit moves left for weaker organisms. This will result in a *concatenation*, that will push some populations into directional changes. The oceans are huge, but if life reproduces prolifically eventually the oceans will saturate with all types that can be optimally adapted to life in the sea. This will push life onto land. The first time it occurs the existing phylogenies, adapted for life in the sea, will need to alter greatly. This need to alter not only a habitat, but a phylogeny to a new mode of life will place large directional pressures on organisms making this move for the first time. All major phylogenic change evolved during concatenations.[30]

1. There was saturation among an existing *phylogeny*. This led to expulsion of organisms into a peripheral, under-exploited *niche*.
2. The exiled population then evolved in a narrow line against heavy copy fitness costs, altering radically from what it had been in the old *niche*, into a type that had not previously existed anywhere on Earth.
3. Once the new type matured and the new technologies and body plans were perfected the type *radiated* into many new ranges, as a step

2.3.4 The Hierarchy of Life

Any environmental range a population is forced to adapt to outside of its norm is a peripheral *niche*. Plains are peripheral to forest dwellers. Loss of heat is peripheral to thermophilic life. The shoreline is peripheral to fish. Cold is peripheral to reptiles. An unpleasant or low quality diet is peripheral in minor speciation. Peripheral niches become *supernovas* of evolutionary change, from which species emerge 'higher' up the scale of life than species that stayed in a comfortable *niche*. But we confuse the term 'higher' with 'fitter'. Because we see mammals as 'higher' organisms than reptiles, we assume that mammals 'climbed' or 'ascended' a fitness slope to get there, as though motivated to become 'better'.

However, mammals were pushed out from a comfortable niche by competition. They ascended a complexity slope, but their exact copy of total DNA went down, to allow a more versatile genome. When a lineage enters a niche where it is forced to alter to survive, its DNA must keep changing. Exact DNA copy of a prior design will not be optimized for the new niche. An exact copy of dinosaur DNA was not optimized for the *niche* where birds had to evolve feathers to keep warm. A creature

[30] This is a hypothesis. There could be other explanations, that need research.

intermediate between a dinosaur and a bird will still not be optimal, so its lineage will alter further. There might be thousands of intermediate steps between a bird and a dinosaur, before an optimum is found. While each step in the lineage is fit in isolation, no intermediate is stable, so the type continues altering. It will be subject to "directional" selection, for as long as the type stays confined to a narrow line and cannot radiate.

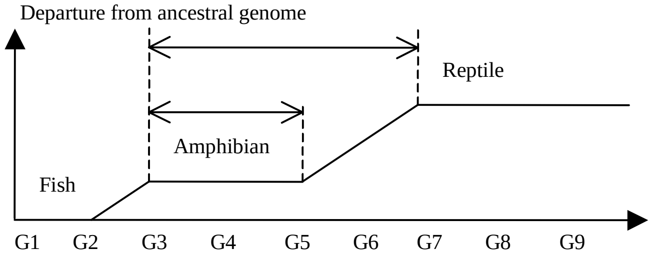

Fig 2.3.4 We think that types "higher" up the scale of life are fitter. If we measure fitness by exact copy of genome, the founding amphibian, say for line G3 – G5 was very fit. Yet over distance G3 – G7, the founder of the reptile line lost copy fitness away from the G3 – G5 line. (See also Fig 2.3.1)

In all these changes types move a large genetic distance from where they were in an ancestor, to where they evolved. The genetic distance from the LCA of dinosaurs and mammals over 200 myrs, was less for the dinosaurs than mammals over the same period. Notice (Fig 2.3.1 and above) that the ancestral fish was the fittest, as it spawned the entire line. An amphibian was next fit, then the reptile. A shark is not far diverged from a fit ancestor, but a porpoise is a huge 'distance' from it. Between the shark and porpoise genes of the shark diverged less from *trajectory*. Lines diverged about 10^8 generations ago. Genes expressing a basic *phylogeny* such as a vertebrate body plan are conserved genes that mutate slower than this rate (10^{-8}). Many genes mutate faster than 10^{-8}, but these genes express differences. There will be more faster altering genes in the porpoise than the shark, because the porpoise diverged further from the original type, and accumulated newer novelties.[31] We see a porpoise as a "higher", and hence 'fitter' than a shark, but genes in the shark diverged less from the *trajectory* of the original type.

Any creature is always best adapted to the niche where it evolved. Only when the niche alters, or organisms are expelled by other pressures, will new forms be *forced* to evolve. The forcing is against a loss of exact copy of DNA from the ancestor to the modern type, as the complex new type moves 'higher' up an alleged scale of life.

[31] Many ancient creatures accumulate large amounts of "junk" DNA. Even so, useful genes are of greater variety for a complex, newer evolved creature like a porpoise than a shark.

2.3.5 Phylogenic Saturation

Large changes only occur a limited number of times in the history of life. Migration to the edge of a forest, or change of diet, is a common evolutionary event. However, on any planet there are a limited number of totally new environmental ranges, that must be penetrated for the first time. Life begins close to heat sources (common on early Earth). Moving away from these, or moving from oceans to land, or from warm to cold climates is also a one-time, major event the first time it happens. These require major, phylogenic changes the first time they occur. However, once all the new ranges are penetrated for the first time radical alteration to existing phylogenies will not be required again. Anywhere with a livable environment an organism wants to go, a phylogeny as a biological novelty already exists to penetrate that range.

Just as a change of climate or vegetation is an endless process, many adaptive features of organisms are endlessly variable. The length of a worm is physically constrained to a maximum possible, but the property "length" is infinitely and minutely variable. Length, shape, color, size, and behavior have ultimate constraints, but combinations of each size, shape, and behavior are endless. Species are an **inclusive set** of traits; they include variable traits that cannot *saturate*. However, phylogenies are an **exclusive set** of traits; they exclude all traits that are continuously variable. So, if species as **inclusive** traits never saturate, do phylogenies as **exclusive** traits always saturate?

There can be a two, three, or four-chamber heart, but never a six chamber heart for life on Earth. RNA evolved into DNA, then saturated. There will be no new genetic codes. DNA might have first coded for a few amino acids, then 16, then 20, but the progression has now *saturated* at 20. All change comes at a cost, and large changes extract large costs, which few organisms can pay. But change not only comes at a cost, it evolves new means to adapt at lesser cost once the new novelties have matured. There is no need to re-evolve DNA every time an organism adapts. Organisms with DNA can already adapt faster than a new code could evolve. Today, reptiles could not evolve endothermic regulation or body fur in competition with mammals. These novelties already allow mammals to adapt at a much lesser cost, utilizing these novelties, than to evolve the novelties from the start.

Unlike for species, phylogenies *saturate*, causing large, directional changes in evolution. Organisms best adapted to the old ways, the 'fittest' of a set of existing organisms stay in the existing, primal *niche*. However, newer organisms will be pushed into peripheral niches, where to survive at all they must evolve new phylogenies, regardless of fitness costs. This continues relentlessly, until every niche is penetrated and every major phylogeny is saturated.

2.4 The Heuristic Process

"Population geneticists have achieved remarkable success by choosing to ignore the complexities of real populations and focusing on one or a few loci at a time… The approach is not without its detractors." **J H Gillespie**

If black moths can replace white moths in a century, then reptiles can become birds in a few million years by the smooth and sequential summation of countless changes. The shift in gene frequencies is an adequate model for all evolutionary process -or so the current orthodoxy states." **Stephen Jay Gould**

"Because of the excellence of his essays, [Stephen Jay Gould] has come to be seen by non-biologists as the preeminent evolutionary theorist. In contrast, the evolutionary biologists with whom I have discussed his work tend to see him as a man whose ideas are so confused as to be hardly worth bothering with, but as one who should not be publicly criticized because he is at least on our side against the creationists." **John Maynard Smith.**

"Together, these two processes ... (random genetic drift and natural selection) ... work to mold the genetic constitution of future generations and, ultimately, species, often acting in the same individual. For example, when a child dies from a genetic disease, all the child's genes which do not affect the outcome of the disease will suffer a chance death."
'Majerus, Amos and Hurst - Evolution - The Four Billion Year War'

"That one body may act upon another at a distance through a vacuum, without the mediation of anything else, by and through which their actions and force may be conveyed from one to another, is to me so great an absurdity, that I believe no man, who has in philosophical matters a competent faculty of thinking, can ever fall into it." **Isaac Newton.**

"Even worse is the mathematical concept of imaginary time... I was savagely attacked by a philosopher of science for talking about imaginary time. He said: How can a mathematical trick like imaginary time have anything to do with the real universe? I think this philosopher was confusing the technical mathematical terms real and imaginary numbers with the way that real and imaginary are used in everyday language."
Stephen Hawking

"The universe is not only queerer than we suppose, but queerer than we can suppose." **J. B. S. Haldane**.

2.4.1 The Equations of Evolution

The previous chapters explained how the need of genes to exactly copy sequence results in a cost or directionality to change. Yet, however plausible the explanation seems, equations now used in evolution do not reveal any such effects. It is not that the effects are not there physically. They simply do not appear on the 'radar screen' of mathematical biology. So, if somebody proposes that these effects occur, that person needs to explain why they are not appearing in any equations.

Needless to say, this is very difficult. The topic is highly specialized, plus much of the subject concerns how diploid alleles will distribute in a mostly stable population. The equations are variations to the equality;

$$(p + q)^2 = p^2 + q^2 + 2pq \quad \text{(The Hardy-Weinberg Equation)}$$

The problem is that diploid organisms in a stable population represent an already highly directional form of change. (The direction is towards the wealth of allele variety.) Yet, the first 2-3 billion years of life were haploid, or even among diploid species, 70-90% of loci are *homozygous* (with little allele variety). So, although it is often derived from a Hardy-Weinberg equation, broader evolution can better analyzed via a so-called Fisher/Wright model (after R. A. Fisher and Sewall Wright).

A very simple Fisher/Wright model can be shown here. Suppose an individual has a locus X on a chromosome, which can be occupied by a range of genes or alleles x_i, where i = 1, 2, 3... (x_i means the distribution value, so 1 in 100 is 0.01. Here it also refers to the gene 'x_i'.) If each variation of x_i has a fitness w_i, the population has a mean fitness $\overline{w}$ (w bar) of $\Sigma w_i x_i$ about X. R. A. Fisher showed that if w_i of any gene x_i was greater than the mean, $\overline{w}$, rate of spread Δx_i of x_i in a natural population (for a haploid, at t= 0) would be;

$$\Delta x_i = x_i (w_i - \overline{w})/\overline{w} \quad \text{(Call it Fisher's equation.)}$$

This shows that the fitter w_i makes an individual above $\overline{w}$, the greater is $w_i - \overline{w}$, so the faster x_i spreads until $\overline{w}$ rises to w_i.

For example, suppose a mosquito population has 1,000 individuals. One individual has an allele, x_2, resistant to DDT ($w_2 = 1$) and the other 999 x_1 individuals have only 50% resistance ($w_1 = 0.5$) With no DDT, each generation ($w_i - \overline{w}$) = 0, so x_2 does not increase ($\Delta x_2 = 0$). But once DDT is present, x_1 halves each generation, while x_2 quickly increases its frequency from $x_2 = 0.001$ to $x_2 = 1.0$ by about the 18^{th} generation. So although favorable mutations may be small, they can spread very fast. And the spread can be traced by the history, or frequency, of the allele or gene causing the change. This principle is so central that Fisher called it the *fundamental theorem* of natural selection.

However, by 'mean fitness' $\bar{w}$, Fisher's theorem refers to the mean about a single locus X. But genomes contain many loci, X, Y, Z. If one takes a different mean fitness over all genome loci X, Y, Z... as w_G, then most equations (not just Fisher's one) rely on a condition $w_G = w_i$. This assumption simplifies calculations by replacing fitness of the thousands of genes in the genome, w_G, by the fitness of just the one gene or allele, w_i, causing the change. Even so, assumption $w_G = w_i$ "throws away the organism", so it needs to be shown exactly which role the organism does play, in how genes spread.

2.4.2 Gene Trajectory

Earlier, Section 2.2.3 introduced the concept of gene *trajectory*. As explained, physically there are many reasons why genes alter or mutate at different rates over the history of life. But whatever the physical cause, one might liken fidelity of copy of a gene or DNA sequence to a force, call it ε_i (eta i). If say, a gene did not alter copy by even 1 bp for eternity, then $\varepsilon_i = \infty$. If a gene could alter each reproduction, then $\varepsilon_i = 0$. No gene can obtain these extremes (life has not existed for eternity) so we assume that there is an average $\bar{\varepsilon}$ (eta bar) for all genes, that can be normalized such that $\bar{\varepsilon} = 1$, for any typical gene.

The concept of ε_i, allows one to investigate the assumption $w_G = w_i$. Basically, when gene x_i increases its frequency, say $0.1 \rightarrow 0.9$, it does so in a certain "direction", in which every gene in the host genome, G, also increases frequency, say $0.1 \rightarrow 0.9$, by the same amount. So it seems safe to set $w_G = w_i$, because for any selective event every gene in G alters its frequency by the same amount anyway. However, the value of ε_i, if it exist, will be very different for each gene in the genome. And while x_i in small populations alters rapidly, ε_i alters slowly over the history of life, and is unlikely to be affected by small changes.

In fact, while it is not the same, ε_i can be derived from mutation rate μ_i (mu i). To be sure, μ_i, is a *scalar*. It measures statistical change in the present time, such as the rate by which an allele $x_1 \rightarrow x_2$ mutates to enter the gene pool of a modern population. On the other hand, ε_i is a *vector*. It is the retentive force that holds a gene within a copy *trajectory*, over the history of life. Genes also mutate for many reasons. Instability at a single region of a gene could cause high μ_i, but low ε_i if the rest of the gene was stable. Or an opportunistic gene can have low ε_i, but medium μ_i. Still, data for μ_i is available. If average normalized $\bar{\varepsilon}$ is a function of average mutation rate, $\bar{\mu}$ (mu bar) such that;

$\bar{\varepsilon} = f(\bar{\mu}) = 1$, then for any gene mutating at rate μ_i, approximately;

$\varepsilon_i = \sqrt[7]{(\bar{\mu}/\mu_i)}$

This formula gives a rough value of ε_i, against a measure (mutation rate) that is familiar. The term is reduced a 7^{th} root because ε_i is a weak force, acting about 1 in 10^7 against x_i. Highly conserved genes mutate at about $\mu_i = 10^{-13}$ which for $\bar{\mu} = 10^{-7}$ gives $\varepsilon_i = 7.2$; a fast mutating gene $\mu_i = 10^{-5}$ will have $\varepsilon_i = 0.52$. In fact, ε_i is never that accurate, and $\varepsilon_i = 1$ would cover a range $10^{-6} < \mu_i < 10^{-8}$. This is to give a broad idea of ε_i. Its precise values are not required here.

Having broadly defined ε_i, its relationship to x_i must be formulated in ways that conserve standard theory. Take distribution D_i of a gene x_i as $D_i = x_i$. Then $D_i = x_i$ for ε_i, is conserved if $D_i = x_i(1 + j\varepsilon_i)$ where $j = \sqrt{-1}$. However, because $0 < \varepsilon_i < \infty$, this must be normalized to keep $D_i \leq 1$, so the full expression becomes;

$$D_i = x_i(1 + j\varepsilon_i)/\sqrt{(\varepsilon_i^2 + 1)}$$

It looks complicated, but notice that the value of ε_i does not alter the value of D_i as x_i, but only varies its complex sign. (If $\varepsilon_i = 0$, $D_i = x_i$. Yet if $\varepsilon_i = \infty$, $D_i = jx_i$.) It is harder to show, but if ε_i was the same for all genes then again $D_i = x_i$. (If for two alleles $D_1 = kD_2$, if $\varepsilon_1 = \varepsilon_2$, then $x_1 = kx_2$.) So, the new notation is not that different from standard theory. If $\varepsilon_i = 0$, is the same for all genes, or has no effect, standard theory is conserved. Just that if ε_i does exist, or is not the same for all genes, one can now examine what is lost when setting $w_G = w_i$.

2.4.3 The Use of Angle Notation

The effects of change in a genome, where different forces of ε_i act on different genes, can be best visualized using an angle notation. When people are told that there is an angle, they expect to see a physical angle, like angles forming the DNA helix. However, the term $(1 + j\varepsilon_i)/\sqrt{(\varepsilon_i^2 + 1)}$ is also an angle, where $\theta_i = \tan^{-1}(\varepsilon_i)$. So;

$$D_i = x_i\,(1 + j\varepsilon_i)/\sqrt{(\varepsilon_i^2 + 1)} \text{ is the equivalent of;}$$
$$D_i = x_i\,(\cos\theta_i + j\sin\theta_i) \text{ or, } D_i = (x_i, \theta_i)$$

Further, for any value of ε_i, broadly;

$\varepsilon_i = \infty$, $\mu_i \approx 0$ ("forever"), $\theta_i = 90^O$
$\varepsilon_i = 1$, $\mu_i \approx \bar{\mu}$ ("average"), $\theta_i = 45^O$
$\varepsilon_i = 0$, $\mu_i \approx 1$ ("each reproduction"), $\theta_i = 0^O$

This is shown in Fig. 2.4.1. There is no physical angle, but the notation helps visualize how genes, genomes and DNA segments interact over the history of life. Highly conserved genes barely alter over huge times, so they are at high angles. Because evolution is adaptation to change, genes will only be able to stay unaltered while adapting into a huge variety of types if other DNA in the genome bears the cost of change. This will appear on the diagram as though, over time, conserved genes 'rotate' higher, but genomes 'rotate' to lower angles.

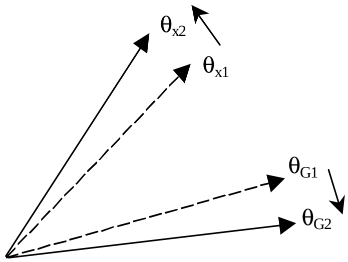

Fig 2.4.1 Genes, DNA, and genomes appear to spread together in single organisms. But over the history of life, individual genes try to avoid altering sequence, by forcing host genomes to bear the cost of change. On an angle diagram, it would appear that genes rotated 'higher' while forcing host genomes into a lower angle.

Still, Fig 2.4.1 only shows how genes or DNA distribute over time when mapped on a diagram of this type. The angles appear to change because the DNA does. Yet if genes really do try to rotate to higher angles, there must be some "force" driving them to do so. True, that force is natural selection, but in a Fisher equation it is the pressure (w_i - $\bar{w}$) that drives the value Δx_i to increase. So how would selection drive $\Delta\theta_i$ to increase in the new formulation?

Well, the equation is not fully derived yet, but to see how it works requires setting a "goal" that all genes try to achieve. In standard theory the gene seeks maximum probability P_i of survival in the next generation. Take distribution of any gene as D_i, and fitness of a host as F_i. The gene has a probability of existing of $P_i = D_i F_i$, with maximum of $P_i = 1$ (when $D_i =1$ and $F_i = 1$). This can be written (in standard theory) as;

$$P_i = x_i w_i$$

The new equations, though, would involve two new terms; ε_i, (the exact copy), and w_G, (the fitness of the organism). The relationship of these new terms to w_i and x_i is not known. However, it is likely that that genes at high ε_i (highly conserved genes) tend to spread anyway, regardless of which host genome they happen to be in. Using this principle, one can approximate the new equation of P_i to be something like;

$$P_i = x_i (w_G + w_i\varepsilon_i^2)/(\varepsilon_i^2 + 1)$$, or in angle notation;

$$P_i = x_i (w_G \cos^2 \theta_i + w_i \sin^2 \theta_i)$$

Note that when ε_i (viz. θ_i) is low, x_i must be inside a fit genome in order to propagate. Yet when ε_i is high, the gene relies on its inherent fitness. And strange as this equation appears, it fully conserves standard theory. For the condition $w_G = w_i$ for any ε_i, or for $\varepsilon_i = 0$, the equation will revert to $P_i = x_i w_i$. (Note that $\cos^2\theta_i + \sin^2\theta_i = 1$.)

However, now we have D_i and P_i, we can obtain F_i by dividing P_i/D_i. Note that P_i has a "real" (scalar) value, but once this is divided by the coordinate D (x_i, θ_i) this will result in a complex form of F_i, so we get;

$$P_i = x_i (w_G \cos^2 \theta_i + w_i \sin^2 \theta_i)$$
$$D_i = x_i (\cos \theta_i + j \sin \theta_i) \text{ or, } D_i = (x_i, \theta_i)$$

Dividing P_i/D_i gives;

$$F_i \approx w_G \cos \theta_i - j\, w_i \sin \theta_i$$

Note that F_i is approximate. (Following division there is an extra term in F_i that mostly reduces to 0, but might concern "past" or "future" events.) Again though, for the condition $w_G = w_i$ or $\theta_i = 0$, then $P_i = x_i w_i$. Or multiplying complex F_i by the complex D_i will also give $P_i = x_i w_i$ (the 'j' terms cancel) regardless of the value of θ_i (with some adjustments). So again, standard theory is conserved throughout.

Still, the equation is interesting. The first term shows that fitness of the organism, w_G, only acts on the real component of selection ($w_G \cos\theta_i$ is "real"). This infers that while organisms can evolve new designs by natural selection, they carry perfected designs into the next generation *without* selecting them out! This is the second term (with $j = \sqrt{-1}$). All genes were first selected in real genomes, but in the past (-ve sign on j). The deeper in the past (as $\theta_i >> 0^O$) the further the chance of selection is rotated away from the effects of modern events.

This is why genes 'want' to rotate to higher angles. They are trying to avoid selection! Selection is costly, for genes and nature. If a gene is already perfected in function, it is inefficient to re-design it by selection each time. It took billions of years to perfect the eukaryotic cell, and hundreds of millions of years to evolve large animals. Yet an intelligent being can evolve in a few million years by reincorporating earlier designs perfected over billions of years past. 'Selfish' gene theory has said that the organism is a way for genes to spread. The new formulation shows how it works. Nature conserves perfected designs by its own processes. But when humans model those processes with the mathematical tools available, it appears as though genes try to avoid selection by rotating deeper into an imaginary plane.

2.4.4 The Fall of Fitness

One of the conditions of the Fisher equation is that mean fitness can only rise as x_i spreads. But in life, this is often violated. Suppose that a genome G_1, consisted of two genes, x_i, y_i at loci X, Y. Suppose that gene x_i could double the total individuals in an area by splitting y_i into two new genes τ_i and ψ_i, then evolving G_1 into two new genomes G_2 and G_3. Suppose now G_1, G_2, G_3 each have 1,000 copies. We get;

$$G_1(x_i, y_i) \rightarrow [G_2(x_i, \tau_i) + G_3(x_i, \psi_i)] \text{ (For this case count the copies.)}$$

Here x_i has doubled but y_i has decreased. Plus if G_1 has gone extinct, its fitness decreased despite that x_i has increased. So fitness fell, but the condition $w_i = w_G$ of the Fisher equation was violated, by the case that;

$$w_{xi} > w_{G1} \text{ but } w_{yi} < w_{G1} \text{ (Again, just count copies.)}$$

Still, what happens when fitness falls but x_i increases is that the angle of the host genome, θ_G, falls. In a Fisher equation, mean fitness is a single scalar quantity, $\overline{w}$. It has not been derived, but in the new model mean fitness would be a complex sum, ($\overline{w}$ - j$\bar{\varepsilon}$). (The j sign is –ve, because broadly, the population evolved in the past.) It would be difficult to sum this over thousands of small changes, but "pressure" about a locus X for change would be $(w_i - \overline{w}) + j(\bar{\varepsilon} - \varepsilon_i)$. The accumulated affects of these tiny decrements in $\bar{\varepsilon}$ over thousands of loci X, Y, Z, would be an eventual fall in the ε_G (or θ_G) of the entire genome.

If anything, one suspects that rather than sum θ_G over thousands of genes and billions of bp, one might assume that for a haploid $\theta_G \approx 45^O$, and a diploid $\theta_G \approx 0^O$. (When a new form of reproduction evolves, θ_G falls slightly. Evolution of sex was the 'great θ_G crash' from 45^O to 0^O, dwarfing all other decreases in θ_G.)

Suppose though, that a gene maximizes spread if it replicates in a genome at an effective 'angle' of 45^O. This will occur at $w_G = w_i\varepsilon_i$. Then for genes at $\theta_i < 45^O$, the gene can afford a lower host fitness, $w_G < 1$, as this helps the gene increase effective angle. For conserved genes where $\theta_i > 45^O$ the gene could afford a lower w_i to get a 45^O effective angle. It is not clear physically what this means, but it vaguely infers how sex works. Highly conserved genes can accept a high fitness penalty for other genes in the host, because they are going to spread anyway.

On the other hand, while the case $w_i > w_G$ is hard to resolve, the case $w_i < w_G$ (the gene damages host fitness) becomes clearer. Note, w_G acts only on the real component of fitness. Broadly, any gene such as a rogue or parasite at $\theta_i < 45^O$ is losing copy at each reproduction at a faster rate than average. (A 10^2 bp long fragment that is mutating at $\mu_i = 10^{-4}$ will destroy its copy in 10^6 reproductions.) The best strategy for such a gene is to "slow" its rate of reproduction, by damaging its host's fitness, at roughly $w_G \propto \varepsilon_i$. (At $\mu_i = 10^{-4}$ then the gene obtains equivalent copy of $\bar{\mu}$ at $w_G = 0.37$. The figures are not researched.) Note too that the equation of complex fitness is;

$$F_i = w_G \cos \theta_i - j\, w_i \sin \theta_i$$

Lowering w_G lowers the "real" part of the equation, so it pushes effective 'angle' of complex fitness higher. As a real process, rogue DNA damages host fitness because that is how it acts. But in the equation, the DNA is trying to increase its effective angle, hence its survivability, by rotating itself further away from the plane of real selection.

Generally, the gene, being "selfish", tries to manipulate a genome to its advantage, but the strategy will depend on the (w_i, θ_i) of the gene. A rogue gene with a low (w_i, θ_i) tries to replicate inside a strong genome with a high θ_G, despite that rogue genes might try to lower w_G of the host. (A low angle genome, like in sexual organisms, can alter rapidly, so it might quickly find a way to throw out the rogue gene.) Yet a very strong gene will, paradoxically, want to see life populated by highly variable (but low angle) genomes, so the strong gene can spread within a huge variety of types. (It is like the computer industry. If you make a part like the CPU needed in all computers, then the larger the variety of low cost computers built, the more parts you can sell.)

2.4.5 An Ongoing Debate

In summary, how is it that effects claimed here to be a major factor in evolution, do not appear in the math of standard theory?

Well, the math of standard theory is explicit. It is describing a well-understood physical process, in that a gene that is fit is also increasing its frequency in a population, say, from 1% to 99% distributed, relative to a rival. Moreover, the gene that is fit, spreading this way, is also contained "within" the equation modeling the process occurring. (The gene that is spreading, is the same gene that the equation is describing.) However, when a favored gene is spreading, say 1% to 99% distributed, other genes in the genome are also spreading, even though, perplexingly, they might be 100% distributed already for that population. The difference is that the gene causing the spreading, the "action" gene, was altered from an earlier sequence to gain the fitness to spread. Yet the genes that spread anyway, that were already distributed 100%, are now carried along by the "action" gene into a new adaptation, but are not themselves forced to alter their own sequence to adapt. These genes, able to adapt into new varieties without themselves being forced to alter, gain slight fitness over genes forced to bear the cost of change.

To model this process, requires capturing the effects of fitness from the perspective of any gene in the genome, not just the "action" gene. This is done using a second quality of gene distribution; the "exact copy" of a gene, here called ε_i. Genes that survived unaltered for billions of reproductions, or adapted into a huge variety of types at no alteration to their sequence are versatile designs, that inherently end up widely copied. And organisms that adapt proven genetic designs (by reshuffling existing genes, rather than evolving new ones) ultimately adapt at lower total cost of change. So although ε_i is the copy fidelity of a gene over the history of life, it approximates the cost and directionality of change.

Yet, using ε_i must conserve the equations of standard theory where these are correct. This is done by adding ε_i to x_i as a complex sum, so normalized distribution D_i, becomes $D_i = x_i(1 + j\varepsilon_i)/\sqrt{}(\varepsilon_i^2 + 1)$. This form conserves standard theory (say, by setting $\varepsilon_i = 0$). Still, manipulating this further provides a new equation, showing how w_i (gene fitness) relates to w_G, (fitness of the host genome in which the gene is resident). This is;

$F_i = (w_G - jw_i\varepsilon_i)/\sqrt{}(\varepsilon_i^2 + 1)$, or in angle notation;

$F_i = w_G \cos\theta_i - j\, w_i \sin\theta_i$

This equation is incomplete. There are missing terms, and it does not show angle, θ_G, of the host genome (which might differ between diploid to haploid organisms). The equation also does not show the time variant conditions, or effective angle for F_i for a gene to maximize propagation. (Though one suspects it is 45^O.) Even so, the equation does confirm how life works! Succinctly, it shows that fitness, w_G, of the host genome acts on the "real" part of the equation, so as is the case, it is the organism (not the gene) that is selected at each fitness event.

Genes reproduce physically, inside organisms. And they pass on to offspring physically, like passing a baton in a relay. Yet genes still only reproduce information. In the famous polymerase chain reaction (PCR) humans provide the chemical ingredients. It is the "information" in the DNA snippet, not the chemicals, that is multiplied millions of times. So, organisms play two roles in transmitting DNA. By physical reproduction they are a chemical relay station. By mutation and selection, they are a way to modify DNA information. DNA as molecules is copied as a "real" physical process, and change of sequence occurs at real physical events, even for events in the past. Even so, when modern organisms are selected for changes of allele frequencies, 99% of the stable sequences in those organisms are being copied in other organisms, in other times, over the biota of life. If one models this among a small population from which the gene has already radiated, it should show as 'imaginary' selection in a correctly formulated equation.

Yet if this equation is correct, it means that any gene at any locus in the genome, tries to increase not just its distribution fitness, x_i, but its total fitness, $x_i(1 + j\varepsilon_i)/\sqrt{(\varepsilon_i^2 + 1)}$, where ε_i is the "exact copy" of the gene. When a gene first comes into existence, at $\varepsilon_i = 0$, the gene relies on the fitness of its host, w_G, to spread. Here, $w_G = w_i$ for that gene, which applies as in standard theory. But as the gene matures and radiates into many types, it will become less dependent on its host to avoid sequence death. Broadly, as ε_i increases the gene sequence *radiates* out from the point of origin of the sequence much like a wave, through millions of descendant reproductions. (When $\varepsilon_i = 0$, the gene is like a particle. When $\varepsilon_i = \infty$, it is like a wave.) It has not yet been modeled, but it is hoped that some fast mutating DNA will exhibit this wave-like effect as a concerted synchronism across physically separate organisms.

Modern evolutionary theory has become divided between so-called gene-centric or reductionist models, focused on genes and equations, and a more holistic, observational approach. The assertions of this chapter seem to take the division to an extreme. Just when the reductionist school is conceding that genes might also be cooperative or parliamentary, this chapter argues why DNA is consistently selfish. Genes might cooperate to spread in unison, but each gene also competes to preserve its own copy unaltered, and force other genes in the genome to bear the cost of change. Just that genes compete for spread over tens of generations, but compete for exactness of copy over millions of generations, and this difference of scale is hard to model. This is the second contention. All the processes of life are real physical events at the instant when they occur. But within equations, humans try to capture events from billions of years past into single events of the present. Within this restriction equations will show strange effects, such as genes radiating like waves of information, rather than processes normally associated with life.

Even so, the math explained here is more a notational argument than proven equations, and no one equation anyway will ever fully capture the vast processes of life. Yet incomplete as it is, the argument here can still challenge existing models of how large-scale evolution works, or how genes and organisms do interact. Also, despite the reductionist approach inherent to equations, there is a cautious optimism. Even from a model of gene selfishness, these equations illuminate the one result that everybody suspected was the case all along. Evolution of complex new creatures, or complex new adaptations such as thought and emotion, will take more than just a few changes in allele frequencies. It is the combined effects of all evolution, accumulating over the history of life.

2.5 Human Evolution

"If the genetic components of human nature did not originate by natural selection, fundamental evolutionary theory is in trouble. At the very least the theory of evolution would have to be altered to account for a new and as yet unimagined form of genetic change in populations." **E O Wilson**

"Seen in retrospect, evolution as a whole doubtless had a general direction, from simple to complex, from dependence on to relative independence of the environment, to greater and greater autonomy of individuals, greater and greater development of sense organs and nervous systems conveying and processing information about the state of the organism's surroundings, and finally greater and greater consciousness. You can call this direction progress, or by some other name." **Theodosius Dobzhansky**

"If a large extraterrestrial object had not triggered the extinction of dinosaurs 65 million years ago, mammals would still be small creatures, confined to the nooks and crannies of a dinosaur's world, and incapable of evolving the larger size that brains big enough for self-consciousness require... We are glorious accidents of an unpredictable process with no drive to complexity, not the expected results of evolutionary principles..." **Stephen Jay Gould**

"As we shall see, technological evolution may be governed by laws similar to those governing pre-biotic chemical evolution and adaptive co-evolution. The origin of life at a threshold of chemical diversity follows the same logic as a theory of economic take-off at a threshold of diversity of goods and services. Above that critical diversity, new species of molecules, or goods and services, afford niches for yet further new species, which are awakened into existence in an explosion of possibilities." **Stuart Kauffmann.**

"At present, workers in these two fields - developmental genetics and complex systems - communicate rather rarely. Developmental geneticists see little need to invoke complex dynamics... Students of complex systems appear to think that development can be best studied by ignoring the facts of biology, and forgetting about the only serious theoretical idea we have - the idea of natural selection." **John Maynard Smith**

"Progress, then, is a property of the evolution of life as a whole by almost any conceivable intuitive standard.... let us not pretend to deny in our philosophy what we know in our hearts to be true." **E O Wilson**

2.5.1 Explaining Evolution

The theory of this book is not just about evolution. It is a theory that human evolution and behavior might be better explained if one assumes that humans evolved along a pathway in which fit moves were those that maximized options of behavior. It does not insist that humans evolved for this reason, or that this alone explains human motivation.

Yet why *did* humans evolve?

Why did intelligent life evolve on Earth when it did, not an eon earlier? Why did not a dinosaur evolve into an intelligent creature? Why is there one intelligent species? If humans did evolve along a pathway that maximized the options of behavior, why was it this pathway? Why did humans evolve by biological evolution, then transform adaptation outside of biology? If it is fit to evolve large brains why do not other creatures evolve them? Such questions imply something unique to human evolution, whereas the fashionable view now is that human evolution is a trivial, insignificant event. This raises another question: 'Why do many biologists think that human evolution is not significant?'

This chapter will outline a model of evolution that can better answer such questions. Still, the reader is warned of the trap, not in suggesting a newer model of evolution, but of inferring anything about intelligent life from having seen it on only one planet. Given sufficient time abundant life will evolve towards a *saturated* state. Beyond this intelligent life will evolve, not into humans, but it will shift adaptation outside biology. This is reasonable, because large animal life had been evolving higher rates of adaptation, versatile behavior, and intelligence long before humans. And if humans discovered life on other planets, even if not intelligent, we could infer if intelligent life had a chance to evolve there based on trends we saw on Earth. Just we could not say of competing models of evolution that one is correct because it predicts the evolution of intelligent life. A theory could be disastrously wrong about this, because out of millions of planets that exist we only know about intelligent life on one. Indications are that it is very difficult to get a combination of planetary factors that will allow long term, stable development of life.

Even so, to those not familiar with evolution the model here might not appear different from orthodox, in ways that are easy to understand. (Cynics will complain that it is not different in ways that anybody can understand!) Yet a prominent idea is that organisms increase complexity against a loss of copy fitness. Individuals can be fit, but over a *lineage* in which complexity increases from a much simpler ancestor into a complex modern descendent, exact genome copy falls. Yet, organisms try to avoid a loss of copy, so even if higher forms evolve inexorably, they try to avoid it. Organisms try to stay simple and only evolve complexity when other pressures, over the biota of life, force them to do so.

2.5.2 Hard-to-Enact Changes

Explaining why pressures that force organisms to seek fitness over a small scale might force loss of copy fitness over a large scale is not easy. Forces of mutation, selection, and adaptation act all the time, but mostly in countervailing ways, so their net effect is slight. Yet, at other times these forces align so that their net effect is to drive evolution very far in one direction. It is similar to the easy and hard changes. The wind blows steadily across an ocean and the sea tries to move with the wind. But though both are fluid, a large mass of water is harder to move in one direction than a mass of air. So, near the surface it is easier for water to bob up and down than move in one direction. This creates an energy wave, which travels for hundreds of miles. Near a coast the sea becomes shallow, so now it is easier to move water than sand, and the waves start to break. Steady movement of air on the open sea is producing movement of water that shapes a coastline hundreds of miles away.

The action of wind on water would not be easy to visualize if we had not seen it. (Even so, how many people realize that waves form because it is easier to move wind than water?) Yet we do not picture evolution as easily as we do ocean waves. We only observe via the fossil record that new species evolve relatively suddenly then persist unchanged for long periods. We also observe, or think we do, that genes mutate at steady rates, and natural selection brings constant change. We observe DNA in isolation and conclude that it is easy to change. So, change in DNA at a steady rate should produce evolution at steady rate. Small changes in evolution do occur steadily for small changes of DNA, which reinforces our convictions. Yet on the scale of an ocean to a droplet, evolution does not act the same way, and this is very puzzling.

Step changes in the fossil record, or loss of copy fitness as organisms evolve complexity, arise because steady forces push against properties of life that are easier to alter than others. Nature adapts low cost changes first. It is only when all the easy, low cost changes have been consumed, that nature will adapt high cost, hard-to-alter changes in concentrated efforts. The step is not *radiation* of an altered type, but the build-up preceding it. The radiation of mammals 65 myrs ago looks in the fossil record like a step. Yet mammals radiated rapidly because the high cost changes had been paid in the previous 140 myrs when mammals accumulated novelties such as body fur. The Cambrian Explosion within 160 myrs was the result of a prior accumulation that might have begun with the evolution of sex, half a billion years earlier.

Even so, while the inanimate properties of matter and the developed phenotypic traits of life appear easy or hard to alter, life on Earth is encoded by DNA (some by RNA). These codes in isolation seem easy to alter, so people cannot visualize how traits encoded in DNA are hard-to-alter, enough to cause step patterns to evolution. The chapter on Easy and

Hard Changes explained why in life, codes that appear easy-to-alter in isolation can be hard-to-alter in reality. The DNA code did not evolve independently of how the universe exists physically, but it evolved in ways to reflect its extant properties.

When traits are at low cost to evolve there is no massive change. Only when phylogenies *saturate* do hard-to-alter traits accumulate. Life is fragile. Thousands of different species scattered over the globe cannot all discover that it would be fit to evolve feathers, placenta, or a large brain. Instead, among billions of individuals forming the planet's biota, each tries to adapt at a minimal cost. A pterosaur will not evolve feathers if it can fly slightly faster via a thinner wing. A dinosaur will not evolve a complex metabolism if it all it needs to run faster is a longer leg. Yet over time, over all the biota of life, all the easy changes; bigger, longer, sharper or faster become consumed. When there are no easy, low cost changes left, a peripheral population avoids extinction by paying the fitness cost of radical change.

Nature will only evolve complexity if there is a cost-efficient way. Organisms do not gain fitness by increasing complexity, but lose it if there are easier ways to adapt. As existing biota saturate, populations get pushed into marginal niches. Pressure to alter and lessened competition in the *niche* allows organisms a broader fitness cost margin. Any change of DNA extracts costs, but there are other ways to pay. Evolution from prokaryote to eukaryotic life required a large change (DNA in eukaryotic cells had to be reconfigured) which took a billion years. However, once it evolved, eukaryotic life provided mechanisms that allowed genes and chromosomes to be copied first and modified later. This lowered the cost of change by providing DNA templates for future designs. Sex further lowered the cost of change by providing greater variety at reduced risk of disruption. Although new DNA had to evolve for eukaryotic life, the cost was paid in a billion years of accumulation. By contrast, humans evolved from great apes in a few millions years, but only 1-2% of DNA needed to be modified. Costs of human evolution were paid earlier in the evolution of mammals, or earlier in the evolution of sex or eukaryotic life.

Only by allowing that complexity evolves at a fitness cost can we understand why it evolves at all.

a) Simple organisms exist first. While ever these refine by incremental fitness there is no impetus to increase genome size or complexity. Organisms at any stage are already optimized to that mode of existence. From that level no organism will enhance fitness through a large, complex change, if a rival can become slightly fitter from a small change.

b) Simpler forms of life are enduring. Bacterial designs from billions of years ago persist today, and are prolific forms of life. (Or if we seek life on near-dead planets we seek a bacterial mode, at a low cost to sustain.) Early life also appeared to evolve near rich energy sources, where it would be at the least cost removed from thermodynamic equilibrium.

c) Once existing complexity becomes *saturated* with fit types, other types will seek less fit existence at higher complexity in order to survive. If ecological and genetic resources of the planet available at the time can afford the cost of a further increase in life's complexity, selection will search out a solution.

2.5.3 Human Evolution

How then, from these preliminary remarks on a complex concept of evolution, might human evolution be explained?

Again, there is dispute about why intelligent life evolves, or which planetary conditions would allow prolific life. Yet even when planetary conditions are favorable to life, as on Earth, most biologists see human evolution as a toss of the dice. A few alleles the other way and we would be an ape. Or a few alleles a different direction, or no asteroid to wipe them out, and dinosaurs would not have given way to mammals. True, if these events had unfolded differently a man named Brutus would not have stabbed Caesar. However, trends occurred in the evolution of life on Earth, such as the increasing rate at which species were able to evolve as life became complex, which requires an explanation.

Complexity evolves at a cost, which must be paid by the time, energy, and ecological resources of a planet. If life on any planet cannot afford the cost to evolve beyond simple forms it will arrest at that point. Earth though, retains a prolific ecological account. Not just for human evolution, but for billions of years, life on Earth has never encountered a cost to evolve further complexity that the planet could not afford. So, we want to know what happens when the resources of any planet can furnish the cost of any level of biological complexity.

Complexity makes types variable so they adapt faster for equivalent cost. When one type within an existing level of complexity (here we call a complexity level a *phylogeny*) can adapt faster than any other type can afford the cost of change, that phylogeny *saturates*. But as phylogenies saturate, they split into sub-phylogenies, which also saturate. Some early mammals evolved a primate *phylogeny*, which was more variable still; litter sizes went down, paws evolved into hands, backbones and limbs became flexible, brains become larger, and behavior became social. This allowed the new creatures to adapt still faster. Once primates can adapt fastest of all species, phylogenies of species who cannot adapt as fast become saturated for like fitness. If a cat has a paw, but the primate has a hand, a cat cannot evolve a hand at the speed at which a primate can further adapt behavior. Once primates have hands, versatile limbs, large brain, varied diet, stereoscopic vision, opposed thumb and crude tools, little more can be squeezed from evolution of large animals as new novelties. At least, no large animal species can evolve as fast as advanced primates can adapt.

Another factor causing *saturation* is evolution of the brain. Early neurology evolved for reflex. Then circuits evolved for simple learning such as imprinting. Mammals evolved learning circuits that lower the cost of neural evolution, because by being rewired after birth, one basic circuit design can perform many functions. Yet once brains can evolve quickly, over the biota of life the cost of evolving new novelties in any species must be measured against the cost to an ape to evolve a bigger brain. We see this effect in flight. In any age there is a cost for a large animal adapting its phylogeny to flight. Until birds evolved feathers, pterosaurs can evolve wings at the least cost of change. Yet once feathers evolve, they are so efficient that long-range flight becomes *saturated* for all other tetrapods. Mammals can adapt short-range flight as bats, but there is one more option for flight among advanced mammals. It is to build an airplane! Remarkably, this adaptation is very fast; only five myrs of evolution from human ancestors to airplanes. So any trait, like flight, is only easy-to-evolve if there is a fitness impetus to do so, in rivalry to other means of adaptation.

Life on any planet always begins at a layer of simple organisms, but if the planet can sustain the cost, new layers add above older ones. New complexity will only evolve if it can lower the cost of further change. On Earth, evolution of increased adaptability for an increase in complexity produced trends. Everywhere, rates of evolution among recently evolved types, whether large animals, insects, birds, viruses or flowering plants increased. Large animals evolved versatile behavior, more intelligence, and higher metabolic rate, plus trade-off trends such as decreased litter sizes for increased parental care.[32] Evolution of complexity increases rates of adaptability. For large animals this shifts adaptation from altering hard biology, to altering easier attributes to adapt, such as intelligence, learning, behavior, and emotion. Eventually, the fastest rate of adaptation comes from evolving to shift all future adaptation outside of biology, into learning, behavior, and culture.

There must be important lessons in evolutionary theory from the fact that humans have evolved. Evolutionary theory, to be complete, must explain all the biological forms that have evolved on Earth, from the most simple to the most complex.

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[32] Parental care increases adaptability. Learning is more flexible than inherited behavior, so if greater care is spent on fewer infants, who survive, learning is easier to pass on.

3.0 THE THEORY OF OPTIONS

3.1 The Theory of Behavior

"How did the hominids come to be the kind of man that I honor: dexterous, observant, thoughtful, passionate, able to manipulate in the mind the symbols of language and mathematics both, the visions of art and geometry and poetry and science?" **Jacob Bronowski**

"Let us then suppose the mind to be as we say, white paper, void of all characters, without any ideas; How comes it to be furnished? Whence comes it by that vast stone, which the busy and boundless fancy of man has painted on it with an almost endless variety? Whence has it all the materials of reason and knowledge? To this I answer in one word, from experience: in that all our knowledge is founded, and from that it ultimately derives itself." **John Locke**

"The thousands and thousands of genes that influence human behavior-- genes that build the brain and govern neurotransmitters and other hormones, thus defining our 'mental organs' --are here for a reason. And the reason is that they goaded our ancestors into getting their genes into the next generation. If the theory of natural selection is correct, then essentially everything about the human mind should be intelligible in these terms. The basic ways we feel about each other, the basic kinds of things we think about each other and say to each, are with us today by virtue of their past contribution to genetic fitness." **Sewall Wright**

"As an enthusiastic Darwinian, I have been dissatisfied with explanations which my fellow enthusiasts have offered for human behavior. They have tried to look for 'biological advantages' in various attributes of human civilization… The argument that I shall advance, surprising as it may seem … is that for an understanding of the evolution of modern man, we must begin by throwing out the gene as the sole basis of our ideas on evolution." **Richard Dawkins**

"The forces of human destiny are foursome and fearsome, demonic parental programming, abetted by the inner voice the ancients called the Daemon, constructive parental programming, aided by the thrust of life called Phuis long ago, external forces, still called fate, and independent aspiration, for which the ancients had no human name..." **Eric Berne**

"While ritual, emotion and reasoning are all significant aspects of human nature, the most nearly unique human characteristic is the ability to associate abstractly and to reason. Curiosity and the urge to solve problems are the emotional hallmarks of our species; and the most characteristically human activities are mathematics, science, technology, music and the arts... " **Carl Sagan**

3.1.1 Evolution and Behavior

The *Theory of Options* is a suggested way to explain modern human behavior by evolution. There are already many theories of behavior, but mostly they are not based on evolution. Or, where a theory is specifically about evolution, such as *evolutionary psychology*, there is dispute over whether such theories can explain human behavior at all. However, if one allows that humans evolved along a fitness pathway that maximized the options of behavior, it is possible to derive a theory of psychological motivation from this. At this stage this theory is far from perfected. Yet it seems able to provide features, such as methods of therapy or testing, that one might expect from any theory of modern human behavior.

What is this proposed theory?

Well, one should not classify the topic so broadly, but generally, it might be claimed that all the modern theories of behavior fall into one of the following very general categories:

1. **Pure Psychiatry**: This is a broad group of theories originating in the ideas of Freud, though to critics Freud is now discredited. Theories in this group teach that the human mind is conditioned from an early age by parents, peers, or some traumatic experience, which affects the consciousness, or subconscious, throughout adult life.
2. **Behaviorism**: Pure psychiatric theories are difficult to test. This has led to a theory that outputs of the mind are a response to stimulus from the environment. Throughout life minds will be conditioned by environments, and these will determine behavior.
3. **Cognitive Psychology**: Behaviorism reduced mind to mechanical response to environment. Yet the brain has independent qualities that can be tested just as mind. This has led to a theory that mind has modules much like computer programs, which respond to inputs
4. **Evolutionary Psychology**: This theory is that if mind has modules, they must have been selectively adapted. The modules are 'content specific' to evolutionary needs, such as drives for sex or territory.

Onto the four existing theories, Freudianism, behaviorism, cognitive psychology and evolutionary psychology, it is now possible to add a fifth theory. This theory argues that of all the goals that humans try to achieve through behavior, people most attempt to *maximize options*. Individuals have many drives, including hungers for food, sex, or power. But the goal that humans most seem to strive for is choices over what to do next. Even so, the point of a theory about options is not to focus on one aspect of behavior, but to give a broad understanding. Human behavior is highly varied. While any theory can focus on a particular behavior, none could deny contributing influences of childhood trauma, social conditioning, evolutionary drives, or self-directed effort. A broad theory should be able to account for all these aspects of behavior, plus explain;

1. how human behavior arose through evolution
2. cultural and psychological influences on behavior
3. deep human drives like the need for religious or moral expression
4. the causes of abnormal behavior
5. how the mind works and can be tested.

As well, any theory of behavior must be sustainable against the reality of human variety. A theory of physics only has to convince specialists, but a theory of behavior has to be plausible on its own, or people will not take it seriously. A theory about the subconscious, conditioning, or genes will work in part, but human behavior is so varied that it is almost therapy resistant against attempts to explain it. This is partially what happened to Freud's theory, or theories of behavior that take evolutionary impulse to extremes. Such theories become unsustainable as more is learned about behavior, or as ideas spread and people adjust.

In this, the theory expounded here is intended not just as a scientific understanding of behavior, but a plausible explanation in everyday terms. The options effect is commonly observable. In a crisis, leaders state they will "keep their options open". To stay competitive, businesses must stay responsive to changes. In personal relations, if individuals feel edged into a position that they can no longer control, each person examines "other options". One predicament in any theory is how to explain suicide. Yet, people are driven to suicide when individuals feel that all the options in life have been closed off. Society punishes people by depriving them of options. People broaden options through acquiring wealth, knowledge, freedom, and new opportunities.

Also, no matter how much one learns about behavior, ultimately it is knowledge to increase options. This confronts humans with choices over how to utilize the new information. So, this theory need not be inherently frozen at any level of knowledge, or structured around any one "cause" of behavior. All knowledge about behavior helps humans delineate choices, which is what this theory teaches.

3.1.2 The Model of Psychology

A model of psychology derived from examining options will follow established patterns. For humans, life is not always harmonious, but is a constant jostle between colleagues, spouses, children, or parents. These conflicts arise from the dynamics of life, and from countervailing drives of a learned psychology and an inherited biology. None of this is new, except whereas other theories teach that there is a jostle for direct power, dominance, or sex, the motives in fact are mostly indirect. Humans seek not direct power, sex, or advantage, but the *options* of it.

Take drives for sex. People in all societies have had extra marital flings. Yet, while this reflects a need for offspring, the human peculiarity is that in extra-marital flings people often try to avoid offspring. Still, this explanation is enigmatic, because the physiology of the human female has ways to avoid pregnancy with less preferred males (it is claimed). Male physiology has no mechanism to avoid pregnancy though, despite that the human male might try to avoid pregnancy even if a female wants it, contrary to evolutionary intent. Fresh arguments construe how this too is a fitness advantage. Eventually though, such arguments become so convoluted that they are no longer credible, scientifically, or against how humans truly behave. So, one wonders if there is an explanation more logical scientifically, but which also makes everyday sense.

For nature to meet many competing needs it would select neurology for that purpose. Basic drives such as for sex are encoded genetically. However, complex drives (deciding an opportune time to have offspring) must stay flexible. Heterogeneous drives are enacted through the learning neurology of the higher cortex. This leads to an "inner conflict" between a biological need programmed by genes, and social restraints that are learned via culture. Yet competing drives between biology and inhibition result in a deeper need. This is for psychological reassurance that the individual is in control of biological drives, and could enact or restrain them as an option. To return to the cliché of sex, genes might "urge" the male to procure many offspring. The human male, however, most needs assurance that he has the option to do this dependent on his choosing. As motive this allows a range of observable behaviors. These include the male who philanders but does not get his liaisons pregnant, satisfying his ego that way. It also includes the male who prefers to remain chaste, or abjure female company, but who meets a psychological need of "I could if I wanted". However, people fool themselves over their options too, and this is where conflicts arise.

People do not just think through their options, but test them. While humans might only act out biological drives in fantasy or (according to Freud) subconsciously, they do test the limits of how far their options extend. There is hierarchical jostling in the primate troop or wolf pack, but human society is too complex to understand as alpha-beta hierarchies. Instead, humans evolved in ways that allow them to adapt and survive in a multiplicity of hierarchies. This motivates humans as a generality, that from whichever point in a social scale they are at, the individual tries to maximize options from that point forward. So, even if genes motivate us to mate with biologically fit partners, many humans might not physically try to produce offspring that way. Yet people will still test their *options* of how they might fare in such a competition. Individuals will constantly assess among themselves each person's attractiveness, influence, or control. Individuals also make moves throughout life to enhance options for future moves. But (as one observes) not all moves to increase options are smart, and not all displays to test one's attractiveness or influence are carefully thought through. In sex people flirt and philander to test their options, but they make stupid moves too, outside of their true power and influence. In politics, school, business, and the family, people constantly make moves to improve options vis-à-vis rivals, or to assess how they would fare in an overt confrontation.

Moves to increase options give human life its dynamic. Humans do not engage (mostly) in fratricidal struggle because they depend on each other for group cooperation. As well, the human gene pool is so mixed that raw biological motive is lessened. So, rather than evolve a gene for each behavior, it was simpler for selection to program human psychology as a generality to pursue moves that enhance one's options, but avoid moves whose net consequences decrease options.

3.1.3 The Method of Therapy

One criticism of so-called evolutionary theories of human behavior is that while the mechanisms that they explain are interesting, they offer no method of counseling or change.[33] However, an evolutionary drive for humans to maximize the options latent in any situation is a need that can be adjusted. Humans evolved to maximize options, but individuals enact within a constrained range of choices, depending on each person's age, experience, abilities, and opportunities. From understanding constraints, individuals can determine the viable options, and broaden them from that point forward. Some of this is obvious. To preserve options, one does not have more children than one can support, destroy one's health, gamble away the pension fund, or addle one's brain with drugs. If paths in life that seem enticing close in one direction options that should otherwise be available, it will bring frustration and burden. In evolution, learning is only fit if it is retained. Those who never learn will suffer not just from society, but from an evolutionary program that can sense when restraint within the upper cortex is no longer working.

Therapy or counseling then, begins when an individual's endeavor to maximize options goes awry. Humans should have viable options, but an individual might feel that his or her options have closed to a point where drugs, violence, or falling down drunk every night are the only choices left. Each individual inherits a capability to maximize options, except flexible human behavior is impressionable, driven by mood, or childhood or cultural perception. Within the impressionable human brain individual perceptions can become distorted, or behaviors become self-destructive, in ways that close off options that would otherwise be available.

[33]The argument could be that most abnormal behavior is genetic, which might eventually be corrected that way. But many of the therapies are a long way off, and maximizing spread of one's DNA is hardly a principle to establish normal modern behavior.

Details of the therapy are not developed. But a suggested procedure would be to first explain that the deepest satisfaction for any individual would come from each person knowing that he or she has viable choices in life, or control over a situation. (If a someone is about to jump out a window, the procedure is to first calm the person down.) After explaining the theory, a counselor would then try to establish facts surrounding any situation that an individual might be facing. One harsh fact is that any person has a limited set of options physically. Often people do not have the wealth, attractiveness, or opportunities that a person might consider necessary to obtain the options that some individuals crave, or obtain the recognition to which a person might feel entitled. Counseling can only establish the options that are available, within the realities of a situation. Then the counselor needs to establish two more things.

1. If the individual insists on pursuing options that are not real, or are physically unavailable, the counselor needs to find out why, as there is a problem with perceptions or expectations.
2. Even if the options are achievable (such as not falling down drunk every night) one must examine why a person has difficulty obtaining options that should be available to any mature individual.

These problems could be of the deep psychology, perhaps related to destructive childhood influences, pathology, or habituation to alcohol or drugs, that has a deeper cause. This is standard counseling. Where this method might differ from other theories though, is by insisting that all knowledge, even from counseling, results in choice. Interchange among people of a counseling type is to delineate for individuals their viable options. If counseling establishes that an individual needs to modify his or her behavior and that person chooses not do it, that is information for further choices by other individuals. One confronts an individual with viable choices, to see how he or she responds.

Even with drives for sex, the need is not reproductive fitness (drives needing therapy are mostly not reproductive) but to test an individual's 'I could if I wanted' options. Counseling is to establish the individual's real doubts that he or she felt entitled to as options, or why the options might not be available. Normal behavior is an ability to assess or fulfill options in a mature way. It is when unbalanced drives for aggression, sex, or greed take control, limiting real options, that there is a problem. The task of therapy would be to uncover the problem, then suggest viable options for the individual to improve life from that point forward. This might differ from Freudianism, in that one should examine the options available to an individual first. Only then should one consider if childhood trauma was a factor interfering with current options, or if there was another problem, of which childhood trauma was an effect.

3.1.4 How the Mind Works

Modern theories of behavior must not just explain motive, or provide a method of therapy. They also need a theory of how the mind functions. Science though, requires more than just an abstract theory. It needs ideas that can be tested. However, while all modern theories use testing, they tend to treat the mind as a 'black box'. This presumes that the working of the mind can only be understood from the responses it makes.

For example, cognitive psychology treats the mind as a computer, by which it means 'hardware' and a 'program'. However, it incorporates an esoteric principle (from days before people actually built computers) that apart from speed, all computer hardware is equivalent. So effectively, only the 'program' needs testing. However, computers that people build are not just abstractions, but machines assembled from many parts; clock, power supply, CPU, memory, video, and so on. The parts have different costs, run at different speeds, and perform different tasks. To be a success (to survive in a competitive market place) a computer must be built in a way that maximizes performance against the cost of each part. Brains are not computers, but even if we took the brain as 'hardware', we should expect that it will also compose of many parts. Each part would have evolved for different functions at different costs, but all the parts must work together to maximize some benefit against a cost to evolve. The diagram shows a simplified human brain, although all brains grow, mature, and modify over the lifetime of the individual.

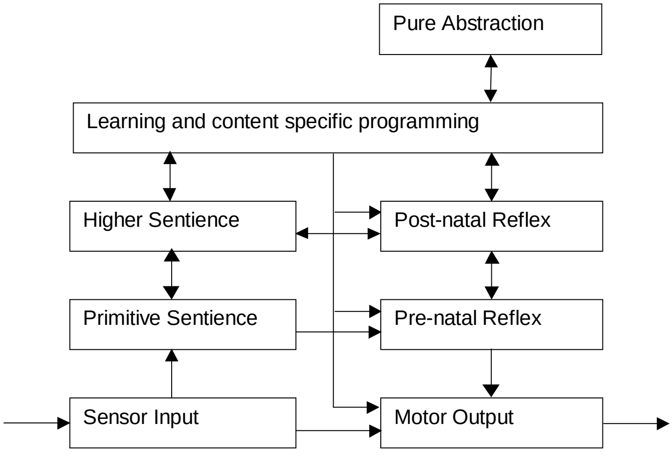

Fig 3.1.1 Even to test the brain as a 'black box', one would not expect it to be less complex than a computer, or a minimum complexity shown here. (Centuries ago, to explain the brain, we would have drawn a diagram with angels, devils, or watch mechanisms inside a person's head. Today though, we explain many processes, including how brains or computers work, by a simple flow diagram.)

As the brain evolves it builds in layers. Input/output of the lowest layers is fast and reliable. Just that pre-natal reflex is inflexible, and each circuit must be expressed maybe at a gene per circuit. Post-natal learning lowers the genetic instructions per number of circuits (genetic density), because the neural circuits can complete connection details after birth by experience. This allows an expanded brain for minimum genetic costs, and allows a flexible brain. Yet speed and reliability go down as learning increases, and brain bulk has high metabolic costs. As well, the functions of the layers optimize. As functions become fixed by repetition selection will refine them into reflex, but when the species must increase brain bulk, or new challenges arise, learning circuits increase. We have learned from the computer industry that design success comes from selecting an optimal balance of cost, speed, and reliability. Over the history of life, selection balanced the cost-effectiveness of which brain functions could best enact which types of modules.

So, although one tests the brain to find out how it works, it would be from a premise that the human brain evolved in a way to maximize the *options* of behavior, for a given cost to evolve.

1. First test to establish which functions are pre or post-natal reflex, long term or short term learning, or any combination.
2. Having established which modules the brain uses, one then questions why. Using the broader theory, a brain offering the *maximum options of behavior* for the *least cost to modify* was the one that triumphed.

At this stage none of this testing has been done. This theory was formulated for a slightly different purpose of the evolution debate. There are also many other theories of how the mind works, and ways of testing these theories, not concerned with the physical structure of the brain or how it evolved. But this is the issue too. Theories of a pure psychology tend to see the mind's modules as 'software' only, pliable to any degree of conditioning or manipulation. Theories such as evolutionary psychology see the modules as fixed, hardwired by evolution. However, a theory that humans evolved to maximize options allows that the brain evolved as a composite. Modules might be hardware, software, or any combination, depending on the selective advantage to each solution (Further details are given in Chapter 3.3 and all of Part 4.0) The concept of maximizing options also suggests how the functioning of the brain can be tested, in a way that makes predictions.

The usual prediction is that the brain evolved in a way to maximize survival. It did, but human survival depended on a brain that maximized the options of behavior, for a given cost to evolve.

3.2 The Theory of Emergence

"Human evolution began when the African climate changed to drought: the lakes shrank, and the forests thinned out to savanna. And evidently it was very fortunate for the forerunner of man that he was not well adapted to these conditions. For the environment extracts a price for the survival of the fittest; it captures them." **Jacob Bronowski**

"The evolution of anatomical adaptations in the hominids could not have kept pace with these abrupt climate changes, which would have occurred within the lifetimes of single individuals. Still, these incremental environmental fluctuations could have promoted the incremental accumulation of mental abilities that conferred greater behavioral flexibility." **William Calvin**

"Neanderthal people ... were probably much better adapted to the cold than modern man... But the Ice Age did not last. The North warmed up again and the Neanderthals no longer had their advantage. True to the evolutionary pattern, however, *Homo* had kept its options open." **Gribbin and Cherfas; The First Chimpanzee**

"Human social evolution proceeds along the dual track of inheritance: cultural and biological. Cultural evolution is Lamarckian and very fast, whereas biological evolution is Darwinian and usually very slow." **E O Wilson**

"What a piece of work is man! How noble in reason! How infinite in faculty in form, in moving how express and admirable! In action how like an angel! In apprehension how like a god! That beauty of the world! That paragon of animals!" **Shakespeare**

"We must, however, acknowledge ... that man with all his noble qualities, with sympathy which feels for the most debased, with benevolence which extends not only to other men but to the humblest living creature, with his god-like intellect which has penetrated into the movements and constitution of the solar system- with all these exalted powers- Man still bears in his bodily frame the indelible stamp of his lowly origin." **Darwin**

3.2.1 Why Humans Evolved

The theory in this book is not special pleading that human behavior can only be explained by evolution. It is instead two theories, one about behavior, the other of human evolution, each self-supporting;

1. **Theory of Human Evolution:** Human evolution is best understood if we consider that the fitness pathway leading to the modern human physiology was to maximize the options of behavior.
2. **Theory of Behavior:** Human behavior can be best understood if we consider that each individual strives to maximize his or her options in life. (Individuals strive as psychological compulsion. If they do not succeed, it could lead to frustration, trauma, violence, etc.)

Theory 1 concerns evolution of human novelty. If one wonders why humans evolved a hand delicate enough to perform brain-surgery, it was not for that end. So the question becomes; which design of a hand would maximize the options of behavior? One discovers that the modern hand offers the most flexibility for a given cost to evolve from what it was (an ape hand) into what it became. A hand more delicate than a human one is conceivable, but all change bears a cost. A hand that evolved maximum flexibility for the least evolutionary cost of change happens to be capable of performing brain surgery, although it might not be delicate enough for other tasks, which might need a robot hand. It is similar with body fur. For maximizing options a body devoid of fur offers the option of going naked, if other means can be found of keeping warm. Yet the body need not be totally naked. There is a balance of maximum flexibility against the cost of evolving. This pathway leaves the human body mostly devoid of body fur, but with some residual covering.

All human biology evolved along a fitness pathway of maximizing the options of behavior against a cost of evolving. The most controversial path was leading to the brain. There was a high fitness cost to evolving a large brain, especially in dangers to the birth process. More perplexing, pre-humans walked upright, hunted, propagated and survived with a much smaller brain, evolved at far less cost. Plus our large brain is easily traumatized into unfit behavior, such as psychoses, sexual dysfunction, or actions that restrict options, rather than maximize them. Even so, a force in pre-history must have favored individuals with this large, difficult to bare, easily traumatized brain, to pass on more DNA than rivals, The task of Theory 1 is to explain those selective advantages.

The process by which humans evolved can be called *emergence*. It began 4.5 myrs ago when pre-humans first walked upright. Emergence ended when modern Homo *sapiens* "emerged" towards the end of the last Ice Age. The first act of emergence was when a group of ancestral hominoids split in response to environmental change. One group stayed within the forests, to adapt to it. The other group split off in search of a better way to adapt. The better way was through cooperation and sharing skills and knowledge. Many anthropoid species, not just humans, do that, but this was not the real transformation. The real change was in the processes that drive a species to modify. Chimpanzees adapt culture to their biology; the biology is given. Human ancestors, though, adapted the biology to the culture, which is harder to explain.

Prior to *emergence* hominoid evolution was Darwinian, and since then it has been mostly cultural. But during emergence, biological and cultural evolution interact. It is not biologically fit for humans to evolve delicate teeth and jaws, if they do not know how to tenderize food. It is not fit for them to shed natural body fur (especially as temperatures fall) unless they have found alternative ways of keeping warm. And there is no fitness advantage for humans to have sensitive hands if these have not learned how to fashion tools or grasp weapons. Yet while culture arises from cooperation, species modify from competition between individuals. One must explain how emerging individuals were cooperating culturally while competing for fitness. Textbooks are replete with statements that activities such as tool-making increase brain size, but tool making is an acquired characteristic, and brain size is inherited. Acquired changes cannot produce inherited ones (or not directly). So, there must have been other selection processes at work, or humans would not have biologically modified to the extent that they did.

The mechanisms are outlined Chapter 2.5, *Human Evolution*. As life evolves, different evolutionary pathways open while others close. Human evolution began when life was at an advanced, *saturated* stage. There were selective pathways, but most were closed by existing species. The path of adaptation to forest life, say, was closed by the line of chimps. Pre-humans migrated from woodlands to the plains, but the pathway for adaptation to four-footed locomotion on the plains was closed by animals such as lions or gazelles, which adapted millions of years earlier. For highly evolved life to be fit an organism must not only be able to adapt, but adapt faster than rivals. Yet though faster, any organism only has to be slightly fitter than its rival, because change incurs costs. This is why selection tends to drive organisms into specialization, because this is the easiest way to gain slight fitness for the least cost of change. However, once pre-humans started using tools and organizing socially, it became fitter to specialize outside of biology, especially in competition between groups. Once it was fitter to specialize into cultural and social adaptation, within biology it was fitter to generalize versatility. In human evolution individuals competed for fitness, but they did so along a narrow pathway to maximize the options of behavior. The struggle for fitness was to maximize offspring, but it assumed subtle, complex forms.

3.2.2 Mechanisms of Human Selection

Generally, human emergence saw four types of selection as follows;

1. **Environmentalism**: This is "Darwinian" selection, in that among a population, some individuals are randomly born better fitted to the prevailing conditions of struggle. (Such as a light skin being better adapted to cold climates.) Organisms not well adapted perish before they reproduce, so only the best-adapted individuals pass on DNA. This method of selection is clearly effective, except it is somewhat slow, in that fitness emerges as a statistical trend from many random failures, and it does not allow behavior to affect selection.
2. **"Behavior First"**: Means that advanced species can adapt behavior faster than they adapt biology. Early giraffes did stretch their necks to reach leaves. Following behavioral adaptation, environmental, Darwinian, selection will better adapt the species biologically to its new means of survival. Giraffes with tall necks were selected first behaviorally by the proto-species seeking taller leaves. Darwinian selection was genetic mopping-up, following behavior "first".
3. **Sexual Selection:** This means partner selection using preference or consent, rather than brute strength. It increases selectively, because it will bring many behaviors, effectively of the whole group, to focus on the problem of selection. Roughly, not just the partners select, but just as in human society, group preferences will influence individual selection. The two most successful large animal classes to flourish after the Cretaceous extinction, mammals and birds, heavily use sexual selection, so it must have advantages. Sexual selection speeds up evolution by making selection less random and more dependent on the collective group experience.
4. **Splitting-Up**: Most evolution is by *cladogenesis* in which species split into sub-groups. There was much migration, sub-branching and splitting into differentiated competing groups in human evolution. Splitting-up speeds up evolution, by bringing behavioral and group pressures to bare on the selection process. (Groups are formed by behavioral preference.) Splitting-up can be termed group selection, meaning that individuals survived or perished as groups. However, this should not be mistaken for a discredited idea, that individuals sacrifice their own fitness 'for the good of' the group.

All these processes work in mammals, and especially in hominids. Environmental selection works throughout all classes. However, as types become complex the mix of selective processes becomes increasingly behavioral. This applied to human evolution.

Take sexual selection. Mention of human sexuality always invokes interest. Yet, if sexuality is a fascination for humans there is a reason for it. One clue is that gestation, childbirth and child-rearing are more arduous for the human female than in any other species. When this occurs elsewhere in nature, such as nesting and raising young in birds, selection involves rituals like courtship and monogamous pair bonding (except the partners cheat). Even so, in species like ours where the male is physically larger, the other trend is for male sexual dominance, or even harems. Yet other attributes of humans, including the female's concealed ovulation, indicates a sexuality of monogamous pair bonding in which the female has significant choice. Plus for human ancestors, physical protection most likely came from the group, so to the human female physical strength might not be the only selection criterion. Intelligence, loyalty, adaptability, and responsibility would also be selection factors, and this might influence how the male selected females too.

However, there is another way that monogamous pair bonding would affect sexual selection. A bodily larger male in a species indicates a bully factor in male sexual selection. Yet, if the behavior of the group demands monogamy, the next best goal a large male can seek is that the mate he will be bonded to for a long time will be attractive. But what *is* sexually attractive to the human male? The esthetics of sexual partners is of great importance to humans, but few have questioned why. Perhaps the human species was trying to increase morphological distance from its ancestors. In lush forests the body of a female chimp might appear attractive to the male, but hobbling across a hot, open savanna, in a body designed for swinging through trees, would force drastic revisions to the esthetics of the body beautiful. On the savanna the lumbering chimp-like pre-humans would see the graceful creatures of the plains; the gazelle, lion, and cheetah, or birds that winged effortlessly overhead, and early hominids must have wondered why they could not move like this. We are primates, but the esthetically pleasing species to us are the panther, swan, or deer. In defeat we protrude the lower lip, hunch our backs, and shuffle like a stupid ape that thinks it can walk. In triumph we strut like the lion in its pride. Upright stature, fluid movement, delicate face, graceful walk; perhaps the intense allure of human beauty is not just for the sexuality of procreation, but reflects an innate desire bred of human evolution to liberate itself from the body of an ape.[34]

3.2.3 Splitting-Up

All species split into groups, and as groups become isolated in time they speciate into varieties. Human splitting-up would be behavioral. One basis for a split is the adventurous migrating to search for new food resources, while the cautious stay with the existing food supply. (We see a human tendency to 'stick with your own', though this is contentious.)

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[34] Other researchers have noted that the male would want a younger partner, so that she could produce children for a long time. This would also select women who looked young.

From one early split stay-at-homes evolved to become modern chimps. The wanderers became us. Because many sub-species were competing for bi-pedal life on the plains, the split-up process must have occurred many times, producing many intermediate varieties.

When other species split one outcome is each group finding a niche it can specialize to. Because evolution is towards survival in a specific niche, it will result in as many varieties as there are environmental niches to accommodate them. While because selection is forever variable with environment, adaptation never saturates. It is an 'open' process. However, human ancestors were not specializing to a one niche, but generalizing adaptation to all environments. One species can always specialize to a desert better than another can specialize to a forest. But to generalize adaptation to all environments, especially fluctuating ones, one group alone will be better adapted than all the rest. As a result human evolution becomes a closed process.. Once started the process will continue, until one species is better adapted for competition and survival than any intermediate type in every environment on Earth.

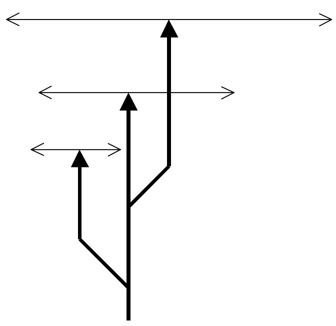

Fig 3.2.1 Human evolution was a three step process;

1. Splitting-up from main group
2. Rapid, focused evolution as a stem.
3. Radiation (migration) as a matured type.

The trap was that if a sub-type radiated too early, it lost a capability for fast, large scale evolution. A more highly evolved type (from Africa) would then radiate, displacing the earlier species, which radiated too soon.

Splitting-up explains a propensity to maximize options. Suppose that every time a new human sub-species evolved, individuals differentiated into mixes of genes; "better chances" and "better options". Each gene mix gambled on how the environment would alter. "Better chances" gambled that the environment would alter slowly over millions of years, allowing time to specialize to any change. This is not what happened. From four to three myrs ago the environment might have been relatively stable, but then it began to fluctuate. Temperatures rose and fell, rainfall varied, and forests shrank in periods as short as centuries, faster than biological evolution could adapt. At each drastic change it is possible that "better chances" was wiped out by failure to adapt in competition with versatile "better options" individuals in harsh times.

Even after "better chances" genes were wiped out, the differentiation genes survived in the remaining group, so the process would be repeated. Maybe 'strong but stupid' individuals stayed in one place, while 'slender but smart' split away. Whatever happened during rapid environmental change the "differentiation" and "better options" genes were surviving no matter what else happened. Perhaps over an era of environmental change certain genes found a way to guarantee their survival, by refining design of a species to adapt to survival in any environmental condition.[35]

Consider how events might have unfolded when the Earth began to cool. One way for a creature to increase fitness during cold would be to evolve longer fur for warmth. Still, longer fur might not increase options in a fluctuating climate, but could endanger it, as happened to the woolly mammoth. The way humans evolved, abandoning body fur and relying on wearing the furs from killed animals during cold periods provides the maximum options. If the climate became colder, one could wear more furs. If it warmed, the furs could be abandoned or used for something else. This does not mean that all humans were affected by cold. The Ice Ages produced rapid climatic changes, placing a premium on flexibility. During an Ice Age a thicker-furred hominid might have evolved.[36] Yet, when the climate warmed again the thicker-furred adaptation became disadvantaged, and the long-term survival of the hominid species using artificial fur became manifest. The creature that developed *options* over *chances* is the one that survives today.

3.2.4 The Point of Emergence

Which modification process guided human emergence?

The history of humanity suggests an intermingled selection process. Splits occurred many times. The first was evolution of *Ramidus* five myrs ago, followed by *Australopithecus* and other varieties. The primary achievement of early species was reorientation of the pelvic structure for standing erect. This biological modification might have been straight 'survival of the fittest' selection, to a point of encouraging 'better walkers' to split from slower moving cousins. *Ramidus* and later *Australopithecus* neither developed tool-making or cultural-oriented adaptations such as greatly increased brain size. So, although splitting-up occurred in the early species, direct fitness was a strong driver. Sexual selection occurs

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[35] This is a where the author first thought of the equations with an imaginary component ($\sqrt{-1}$) explained in Section 2.4. Still, it is not possible to evolve totally new genes in short evolutionary times, plus humans share 98-99% genes with chimps. Instead, genes causing groups to split and compete this way must have evolved from much earlier in life. The crucial insight too is not about genes, but how to model a prediction element that would allow DNA to anticipate what would happen next.

[36] Neanderthal man now seems to have been an Ice-Age adaptation, with a sturdier frame better adapted to cold, who was out-competed by the more versatile humans.

in all higher animals, only in hominids, the effect would be reinforced by a sexual esthetics selecting away from the body of an ape.

About 2.5 myrs ago with of Homo *habilis*, tool making emerged as an organized activity, and by 1.5 myrs ago, with Homo *erectus*, ancestors began migrating from Africa as far as Asia. Tool making and migration require cooperation, so environmental selection between individuals was giving way to competition between groups. Even so, group and sexual selection can only operate once environmental selection has stamped sufficient individual variation for the processes to select on. Migration, wiping out subspecies, or major evolution such as increasing cranial capacity is likely a group 'split-up' process. Adaptation by a group to the local environment, or racial adaptation, is regression to environmental selection. Possibly major evolution was by splitting into groups or "behavior first". Continuous modification was environmental selection, while sexual selection occurred, and still does, all the time.

Also, while only 1-2% of human DNA changed, at some point there was a major change in the chromosomes. The ape chromosomes 2 and 3 fused and some inverted. Uniformly, *all* apes have 24 chromosomes, and *all* humans have 23. It is hard to conceive of such a precise and complex change resulting from random drift among hundreds of separate groups. Such a drastic change occurred once at the start of emergence, kicking it off, or it must have occurred in a small group, and all groups without the new arrangement must have perished. Whatever the case, it is clear evidence of a tight bottleneck in human evolution. There was at least one, but there could have been many.

Still, migrating species were becoming environmentally specialized at their destinations, while not evolving much beyond attributes brought from Africa. The final split from Homo *erectus* into Homo *sapiens* less than 500,000 years ago, involved one final migration replacing all other species. Over a five myrs period many biological adaptations were tried, but for reasons mentioned only one final variety emerged. When cultural evolution takes off, the species continues to evolve biologically, but not into a new species. So for humans, the "point of emergence" may have been as little as 35,000 years ago, near the end of the last Ice Age. Humans had by then maximized their biological options. Beyond that no higher species had emerged from the boiling-pot of Africa, to displace species already migrated. At that point too a uniformly human species began to slowly occupy every continent on Earth. Though again, the final migration from Africa might have been earlier, and now racially distinct species were 'holding their ground' in Europe and Asia against any further African migrations.

What is to be made of the "point of emergence" occurring near the end of the Ice Ages? If fluctuating climate was driving human evolution, when the climate stabilized (we are not sure it has), had humans emerged optimally adapted? Cold might have accelerated human evolution, but maximizing options was a process that once started continued regardless of climate. The struggle was between emerging new species and sub-species not yet optimally adapted. This process reached a culmination, because no sub-species remain. Even if the African boiling-pot had shut down prematurely, if there were any potential left to human evolution another group might have thrown it up, unless there was something unique driving the process in Africa.

Emergence was complete when centrifugal forces of evolution in African became counterbalanced, once the earlier migrated species could competently resist by whatever means pressures from African migration. At that point human biological evolution into a new species was now complete. The end condition, not slow biological evolution, but fast culture evolution would take over. Significantly, when cultural evolution did take off, it was among migrated species in Europe and Asia. This is a vague reinforcement of the premise that the 'stay-at-homes' were the more successful Darwinian types, but those types forced to wander were the more versatile adaptations. This is controversial though, because the distribution of culture with migration is not a uniform effect.[37]

Even if one were looking for an end-point of biological adaptation, having never seen such a thing, what could it reasonably have been that the human species did not have? If say, the end-point of adaptation of body fur was dispensing it for use of an artificial covering, humans reached that. If it were replacing the bumbling gate of a chimp with a graceful bipedal movement, humans achieved that too. Humans have a body that can swim underwater or swing on a trapeze, a voice which can sing opera or give technical instructions over radio, hand and eye which can paint the Mona Lisa, and hands that can perform brain surgery. So even having not seen anything else, one feels like Miranda sighting Ferdinand, that one need look no further.

The human population is still evolving, possibly at a rapid rate. But it is no longer evolving by the split-up process, into a distinct species reproductively isolated from a species already existing. As a species that occupies every continent, and as the intelligent creature with culture that maximizes its options, whatever other phases are just beginning, the *emergence* phase of human evolution is now complete.

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[37] Eskimos or aboriginal people migrated far, but did not evolve significant culture outside of nomad existence. South American Indians migrated further than North American ones, but evolved a more intricate culture, so there must be several factors at work here.

3.3 The Theory of Knowledge

"There has been no significant biological evolution, or change of DNA, in the last ten thousand years. Thus, our intelligence, our ability to draw the correct conclusions... would have been selected for on the basis of our ability to kill certain animals for food and avoid being killed by them. It is remarkable that mental qualities that were selected for those purposes should have stood us such good stead... There is probably not much survival value in discovering a grand unified theory." **Steven Hawking**

"It is even possible that that man's swollen brain, and his predisposition to reason mathematically, evolved as a mechanism of ever more devious cheating, and ever more penetrating detection of cheating." **Richard Dawkins**

"For whether I am awake or dreaming, it remains true that two plus three make five, or that a square has but four sides. Nor does it seem possible that truths so apparent can ever fall under a suspicion of falsity." **Descartes**

"For Descartes, after all, the difference was absolute and metaphysical: animals were just mindless automa; *we* have souls. Descartes and his followers have suffered calumny ... at the hands of animal lovers who have deplored his claim that animals have no souls. More theoretically minded critics have deplored his faintheartedness from the opposite pole: How could such a sound, ingenious mechanist flinch so badly when it came to making an exception for humanity? **Daniel Dennett**

"I suggest that the neo-cortex is not primarily or exclusively a device for tool-making, bipedal walking, fire-using, warfare, hunting, gathering, or avoiding savanna predators. None of these postulated functions alone can explain its explosive development in our lineage... The neocortex is largely a courtship device to attract and retain sexual mates: its specific evolutionary function is to stimulate and entertain other people... " **Geoffrey Miller**

"Objects have no discoverable connection together; nor is it from any other principle but custom operating upon imagination, that we can draw any inference from the appearance of one to the existence of the other". **Hume**

3.3.1 Evolution of the Brain

Theories of behavior should contain a theory of knowledge. This is crucial. To understand behavior, one needs to know how the brain works. Yet the device for understanding this is the brain itself, so one first needs to know if the brain works reliably. Especially, one needs to know:

1. Why did the human brain evolve into the size and structure that it reached? Humans could have survived with a much smaller brain. So, why on the savanna did the brain evolve at great fitness cost to be a much larger one than needed for primitive life?
2. Is the modern human brain reliable for assimilating knowledge? The brain evolved into a certain size and structure then it stopped. How can one be sure that when the brain stopped evolving, driven only by primitive needs, it was sufficiently evolved for civilized life?

A fitness pathway maximizing the options of behavior helps provide an answer. Pre-humans might have been able to survive with a smaller brain, but if that brain did not maximize options the pathway along which humans were evolving had not reached an end point. At an intermediate plateau a smaller brain might have been optimal, and human evolution did stabilize at intermediate steps for short periods. Yet human evolution was not adapting for any particular niche. (Even early humans migrated quite far.) So no matter which plateau hominid evolution might halt at, new individuals with larger brains were evolving. Selection would be for individuals, but as groups grew they split. Over time less intelligent sub-groups were wiped out. A less intelligent monkey can adapt its biology to a niche more intelligent monkeys might not adapt to. But there exists no forest, plain, valley or mountain, where a more intelligent hominid could not adapt better than a less intelligent one.

The process continues until a group evolves with a brain for which there can be no easy improvement. The pattern of human evolution was for types to evolve in Africa, then *radiate* once the new feature matured. Even so, populations must remain small to evolve, so that new novelties can sweep to fixation. (This is disputed. See references to the evolution debate.) Once a population radiates it distends its means of species-wide evolution. (Also see Fig 3.2.1) Hominid types with smaller brains such as *erectus* had a brain sufficiently versatile so that the species could radiate, only the radiation was premature. A brain large enough for migration but not maximally large was a trap. Once a new group evolved with a still larger brain it too could radiate, but by then the widely dispersed earlier species had no mechanism by which to compete. It was a form of optimal search. From Africa, types with bigger brains continued evolving and then radiating until a universally adaptable type was found, which could not be displaced by further radiation.

Although there was selection to evolve a large brain other restraints would stop it evolving once optimum was reached. Humans evolved a brain that maximized the options of behavior, but only as an inclusive fitness of all things that humans do. Fitness is of individuals, but once the group can survive most hazards because all its members are intelligent, selective pressure to evolve further intelligence diminishes. If above a minimum size brains can use language, the group has many ways to compete apart from bigger brains. From when language emerged it might take another 2,000 generations to evolve a larger brain. Yet in fewer generations humans could build computers with the brains they had. No one is certain that language marked a point of fitness saturation, just an optimal search is along a pathway. It continues in fits and starts along the pathway until optimum is reached, then it stabilizes.

Even so, all previous pathways in evolution were for adapting to a unique environment or niche. Humans were adapting to maximizing the *options* of behavior. So, what was the end of that pathway as brain size? Why would an average 1,000 cc size brain not maximize the options of behavior, while a 1,350 cc brain would?[38]

It is like asking which covering of body fur offers the most options. If other means can be found to keep warm, a body devoid of fur does. Humans have a ratio of abstraction to reflex that would imperil survival by instinct, but if ways can be found to alleviate dangers, the optimum is to totally abstract thinking from reflex. On the savanna a hominid does not need to recite The Iliad or understand quantum gravity, but if his line does not evolve a brain that can abstract thinking from reflex, it will be replaced by a line that can. There are costs to evolving a large brain, but mostly in the birth process. Perhaps once the brain evolves over 1,000cc, most evolutionary costs are paid. If abstraction requires a few hundred more cc to reach it, one line will search out this option, because the pathway stays open until the maximal state is found.

3.3.2 Abstraction and Reflex

Despite evolving extra size for abstraction, does the brain work reliably? Human brains ceased species-wide evolution 35,000 years ago as the brain of Stone Age hunter-gatherers, but not of a technically advanced race. So, if evolution to a hunter-gatherer stage did not evolve the brain that civilized beings need, all human knowledge (including of how brains work) might be founded on illusion.

This problem is not new; attempts to assess the native reliability of the brain began in antiquity. The basic idea, from Greek times, was that

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[38] *Caution*: Brain size in cc is a crude measure. It is total 'free synaptic connections' that will determine if a brain can abstract. This depends on total neural density, very high in humans, and the free connections available after birth.

the senses could not be trusted, but reason had inherent methods of proof. That 2 + 3 = 5 is inherently true, even if the sense are unreliable. This was the argument of the great French philosopher-mathematician René Descartes. Descartes hypothesized that the body was animal or machine, but because it could reason, mind came from the soul. So, he split the mind from the body, roughly in the following way.

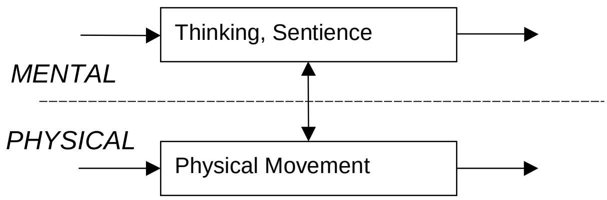

Fig 3.3.1 A Cartesian brain. It looks strange to us, but it is good start for someone who knew nothing about modern neurology, evolution, or computers.

Descartes' model was advanced, but he erred in assuming that there could be an isolated mental input and output. This is not possible. Shortly after, the English philosopher John Locke (1632-1704) pointed out that all mental impression must arise first in the senses. (So, an image of a mermaid is conjured from an impression of a fish and a woman.) Locke's idea leads to a deterministic model of the brain (not Locke's intent) in which thinking lacks an independent character. This model, shown next, is the basis of all deterministic models of the brain (both behavioral and evolutionary). This model applies to brains of simple animals, analog-type computers (Chapter 4.5) or any models in which all behavior is determined solely by the organism's evolutionary history.

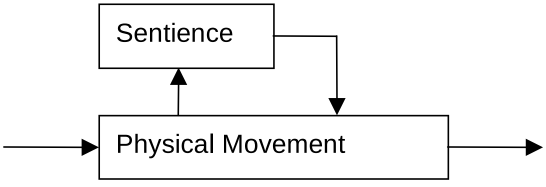

Fig 3.3.2 A deterministic brain used in some theories today, Output is determined solely by input and the physical structure of the brain.

Yet even if all thoughts arise in the senses, mathematics can derive truths independently from thoughts that humans experience as sentience. (Computers say, can derive theorems without a need of sentience.) This problem was partially solved by Hume, who showed that all impression in the thinking part of the brain is imaginative. If we observe an event repeated enough times we imagine it as law of nature, while if we organize thoughts logically, as in mathematics, we discover which ideas avoid self-contradiction. Logical truths are independent of experience. They are disciplined imagination; free but obeying laws. The senses gather data, but placing data into a picture of reality is performed in the imaginative, independent part of the brain. This requires a brain which can combine both dependent and independent modes of thought.

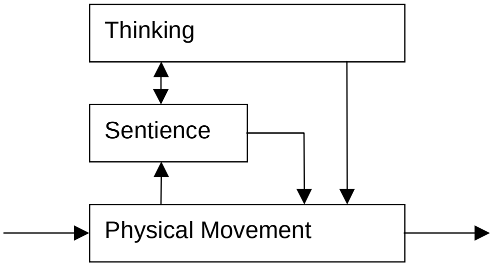

Fig 3.3.3 A composite brain, allowing both autonomous and deterministic behavior.

Although it dispenses with the soul (as an input independent of the senses) a composite brain still results in dualism, except one of types of knowledge rather than a split of mind from matter. The composite brain breaks knowledge into two branches, at least for modern humans;

1. **Analytical**, which can be proven by symbolic manipulation, such as mathematics or formal logic, but is independent of experience.
2. **Empirical**, which cannot by proven by symbolic manipulation, but must in each case be verified against the evidence of the senses.

Dividing knowledge into analysis and reflex is much criticized by evolutionary biologists, who insist that the brain evolved as a composite, down to its thoughts. Yet the split assists in resolving a circular problem of understanding how the brain works, using the brain as a tool. It allows us to note if there exist thoughts in the brain that are true regardless of how we evolved. Because of how we evolved, to our brain a monkey looks ugly but a swan is beautiful. Because of how our brains evolved, we believe in territory, Gods, or that our race is superior. Yet despite this, logic or mathematics is true independently of how the brain evolved. Humans appear good at math, and most humans have a natural grasp of ballistics and quantity. Chimps have the brain of a 1-3 year old child, but it is beyond this age that children start to grasp math. And there are other arguments that the truths of mathematics are independent of how the brain evolved. Computers can solve theorems, even though they are non-living devices. And humans could exchange mathematical knowledge with beings from another civilization by radio, knowing nothing about their biology, their brains, or how they evolved.

3.3.3 Explaining Fitness

Large brains allow abstraction, but using abstraction mostly benefits groups. So, why would a brain capable of abstraction allow an individual to pass on more DNA? Every biological enhancement comes at a cost. For the cost of evolving a brain that can abstract, a rival individual might evolve greater cunning. Other animals do not evolve large brains either, because all an organism needs is information for its survival. This is why scientists hypothesize that our brains evolved for courtship or attracting mates. Once an individual can entertain, others individuals must compete in a peacock's tail effect. (See quote by Miller.) This explanation looks desperate, but it at least accounts for individual fitness.[39]

Except this is trying to explain imaginative brains, rather than large ones. The large brain evolved because of the fitness pathway. If there were not other selective pressures driving it, species would not have kept migrating from Africa. There was a force in Africa that meant even fully erect, versatile tool-making hominids with larger brains such as *erectus*, were being pushed from the center. We assume they were being pushed away by hominids with still larger brains. If it is competition for a unique *niche* the organism only needs so much intelligence, then it can stop. Yet once a creature is maximizing options of behavior for all environments more intelligence is never enough, until requirements of full abstraction are met, or all reasonable costs are saturated.

Whether it is used for gossiping or competing for food, the fastest way to evolve a large brain is by multiplying those neural circuits with the greatest generality. When each neural circuit is designed by selection neural power is expensive, so it increases slowly, but learning circuits can be multiplied quickly and programmed after birth. Humans evolved large brains because the extra neural circuits came at a low genetic cost, though there are other costs in large brains. Low cost circuits encourage imagination, because they are highly generalized circuits that can be programmed for any requirement. The flaw in Miller's theory is not about using the brain for courtship, but that the neurology could be specific towards gossip or entertainment. The brain evolved quickly for whatever reason, but the segment of the brain that multiplied greatly was general-purpose neural circuits with a very high ratio of postnatal learning. Such brains subtend to many uses, including gossip or entertainment.

Optimizing the mind between imagination and reflex maximizes the options of thinking. Human reflex for crucial functions like metabolism, vision, voice, balance, touch, and movement, are superb where reflex alone will do. However, if basic reflex functions well, it is efficient to allow lesser reflex functions, like those for hunting or food gathering, to

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[39] A more plausible hypothesis is that as humans evolved, groups became larger from 50 to 150, so a larger brain was needed to work out the more complex interactions among larger groups. This tells us about the optimum sized group for personal contact, etc.

be generalized. Having core reflexes optimized for the functions that they perform best, but less essential circuits generalized, offers maximum versatility. Learning can program the imaginative elements of the brain for reflexive response, as for an athlete or hunter, or it can optimize the brain for another function not yet considered. However, the elegance of this is that the most intense mental activity, analytical thinking, requires verification against reflex anyway. Long before philosophers discovered this truth, evolution searched it out anyway.

So, the human brain encompasses a double optimization, offering both maximum versatility of function and expediency of design. While one set of genes specialize responses to input, other genes mold the higher cortex where the brain processes thoughts. All sentience, whether from external or internal stimuli, is expressed in the lower parts of the brain. Thoughts coursing through the higher cortex trigger emotions, but are not directly connected to response outputs. Physically, about 85% by mass, but possibly 95% by circuit of all neurons within the higher brain are connected with each other, for leaning, imagination, and reflection. Physical input and output including the control of the physical emotions and regulation of the vital functions is controlled by about 15% of the neural mass, but possibly only 5% of its circuits.

How the brain, an organism developed by evolution has become an instrument of reason and abstraction is contentious. Philosophers have long viewed the brain as a context-free 'white paper' (*tabula rasa*) onto which the experiences of life are written. Yet science has revealed a map of the upper brain as content specific to apparent reflex such as speech or coordinated movement. Still, the brain might only be 'proximity' mapped to those functions, but remains homogenous in circuit design. Evolution would select the memory 'map' of the brain, but this does not mean that selection coded (from 20-25,000 genes) one design for each of 80 billion neuron circuits of the upper cortex. And it would not select this way in just 150,000 years, when neurology has been evolving towards increased generalization for the last 500 myrs! A better interpretation of evolution is that only the brain within the total physiology must be fit. Fitness will select a higher brain that is imaginatively free, so it offers the maximum options of behavior for the least cost of adaptation.

There should be no conflict between the theory of knowledge and the theory of how humans evolved, in explaining the large human brain or its imaginative qualities. Once understood, conundrums of philosophy about the brain that have plagued mankind for millennia were solved by nature in the emergence phase of human evolution.

3.4 The Theory of Morality

"An advancement in the standard of morality will certainly give an immense advancement to one tribe over another". **Darwin**

"Innate censors and motivators exist in the brain that deeply and unconsciously affect our ethical premises; from these roots morality evolved as instinct." **E O Wilson**

"Evidently that helped to promote (by natural selection) the tendency of all primates to interpose an internal delay in the brain between stimulus and response, until it developed into the full human ability to postpone the gratification of desire." **Jacob Bronowski**

"If I am right and people are just animals with more than unusually trainable instincts, then it might seem that I am excusing instinctive behavior. When a man kills another man, or tries to seduce a woman, he is just being true to his nature. What a bleak, amoral message. Surely there is a more natural basis for morality in the human psyche than that?" **Matt Ridley**

"According to this orthodoxy, all of the specific content of the human mind originally derives from the ... environment and the social world -- and the evolved architecture of the mind consists solely or predominantly of a small number of general purpose mechanisms that are content-independent... According to this familiar view -- what we have elsewhere called the Standard Social Science Model -- the contents of human minds are primarily (or entirely) free social constructions, and the social sciences are autonomous and disconnected from any evolutionary or psychological foundation." **Tooby: Evolutionary Psychology**

"It is quite entertaining to watch a computer simulation which starts with a strong majority of suckers, a minority of grudgers which is just above the critical frequency, and about the same sized minority of cheats. The first thing that happens is a crash in the population of suckers as the cheats ruthlessly exploit them. The cheats enjoy a soaring population explosion, reaching their peak as the last sucker perishes. But the cheats still have the grudgers to reckon with..." **Richard Dawkins**

"For love *is* strong as death. Jealousy *is* cruel as the grave: the coals thereof *are* coals of fire, *which hath* a most vehement flame." **The Song of Solomon**

3.4.1 An Ancient Debate

Any theory of behavior should include a theory of morality. Humans might strive to maximize options, but once a person enjoys the maximum range of choices there needs to be some basis for choosing one course of action over another. There is a principle for this, nurtured over the history of civilization, about how to make such a choice. Traditionally, religious or ethical systems have taught that a person should choose moral 'good' when facing an unconstrained choice. Or broadly, people should always act in ways that choose good actions over evil ones.

Of course, it is not always clear which is the best moral choice, even if intentions are good. Moral values fluctuate. Killing or keeping slaves might be valued in one society, but vilified in another. Or even if values are clear, most choices are not simple. Actions have consequences, and from the best-intentioned moves people can still be hurt. If anything, one fitness advantage of morality is that it helps people make decisions. PET scans reveal that certain parts of the brain light up when an individual faces a decision that will encompass not just computation, but emotions and judgement. When that part of the brain becomes damaged, it might seem that a person would become more logical in decision making, but the opposite happens. Individuals with damage to their emotional seats of judgement easily become dominated by trivialities and paralyzed into indecision by too many choices.[40] On the other hand, too much emotion, as in anger or obsession, might also manifest as behavior that does not appear moral in an ethically understood sense.

This is how modern theories explain morality as an impairment of normal behavior. But while this might be useful for therapy, it is still not moral theory as a principle of why it *is* good to *do* good. And this applies especially to explaining morality via evolution. Many mechanisms can explain how seeming moral attributes would evolve, but regardless of the effect, moral appearing mechanisms are a stratagem to assist the spread of an individual's DNA over a rival. Yet in human society, moral good is its own end. If anything, the most saintly human behavior is regarded as abstinence or self-sacrifice, forgoing spread of one's genes for a higher good. Illicit sex or unwanted pregnancy can evoke remorse, and remorse feelings evolved for fitness. So why would it be fit to evolve inhibitions against sex, when fitness is to reproduce?

One answer is to ascribe moral perceptions (especially those such as seeing virtue sexual abstinence) to religious influence. Now it is true that perceptions such as good, evil, virtue, or sin, arose in a language-enabled, social context, influenced by religious tradition. But humans face moral torment whether under religious influence or not, and there remain other

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[40] This has been the strength of great moral leaders (such as Abraham Lincoln). It is an ability, by using principle or judgement, to cut through all the distractions surrounding a circumstance, to grasp the essence of an issue.

sources, in folk tales and legends, of a struggle between good and evil apart from religion. Moreover, complex religions arose only in the last few thousand years, after humans ceased significant evolution. Religious tales of good and evil, or heaven and hell, were more to explain feelings such as shame, guilt, remorse, or ecstasy, which already existed. So the puzzle remains of why physiological feelings that religion could exploit evolved long before complex religions existed.

Moral feelings also present a puzzle from how people might think in everyday terms. Even from a crude understanding of evolution, it might seem fit to evolve a large brain, because one thinks that by being smarter one could do better. For morality though, ruthless people often seem to do well, so one wonders how it is an advantage to be moral when it might only hold one back. In fact, long before the theory of evolution astute philosophers realized that people were individually selfish. Yet, there is no advantage to moral feelings among selfish beings, or no explanation of why the feelings would arise. There have been attempts to explain this as an ethical mean, or a calculus ensuring that one person's pleasure did not cause another one's pain. But none of these theories were convincing against how people truly acted and felt, while nothing could explain how these forces would arise naturalistically.

The evolutionary answer is that an individual only thinks that he or she is being moral, but the underlying motive is selfishness of the genes. Yet if other species survive in the wild without morality, it makes it even harder to explain why moral feelings evolved in humans. Any change extracts a cost, which must be measured against another change, such as evolving more cunning. What would be a fitness payback for individuals who were fooled into thinking that they had morals, against an individual who was not fooled by this? Theorists think that it must be an incredibly subtle game within a game, if there is any explanation at all.

3.4.2 Maximizing Options

One problem in explaining morality might be that researchers often seek immutable, fixed causes of it, but the real advantage for morality is its flexibility. This seems strange, because the usual concept of morality is that it inhibits freedom of behavior. Yet that is the point. All behavior is constrained in some way, but psychological constraints offer maximum flexibility because they are the easiest types to alter! Moral inhibition against reproduction might appear to be unfit behavior. But it would not be as unfit as an inherited inhibition against mating for certain conditions with no flexibility to adjust. The physiological attributes of morality, the moods, facial expressions, or the heart palpitations are 'hardware', and are indelible constraints. Yet while precepts of morality are also constraints, they are 'software', stored electronically in the learning-enabled higher cortex, and so they are much easier to adjust.

Still, there has to be a reason why the flexibility would evolve, and it raises several difficulties. First, there is the problem of cheating, in that while psychological constraints might be flexible, throughout evolution individuals cheat when constraints are not of a physical form. Next, while morality might offer maximum flexibility of behavior in a group context, populations still modify by individuals being slightly fitter than rivals, so one still needs to explain why it is 'fit' to be moral. Finally, if precepts such as moral good only develop in a language-enabled, social context, one must explain the evolutionary *trajectory* that leads to such precepts developing, after significant evolution has ceased.

The mechanisms of evolution expounded in this book should be able to explain these difficulties via a consistent model of selfishness at the DNA level, and direct fitness at the level of the individual. For example, while fitness confers to individuals, there has been a trend of increasingly complex group behavior throughout evolution. The "selfish" DNA reason is that while an individual's genes must share a group's success, group cooperative behavior is more adaptable, so genes already shared among the whole group are forced to alter sequence less, for new ways to adapt. Human evolution in these terms was no less selfish at the DNA level than for other species, it simply maximized an existing effect. Through group cooperative behavior say, 99% of human genes are not forced to alter sequence, for humans to adapt to a range of environments from jungles to the arctic. Or, humans could be even more naturalistically cooperative, but it would not benefit the "selfish" interest of the DNA for them to do so, against gains in adaptability already in hand.

Even at the individual level, moral-enabling behavior enacts as direct fitness, for a pathway maximizing the options of behavior. Along such a pathway, it was not fit to evolve moral inhibitions directly, as hard-wired reflex, but it was still fit to have a large, flexible brain. However, for the speed of human evolution, the brain needed to expand quickly. Reflex neurology evolves slowly, but learning circuits can multiply rapidly. So, the more responses that can be transferred to learning, the faster brain size can expand. This also leaves reflex circuits specialized for automatic response, for a similar density of genetic instructions.

The result of this rapid brain expansion is a high ratio of learned to instinctive neurology. In chimps, the most intelligent animals, the ratio is three to one, but in humans it is eight to one. Even so, expanding the brain this way only works if leaning can sublimate the power of reflex. Because it is fit to have a large brain, it is fit to transfer responses from reflex to the more numerous and flexible learning circuits, but it is also fit to ensure that the process works reliably. Human behavior requires inhibition for several things, such as sharing food, cooperating on a hunt, raising orphaned children, caring for the sick, or trusting women left at home to remain sexually faithful. Perfecting neurology for a complete impulse-restraint-reward would take a long time to evolve, and it would be a tedious evolutionary effort if all inhibition performed a similar function. Instinctual punishment and reward is reflex, but the *reason* for the delay could be for sharing food in case, but sexual fidelity the next. Moving response to the upper brain makes the responses flexible, plus it allows for rapid expansion of brain capacity.

Research also shows that neurology works very much on a basis of proximity. Reasons for an inhibition need not be directly hard-wired by reflex, but the learning neurology for that function in the upper brain can be routed close to the inhibitory responses in the middle brain.[41] This way, a brain that rapidly expands its ratio of learning to reflex can with equal rapidity evolve powerful regulating moods. These ensure that the transfer of reflex to learning works reliably. Inhibitors and controllers of behavior, fit for a purpose for which they were adapted, are interpreted as feelings of "moral inhibition" at a different phase of human development, when one tries to explain them.

3.4.3 From Feelings Into Precepts

Even so, while there are evolutionary explanations of why inhibitors and regulators of behavior might evolve and be fit, especially in a rapidly expanding brain, this is not the real issue. Maximum options of behavior come not just from how the brain evolves in a physiological sense, but from precepts that the brain learns as accumulated wisdom in a social, language-enabled context. And human culture has taught that individuals are expected to act in morally responsible ways. So how did this precept develop, after evolution ceased to mold the species?

Later chapters on the origins of ethics, religion and moral feelings discuss the problem more fully. Essentially, the precept of moral good is simply the most generalized possible response to a circumstance, framed in an ethical, language context.[42] Again though, this raises the problem of why individuals do not cheat, to let the naive do good, while the cunning cheat and get away with it.

However, the problem of cheats applies to all evolution. Humans can survive with delicate hands if they learn to make tools and weapons. And humans can survive with a large, high cost brain, if that brain is educated, socially, in precepts making the human unit cohesive and efficient. Why some individuals cheat is just a statistical effect. Data does not show that evolution favors cheats, but it shows that every population has a minority of cheats who exploit weaknesses. If cheats multiply populations crash, so every population evolves anti-cheat mechanisms. In raw nature, genes

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[41] This can be called 'proximity mapping'. It allows that the brain be highly structured, but it leaves a *homogeneous* genetic circuit design, that can be modified as post-natal experience.

[42] Such as, when one advises "do the best that you can", one is offering a principle for a complex or fast altering situation for which there is no fixed solution.

determine how much an individual will cheat, but morality offers choice of which role an individual will play. The mean of intelligence by which the average human is fit allows a statistical minority of geniuses and morons. The mean by which most humans are moral, allows a statistical minority of suckers and cheats. Nobody is forced by DNA to be honest, but most people learn anyway that cheating does not pay. Cheating, like rape, is only fit if it does not incur risks, and it is only fit if rivals cannot find other less risky ways to obtain like gains.

Moreover, physical feelings, even for morality, might have a simple explanation. There is, for example, an alleged 'sexual guilt' feeling that is much discussed. Yet there is no 'sexual guilt' chemical in the brain, punishing one exclusively for sexual misdemeanors. Rather, there is a range of moods that humans can experience to regulate a range of needs. Humans might feel pain or remorse over a sexual misdemeanor, and might feel a similar quality of pain for a blundered opportunity. One presumes to know why pain in the latter case was fit, but not the former, because one instance of the pain assists selfishness, while the other works against it. Except this is trying to explain an entire transaction embracing a mix of sentiment, reflex, and moral perceptions. However, all that one must explain as fitness, really, is why this quality of pain exists in the human repertoire of responses to emotional input.

The fitness advantage arose because humans evolved not towards adaptation for a specific niche, but general adaptation. A culmination of human evolution is a species with maximum options. Because morality as learning is easier to change than inherited reflex, maximum options occur when all constraints on behavior are moral. All other organisms are trapped by their mode of evolution so that options are constrained by the dictates of reflex. Humans became free from reflexive constraint by individuals being selected to control behavior outside of impulse. Human evolution in these terms, is substitution among all behaviors of biological constraints for moral ones.

For the path of human evolution then, there were many fitness gains in a large brain and flexible behavior. Morality evolved not from a single act of fitness, but over the whole complex of human evolution;

- The shift from evolution by competition between individuals, to individuals grouping on behavioral lines, then surviving as groups.
- Optimization of biological adaptation towards cultural ends.
- The long learning period of the human infant, where parental or group instruction must be retained for a payback of the nurturing time invested.
- Rapid brain expansion with encephalization of response from the circuits of reflex to those of the learning-enabled higher cortex.
- The need for powerful inhibitions in a non-reflexive brain, to ensure that the transfer process from reflex to learning worked reliably.

3.4.4 Modern Implications

In humans, the middle part of many mental transactions is shifted to the higher cortex, and becomes learned behavior. Impulse is reflex, but the response part of morality is also reflex. If humans feel shame, love, or grief, the sentience is a product of reflex, and hence evolution. But why humans feel any particular effect arises from perceptions in the higher cortex. So, the brain has optimized the moral response function until it becomes the single most powerful reflex, overcoming fear of death. Yet it has left motivators of this powerful reflex in the imaginative part of the brain, subject to the vicissitudes of social manipulation. It is this double effect of an easily influenced cortex combined with powerful feelings of reflex, which make moral responses unpredictable when harmful cultural influences control learning.

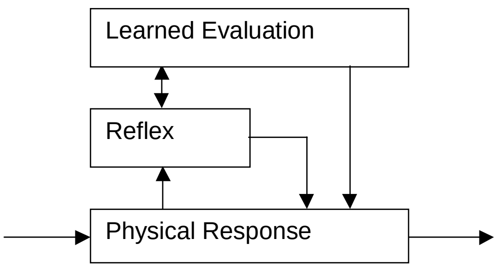

Fig 3.4.1 Humans have a complex brain for many reasons, all of which were fit at the time. Moral evaluation utilizes all available features of the brain. Morality is partly reflex and partly learned. Reflex will come from evolution, but the learned evaluation can be manipulated by society.

Moral feelings are thus partly reflexive and partly learned[43], with the learned parts easily manipulated. The leaned and reflexive segments of morality often conflict between the individual psyche and the strictures of society. The chapter on Ethics defines conflict between learned and reflexive response as the *ethical problem,* noting that this problem has never really been solved. (Chapter 5.3 suggests a solution.)

Another enigma of having moral reasoning retained in the higher cortex is that the reasoning segment of morality can be abandoned. The survivalist function of the higher cortex is learned enhancement of reflex. When times were tough, hunting, fighting, and foraging would keep the higher cortex occupied, and moral reasoning would have to compete for available neural space. Consider looking after the old, sick, or wounded. When times were good this could be a moral act with long term benefits.

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[43] As with intelligence, arranging the brain this way was an expedient of biological design. It is easier to produce billions of non-specialized neural circuits in the higher cortex and leave it to learning, than to design by trial-and-error complex circuits of reflex

Yet when times turned tough the old and sick could be abandoned, just as the reasoning which says one should care for them can be abandoned, and the neural space used for morals can be turned to survival. One can see the advantages to a species who can be moralistic when times are good but brutal when times are tough over another species, forced by limited neural flexibility into fixed responses.[44]

A further manner by which inherited moral make up affects people concerns the difference between options exercised wisely and impulse. Life for organisms is one of fixed responses. Humans escaped from this mode of evolution, but in tribal life conditions were severe enough that choices of food, survival, and procreation were limited anyway.[45] Once civilization arrives this natural restraint enforced by a limited range of options decreases, and vastly. Humans have now reached the point in civilization where broad range of options for food, sex, drink, or drugs are available, and are unsure which restraints to impose on this, if any. Historically, religious ethics dealt with this problem, but with a decline of religious influence secular answers must be found.

The precepts of morality in a modern, cultural and language-enabled context then, arise not directly from evolution, but from the entire human ethical experience over millennia of civilization. These precepts, teaching that it *is* good to *do* good, offer humans maximum range of choices, by ultimately constraining behavior to its most generalized possible goal. Yet the physiology of moral sentiment evolved for reasons not directly fit in its ethical interpretation, but only fit within the selective circumstances by which all natural attributes evolve.

Morality, ultimately, is confrontation of humans with choice, and no explanation of how morality arose diminishes its ultimate purpose. The previous chapter showed how a concept of maximizing options allowed an evolutionary explanation the brain compatible with other truths known about how intelligent beings acquire knowledge. This chapter has tried to show how the options concept leads to an explanation of moral impulse, compatible with truths established about morality by human experience, over millennia of ethical debate.

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[44] Correctly, individuals were fit if they had large brains. Groups of fit individuals with large brains survived when groups of smaller-brained individuals perished.

[45] There could even be a selection process here, in that individuals who abandoned moral restraint for impulse were banished from the tribe, or tribes which reverted to response by impulse were wiped out by morally disciplined competitors.

4.0 MIND AND CONCIOUSNESS

4.1 Brains to Consciousness

"These are the central questions that the great philosopher David Hume said are of unspeakable importance: How does the mind work, and beyond that why does it work in such a way and not another, and from these two considerations together what is man's ultimate nature?" **E O Wilson**

"What in the soul is a passion in the body commonly speaking an action; so that there is no better means of arriving at a knowledge of our passions than to examine the difference which exists between soul and body in order to know to which of the two we must attribute each one of the functions within us." **Descartes**

"It follows that our mental conditions are simply the symbols in consciousness of the changes which take place automatically in the organism; and that, to take an extreme illustration, the feeling we call volition is not the cause of a voluntary act, but the symbol of that state of the brain which is the immediate cause of this act." **T H Huxley**

"What, in fact, is the alternative to this through-and-through Darwinian vision of the mind? A last hope for the Darwin-dreaders is simply to deny that what happens to memes when they enter the mind could ever, ever be explained in "reductionistic, mechanistic terms. One way would be to espouse outright Cartesian dualism: the mind just can't be the brain... " **Daniel Dennett**

"Brains exist because the distribution of resources necessary for survival and the hazards that threaten survival vary in space and time. There would be little need for a nervous system in an immobile organism or an organism that lived in regular and predictable surroundings." **John Allman**

"We are now in a position to compare the gradual increase through evolutionary time of both the amount of information contained in the genetic material and the amount of information contained in the brains of organisms. The two curves cross at a time corresponding to a few hundred million years ago... Much of the history of life since the Carboniferous Period can be described as the gradual... dominance of brains over genes." **Carl Sagan**.

"What a waste it is to lose one's mind. Or not to have a mind is being very wasteful. How true that is." **Dan Quayle**

"Loosing Our Minds to Darwin" **Chapter heading of Dennett**

4.1.1 How Brains Work

All human physiology is an integrated whole, each part balanced with the other. The relationship of the human hand to the foot is a special optimization of function, where four general-purpose primate limbs have become optimized into two sets of limbs, one for locomotion and one for manipulation. Many parts of human anatomy form this optimization. It is hoped that if this idea becomes popular, experts will restudy all of human anatomy from this perspective.

Even so, this theory will not be accepted because the evolutionary design of the human hand, foot, or face could not be explained any other way. Instead, that unique anatomical feature, the brain, has become the enabling technology of humanity's shift from its mode of biological to cultural evolution. This was a brain rich with the learning circuits of the higher cortex. Reflex circuits existed for 600 myrs, but these are costly designs in evolutionary time or effort. Yet once they had evolved, and all mammals have them, learning circuits can be rapidly multiplied millions of times for effect. This expediency of evolutionary design is important in human development for two reasons.

1. Through learning and cultural evolution, it allows the species an alternative to the biological struggle to adapt.
2. Through the highly flexible circuits of the higher cortex learning allows breaking the chain of cause-and-effect inherent in reflexive thinking. This allows humans such novel modes of thought as imagination, abstraction, reason and moral ideals.

Yet how do brains work? It is said that humans possess intelligence, but what is that? Brains evolved by natural selection. However, if the outstanding feature of the human brain, its learning circuits, is merely a multiplied effect of an attribute evolved in primitive brains, what makes the human brain unique? The human brain is optimized for versatility and intelligence, but how do we know this?

Generally, the brain as an anatomical entity does three things.

1. It centralizes and coordinates nervous functions (a nerve center) much as a telephone exchange might.
2. It registers a reaction we call *sensation*, giving rise to consciousness.
3. It gathers information and makes responses.

Brains, as opposed to nervous systems, did not exist until sensation and organized response to stimulus evolved. Microscopic or primitive organisms and plants mostly do not register sensation, even if some possess a primitive nervous system. Yet as available *niches* fill newer organisms are forced to become mobile, actively seeking nourishment or reproduction. However, mobile organisms encounter many more effects. Rather than program a response for every effect, it is efficient to group effects, such that "this group is harmful" or "this group is beneficial". Sensation gives grouped effects immediate identification by labeling a harmful group with sentience of "pain". This allows a general response such as; "always avoid pain" or "seek things which are pleasurable". As organisms became larger outer surface area needs to react to temperature, texture, or impact. Rather than program a complete response for each nerve receptor, it is more efficient to route the receptor information to a central area sorting incoming signals as a category of sensation, which other circuits are programmed to respond to.

4.1.2 Reflex and Sensation

Use of sensation is not only efficient design, but it increases options. Without sensation the response is fixed. The receptors receive an input, which is processed by dedicated inter-neurons, and motor nerves respond via a muscle twitch. Sensation provides additional steps. Receptor nerves send a signal to the inter-neurons, but while these respond with a direct signal to motor nerves, they send additional signals to a set of inter-neurons stimulating sensation. This becomes an impetus to further inter-neurons, and so on. This way the brain can receive several signals and evaluate them for a best response. An organism can be programmed to seek food and conserve energy, but with sensation it can evaluate which response optimizes the opportunity latent in any situation.

With motive as behavior, organisms can adjust to the situation needs for procreation, food, conserving energy and avoiding danger. Balancing options broadens selective factors and speeds evolution. If an organism faces danger seeking its usual food source it might expend extra energy to seek alternative food. Organisms that do not have brains experiment with alternative food sources too, except they do it the hard way; by individuals who do not make it going extinct. Extinction is the selection mechanism among organisms with brains too, only with brains extinction has a greater selectivity because it can select out inopportune behaviors, rather than just selecting out less specialized designs.

Still, brains do not just evaluate responses. They gather information. Over evolutionary time, pleasure of light or fear at movement produce a new form of sensation. This occurs when light and movement awareness produces sensation as information only, without direct motive of "pain" or "pleasure". Higher awareness manifested as vision, and later hearing, allows organisms to register sensations that inform rather than compel. Sudden movement might compel flight as reflex, but with consciousness an organism can evaluate if the situation does require flight, or if it is safe to stay and gather more food.

Mind occurs when a brain experiences sensation without stimulus. In any brain, response to input is still biochemistry. However, as organisms become complex nature utilizes biochemistry for sensations acting as affection or emotion, without stimulation. The affection "fear" say, is an abstraction of the sensation "pain", so a higher organism can experience fear, without experiencing pain. This way "fear" motivates an organism to avoid situations causing "pain". Moods also help organisms evaluate situations where stimulus provides conflicting signals, such as sighting food and danger together. Sensation without stimulation, as occurs in *mind,* can produce impression when the brain is asleep, or unconscious. Because all higher mammals dream, learn, and feel emotion, they possess mind, though critics argue that only humans truly possess mind.

4.1.3 Learning Circuits

Early, embryonic vertebrate brains consist of three small bulges,[46] recapitulated in the embryo. The topmost bulge is the forebrain, then the midbrain, and the first bulge is the hindbrain.

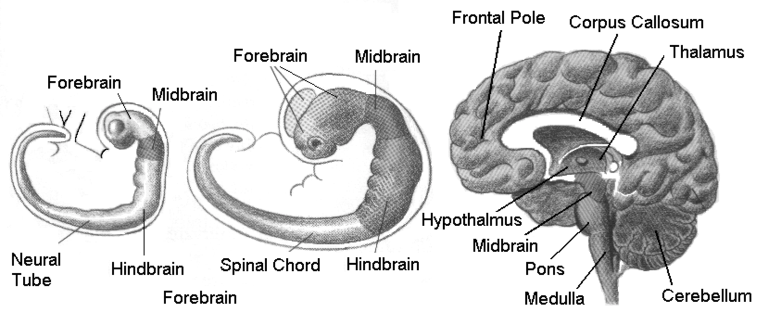

Fig 4.1.1 All vertebrate brains begin as three small bulges, recapitulated in the embryo. While the forebrain stays small in fish, it grows rapidly in higher animals. Humans grow about 80% forebrain, 15% hindbrain, and retain a small midbrain.

In a fish the hindbrain handles movement, the midbrain vision, and the forebrain smell. Movement, vision and smell were the evolutionary sequence by which needs first evolved, which suggests how the circuit types evolved. In neurology, learning takes at least two forms;

- "Memory" at a synaptic joint where wires connect to other neurons.
- Wiring of the inter-neurons in ways that can be altered after birth.

Synaptic or "memory" learning possibly evolved first, even in totally reflexive brains such as those of invertebrates. The first neural circuits of any type were reflex, with fixed wiring.[47] Fixed, reflexive circuits are ones in which axons and dendrites connect to neurons in specific patterns encoded in genes; a pattern that could only refine slowly by selection. By

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[46] An early creature had a single bulge, but apparently a mutation first into one then another extra bulge, quickly proved its efficiency.
[47] Wiring is an easily misinterpreted term, see next chapter.

contrast, with learning circuits genes do not encode wiring for a specific pattern, but instead the wiring pattern develops from stimulus that the brain receives after birth. The evolutionary advantage is that thousands of distinct reflex circuits require thousands of instructions of how to wire them. A leaning circuit however, will need only one genetic instruction to form it, but this generalized circuit can then be multiplied many times for effect. Such circuits solve two problems at once. Firstly, they allow a more flexible neurology that can be adapted to needs. Next, despite that they will result in a more complex brain, learning circuits require less genetic instructions per total number of circuit (genetic density). This becomes crucial as the information needed in brains exceeds the "bits" of information which can be encoded in genes.

The simplest rewired learning circuits are of the "wire once" type. They allow one time learning after birth by mimicry or imprinting. There is little data on this, but these circuits might have evolved with the first forebrains.[48] Yet though all vertebrates might have "wire once" learning, mammals have evolved "wire many times" learning, which provides a capacity for learning out of all proportion to primitive brains.

The factor making mammal learning so powerful is how the learning circuit is connected to the next circuit. Learning circuits, even of a "wire many times" type will not allow much learning if they are connected to fixed, reflex neurons. However, once learning circuits are connected to each other, learning will multiply rapidly.[49] In birds a "wire once" circuit can be triggered at different periods in the bird's life, on an instruction from a fixed circuit. Yet if a "wire on command" circuit separates from the fixed circuit, and becomes connected to another learning circuit, the learning process becomes freer from the genetic instruction.

Perhaps primitive brains had most of their wiring fixed at birth, but the new bulges, especially the forebrain, evolved with "loose" wires at birth, which could be modified by learning. From then on different parts of the brain expanded at different rates. Learning neurology is flexible. It can acquire new skills in short evolutionary time, and allows increases brain bulk because similar circuits can perform many functions. Reflex circuits are reliable and faster, just as the fixed computers circuits are faster and more reliable than software. Even so, each new reflex circuit must be refined by selection, a slow, costly process, so selection must strike a balance between flexibility, speed, cost and reliability.

In human brains there is massive interconnection between the "wire many times" learning circuits, and this is larger than any other form of connection. This interconnection allows thinking and learning which is *reflective* rather than *reflexive*, to an extent of allowing 'learning about

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[48] If true, then post-natal learning by rewiring might only have evolved in vertebrates.
[49] This is possibly how the "wire many times" circuits evolved.

learning'. Human DNA is 1-2% different from chimps. So, considering the other differences between chimps and humans probably not much DNA goes into neural design, apart from specifying the number of interconnected "wire many times" neural learning circuits.[50]

4.1.4 Encephalization

In early land vertebrates walking was controlled by the forebrain, which is the most flexible segment of the neurology with the highest concentration of learning circuits. However, as walking became reflexive its control was transferred to the hindbrain, leaving the forebrain free for other things to learn. Humans too have a large hindbrain for complex tasks such as muscle coordination for walking upright. The hindbrain is has about 15% neural bulk, with 11% of total brain bulk an outgrowth of the hindbrain called the cerebellum. In humans though, the midbrain remains tiny, at about 5% of neural bulk, while the forebrain dominates, with some 80% of all neural bulk. As with early computers, novel tasks were first performed by software, but as tasks became universal it became efficient to move these to hardware. Just that for humans the cerebellum expanded too quickly to have a totally fixed neurology. Most of its wiring is completed shortly after birth, though the embryonic hindbrain might be totally wired at birth.

Shifting skills from the fixed circuits of the lower brain to the learning skills of the higher brain is *encephalization*. New skills are transferred to learning neurology, but long established, essential skills are refined into hardwired reflex. Encephalization is not just an increased role for the higher cortex, but selection will shift repetitious skills to the lower brain, or refine functions for the lower brain to specialize.

This bi-directional transfer of function has several advantages. First, the behavior becomes more versatile when relocated to learning. Next, because learning circuits have an essentially similar design, they can be multiplied in great quantities for lower number of genetic instructions than is required for individual circuits of reflex.[51] Finally, though encephalization takes some tasks from reflex, the number of genetic instructions will not go down. Instead, for a similar density of genetic instructions, it is possible to refine essential reflex such as vision, metabolism, balance, and reproduction.[52]

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[50] This is why one must be careful about using just brain size as a measure of intelligence. It is the total 'free synaptic connections' wired after birth that count.

[51] This will increase the genetic density, or total number of neural circuits coded per gene.

[52] As in computers, the hardware and software both evolve. Roughly, the hardware becomes more specialized, the software becomes more generalized.

Note too that circuits for sensation are available long before learning circuits. Nature is an efficient designer, but especially with respect to neurology. So if circuits producing sensation already exist there would be no need to reinvent them once learning circuits arrived.[53] Also, learning is a more versatile and advanced circuitry, so evolution will select learning as one more 'layer' over the top of existing structure, as it did in every other advance, utilizing at a lower level designs already there. This way the learning circuits of the upper cortex are tied through inter-neurons to those producing "sensation" in the lower brain. In the human brain this works by thoughts of the higher cortex, the cerebrum, producing emotional responses in the limbic system.[54]

Because encephalization adds learning as one more layer on top of sensation, one further item of neural machinery is required, especially for human neurology. This is a "transfer circuit". These circuits supervise encephalization. They ensure that learning circuits, which are modifiable, work as reliably under stress as do the "hard-wired" circuits of reflex. Encephalization is efficient, but it transfers crucial behaviors to recently evolved learning circuits, whose behavior will not be directly controlled by the genes. This will require other circuits still programmed by genes, to control learning. There might not be an actual DNA encoded transfer circuit, but it is likely that reasoning requiring tight emotional control is routed in ways to be in physical proximity to the inhibitory neurology of the middle brain. In this sense a "transfer circuit" is more a combination of paths through the brain to ensure that emotion, which is reflex, plays a role in judgement, depending on need.

The brain then, is a purely biological organ formed by evolution. But it is an efficient organ, building in layers of added complexity since the first brains in pre-Cambrian seas. Though it evolves in layers, the brain is an integrated whole, and sentience to an organism having a brain appears as a continuum.[55] Yet when humans analyze it, consciousness appears also to evolve in layers, from reflex, to sensation, to mind, to learning and reasoning, from the simple to the very complex.

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[53] This would be especially once saturation of genetic instructions caused learning to arise.

[54] The limbic system is composed of several earlier evolved parts of the brain.

[55] Psychologists might argue that we have several layers of sensation or thought. True, but actual 'sentience' only evolved once. Normally functioning humans have only one sentient 'self', though it would be hard to test if this held for all creatures.

4.2 The "Wiring" of the Brain

For seeing life is but a motion of limbs, the beginning whereof is in some principle part within; why may we not say, that all automa (engines that move themselves by springs and wheels, as doth a watch) have an artificial life? For what is the heart but a spring; and the nerves but so many strings, and the joints but so many wheels, giving motion to the whole body such as was intended by the artificer?" **Thomas Hobbes**

"Over the years, the technological metaphor used to describe the structure of the human mind has been consistently updated, from blank slate to switchboard to general purpose computer," **Tooby: Evolutionary Psychology**

"Thus the history of neuroscience is the history of analogies, of brains as wax writing tablets, a hydraulic systems of pipes and valves, as telegraph and telephone systems, until we arrive at today's most seductive of metaphors, that of the brain as a computer. To me, this analogy is powerful but ultimately flawed." **Steven Rose**

"The newborn infant is now seen to be wired with awesome precision... This marvelous robot will be launched into the world under the care of its parents... Yet to what extent does the wiring of the neurons, so undeniably encoded in the genes, preordain the directions that social development will follow?" **E O Wilson**

"First, and most obviously, the brain is fundamentally a chemical system - even the electricity it generates comes from chemicals. More significantly, beyond the fluxes of ions into and out of the neurons, a wealth of chemical reactions are occurring incessantly in a bustling but closed world inside the cell. These events, some of which determine how the cell will respond to signals in the future, do not have a direct electrical counterpart or any easy analogy with a computer." **Susan Greenfield - The Human Brain**

"The viewpoint of strong AI, for example, maintains that a 'mind' finds its existence through the embodiment of a sufficiently complex algorithm, as this algorithm is acted out by some objects of the physical world. It is not supposed to matter what actual objects these are. Nerve signals, electric currents along wires, cogs, pulleys, or water pipes would do equally well. The algorithm itself is considered to be all-important." **Roger Penrose**

"And does not a plant or an animal, which springs from vegetation and generation, bear a stronger resemblance to the world, than does an artificial machine, which arises from reason and design?" **Hume**

4.2.1 The Debate Over the Brain

It is said that the hand that rocks the cradle rules the world. Not quite, but it can contribute small victories. The February 97 issue of Time showed an intent but happy baby on its cover. Inside were more pictures of babies being nurtured and advice on the growing brain. The article spoke of the wiring of the brain, but the rest of the message was clear. The human brain is not a computer that is switched on. It grows with environmental influences beginning in the womb. Genes wire the basic circuits and encode how to build a brain, but much of the infant mind is learned, and the effects are startling. Children raised in non-stimulating environments developed brains 20% to 30% less than normal size. Even rats raised in stimulating environments developed 25% more synapses per neuron than ones in drab surroundings.

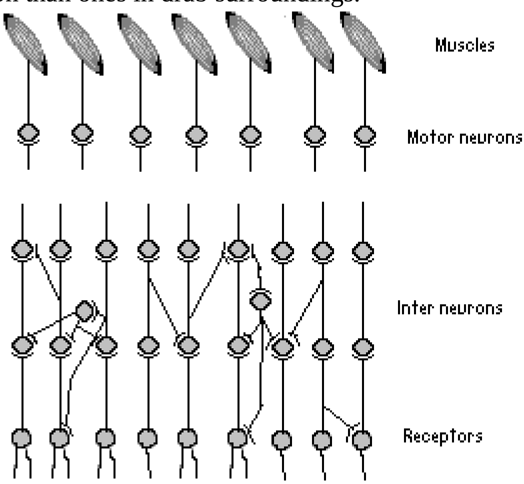

Fig 4.2.1 Diagram of inter-neurons between receptor and motor neurons. These types of circuits, fixed genetically, are the alleged 'hard-wiring'.

To those who had studied the history of debates over the brain, none of this was a surprise. It was known a long time that most connections in the human brain grow between birth and three years.[56] Other facts about the brain, such as that at birth a human child has only 25% of adult brain size, compared to a chimp's 65% were not mentioned. Nor did the article explain that even basic functions like vision are partially learned. Still, the crucial arithmetic of why it is impossible for genes to encode more than a fraction of the brain's total knowledge was given airing. "Quadrillions" of connections are required from 25,000 genes[57] available

[56] For 100 billion neurons, the connection rate averages 30,000 *per second*!
[57] The article said 50,000 genes based on a (then) 80,000 gene per genome estimate.

to specify how the brain is wired, so the rest must be learned. Much of this was known scientifically, but parents needed to know too. So it was time to amend in the public eye one of the 20^{th} Century's more enticing myths; the alleged wiring of the human brain.

"The newborn infant is now seen to be wired with awesome precision" wrote E. O. Wilson in his book *On Human Nature*. He asked to what extent the wiring "so undeniably encoded in the genes" would determine all development. *On Human Nature* was written prior to the latest research, and people are more careful with terms such as 'wiring' nowadays. Even so, the metaphor for wiring is unavoidable. The term for complex devices controlled by electrical signals is 'wired', and brains do work by electric signals travelling along wire-like fibers. If anything, in the days before people understood electrical wiring, nobody understood how nervous systems could work. However, while a metaphor for wiring is unavoidable, a thesis that genes determine human behavior because they precisely wire each neural circuit is not. So beyond the metaphor, to which extent is the brain wired really?

4.2.2 The Technical Analogy

Firstly, axons and dendrites form tubes that carry an electrochemical fluid, rather than wires. An electrical wire will not flow current until it is anchored at both ends, but tubing can flow a chemical bubble of potential along it, similar to how water can flow down an unsecured hose. This is why healthful stimulation of the newly formed brain is vital. Potential flow stimulates brain growth, so tubes that get good use find suitable connections, while those that atrophy suffer from retarded development. Connections are remade during the neuron's life, but the most dramatic changes are during the growth spurts of infancy. Parents need to check details, but the first three years are crucial for later life.

Moreover, tubing of the brain allows further learning where tubes connect to other neurons or dendrites at a synapse. In computer wiring, the number of pulses fired down a circuit will not affect how many times that circuit will fire in future, apart from instructions from the program. However, a synapse remembers how many times it fired, which affects its fire rate in future. If tubing of the axon or dendrite paths is "hard" learning, modification of the synapses is "soft" learning. So there are two learning processes in the brain, both allowing extra-genetic modification, but with no real analogy in switchboard wiring.

The third break of analogy with wiring is the firing of the neurons. In a typical circuit, many dendrites and axons from other neurons feed a neuron cell (a *soma*) via synapses. When the soma 'fires' it sends a signal down its own axon. However, the actual firing of the soma results from not one signal, but many. There is a potential build up from synapses, that results a summated firing, apart from direct potential. Other effects, such as biochemical mood, neuron memory, and quantum fluctuation, gives each neuron a tiny amount of "free will" in its decision to fire. Over billions of neurons, these tiny effects accumulate.

Moreover, even in technology the design of control circuits always differentiated between 'hardwiring' and 'softwiring'. The hardwiring was of a tougher, less flexible wire, used for essential circuits unlikely to alter. The softwiring was of a less rugged wire, easier to bend or thread. (How the terms first arose.) As technology developed, softwiring was replaced by modern electronic circuits, while hardwiring remained the physical wiring. For control systems used in industry, the rule was; "hardwire safety, softwire process". So how does this work?

Consider a water pumping system. For any pumps there are safety conditions that apply regardless. For instance, one must not run a pump dry of water as it would destroy the pump. And for any large device there is a lockout switch to disconnect power in an accident. These minimal safety devices would be hardwired into the control circuit, so that the pumps could not be run without them. However, the process could alter in ways not affecting safety. (One might run more pumps on weekdays.) Whatever it is, one must allow for change. So, providing that all the safety devices had been hardwired, one would softwire the process to make it easier to change. It is the same for traffic lights. Changing traffic lights can be complex. Yet no matter how much traffic light signals change the circuits must never allow all the lights to "fail green", such that lights facing intersecting traffic could all be green at once. Or even if a "fail green" instruction was issued, the hardwiring of the circuits should prevent it being carried out.

This is why, even for a technical analogy, people should not claim that the brain of a newborn is 'wired' without explaining first which circuits are analogous to 'hardwired', or why nature might hardwire some circuits, but will softwire others. This is how the human brain works. The embryonic mid and hind brains are hardwired at birth, with the more recently expanded cerebellum partially wired shortly after birth. On the other hand the higher brain is mostly loosely connected at birth and wired postnatal by the learning process. Just like an engineer, Nature selects a mix of solutions appropriate to each problem. Humans have roughly 80% of neural mass in the learning cortex, about 15% mass in the slightly modifiable cerebellum, but only 5% neural mass in the more primitive brain, which might be totally hardwired at birth. Part of the cortex is hardwired at birth, but humans have only 25% of adult brain mass at birth compared to a chimp's 65%. This results in about a twenty-fold increase in synapse connections after birth, which indicates how learning intensive the human brain development is.

4.2.3 The Learning Ratio

For the brain, crudely, we can call hardwired neural circuits *reflex*, and the softwired circuits *learned*. Each species then has an optimal ratio of learning to reflex, which we can call the *learning ratio*. There has to be a balance, because the greater the number of learning circuits the less instinctual safety circuits any creature would start life with. There is no data on the ratio, so one can infer that learning circuits occupy the bulkier cortex, while reflex circuits occupy the more primitive parts of the brain. As life evolves all segments of the brain grow, but the forebrain grows fastest. In early vertebrates the forebrain, midbrain, and hindbrain, each take about a third of the total cranial capacity. However, in humans, while all segments of the brain grow, the forebrain grows seven to eight times larger than the other segments combined.

Attribute	Chimp	Pre-man	Human
Brain cc	400	900	1350
Body kg.	45	54	65
Body grm./Brain cc	113	60	48
Learning cc	297	776	1201
Reflex cc	104	124	150
Learning Ratio	**2.9**	**6.2**	**8.0**
% Frontal Cortex	17%	22%	29%
Frontal cc	50	171	348
Front Learning Ratio	0.5	1.4	2.3

Humans have 3.4 times the brain volume of a chimp (about 1350cc for man to 400 cc for a chimp) but four times the area of higher cortex. This gives a three-to-one ratio of learned to reflex neurology for a chimp, but an eight-to-one ratio for the human brain.[58] More dramatic is the larger frontal cortex in humans, about 29% of the human higher cortex against 17% for chimps. If the cortex evolves from encephalization of functions previously reflex, the frontal cortex is a further encephalization of the learning of the middle cortex. This gives a frontal cortex to reflex ratio of 50% in chimps, but 230% in humans, or a human frontal cortex about seven times that of a chimp one (see Table).[59]

Absolute brain size is a function of body size for reflex, but the frontal cortex size is in direct proportion to capability. In these terms the

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[58] Assume that both species possess similar reflex in proportion to body weight. The table uses 2.3 cc of reflex brain for each kg of body weight for both humans and chimps.

[59] Neanderthal Man had a larger cranium than humans, but possibly a lesser packed neural density, especially for body size. It is also claimed that the Neanderthal baby was an extra three months in the womb, which would reduce the crucial window of post-natal learning.

human brain could posses almost a 99% commonality of circuit design with a chimpanzee, but still be a radically different brain because of the ratio of reflexive, learning, and prefrontal cortex circuits. We see the evolutionary design advantages of quickly expanding the neural capacity the human brain this way. It probably took as much evolutionary design for the large human cranium to egress the female pelvis, than to multiply the learning neural circuits.

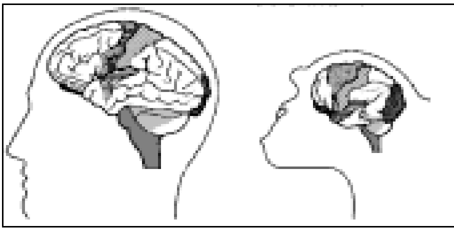

Fig 4.2.2 In a comparison of human to chimp brain, shaded areas for fixed responses are much less in proportion in the human brain. The human has about seven times more frontal cortex than a chimp, for the most recently evolved part of the brain.

4.2.4 The Large Human Brain

Why is the learning to reflex ratio so high in humans?

First, it is a quick way to expand brain size. If the brain needed to be large and available genetic transmission was saturated, learning circuits are a means to do it. Still, an excessive learning ratio creates dangers. It makes the human infant vulnerable, and requires long periods to raise the young. It also makes a young human group dependent because nearly all survival skills must be learned, plus the large cranium vastly complicates the birth process. So there must have been great evolutionary advantage to this high learning ratio, or nature would not have pushed it to such biological limits. The reason was that human evolution was filling the last *niche* on Earth, via adaptation to all possible environments. The process once set in motion did not stop until maximization was achieved. A brain that can imagine and abstract provides maximum options, and the very high learning ratio achieves that end.

Why this particular ratio? Or, if the brain kept expanding until an optimal ratio was reached, why at 7:1 was the ratio not optimal, but at a slightly higher 8:1 ratio no further modification was required?

The modes of thinking of the human brain, imagination, intuition, and reason, require breaking a chain of cause-and-effect in the universe. The brain needs to do what humans often need to do; isolate themselves from active surroundings and think things through. There are 100 billion neurons[60] in the human brain. Some 90% of these will be associated with the learning process, which cannot be exactly mapped to genetic cause-and-effect. Especially, there will be a small random noise of the electron

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[60] At one "bit" per neuron, that is only 100 Gb (gigabyte), which actually seems low. Brains should hold "terabytes" of data, perhaps stored as synaptic rather than neural memory.

firings at each synapse. One assumes that the inner neural circuits among the ninety billion learning neurons have pure reflection in their operation. The high learning ratio is a critical mass of a required number of learning circuits, to achieve abstraction in the brain. Dolphins and whales have large brains, but without the same packed neural density and post natal learning it is doubtful if they can abstract. (See footnote on Neanderthal man previous.) The crucial requirement for abstraction must be the learning ratio and total neurons, or the total number of free synaptic connections available after birth. However, there is little data on what any of these numbers should be.

This very high learning to reflex ratio in the human brain coupled with the brain's unique abstraction qualities, allows one parting remark on the wiring of the brain. When Hume discussed whether the features of the world might liken it to a well-designed house, he argued that for intentional design, one could as easily liken the world to a vegetable as to a house. Similarly, if asked what artifact the human brain might most be likened to, one answer might be a thermos flask! Just as a thermos flask isolates heat information from the inside to the outside of the flask, so the higher cortex of the human brain isolates cause-and-effect information outside of the brain from the processes that occur within it. This is how humans use imagination, reflection, and symbolism to abstract from the physical cause-and-effect of nature real human options.

The thermos flask analogy of the human brain, even if only partially correct, would make the human brain unique in the universe. One is told that every action in the universe mechanically influences every other. Brains are part of the universe responding to its inputs. However, brains, or human ones, form a critical mass of learned circuits sufficient to form an "information insulator" against outside cause-and-effect, leaving the internal circuits free to abstract. To return to the dualism of Descartes, we wonder how there can exist perfectible thoughts such as mathematics, in a universe that is not perfectible. It is achieved though the abstraction effect, which isolates perfectible thoughts of logic within themselves, obeying their own laws.

Abstraction maximizes the options of knowledge. But its effect only occurs when there is an information separation of the outside world of cause-and-effect from the inner world of self-contained analytical logic. The human brain appears to achieve this effect by a combination of large size and a packed neural mass of about 100 billion neurons. With 90% of these neurons available for synaptic modification, coupled perhaps with quantum fluctuation, the inner separation seems to be achieved.

4.3 Intuition and Judgment

"What is truth? How do we form our judgements as to what is true and what is untrue about the world? Are we simply following some *algorithm* - no doubt favored over other less effective possible algorithms by the powerful process of natural selection? Or might there be some other, possibly non-algorithmic route - perhaps intuition, instinct or insight - to the divining of truth?" **Roger Penrose**

"There are of Knowledge two kinds; whereof one is *Knowledge of Fact* : the other is *Knowledge of Consequence of one Affirmation to another*." **Thomas Hobbes**

"If we take in our hand any volume - of divinity or school metaphysics, for instance- let us ask. *Does it contain any abstract reasoning concerning quantity or number*? No. *Does it contain any experimental reasoning containing matter of fact and existence*? No. Commit it then to the flames, for it can contain nothing but sophistry and illusion." **David Hume**

"So too, it is impossible that for there to be a propositions of ethics. Propositions can express nothing that is higher." **Wittgenstein**

"These *a priori* ideas are utilized by the faculty of understanding as the way of attempting to organize and make sense of the information provided by the faculty of imagination." **Kant**

"We can now see why it is impossible for finding a criterion for determining the validity of ethical judgements. It is not because they have an 'absolute' validity which is mysteriously independent of ordinary sense experience, but because they have no objective validity whatsoever… And we have seen that sentences which simply express moral judgements do not say anything." **A J Ayer**

"There is also a Darwinian reason that we believe in free will: A society in which the individual feels responsible for his or her actions is more likely to work together and to survive to spread its values." **Stephen Hawking**

"Ye eat thereof, your eyes shall seem so clear, Knowing both good and evil, as they know." **Milton**

4.3.1 How Ideas Form

This section about mind and consciousness tries to explain both how the mind works, and how humans evolved advanced modes of thinking such as reason. They are not the same. One hopes that all humans will think and act rationally, and one hopes that explanations of how brains work will be scientific. Just that the human brain does many things; it imagines, fantasizes, and dreams. It possesses intuition, judgment, and creativity. It provides survival skills, and interacts as a complete organ. While an explanation of the brain must be scientific and logical, that does not mean that thought processes not meeting this criterion are invalid, or do not provide useful knowledge.

Long ago, philosophers discovered that truth can be of two types;

- **Analytical**, as mathematical, or deductive proofs
- **Empirical**, as facts of observation and measurement

Still, these categories allow no place for moral or judgmental truth, which Hume dismissed as mere "sophistry and illusion". Even if skeptics dismiss truths of this form, however, there is a problem. Hume reasoned that data originated in the senses, but it was associated into thoughts in the higher mind via a *grammar* of the inner psychology. This grammar will place cause before effect, just as in English one puts the object after the verb in a sentence. Still, Hume never explained where this grammar came from. Young children are not taught sentence syntax, but they still get the subject-verb-object relationship right. If senses only provide an unconnected stream of data, how from this unorganized data flow can organized thought be perceived within the higher cortex?

This question was posed by the great German philosopher Immanuel Kant (1724-1804). Kant worried that Hume had dismissed judgmental truth too easily. If thought is just a re-association of data, Kant asked, how can a mother indifferent to background noise filter the cry of her child? Kant retraced Hume's argument, reclassifying reasoning as either *analytic* or *synthetic* knowledge, depending on the *proposition*;

1. "A square has four sides" is *analytic*, because the predicate "has four sides" merely extends the meaning of the subject, "a square".
2. "This square is large" is *synthetic*, because the predicate "is large" adds new information about the *subject*, "this square".

Kant then restated Hume's argument as;

a) **Analytical** statements only prove non-contradiction. (That a square could not have three sides).
b) **Synthetical** (Kant's term) statements must be verified by evidence of the senses, such as if the square is in fact large.

Kant then proposed that certain s*ynthetical* propositions might be true *a priori* (without experience) and this allowed data to be processed in the mind. (The theory is called *apriorism*.) Kant tried to show that the truths of mathematics are also true *a priori*, such that 5 + 7 = 12 is a fact of evidence, not an analytical proposition. He was badly wrong on this, but how do categories and values form in the brain? How, from a stream of sense data does meaning, intuition, and judgment form?

4.3.2 The Learning Process

Today, there are many debates over this. Evolutionary psychology has become a surrogate of Kant's *apriorism*, supposing that innate skills of language or reason exist preformed in the mind, but that they come from "evolution". It is true that any neural function that is consistently repeatable will be refined as reflex,[61] but how much time was available during human emergence to evolve complex reflex circuits? If a chimp brain has speech or logic modules, it would be easy to multiply these for humans. Yet significant learning, distinguishing humans from chimps, especially reasoning and language, evolved in the last 100,000 years. The big change of neurology in that time was to the homogeneous frontal and upper cortex, the least likely place in the brain for specialized, pre-wired circuits. Sudden, rapid expansion of brain bulk is realized through the learning neurology, which is a pattern of evolution, that novel tasks are performed first by learning.[62] The most complex tasks ever performed such as language or reasoning are hardly going to exist the first time in the universe as hard-wired reflex. And they will not form in the short evolutionary time they appeared at an advanced, *saturated* stage of life, in a brain that is 85% leaning capable anyway.

Still, if only consistent functions are converted to reflex, one needs a measure of consistent human behavior. If human tribes survive they must do things that humans perform well, such as use language or reasoning. Humans do not have natural weapons, so tribes that tried to exist as tigers say, rather than humans, would not survive. Yet because using reason is culturally consistent it does not make it biologically consistent. Killing is a culturally consistent behavior in lions, because prides that do not kill do not survive. Even so, lion cubs raised in captivity must be re-taught to kill, so killing is not a biologically consistent behavior in lions, though we would mistake it for one if we observed only wild lions. Similarly, a human child raised by wolves would not use language, just as modern children raised in great adversity might never acquire the grammatical speech of a privileged child. There is a tragic case of a child that had one

[61] Like in computers functions first programmed in software, such as math co-processing or speech synthesis, get transferred to hardware.
[62] The very clear example was that walking was focused first in the learning cortex, and only after millions of years was it solidified as reflex.

eye bandaged for a minor ailment for the crucial few weeks when the eye "learns" to see, and lost sight of that eye. Until this case no one would have said eye coordination was learned. Horses communicate based on gestures, but blind foals perish in the wild. Humans have to raise a blind foal, then have the veterinary skills to restore its sight, then discover that this horse cannot 'talk' to other horses, before discovering that gesture language is a learned, not inherited skill in reflexive animals like horses. Evolution also repeated a pattern in that humans learned bipedal walking in the cerebellum. The cerebellum is more reflexive than the cerebrum where reasoning and speech originate, and bipedal walking evolved far longer and earlier. If early walking is learned, or vision is, after millions of years, how can sentence language suddenly appear *a priori*, the very first time it exists anywhere the universe?

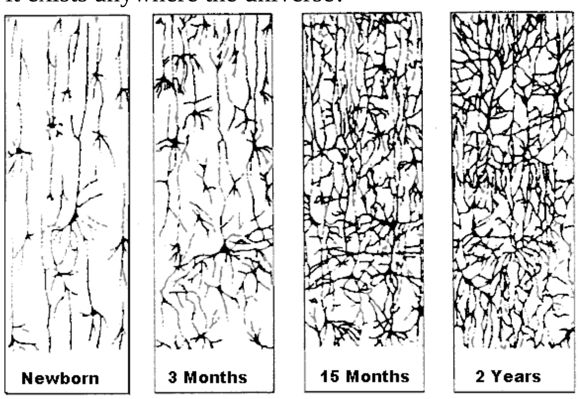

Fig 4.3.1 Growth in neural density from newborn to two years. The extent and density of the neural connections is influenced by the early learning process. It is crucial that young children get a healthy, stimulating, mental environment.

This is why Kantian organization of knowledge arises not directly by selection, but indirectly from the circuits of post-natal learning. These are possibly the 'learn-once' rather than the advanced 'learn-many-times' circuits. In the human brain these circuits are mostly in the cerebellum (hindbrain), but there must also be a great scattering of them throughout the higher brain. The brain of the human infant is completely rewired between birth and three years old. By demonstration of what this means individuals have no normal recollection of those early years. From an evolutionary standpoint it would not benefit an individual to recall the early years, but that is not the reason we do not remember. It is during the early years the brain is being "wired" not with event memory, but the post-natal reflex it will need for later life.

Unlike electric wires, the axon and dendrite tubes flow data, and it is this unordered data flow that modifies the brain. The newborn brain can process pure streams of data impinging on its senses, and from this the infant brain sorts sensation into logical categories. Kant was correct in supposing order and relation could not arise from a mere stream of sense data. Just that he got his neurology wrong, because in the brain of the newborn infant it is exactly from this stream of sense data that order and relation arise. This is why these early years are important. Kant's famous theory is so obscure that few adults today can follow it. The problem he posed however, is solved in the brains of newborn infants, between birth and three years old.

Logic represents optimization of thought processes, but the human brain is still a living organ formed by evolution. It grows, interacts, and learns. Morals, intuition, and judgment are adjuncts to thought embracing the entire neural process. Facts are *synthetical* knowledge; statements which can only be contradicted by other facts. Proof of *non-contradiction* is analysis, which includes mathematics, logic, and deduction. If humans were infinitely wise all *non-contradiction* would be *tautology*. In older philosophies knowledge had no purpose outside of its perfection. Yet the purpose of knowledge is not its perfection, but to delineate choices. Plus analytical and synthetical knowledge are not perfect forms of it. They are only the limits of knowledge to which humans proceed before they must turn to other deeply human forms of knowledge, such as intuition, or moral and judgmental reasoning.

4.3.3 The Moral Issue

In a world other than Planet Earth, the non-specialist might not care how the brain worked. We care intensely over this issue on Planet Earth because it impinges on the great debate over whether humans can be held accountable for their actions. We care because things on our planet are not going well. There is great moral good in the world, but there is also great evil. So, we want to know if human actions are responsible for the bad things in the world, or if society evolves by laws over which humans have no control. Some of us hold a view on this. "The fault, dear Brutus, is not in our stars, but in ourselves." We debate this with people holding the opposite view. Protagonists do not change their views, but the forum changes. Sometimes it is ethics or logic, sometimes it is how computers work, or sometimes it is evolutionary theory

This debate carries on through the ages. The claim that humans are not morally accountable has been buttressed through various arguments since debate began. In Greek times, the Sophists argued that the world formed by chance, that there was no naturalistic good and evil, and that teachings about morality merely reflected the views of those who held power. Two centuries ago, the argument was that far from the world existing by chance, every particle followed a strict Laplacian trajectory set for all time. So individuals, who composed of "nothing but" atoms could be held no more morally accountable for actions than planets were accountable for following fixed orbits. In the 20th Century the arguments took a different flavor. One was that the brain is formed by evolution, which is an algorithmic process that does not allow choice.

When evolution is examined carefully, though, it is discovered that morality exists for complex evaluation in a highly variable universe. Over the history of life the brain evolves different levels of complexity, from reflex, to learning, to evaluation. At each stage the brain's response to stimulus becomes more generalized.

- Pain is a sentient generalization of stimuli requiring retreat.
- Fear is an emotional generalization of situations causing pain.
- Caution is a generalized emotion concerning situations that result in unpleasantness.

Humans too face situations so probabilistic that they can only be evaluated morally. Brains that can do this are directly fit, if for no other reason than they allow larger, faster evolving brains. Modern neurology has also shown that people with damage to the emotional parts of their brain become not logical, but paralyzed with indecision. This is the issue. One perceives morals as honesty or cheating. In a computational sense, though, morality is ability to resolve choices by judgement or principle when facing the unexpected. It would be like sending a robot probe to another planet. If the robot can only perform mechanical responses, it will be less valuable to the mission than if it could reassess mission goals when facing the unexpected, based on principle.

Having morals increases options in an indeterminate world, because the broadest option is when the constraints on behavior are non-material. Non-material constraints are easy to break, which leads to debate over how they evolved, because when constraints are weak cheats will take advantage. However, a statistical population of cheats exists at every level of evolution, from DNA to humans. Change in evolution comes at a cost, including the cost of dealing with cheats. Humans paid huge evolutionary costs to evolve morals and a large brain. If they could have avoided evolving morally constrained behavior they would, cheats or not. Other evolutionary pressures confined humans within a fitness pathway where all the niches that could be filled by creatures with impulsive behavior were already saturated. Humans evolved morals and intuition to increase options in an increasingly complex world.

No theory can afford to turn away from judgment, intuition, or moral principle. Quite the contrary, humanity must examine its full range of knowledge, including its moral and intuitive experience, before it can decide from a range of values what its true options are.

4.4 Artificial Intelligence

"It seems to me that there is a fundamental conflict, as revealed by the Goedel (and the Turing) theorem, between mathematical understanding and purely computational processes. There is no obstruction to our mathematical understanding being the product of evolution provided that the physical laws with which natural selection operates are not of an extremely computational nature." **Roger Penrose**

"I have shown that those who deplore Artificial Intelligence are also those who deplore the evolutionary accounts of human mentality: if human minds are non-miraculous products of evolution, then they are, in the requisite sense, artifacts, and all their powers must have an ultimately "mechanical" explanation. We are descended from macros and made of macros, and nothing we can do is beyond the power of huge assemblies of macros." **Daniel Dennett**

"As an evolutionary biologist, I have learned over the years that most people do not want to see themselves as lumbering robots programmed to ensure the survival of their genes. I don't think they will want to see themselves as digital computers either. To be told by someone with impeccable scientific credentials that they are nothing of the kind can only be pleasing." **John Maynard Smith**

"On two occasions I have been asked (by members of Parliament), 'Pray, Mr. Babbage, if you put into the machine the wrong figures, will the right answers come out?' I am not able rightly to apprehend the kind of confusion of ideas that could provoke such a question." **Charles Babbage**

"Computers in the future may weigh no more than 1.5 tons." **Popular Mechanics, 1949**

"There is no reason anyone would want a computer in their home." **Ken Olson, founder of Digital Equipment Corp**.

"640K ought to be enough for anybody." **Bill Gates, 1981**

4.4.1 Defining A Computer

One modern paradigm of the brain, not available to an earlier age, is that of evolution. One learns about the brain by studying how it evolved. Sill, one also learns to qualify evolutionary explanations of the brain with the caveat that arguments must be based on how evolution truly works! A man having trouble with his waistline hypothesizes that the brain was selected to seek rich foods. One having trouble with his wife, rationalizes that women were selected to cheat. In reality, attributes are only fit along available pathways for sustainable costs. The human brain was selected to be fit, but only along pathway that enabled hominids to maximize the options of behavior, for the least cost of adaptation.

However, there is another useful paradigm of the mind, from which people can also learn, providing again they apply the necessary caveats. The brain processes information, but humans build machines that can do this too. And although living entities are not machines, all devices that process information likely obey similar laws. For example, humans did not know it until they built them, but tasks that humans thought were difficult, like playing chess, computers can do well. Yet simple tasks like vision, that a fish can do, computers cannot master.[63] Or, to play chess, brains must do 'terascale' computation (trillions of operations on trillions of bits of data) in a remarkably compact device. So, we need to think about things like this, and explain how brain does it. Once we know how evolution works, we can better understand how the brain works. And once we understand how computers work, we can see if the lessons learned about computers can help explain the brain.

But how *do* computers work?

A computer is a device for processing information such that from the information put in one gets higher quality of information from it. Nothing is for free, so computers enhance information two ways. They;

1. Convert the order available in raw energy into more usable forms.
2. Conserve the design energy of the device as information.

The first process is a consequence of the Second Law. Energy has an information order when it is available for useful work, higher than after the work is consumed. All computers consume energy by extracting the order available from the energy source. Computers consume far more electricity as heat and noise than goes into computation, or consume as much power when sitting idle (most of the time) than doing a calculation.

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[63] The problem might be human attitudes, more than the machine. Humans love the idea of central processing – one huge computer and one 'do it all' program. This works for chess, but not multi-function tasks like vision. Although the brain is a single organ, its functions evolved in layers, building solutions from simple to complex.

Similarly, despite that the human brain is only 2.5% of the body weight, it consumes about 20% of the energy used by the whole body.

The other way computers enhance data also results from the Second Law, only as the energy that went into the design. Whether by evolution or human engineering, design consumes energy. The microchip has made cheap computers possible because a huge amount of design "energy" has become concentrated into a very small device, including the energy of designing early microchips recycled into later designs. The brain too, designed by evolution, is so versatile because the energy of hundreds of millions of years of neural design has been concentrated into it. Again, the human brain uses about 65% of total genes for its expression, despite that it composes 2.5% of the total body by weight.

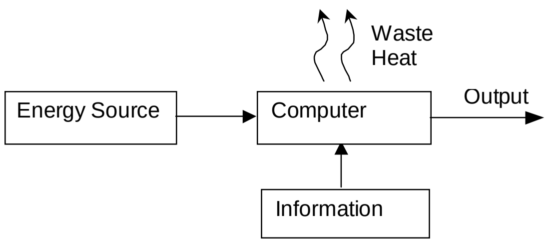

Fig 4.4.1 Computers, like any machine, display energy balance and obey the Second Law of Thermodynamics. Any new information a computer produces is extracted from the energy source. Low order information is ejected as waste heat.

4.4.2 Types of Computers

Even so, whether by nature or machine, there are two different ways to design a computer. The first is to concentrate the energy of design into hardware. So the computer will consist of three minimal components any computer requires; an energy source, data, and design hardware. This will be the simplest type of computer, because once it is connected to the energy source and data input, it can process data straight away. Industry used these types of computers for over two centuries, because they are simple and they work straight away.

A term for hardware only computers is analog, but this is not precise. Analog means 'analogous to' some process. The first computers, such as the fly-ball governor used to control the speed of steam engines, were analog computers. Other analog computers are built from gears or sliding scales. (An analog computer using gears has been discovered from Greek times.) In industry early analog computers used pneumatic pressure or an electrical current of variable strength to control processes. This gave rise to the term 'analog' meaning any variable signal, such as in telephones. However, analog signals suffer degradation, so it is usual to replace these by discrete, digital signals. This is where the terms become imprecise, because modern analog computers mostly use digital signals.

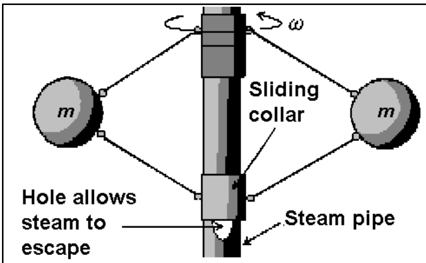

Fig 4.4.2 Simple and elegant, the flyball governor is a classic analog computer. Power to the shaft drives the computation directly, without any separate program.

(This sketch was obtained from the Brown University web site.)

For all their charm, though, analog computers remain specialized by the initial design. An analog device for calculating orbits of the planets could never play chess, or control traffic lights. So, after World War II hybrid computers arose featuring two major innovations.

a. They began using discrete digital signals for the data, to replace the less reliable analog type data signals.
b. They began using softwiring of the design, so the design could be rewired quickly when a new process needed to be modeled.

Later it was realized that digital signals, successful as the data, could also softwire the design. Part of the energy of the design, instead of manipulating wires, was arranged in an electronic program, fed into the computer before (or between) the data runs. This results in the modern programmable computer. Analog computers are three element, consisting of energy E, design, d, and input-output, x. Digital computers are four element, containing energy E, design, d, input-output, x, plus an electronic program p. One could characterize the two types as;

Analog: (E, d, x)
Digital: (E, d, p, x)

4.4.3 The Boot Problem

One advantage of digital computers, why there are so flexible, is that the design energy goes into the computer in two stages;

1. Into the hardware.
2. As the computer program.

Plus, one set of hardware can run many programs, so there is maximum utilization of the hardware design. Yet there is also a great disadvantage to the modern computer. It goes back to the problem surmised by Kant for the brain. Analog-type computers had a simple charm that they could always process data straight away. This is how the original fly-ball governor worked. Once the shaft began rotating its energy worked the fly balls, which adjusted the throttle. Programmable computers will not start so simply. The problem is hidden on modern computers, but the term 'boot' does not mean to kick the computer to start it. It refers to the idiom that 'you cannot pull yourself into the air via your own bootstraps'. Basically, a computer can only run if it has a program resident, but only a program can load another program. So, the first computers were started by feeding in the initial program manually, through electronic switches. On modern computers this initial load-up is by a hard-coded microchip (the BIOS). Then the operating system is loaded, followed by other programs, until finally the data can be processed.

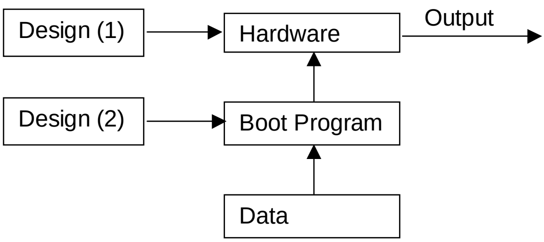

Fig 4.4.3 Design goes into analytical computers in two stages, as hardware design and a boot program, which all analytical machines require to run. Analog computers do not require a boot program. (See flyball governor previous.) In brains, the boot program appears to arise from the flow of data.

The need for a boot program is endemic to a universe inhabited by intelligent beings. In 1931 Kurt Goedel proved that within any axiomatic system at least one axiom must remain unproved, effectively the 'boot' axiom. Alan Turing proved that for any machine that could run via a program (a Turing Machine) the first program in the first machine cannot be written by another Turing Machine. Or there is Kant's observation that a stream of data alone will not provide information without an organizing principle of how the data should be processed. Such an organizing principle could not arise from the data itself.

One can call devices requiring a boot program *analytical* machines. The term is not used, but we could call hardware only devices *synthetical* machines. Early analog computers took measurements such as pressure, temperature, or engine speed, so they did add extra information as data, which is the *synthetical* function in Kant's logic. Synthetical machines include analog devices such as fly-ball governors, machines not requiring a program to process data, and the neural reflexive circuits of the brain and nervous system. Programmable computers rearrange information internally; the *analytic* of Kant's logic. These include digital computers, Turing Machines, and the higher cortex of the brain.

Using these definitions, it is possible to state the problem applying to all computers in the following way.

1. There is in nature and technology **synthetical** (analog) machines, consisting of energy, design, and input-output, of a type (E, d, x). Once assembled, all synthetical machines can function straight away, without any need of an electronic program to boot them up.
2. There also are **analytical** machines. These contain energy, design, and input-output, x, plus a program p, of a type (E, d, p, x). However, all analytical machines require a boot program to run. It would be impossible for the boot program of the inaugural analytical machine to be written by itself. Yet even if the inaugural program was written with the human brain, this only pushes the problem back one notch, because human brains too are analytical machines.
3. So, somewhere there must occur a transformation of a **synthetical** into an **analytical** machine of the type;

   (E, d, x) → (E, d, p, x).

Over the history of life this type of transformation occurred in successive generations as complex animals evolved. Yet in the brain of the newborn there also occurs a transformation of a *synthetical* device of reflex into an *analytical* device of reason. Natural neurology overcomes in newborns a formidable problem. Transforming the pure data stream into a program is a difficulty that scientists have not been able to solve. There does not exist a practical computer from which flowing data through its circuits, it could develop a Kantian program of order and relation.

This self-generating boot program might be the barrier to intuitive behavior among computers. Computers are good at analytical functions such as mathematics, and sorting data. This is resolution of tautologies. One feeds computers a set of information, from which there is only one solution.[64] As computers become faster it takes less time to arrive at solutions to complex constraints. Yet no matter how fast computers become all they are achieving is reduction of mental effort by humans. Computers, by their speed and accuracy can solve problems it would not be practical for humans to solve, so this way computers bring knowledge into the world that might not exist otherwise in practical form. Yet all the knowledge any computer has produced so far already existed in potential form. Computers add no new knowledge. All they do is arrive quickly at solutions that were too tedious to calculate any other way.[65]

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[64] For example, there is only one solution to the problem of how many people called Smith live next to a neighbor called Jones in all the streets in America. Yet despite that there is only one solution, to work it out by hand would take a massive effort.

[65] This is probably why computers are good at chess, because all possible moves in a chess game, which follow strict rules, already exist in potential forms.

Scientists can program computers to learn, though so far the learning is in the program. The hardware does not modify via learning the way the brain does, although this might be a practical rather than a technological limitation. Also, during learning the brain undergoes random inputs that supply each brain a unique learning experience, though this too might only be a problem of technology.[66] In the human brain randomness of decision making results from several processes.

a) The learning experience (unique for each individual)
b) The mood of the user affecting the synapse firing.
c) Quantum fluctuation of finely balanced firing states.

Perhaps all these effects could be simulated by a random noise. One could also simulate the learning process in hardware, such that as data flowed, decisions would be remembered for influencing the next output. Whatever way, there must be sufficient randomness to the process that it could not be repeated exactly. The computer could only exercise its own judgment when humans could no longer simulate exactly why it reached the decisions that it did.[67]

4.4.4 Machines and Consciousness

If all these technical barriers were overcome, would humans be able to build machines with true consciousness?

Such questions often lead to a debate that humans are "nothing but" machines, and can be held no more morally accountable than machines. Or it might be related to a fetish about machines, that people could make good frustrated emotional relationships by transferring affections to a non-living device. In either case, one presumes that a person asking such questions already has an answer in mind.

Still, there are areas where the intuitive power of artificial devices could be enhanced. One example is interplanetary robot probes, where these probes have less processor power than available to home PCs.[68] Also, industry needs better auto-pilot controls for emergency responses, and better controls to industrial processes, or the traffic system or the economy. This could be by hierarchical learning, with gradated forms of response. One could call higher levels of generalization 'principles', as is done for mind. Generalized responses could be learned by an evolution program, that would solve problems at the lower level first, but defer to higher principles if the situation developed unexpectedly. Such programs

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[66] In early anti-aircraft gunnery, to get the controls of a gun to follow the random evasive action of a human pilot, engineers fed a random noise into the tracking mechanism.

[67] Suppose we built two identical computer for playing chess, and subject them to a similar learning process. If each machine still played its game slightly differently, we could assume the machines were intelligent, and we could learn something new from them.

[68] Only x486 level processors have so far been 'radiation-proofed' for outer space.

might offer solutions not apparent to humans in a form of fresh, original knowledge, rather than just the speedy resolution of tautology.

Yet even if computers could learn high level responses, they might still not feel in a sentient way. Consciousness evolved to meet a need proportionate to the complexity of a problem. Initial sentient responses were pain or pleasure, which were generalized groupings of responses such as 'withdraw' or 'do again'. One could try programming a machine with low level responses such as pain or pleasure and build sentience up from there. Still, even low level responses evolved in creatures already alive, and only in life mobile enough to face choices. So life, mobility, and adaptation might be prerequisites for natural sentience, even at a low level. Humans have not been able to build devices capable of responding to the environment this way even without sentience. So, devices able to display advanced sentience such as mood or emotion must lie very far in the technological future from anything that we can build now.

Rather than seeing computers as alternatives to natural intelligence, we should see them as an extension of human intelligence, the way that machines extend muscle power. Even non-intuitive computers are fast and accurate, freeing the mind for other tasks. A computer can take a data collection of millions of bits of information, and quickly resolve it into a graph, picture, or logical representation, a task that human minds cannot do quickly. Intuitive intelligence in computers should extend this type of mental assistance. In the future it might be possible to produce intuitive-type computer runs based on the computer's prior learning experience or principles. Operators could ask the computer to delineate among the high moral and low moral case scenarios, based on principles that people or an institution has set as guidelines.

Computers are always for presenting choices, not making them. One might feed a computer with thousands of dates by which events happen, but the computer will resolve this into a single crucial date by which the operator must make a decision for everything else to follow. All that the computer has done is taken the constraints and resolved the available information into its simplest presentable form, but the choice is still with humans. Computers as analytical machines also can extent the original task of abstraction; running scenarios. One future task of computers will be modeling of possibilities, to help quantify the choices that humans face. If intuitive or judgmental knowledge can be programmed into computers which do this, it will increase options, and the choices that humans alone will have to confront.

Still, practical limitations do not stop people inferring conclusions, especially about behavior and free will. Those who view human will as determined, leaped on issues such as evolution or cause-and-effect to justify a view. So, when the debate switches from evolution to artificial intelligence, the same people find fresh arguments here to buttress views that they always held. This time the issue is what type of computer could humans ultimately build. If scientists could build a computer that could "think like us" somehow this will prove that the human will is not free.

By contrast, those who see humans as free and responsible adopt a stranger reasoning. This is that the practical limitations of computing must be contained in an analytical rule demonstrable within itself. This rule would prove that all computations reduced to propositions that could be connected to other propositions, but would reveal nothing about the real world. This is the concept behind analytical philosophy, and similar arguments are made using Goedel's or Turing's theorem. Plus there are arguments from complexity or quantum theory to show that brains must be unique in ways that machines cannot emulate. (Although critics claim these arguments are never properly understood.) Some people think that proof that the human will is not free will come once humans can create artificial intelligence. But the truth might be the opposite. One could only classify a machine as intelligent when it exercised "free will" to the extent that its human programmers could no longer be sure exactly why it made the decisions that it did.

Knowledge increases options by more clearly delineating choices, while the freedom to exercise choice makes us human. The machines of an earlier industrial age did not in the end replace humans, but relieved them of physical labor and mechanical chores. It is hoped that computers too will eventually relieve humans of rote mental labor. Computers are so useful because they relieve the brain from mental tedium, leaving it free for creative tasks that brains are good at.

Computers providing intuitive or judgmental knowledge will not replace the human role. They will let humans arrive more quickly at the task that humans do best; confronting choices over what to do next.

5.0 ORIGINS

5.1 The Origins of Culture

"Most of what is unusual about man can be summed up in one word: 'culture'. I use the word not in a snobbish sense, but as a scientist uses it. Cultural transmission is analogous to genetic transmission in that, although basically conservative, it can give rise to a form of evolution." **Richard Dawkins**

"The same conclusion may be extended to man; the intellect must have been all-important to him, even at a very remote period, as enabling him to invent and use language, to make weapons, tools, traps, etc. whereby with the aid of his social habits, he long ago became the most dominant of all living creatures." **Darwin**

"And that series of inventions, by which man from age to age has remade his environment, is a different kind of evolution - not biological but cultural evolution." **Jacob Bronowski**

"The theory of population genetics and experiments on other organisms can show that substantial changes can occur in less than 100 generations, which for man reaches back only to the time of the Roman Empire... The question of interest, then, is the extent to which the hereditary qualities of the hunter-gatherer existence have influenced the course of subsequent cultural evolution." **E O Wilson**

"The missing ingredient may have been a change in only 0.1% of our genes. What tiny change in genes could have had such enormous consequences? Like some other scientists who have speculated about this, I can think of only one plausible answer: the anatomical basis for spoken, complex language." **Jared Diamond**

"A great stride in the development of the intellect will have followed, as soon as the half-art and half-instinct of language came into use; for the continued use of language will have reacted on the brain and produced an inherited effect; and this again will have reacted on the improvement of language... The largeness of the brain in man relatively to his body, compared with the lower animals, may be attributed in chief part to the early use of some simple form of language,-." **Darwin**

"Or, ... there is a specific 'language organ' in our brain, analogous to a 'language chip' in a computer; this organ is to some degree hard-wired ..." **John Maynard Smith**

5.1.1 Defining Cultural Transmission

The idea of options is not intended as a theory of history. One can explain history as people exercising options, but using theories of natural development to explain history has bad precedent. Earlier, advocates of Darwin's theory had increased its scope from a theory of natural selection in the wild, first to a theory of human motives, then to a theory of society and history. Yet, natural selection in the wild cannot explain something as complex as modern human behavior, while grafting Darwin's theory onto concepts like race or state has led to grossly faulted ideas. In this sense, even if an options effect can explain human behavior, one must be careful of naturalistic motive as history.

A similar caution applies to culture. In refinement culture means one thing, and as geography it means another. In evolution culture means passing on *acquired* characteristics. Learning offers a rapid adaptation to change, but only inherited skills are passed on. No matter which skills the individual (the *phenotype*) acquires in a lifetime these will not be passed on to the *genotype*. (*Phenotypes* do not alter *genotypes*.) Each generation the DNA of parents is passed to offspring, but that DNA is not altered during single lifetimes by any characteristics that individuals acquire. Humans learned to use tools, and tool making needs a large brain. Heavy use of brains, especially in the young, increases synaptic connections, so brain use and a nutritious diet would make some brains physically larger during individual lifetimes. Because brains nurtured into larger types were more versatile during single lifetimes, this would favor selection of individuals with expansive brains. Yet, while nurturing a large brain in a single lifetime is fit, and those individuals will reproduce more, it is only when the genes that can express large brains are passed on that mean of brain size will increase genetically within the species. [69]

Any creature can only learn a limited amount in a lifetime. Reflex circuits provide safety, so if the ratio of learning to reflex circuits is too high the creature will have few in-built survival skills. However, with culture learning is passed on, so more than one lifetime is available to learn new skills. All higher creatures have small amounts of culture. A chimp using a stick to get termites is that chimp's learned behavior. If the trick is passed on it forms the culture of those chimp groups that acquire it. Because using sticks is not an inherited characteristic of chimps, only some groups know to do this.

However, once brains are already large, acquired characteristics pass on more easily, so that knowledge acquired in single life times are not lost to the next generation. This speeds up adaptation, another trend of

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[69] The theory that the acquired characteristics are passed on directly is called *Lamarckian* evolution after the great French scholar who proposed it, though for different reasons. Only there is no evidence of Lamarckian evolution in genetic terms, though many interactions of genes to environment, like with brain size, are not totally understood.

evolution. Learning allows animals to adapt their behavior first, then let Darwinian selection catch up. People say with metaphor that biological evolution is Darwinian and slow, while cultural evolution is Lamarckian and fast.[70] And although Lamarckian evolution does not occur in a misunderstood sense, early giraffes did stretch their necks,[71] just as early human individuals acquired large brains in single lifetimes through rich diet and increased brain use. By use of tools and activities that use brains, pre-humans adapted faster in changing environments. Within such conditions of struggle individuals naturally born with large brains tended to survive and pass on more offspring. Just that with humans the process once begun did not stop half way. Unlike giraffes adapting to taller trees, humans were adapting to all environments. The result was a species that tended to shift all adaptation into learning and culture.

5.1.2 Leaning and Use of Artifacts

There are three main methods of cultural transmission in humans;

1. learning
2. use of artifacts
3. language

Learning is the oldest form of cultural transmission. It began about 200 myrs ago when species needed more information in their brains than could be passed on by via genes. This corresponds to the first mammals, though there is learning in reptiles and birds. Many birds learn variations on songs whose sound might have arisen by genetic memory only. And because songs are a survival attribute in birds (to attract mates) perhaps all songs first arose this way. But learned songs, which came later, are a culturally transmitted behavior.

Even so, learning in small-brained creatures is often by imprinting, learning the first thing that happens along. (Like ducklings following the first object they see which moves.) However, the next form of learning, imitation, is more versatile. Perhaps the outstanding example of imitation learning in any species is the human 'crawl' stroke in swimming. All through emergence and until late civilization, humans did not know the basic skill of how to swim at speed over distance. Yet once the skill was demonstrated to others (by movies and TV) it was rapidly copied. To evolve the human species to swim at the speed over distance of the crawl stroke would take thousands of generations, if possible at all. Thus, the crawl stroke is a culturally transmitted behavior of humans, and a recent one, although it is a basic survival skill.

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[70] See quote by E. O. Wilson Chapter 3.2

[71] It is now claimed that the giraffe's long legs are for reaching up, and the long neck is for reaching down to grass and water. Either way, early giraffes "stretched" to reach leaves.

Mostly however, human learning is not by imitation, but the entire biology is adapted for cultural transmission. A striking example is the birth process. The human female is very vulnerable during pregnancy, so it would not be possible for birth to proceed safely without a learned midwifery, existing for thousands of generations. Still, safe reproduction is fundamental. The first time in raw nature the birth process became so complex it was not safe, the variation would terminate. The complication to human birth is the large cranium. Today this is about 200% larger in a human than in a chimp, but half a million years ago it was 100% larger and 2.5 myrs ago it was about 50% larger (in Homo *habilis*). At some ratio of cranium to female pelvis size, assistance with the birth process became culturally transmitted. Learning assists evolution by allowing the brain to acquire more information than the genes can transmit. In humans transmitted learning aids evolution of a bigger brain directly, by allowing a learned midwifery to be passed on. This learned transmission of a midwifery must have continued, and had to continue, in an unbroken line over thousands of generations.[72]

However, many human behaviors are predominantly transmitted by culture; in ways affecting basic human biology.

- Gathering and sharing food,
- nurturing the young,
- sexual courtship,
- seeking shelter,
- organizing the group,
- personal hygiene.

Again, the 'learning ratio' of the cortex to reflex brain mass is very high in humans, about eight to one. This means a long learning period for the human juvenile, so if early humans lived until 30, half their life was involved with learning. Human children do remain vulnerable until about late-teens. If the learning process itself is so complex as to involve half a lifetime, there will be little evolutionary pay back for such a prolonged individual learning if it is not passed on.

It is similar with the tribal organization, which allows long nurturing of the children. Sociobiologists delight at how some males kill offspring of rival males when they take over another's mate, but this would be poor evolutionary pay back for humans. Human males must hunt together, risking an individual's life for the success of the hunt. So if genes are as selfish as Dawkins *et al* assure us they are, they will ensure that before a

[72] No doubt sociobiology has invented a 'gene' for assistance in the birth process. But it would have been a poor investment in evolutionary design for nature to not need a gene for birth assistance for millions of years, then to suddenly require one. Then it would have to abandon the design later when the birth process became too complex altogether.

hunter lays down his life for the group a social system will be in place to ensure his orphaned offspring will be raised to maturity. Similarly, the human female, who makes a heavy investment in time and energy for children, will protect her own offspring against attack from other males within a group. And whatever her social position today, in evolution the human female has a significant biological arsenal of sexual attributes for influencing male behavior, including concealed ovulation, orgasm, and the intimacy of face to face copulation.[73] In the biology of human reproduction one sees long-term commitment to extended learning, group cooperation, and the needs of cultural adaptation.

The next type of cultural transmission is by artifacts. Many animals use artifacts, such as chimps using a stick, or birds building a nest. This often modifies biology, especially nest building, which might have begun 150 myrs ago. In human evolution artifacts will be acquired not only in a single lifetimes, but will be 'passed along', in ways affecting biology. *Australopithecus* could have been using opportune tools of stones, sticks, or bones from four myrs ago, but tool making (shaping a tool and keeping possession of a good tool) began about 2.5 myrs ago, with Homo *habilis*. Tool making caused biological modification, the most striking being that humans do not have any good natural weapons, such as armor, claws, or ripping teeth. Instead, artifacts allowed human biology to be modified away from using biological weaponry. This provides maximum options. Claws would reduce the functionality of a hand for tool making, assistance with birth, grooming, and manipulation. However, even the best natural claw would not be as effective a weapon as a well-made tool, nor as versatile for grasping different weapons.

5.1.3 Use of Language

The final method of cultural transmission is language.

Birds and mammals use signaling language, which includes sounds and gestures, and is partly learned. Humans however, acquire a structured language itself highly adaptable, so that information can be passed on as acquired attributes. Language had a dramatic affect on human evolution. Until humans reached an end point of adaptation, biologically they kept evolving. So, it must have been the most recent adaptations that shifted evolution from biology to culture. Attributes such as walking upright allowed greater cultural transmission, but it did not alleviate the need to keep evolving. Humans evolved at a faster rate than any large animal, but 55-25,000 years ago major modification ceased. Within a short time of ceasing further major modification, humans quickly settled all the large continents, plus they displaced other intermediate subspecies. Whatever

[73] One trick (it is claimed) for a female to avoid rival males killing her offspring is to share her sexual favors around (oh yes). This way, no male is sure of the paternity, plus a group of males interested enough in the paternity stay around, offering additional protection.

the final adaptation of humans it provided an overwhelming advantage to the new mode of evolution, eventually stabilizing it.

The advantage was language. Ability to walk upright and use tools existed for 2.5 myrs, without eliminating subspecies or preventing further modification. About 1.5 myrs ago hominids invented fire, as the species Homo *erectus*, who had 70-80% human brain mass, but humans evolved beyond that. Except one cannot tell from the fossil record when language developed. Human vocal chords are highly developed, being able to sing. Because there is no complex vocal system in other primates to copy, human vocalization must have been selected over hundreds of thousands of years. Complex vocalization must have been pre-adapted, such as a melodious voice making partners sexually attractive. (Similarly to long legs, a melodious voice would demonstrate distance from an ape.) Maybe language was available as vocalization for hundreds of thousands of years, but vocalization is still not abstraction. Ability to fully abstract only occurs above a threshold of neural mass and high learning ratio, that did not evolve until the final spurt of human evolution. Or maybe everything came together 30,000-70,000 years ago, when biologically and culturally humans were ready to emerge.

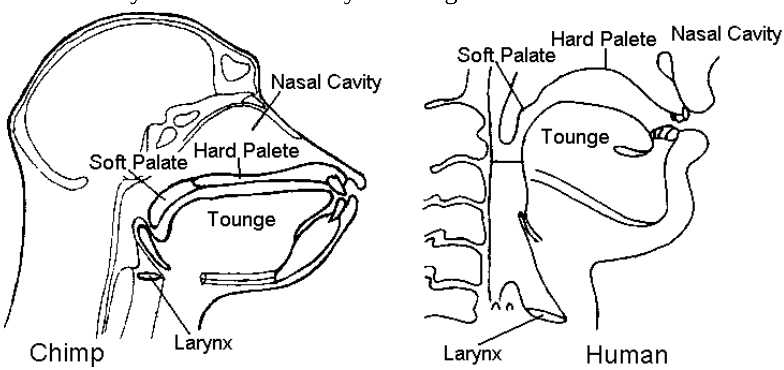

Fig 5.1.1 Evolution of vocalization was pure Darwinism. Many inherited attributes had to adapt, over hundreds of thousands of years, so we must find the fitness advantage. Yet vocalization is not language and not abstraction. Birds can sing, but cannot use language or abstract. Concise abstractions such as $\nabla^2 f = 0$, or $E = mc^2$, "words cannot utter it". There is a huge debate over issues like this.

The attribute making language potent is grammar. Words; "deer", "run", "tiger", "hide", "call", "wait" are useful as single words. However, such words strung in a sentence, provide a means to direct behavior in ways not comprehensible to a species that had not mastered it. To other species, a small group of humans might appear easy prey, or no danger. Once humans have language, a small group can be a scouting party, or a bait, or any "surprise" that there is no naturally evolved way to anticipate.

Until sentence language developed no hominid subspecies enjoyed any advantage great enough that one group could eliminate the others, so in the African boiling-pot splitting of subspecies continued. However, once groups learned sentence language the new skill offered such advantages that groups who had it could resist further encroachment by other sentence-language endowed equals. While those groups who did not have this skill were rapidly displaced everywhere.

Again, there are debates over whether sentence language is inherited or learned. Obviously, there is a complex interaction between learning and biology, and where a physiological trait such as vocalization exists, it could only arise by evolution. Still, there are other explanations of why vocalization evolved, such as the sexual attraction of a voice which can demonstrate distance from an ape. (This explanation accounts for why we can sing and not just use language.) Neurological studies also show that forming even a simple sentence involves many parts of the brain. One part forms nouns as objects, another verbs as actions. Another part of the brain expresses the logic of a sentence, and another translates thoughts into vocalization. (This is why damage to different parts of the brain has different effects on speech.) Humans also have a good mechanical brain, but this might have evolved for abilities such as throwing or hunting, and was adapted to forming sentences later.

This is why, though the brain has areas dedicated to language, these might be 'proximity mapped' as language develops in the newborn, rather than be hard-wired from genes. The term 'language module' is not used in neurology, but arose as explanations used in linguistics and evolutionary psychology. J. Maynard Smith has claimed that the 'language organ' in human brains is similar to the 'language chip' in computers, but it is not that simple. Computers have a chip to interpret a program into machine code (an interpreter); newer computers have a chip that can synthesize computer code as speech (a synthesizer). But the program determines if the sounds will be in English or Chinese. In the same manner a human child will only speak whatever language it has learned, and a child raised by wolves would not articulate in any human language. Speech is not encoded in DNA. To claim that language arose from an inherent property of evolution explains no more than to say that it arises, Kantian style, from an inherent property of reasoning. (See Section 4.3.2 *The Learning Process* for further discussion.)

Human vocalization maximizes the options of communicating by sounds, against a cost to evolve speech organs. Plus the grammatical use of sounds in speech maximizes transmission of information within other limits of vocal communications. All these facilities would certainly have been selected, and strongly so, during human emergence. But speech is not itself content specific to any act of selection, such that humans can only articulate ideas in terms of sex, hunger, or territory. Even then, vocalization does not maximize options of all modes of communication, or even of modes of thinking. Thoughts mostly work faster than speech, despite that language plays a crucial role in organizing thoughts via a reinforcement loop. Symbols convey more information than speech, and the most powerful speech is loaded with symbolic inference. Still, any rigid connection between sounds as in speech, thoughts as in language, or symbols as in logic would be tedious. If thoughts do not conjure ideas that we cannot speak, or symbols express ideas that we cannot think, humans are not using their brains to capacity.

So, while language is the crucial enabling attribute of the sudden rise of human culture, the concept of language modules, or a natural language in humans appears oversold. Today, it has become hugely fashionable to hypothesize that creole or impoverished language is natural to humans, but the sonnets of Shakespeare or Tractatus of Wittgenstein is not. Yet it once seemed "natural" to write computer code top down (from start to finish) because that is the way that humans use speech. However, once modular programming (start anywhere) was invented, the human brain quickly grasped its "natural" advantages. Any theory of how language evolved, must explain why the same DNA that restricts some humans to speaking only by creole, allows other humans to program languages that do not follow any natural vocalization structures.

5.1.4 Art and Symbolism

The adjunct to sentence language was a form of symbolism, and this came from early art. One wonders over the significance of early art, but maybe paintings of deer and bison are symbolic representations of them, and it is symbols as words that humans manipulate in a sentence. This goes back to the much-maligned *Platonic* concept of an idea. A large, living creature running in the forest is a horse, but lines sketched in ochre by human hands deep inside a cave is also a horse. Even more complex an idea is that of the hunt, because the hunt consists of many things. Again, once the animals, hunters, and weapons are sketched on a cave wall, the hunt exists as an idea, available for symbolic manipulation in a sentence. This occurred in Western Europe 35,000 years ago. Just one is not sure if occurred because of a last piece of biological enabling, or the biology was there already, and cultural innovation led to a simultaneous emergence of language, art, and abstraction. Vocalization, listening, and memory, are biological attributes of being human. Yet stringing words in a sentence is cultural, though it might have emerged only a short time after a biological ability was there.

Even so, there is one more explanation of cave paintings or primitive art relating to abstraction. This is the role of a social consciousness, which arises among individuals sharing comparative experiences. Every creature with a brain is aware of a world filled with sense-impressions.

Humans are aware not only of an individual sense-impression experience of reality, however, but a shared one. The reality any individual sees, touches, tastes and smells is not the totality of reality, because reality exists in other times and places, in the experiences of other individuals. For early humans the men went on a hunt as individuals. When they came back, they painted their experiences on the walls, and everyone agreed that they had seen the same thing. So, even if an individual was not there, or died, events that everybody else saw were part of a common reality. The hunt would thus become a socially conscious event in the life of the tribe, existing in a common consciousness, even for members who were not on the hunt. This social consciousness was an early abstraction, because it created a concept of events in time and place, without a person individually present to witness them.

Fig 5.1.2 This cave painting exemplifies the Platonic concept of a 'horse', as an idea that can be manipulated in a sentence, without a physical horse present. (This amazing painting informs modern humans how prehistoric horses actually looked.)

Cultural transmission is not something fortuitous, happening when humans learned a few tricks that could be passed on. Cultural evolution was an end point of human evolution. It became the prime method of adaptation, once evolution reached a point where maximum rates of adaptation became saturated for large animal life. The next phase was abandoning modification by altering biology, and adapting instead the entire biology to maximize cultural and social evolution. Over the last 1-2 myrs humans did evolve rapidly. However, it was evolution towards a point where once reached, humans would achieve the maximum rate of evolutionary change, by having to adapt biologically in minor ways for major changes of sociology, language and culture.

Even if they are still evolving rapidly (20,000 years is a short time to tell) humans are no longer evolving into separate species. Yet, they are continually evolving new cultures, and at a rapid pace.

5.2 The Origin of Moral Feelings

"The development of the moral qualities is a more interesting problem. The foundation lies in the social instincts, including under this term the family ties. These instincts are highly complex, and in the case of the lower animals give special tendencies towards certain definite actions… " **Darwin**

"I believe that the human mind is constructed in a way that locks it inside this fundamental constraint and forces it to make choices with a purely biological instrument. If the brain evolved by natural selection, even the capacities to select particular esthetic judgments and religious beliefs must have arisen by the same mechanistic process." **E O Wilson**

"For moral philosophy is nothing else but the science of what is *good*, and *evil*, in the conversation, and society of mankind. *Good*, and *evil*, are names that signify our appetites and aversions; which in different tempers, customs, and doctrines of men are different." **Hobbes**

"When we study the sage grouse or elephant seals in their natural habitat we can be fairly sure that they are striving to maximize their long-term reproductive success. Yet it is much more difficult to make the same claim for human beings. People strive for something, certainly, but it is usually money, power, security, or happiness. The fact that they do not translate these into babies is raised as evidence against the whole evolutionary approach to human affairs." **Matt Ridley**

"Either we dispense with morality as an unscientific superstition, or we find a way to reconcile causation (genetic of otherwise) with responsibility and free will… Like many philosophers, I believe that science and ethics are two self-contained systems played out among the same entities in the world… Free will is an idealization of human beings that makes the ethics game playable." **Steven Pinker**

"For God shall bring every work into judgement, with every secret thing, whether *it be* good, or whether *it be* evil" **Ecclesiastes**

5.2.1 Why Humans Have Morals

Glendower: "I can call up spirits from the vasty deep."
Hotspur: "Why so can I, or so can any man, Yet will they come when you do call for them?"

Theories of morality are like Glendower's boast; many theories claim to explain morality via evolution, but will the explanation be credible in moral terms? Inaugural moral theories came from religious teachers such as Moses, Buddha, or Jesus; one-in-a-thousand-year persons who met the needs of times now past. Even philosophers who influenced moral theory have been men like Socrates, Augustine, or Kant, whose ageless wisdom is not easily emulated. In a like manner poets who gained moral authority have been of the stature of Dante or Shakespeare. Among the scientists, it takes an almost Einstein-like stature to enjoy authority on moral views. Or among scientists who expounded on moral theory, such as Freud, the contributions remain controversial, even to other scientists.

In light of this, can any secular theory explain morality in terms that people will feel secure with? And if so, what is required?

The first requirement is realistic expectations. Whatever secular explanation of morality is used, an ethical legacy of thousands of years of moral wisdom will not disappear, to be replaced by technical knowledge of genes or DNA. Knowledge increases options, so understanding human motives scientifically increases the range of choices when things go wrong. And knowing why humans subscribe to ancient moral wisdom increases options, by delineating the values that humans feel assured by. Still, moral dilemma will not disappear the first time it can be explained. Science can now explain pain, fear, and death as reactions in the body's biochemistry. But that does not prevent real life pain and fear posing genuine trails, which each person must deal with.

Similarly, some people might think that once morality has a secular explanation, religious injunctions such as the Ten Commandments will no longer be binding. That is like having difficulty discerning right from wrong. Murder is not wrong merely because it is against the law, and it would not be justified if it ceased being an offense. Instead, every action, whether or not within any laws or commandments, must face accounting. Just as every human, no matter how assured they feel in one instance, must at other times face loneliness, pain, or fear. A scientific explanation of life's mechanisms helps humans understand life's options. However, technical description of life’s realities will not morally equip individuals in how to handle them. Knowledge ends in choices. A viable explanation of why humans have morals will only bring people more speedily to a confrontation with issues that everyone must face.

The other requirement of realistic expectations is appreciating the conundrums that need to be explained. Moral ideas form in the higher cortex with the agency of speech and language, and reflect thousands of years of religious and ethical debate. As these thoughts course through the higher cortex they provoke physical *passions* formed by evolution, before language, ethics, or religion existed. One must explain;

1. Why, following the advent of language and culture, religious and ethical ideas developed in the direction that they did.
2. Why, in prehistory, human physiology evolved those passions, which once they arose, ethical ideas could motivate.
3. Why within the broad perspective of life on Planet Earth, after 3.8 billion years of evolution, the last available evolutionary *niche* of behavior required behavioral constraints so complex that they must be transacted through a psychology enacting moral codes.

Chapters 1.3 *The Human Geodesic* and 3.4 the *Theory of Morals* argued that morality is a *modifiable constraint* on behavior. The next chapters, 5.3 *The Origin of Ethics*, and 5.4 *The Origins of Religion*, will suggest why, after human culture formed, ethics and religion developed in the direction that it did. This chapter, on the origins of moral *feelings*, will discuss the most arduous problem; how humans evolved a biology that made their behavior malleable to moral teaching. Always, the difficulty is explaining how individuals modified, and why individuals with moral feelings passed on more DNA than rivals.

5.2.2 Thoughts and Feelings

All higher mammals experience *feelings*. Desire, affection, anger, pride, and shame, exist in higher primates and among domestic animals such as dogs, whose ancestors evolved complex social hierarchies in the wild. Such feelings are strong in humans, who imagine that they can 'feel' if an action meets a criterion of being morally good or bad. This criterion is not how nature might evaluate such moves as fitness. In other species individuals are motivated to gain advantage over competitors for food and procreation. Among humans drives stronger than sex or hunger can inhibit otherwise fit moves. These inhibitions force humans into another round of evaluation, not about the fitness possibilities of a move, but if a move meets group needs in a moral sense.

Yet though such motivates serve the group, but how did they evolve as fitness? There are group selective processes in human evolution, but these only operate once individuals become differentiated by selection, and split into racially or behaviorally distinct groups.

Moral or altruistic behaviors occur for fitness reasons, but not direct ones. Humans have a large, learning capable brain, which easily connotes moral ideas. As well, humans evolved communications that powerfully influence group behavior. These include voice inflection, versatile facial expressions, plus head, body, hand, and arm gesturing. Also, the species has a group oriented biology in that humans hunt and live cooperatively, provide the female assistance with birth, or jointly nurture the young for long periods, and other activities. Finally, humans experience deep *passions*, which philosophers one day label moral feelings (not knowing what else to call them). These feelings are of love, shame, and remorse. To the extent such feelings affect humans physiologically as mood or heart rate, they can only have arisen from evolutionary needs, regardless of which moral needs such passions serve today.

However, although one must explain each attribute facilitating moral behavior, it is only moral *feelings*, which need explaining here. Other attributes; large brain, facial versatility or sexuality evolved for many reasons. The large cortex say, while it enables moral reasoning, assists hunting and foraging, so its fitness can be explained this way. Similarly, the human face has a versatility to express shades of moral judgment, such as the silent rebuke that 'this disgusts me'. Yet, while human facial language is a genuine attribute for enforcing group values, the value it expresses can be about many things; sex in some instances, but courage in battle for another. So, while one must explain the fitness advantage to facial expressions, they need not be explained solely as the moral values that facial contortions express. While facial expressions are an attribute of human behavior, chimps highly evolved them too. So, whatever the fitness advantage it existed at least five to six myrs, long before moral concepts in an ethical sense first arose.

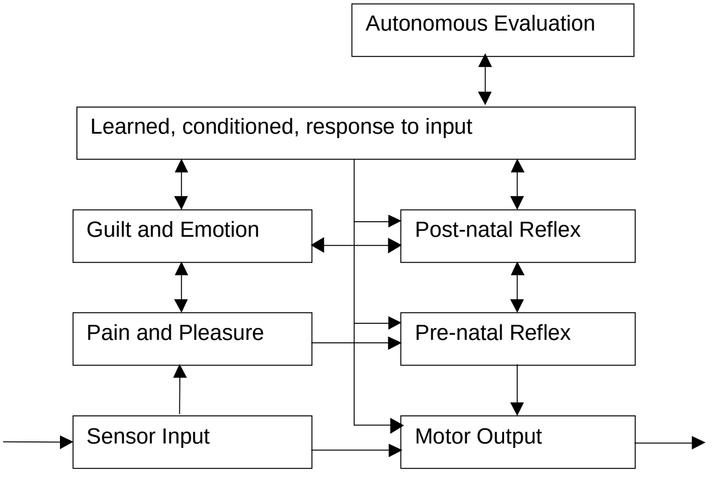

Fig 5.2.1 Whether for hunting or evaluating morals, the human brain is complex. We need to establish why it was fit to evolve such a complex brain, before asking why feelings of moral inhibition might arise in such a brain. Complex brains will feel "guilt and emotion" but from a mix of inputs, from many parts of the brain.

If anything, morally enabling attributes exist in all higher mammals that utilize group loyalty, cooperation, and conformity in the herd or pack. One can train a dog to exhibit behaviors moral in human terms, such as sacrificing its own life for that of its master, or even sacrificing the dog's offspring to save the master's offspring. That dogs can be taught this whereas a cat might not, results from how dogs once survived in the wolf pack. Even then, one need only explain attributes of dogs in natural terms, not moral ones. To return to gestures, dogs also evolved them, for ear, tail, and body. The advantage for higher primates is to concentrate expression of feeling in the facial muscles alone, rather than needing the whole body, and leaving the hands free for other tasks.

To an extent that any feelings produce physiological effects they arose by evolution. Concepts such as ethical wisdom requiring language for elucidation must be learned. Forward planning the consequence of an action is another utility for which the capability of the human frontal cortex evolved. Feelings as physiology evolved as fitness, but in modern humans those feelings are triggered by thoughts within the psychology, which might not have any evolutionary basis. If anything, individuals often make ethical or emotional judgments so intimate that even the specialist will have difficulty analyzing what the real problem is.

5.2.3 The Role of Encephalization

As discussed, there are many reasons why attributes that contribute to moral capability, such as facial expressions, are fit. Yet one capability, the *encephalization* of instinct into learning in the higher brain, plays a vital role. For other reasons it is fit to transfer many actions from hard circuits of reflex, to softwired circuits of learning. Learning circuits need only be designed once by evolution and they can then be multiplied by a simple genetic instruction. Plus learning offers flexibility.

The drawback is that learning might not be reliable under stress, and one sees this all the time. With food, reflex is to consume it immediately. The learned response is to store or share it, offering long term flexibility. However, the needs often conflict. In animals (like squirrels storing nuts) needs are designed into reflex, but this loses flexibility. So the way to enhance learning is by special reflex that can be called a transfer circuit. Such circuits supervise *encephalization,* rewarding the individual with "good feelings" when learned responses hold, or punishing the individual with "bad feelings" for failures to abide by learning.[74]

There might say, be two feelings in conflict; one to eat food, one to preserve it. The first instinct will be genetic, but if the need to preserve

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[74] As neurology, such a circuit might not be purpose designed neurons, but it is more likely a path routed through the brain by selective use of circuits. This way the decision making is kept in proximity to emotional response, and is easily reinforced by it.

food can be converted into a learned response, its delay length can be varied to needs, which would increase options. Hunger, which is reflex, is always there, so another feeling must counterbalance it. If humans can override reflexive drives by learned ones, and the constraint holds, one feels good inside. If one attempts to countenance reflex and it fails, in that the learned behavior does not prevail, one feels bad inside. If it is fit to convert instinctual constraints to learned ones (for a large, flexible brain) it would be fit to evolve a regulating mechanism to ensure that learned constraints will "hold" as effectively as reflexive ones.

Hominids increase options by transferring behavioral controls once locked into fixed circuits of reflex into the more flexible learning circuits. Although circuits that motivate learning to override reflex evolved for reasons not directly to do with morality, they manifest themselves in the human psyche as feelings that philosophers will label moral. So while morality might not appear directly fit, if it allows high *encephalization*, morality is fit at least three ways;

1. It allows a vastly expanded brain, because the easiest circuits to expand fastest are general purpose ones.
2. It increases behavioral options, because the more adaptable the behavior, the more chance of surviving in changing environments.
3. It allows reflex, within an upper limit of total genetic instructions, to become focused on tactile skills and information gathering, which is essential anyway, and cannot be replaced by learning.

It is not in a brutal sense then, fit to have morals. But for humans it is fit to have a large brain. Also for fitness reasons, large brains that evolve quickly require a high proportion of learning neurology. Humans have an eight-to-one learning ratio, so selection for this must have been strong. This high learning ratio requires mechanisms to ensure that such brains work reliably. Ensuring the reliability of learned inhibitions under stress will require powerful regulating and transfer circuits, that will produce moral type feelings. Also, the human birth-growth cycle locks the human species into long periods of nurturing the young, which further requires transfer circuits to ensure the power of learning over reflex. With the first 15-20 years in a lifetime involved in learning, humans will only obtain evolutionary payback for prolonged investment in learning when it is passed on. If parental instructions are passed on in genes, retaining them is automatic. Within the human eight-to-one learning only about 15% of instructions will be 'unbreakable' genetic code and the rest must be learned. So if learning is to be effective, parental instructions must stick. (This observation helps solve the psychologist's dilemma of why parental conditioning arose by evolution.)

An evolutionary explanation of human behavior, including morals, should explain first why a large, learning capable, and psychologically motivated brain is fit. Only then should the inquiry focus on why contributing attributes to moral behavior such as strong feelings or facial expressions are fit, though these might have been pre-adapted for reasons not directly related to moral needs.

5.2.4 Modern Behavior

Theories such as evolutionary psychology try to explain each human thought, including ethical judgments, as selected by a unique gene for that end. But feelings formed via genes or evolution cannot reflect ethical precepts that only arose *post-emergent* in human culture. Instead, when hominids began evolving into creatures no longer locked into reflex, they enlarged the range of choices. If a creature grows wings and flies, it must evolve novel methods of navigation. Similarly, when a creature gives itself options no longer dictated by reflex, it needs new mechanisms to "navigate" the expanded possibilities. These mechanisms for resolving choices, evolved for one fitness purpose, become the physiological basis of moral feelings in another interpretation.

If anything, for it to have any meaning, morality is confrontation by humans with the *options* of their creation. Society imposes moral values, and humans evaluate these in the higher cortex, when they forward plan (or fail to) the consequences of each action bearing a moral impact. Yet while this complex evaluation is proceeding in the higher cortex, deep in the lower brain exist other, highly structured biochemical responses selected for different reasons by evolution. So, if an individual makes a bad move which reduces his social options, he might experience a feeling similar to the notorious sexual 'guilt' biochemical reaction. And if a person once taught to believe in God now questions it, that individual might experience a bad feeling, though in this case it is not from God. Ironically, the guilt feeling comes from an evolutionary reprimand. An individual can only believe in God if he or she learnt about God first, and evolution selected human individuals not to hastily abandon precious payback time invested in learning.

A further complication is that individuals do make genuine bad moves, and with sexual partners, and do enact impulsive, "fail-to-learn" behaviors in many contexts. Such behaviors will provoke a 'guilt feeling' response, maybe in a person who was taught in childhood that certain behaviors will be punished by God. And the people who invented the reasons for God's punishments wrote from their own guilt experiences, so they conjectured remarkably well about the types of actions people would imagine that God was punishing them for.

On the other hand, some people's psychology is scrambled to an extent of believing that some cult figure is a messenger from God. Yet if that person offers devotion to the new leader, the act of discipline might provoke an evolutionary 'good feeling' reward for allowing learned response to triumph over reflex. If that person had previously led a life of impulse outside of the cult, the new 'good feeling' might be enough to convince the misled individual that he or she really has met a messenger of God. The evidence will be the euphoria feeling quickly evinced by discipline, mistaken for devotion.[75]

So the origin of morality, and of moral *feelings*, is not the same.

- Feelings, to the extent that they arise physiologically are not innately "moral" or any quality not part of nature.
- Certain feelings, which motivate behavior, become associated with morality by idiom. When individuals violate in their psychology precepts that they have been taught are 'moral', the biology reacts to an instinctively evaluated fitness move from its evolutionary program.

For all the color that people imagine arising from feelings, they still reflect only basic moves, such as whether encephalization is working, whether learning is holding, or whether a move enhanced status within the group. Our feelings guide us to whether our moves increase *options*. Yet, the middle brain, where feelings originate, is not the higher brain, with a larger picture. The middle brain can only compare responses that the higher brain tells it, with how the body is doing. As we know, often thoughts in our higher brain try to convince the world of one thing but our middle brain "betrays" what our body is experiencing. So, feelings feed back primal reaction to thoughts, sense, and physiological state, based on an evolutionary program to motivate the individual to choose moves that increase long-term options.

This chapter is about the origin of moral feelings, which evolved for fitness. Still, once the topic moves on to thoughts so complex that they must be framed by language, the focus moves to the higher brain, where most impression is by learning.

This is the study of ethics; another chapter, and another topic in the complex, unraveling of the motive of human behavior.

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[75] This is a bit sketchy, but one of the hardest aspects of psychology to explain is devotion to cult leaders, especially as why it would be fit. The danger is underestimating the power of these devotional feelings, merely because they do not seem rational. The issue is only mentioned here to show that the *Theory of Options* has an explanation of why these feelings are so intense, but the topic needs further research.

5.3 The Origin of Ethics

"In school and in society, similar factors operate. "Good" is that for which one is praised; "bad", that for which one is frowned upon or punished… Indeed, the fear of disapproval and the need for approval seem to be the most powerful and almost exclusive motivation for ethical judgement." **Erich Fromm**

"The high standard of our intellectual powers and moral disposition is the greatest difficulty which presents itself, after we have been driven to this conclusion on the origin of man. Yet, every one who admits the principle of evolution, must see that the mental powers of the higher animals, which are the same in kind with those of man, though so different in degree, are capable of advancement." **Darwin**

"The consequences of genetic history cannot be chosen by legislatures. Above all, for our own physical well-being if nothing else, ethical philosophy must not be left in the hands of the merely wise." **E O Wilson**

"Then I presently become aware that while I can will a lie, I can by no means will that lying should be a universal law. For with such a law there would be no promises at all… I do not, therefore, need any far reaching penetration to discern what I have to do in order that my will may be morally good… I only ask myself: Canst thou also will that thy maxim should be universal law? If not, then it must be rejected…" **Kant**

"It is clear that ethics cannot be put into words. Ethics is transcendental. When an ethical law of the form, 'Thou shalt… ', is laid down, one's first thought is, 'And what if I do not do it?' " **Wittgenstein**

"Philosophers since Plato have attempted to organize these imperatives into a single rationally defensible and universal system of ethics, so far without achieving anything approaching consensus. Mathematics and physics is the same for everyone everywhere, but ethics has not yet settled into a similar reflective equilibrium." **Daniel Dennett**

5.3.1 The Debate over Ethics

Ethics (Greek *ethos* custom, way) is the manner by which humans regulate individual behavior in civilized society. One might say that humans regulate behavior by laws, which is true. However, laws cannot apply in every instance. So ethics is how society trains people to behave, or how they ought behave, even when no laws apply.

Most historians consider that ethics arose this way. Primitive tribes do not really need ethics, because under harsh conditions stupid or selfish acts would bring their own punishments. Once agriculture created an abundance, however, people began to live beyond the confines of raw survival. In the new situation humans required a more universal method of regulation than tribal law. Ethics enabled people to carry codes along with them, so as tribal life diversified individuals could adhere to original teachings even after they traveled outside their group. "When in Rome, do as the Romans do" (Shakespeare). "Do not do unto others as you would not have them do unto you" (Kant, and earlier, Jesus), and "he that diggeth a pit shall fall into it" (the Bible) are ethical homily of this type. They teach people how they ought to behave, even in the absence of specific constraints or laws regulating behavior.

How people ought to behave is the *functional* problem of ethics. Without knowing why it arose, commerce, government, and family, need ethics to function. While for those who believe that humans are animals, surviving at the expense of less fit competitors, use of ethics to moderate such needs into civilized behavior is obvious. This is why very society throughout history devised ethical *codes*. These are teachings, reinforced as learning, of how society expects its members to behave.

Learning begins in childhood. Lessons are a religious or moral tale. Reinforcement is affection for good behavior, and reprimands for bad. For adults, teaching is religious or ethical doctrine, while reinforcement is by punishment or reward. Rewards confer acclamation, and honor. Punishment involves reprimand, or deprivation of freedom, wealth, or in some cases, of life. Whether as laws, rules, or norms, ethical *codes* instruct people how to behave.[76]

Still, regardless of social codes, the punishments and rewards that society enforces are not the only ones. Instead, every individual, even a child, learns that deep within the psyche there is another ethics, called *feelings*. These are positive feelings of worth, happiness and fulfillment, and negative ones of remorse or guilt. The feelings are powerful; "for love is strong as death, jealousy is cruel as the grave". They give the individual an intimate sense of right and wrong, plus they also punish or

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[76] One branch of ethics, *casuistry,* teaches that ethics is a search for a set of perfect codes. The Medieval and Catholic Church, Islamic societies and others have devoted much study to casuistry, and tried to create societies in which all behavior is regulated by codes.

reward the individual, but not in the same manner, or for the same reasons, that society does.

So, where do these feelings come from? How does one relate ethical feelings from within to the ethical codes which society imposes from without? This is the great *ethical problem* of humanity, and through thousands of years of debate, it as never been solved.

5.3.2 The Ethical Problem

Explaining the relationship of ethical *feelings* from within to ethical *codes* imposed from without is the ethical problem (no one calls it that) of humanity. Philosophically, the relationship of ethical codes to ethical feelings is usually explained one of two ways.[77]

1. **Ethical Absolutism:** Existence of ethical feelings in individuals proves that ethical values exist as *absolutes*. This is the only way to explain universally held human feelings such as awareness of an innate sense of good and evil, or that life is form of moral test, or an almost universally held conviction that there exists a creator-deity controlling and judging all human actions.
2. **Ethical Relativism:** All ethical ideas, even intimate feelings, arise from the teachings of whatever culture the individual happens to be raised in. This is the only way to explain that while some feelings are universal, every ethics, and every belief system, has a local flavor, depending on culture and social environment.

Still, neither *absolutism* nor *relativism* explains the central problem of ethics, which is the discordance between the feelings and codes. In absolutism, the explanation is that people's morals become corrupted, and if individuals return to pure beliefs, discordance will disappear. This is the religious argument, which has an enduring impact. Even so, for a system of absolute beliefs, historically these have fragmented in pockets of disagreement. This has allowed *relativists* to contend that all ethical codes are contrived by religion or society. When relativist philosophers discovered that codes were contrived, or out of concordance with natural feelings, they tried to discover *naturalistic* codes, free from contrivance, but with which moral aspiration would naturally align. Yet despite 2,500 years of searching, finding the true basis of a naturalistic ethics, like calling up spirits from the vasty deep, has been easier to claim than do. Just as absolutism never uncovered a universal set of beliefs everybody could commit to, relativism has never produced a plausible naturalistic ethics. Nor have relativists agreed among themselves the naturalistic basis of such a system.

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[77] Critics have reacted harshly to this author's reduction of ethical complexity to just two theories of it. The two theories capture the extremes, but there are intermediate views.

Divisions between relativism and absolutism, or codes and feelings, are not just categorical, but neurological divisions within the brain.

- **Feelings**, as a sentient quality arise in the middle brain, but thoughts which trigger feelings, arise within the higher cortex.
- **Thoughts**, which both create and arise from codes, themselves are complex constructs of language. So thoughts must in all instances be contrived, just like any statement of reason is contrived.

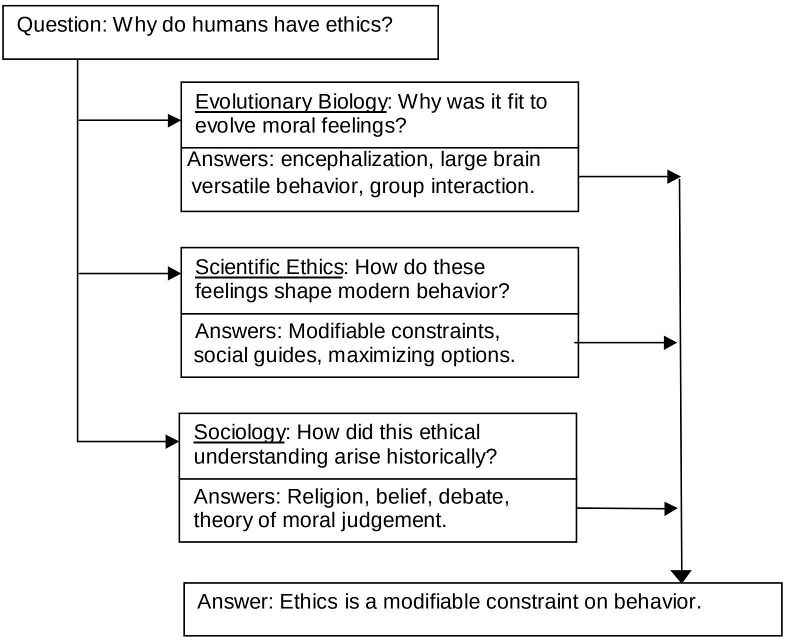

Fig 5.3.1 There is no simple explanation of ethics. Rather, the topic must be pursued via several lines of inquiry, for a complete explanation.

Though they are contrived, ethical codes exist for a purpose. Ethical codes are like governments. There are good and bad governments, and good and bad ethical codes. Yet, there is no naturalistic government in an anarchist sense, that every individual will be happy with. Similarly, there is no naturalistic ethics to pander every idiosyncrasy. Ethical systems, just like laws or governments, arose outside of nature to meet civilized, social needs. They also arose, just like laws and governments, to enforce consensus on disparate individual values.

Even so, while the contrived nature of ethical codes is relative to culture, the natural motive of ethics, its feelings, arise from processes coded within the human genes, which are universal. The *relativist* and *absolutist* arguments are both partially valid, but only in the futility to debating this issue forever. Ethics has both genetic and cultural elements, which must be explained.

5.3.3 How Ethics Arose

Feelings that philosophers would term 'ethical' arose in prehistory. Feelings as mood are biological, and were selected by evolution. (They are physiological rather than ethical feelings.) If one explains these feelings by fitness, it has more to do with facilitating encephalization and learning, than ethics in a moralistic sense. Even so, when wise men first examined the significance of the feelings, the conclusions that they drew were not about encephalization. They considered that feelings existed to distinguish 'right' from 'wrong' in a moral sense. So, the topic concerns feelings whose origins are biological, but whose interpretation of their significance was ethical and cultural.

So what is the origin of ethics in this interpretive sense?

Why say, were humans at the early hunter-gatherer stage of history able to resolve choices without ethics? Yet, why at a later stage of herd gathering or agriculture did ethical explanations of choice arise?

Ethics exists to resolve a certain type of action; an *unconstrained* choice. If a creature is in pain, hungry, or responding to instinct, its choices are constrained. It has choices, but they are not choices free from other factors. In a similar manner, a Stone Age human might have much broader choices over how to divide a carcass, but because this activity is dictated by tribal ritual the choice is also constrained in other ways. By contrast, humans in civilization often face choices whose consequences do not bear on survival, custom, or reflex. If anything, humans often face dilemmas such that they must think of a reason why, from several choices, one might be superior to another!

This is why ethics did not begin until an age of agriculture.[78] Like all higher animals, hominids faced choices for millions of years. At first, choices were resolved by reflex. During *emergence* evolution sublimated human reflex by learned behavior, to give broader choices. Choice was then achieved through tribal codes, controlled by social regulation. With the advent of agriculture this naturally evolved system was thrown into chaos. Agriculture could support such a large population that tribes broke up, and tribal custom became first diversified, then subsumed into larger structures. The crucial problem was of abundance. Stone Age tribal life is a struggle for survival; it is a closed system within other constraints such as a limited supply of food. Tribal behaviors are just survival strategies.

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[78] This essay was written some time ago. Since then, many researchers have argued that early tribes frequently encountered very rich hunting grounds, and enjoyed a good life with time for leisure and cultural pursuits. The argument then is that agriculture was forced on humans by over-hunting, and extinction of large herds of natural game.

There are no choices outside the overriding constraint that from a single mistake, life of the tribe can be extinguished.

Agriculture changes that. Today, we are rediscovering a Stone Age truth that resources are limited. In the first flush of agriculture, though, resources appeared unlimited, especially for those emerging at the top of the new social structures. Customary obligations about how to divide a carcass do not constrain behavior of individuals ensured a lifetime supply of food. If food is abundant or natural peril diminished, non-conforming behavior no longer determines basic constraints like group existence. In fact, once life is placed outside the overriding "struggle for survival" for limited resources, new constraints have to be invented for a person to know which things in life are important at all.

Ethics is the contrivance of a new system of constraints.

Ethics does not teach people how to survive in the wild, nor does it teach a cultural equivalent of Darwinian selection. Instead, ethics teaches people how to constrain behavior when no apparent constraint exists. A tragic illustration is when today's Stone Age peoples are confronted with a white man's abundance. Tribal laws, no matter how felicitously adapted to survive in the wild cannot cope with unconstrained choices. Ethics teaches people that even if an option like drinking alcohol is available, other factors govern choice.

5.3.4 Unconstrained Choices

Ethics first arose from myth and religion. This is discussed in the following chapter, but religion teaches that no matter how unconstrained choices appear, they are still judged, and individuals are accountable. Endemic also to rational ethics is a concept that we choose in our actions between moral 'good' and 'bad’ with an obligation to make wise choices. So apart from a religious interpretation of moral need, which all societies made historically, what other factors lead humans to interpret ethical needs as a choice between 'good' and 'bad' actions?

It was the perennial one; of adaptation. During *emergence* hominids faced a difficulty of physical evolution, so that the species could better adapt to change in environment. The solution was to evolve in a direction in which the maximum number of instinctual constraints on behavior could be substituted for acquired constraints. Millions of years later, in the age of agriculture, a new problem emerged. This was that acquired constraints, custom, ritual, habit, and taboo, were also now undermined. Nature had selected humans to be creatures who could adapt behavior to changes in the environment, but as civilization began humans themselves seized the initiative of change. From a natural environment humans developed an Agricultural Age, which burst the remaining Darwinian constraints. If humans could do this, what other Ages or inventions and discoveries might they render? What changes to a program of maximum adaptability to change would humans now require? One might devise rituals to regulate agricultural life, as surely as rituals can regulate tribal life. However, this will only repeat the problem of growing natural fur to protect against cold. A natural fur will protect against cold, but it cannot help if people prefer a warm climate, or the option to live in either warm or cold conditions. Similarly, hunting ritual will guide a nomad's life, but what if people become agrarian -or go to live in cities?

Aeons ago, humans adopted codes called tribal laws. These adapt people culturally to a niche dictated by nature, but these are particular codes for niche constraints. Once humans learn agriculture, or invention, architecture, trade and commerce, they are no longer dealing with single sets of circumstances, dictated by nature. They are dealing with multiple circumstances, which alter too fast for natural adaptation. Facing diverse circumstances the "tribal laws" break down, just as today tribal peoples dumped among civilization's abundance are unable to cope with multiple choices that civilization presents.

So, is there another way? Is there a set of codes applicable in all circumstances regardless of how inventively humans reduce other constraints? To push the argument, is there be a set of codes valid even if humans achieve maximum possible invention? Even if humans created a circumstance so abundant that it would free them of all natural constraint, could there still be a set of codes, adaptable enough to provide guidance even in this extreme situation?

Ancient religious teachers believed that there was a way, but to explain how it worked required a new ethical concept. This eventually moved away from the tribe, or particular rituals such as food gathering, and asked; 'what in life is required of the individual, facing any possible circumstance?' The answer was that there is a Greater Good to which every individual is committed. The wise men concluded that the author of moral needs is not the requirements of the tribe, or even requirements of life. Instead, there is a universal moral need to which all humans are answerable. So life for humans becomes a test of how adequately each individual responds to these moral demands.

If the natural environment millions of years ago stayed perpetually stable, there would have been no need to evolve beyond ape-like forms. Millions of years later, if the cultural environment were also assured to be stable, settling on tribal life, there would have been no need to evolve ethics. This applies today. If a person wishes to live among bushmen, that person will not require ethics; tribal law is enough, because right or wrong will be constrained by survival. Historically too, humans could have stayed nomads. They could have remained tribal, and it might have lasted that way for an eternity. Humans did not choose this. They wanted the natural constraints removed, preferring to replace them with ethical constraints of human making.

Humans enjoy maximum options when all constraints on behavior are moral ones. Yet, humans do not see this at once as a clearly explained picture, the first time they confront the problem. The argument used here explains ethics this way, but it was not formulated until recent times. So, just as evolution of ethics was a progression of events, as civilization developed, it is one today. Take the case with food. At a primitive level, hominids had to learn how to control instinct, to distribute food among the group. This created tribal ethics, which rewarded the triumph of sentiment over instinct with gratifying feelings. Eons later, in the age of agriculture, humans faced a new problem. Now there was abundance of food for some, but it did not entitle people to gorge themselves, or neglect the needs of the less favored. How to distribute food in this new circumstance required a fresh mechanism, more complex than instinct-into-sentiment. This new mechanism came not from the primitive consciousness, but the rational one, which invented the religious idea to handle the new requirement.

Today humans face acute new problems over the ancient quandary of how to distribute food. Our existing mechanisms, such as religion and philosophy have become overwhelmed by it. This is the point. Ethics is not static, but responds to the intricacy of options faced. When humans faced simple options such as to eat food on the spot or consume it later, they developed a mechanism that could cope. As civilization grew and humans faced fresh choices, such as over whether to keep slaves, humans developed ethical mechanisms that eventually coped too. Ironically, the largest ethical crisis occurs today. Humans now face choices about overpopulation, or environmental destruction for which no previously developed mechanisms are adequate. This chapter has tried to outline an approach to such novel ethical complexities. Unfortunately, there are no guarantees this will work either, so perhaps a deeper understanding of ethical meaning is required again.

Yet, for thousands of years one explanation has achieved reasonable alignment of ethical codes with individual moral feelings. This was the religious explanation of ethics. So how does this work really?

5.4 The Origins of Religion

"The belief in God has often been advanced as not only the greatest, but the most complete of all the distinctions between man and the lower animals. It is however impossible, as we have seen, to maintain that this belief is innate or instinctive in man. On the other hand a belief in all-pervading spiritual agencies seems to be universal; and apparently follows from a considerable advance in man's reason, and from a still greater advance in his faculties of imagination, curiosity and wonder." **Darwin**

"I do not believe in the creed professed by the Jewish church, by the Roman church, by the Greek church, by the Turkish church, by the Protestant church, nor by any church that I know of. My own mind is my own church. All national institutions of churches, whether Jewish, Christian, or Turkish, appear to me no other than human inventions, set up to terrify and enslave mankind, and monopolize power and profit." **Thomas Paine**

"Does that mean that religious texts are worthless as guides to ethics? Of course not. They are magnificent sources of insight into human nature, and into the possibilities of ethical codes" **Daniel Dennett**

"If religions are fundamentally silly, why is it that so many people believe in them? … All successful religions seem at their nucleus to make an unstated and perhaps even unconscious resonance with the prenatal experience." **Carl Sagan**

"So it appears that some of the most baffling of religious practices in history might have an ancestry passing in a straight line back to the ancient carnivorous habits of humankind." **E O Wilson**

"These are some of the reasons why the idea of God is copied so readily by successive generations of individual brains. God exists, if only in the form of a meme with high survival value, or infective power, in the environment provided by human culture." **Richard Dawkins**

"The Gods are first, and that advantage use on our beliefs that all from them appears. I question it, for this Earth I see, warmed by the sun, producing every kind; they nothing." **Milton**

5.4.1 Why Humans Have Religion

The final chapter of this part discusses the most difficult of human propensities to explain by evolution, or by any secular theory. Religion teaches, broadly, that every action by an individual is judged by an all-knowing power, and will have consequences. Throughout history when ordinary people hear this, the idea resonates with a deep feeling that individuals often experience. Religious teachers appeal to this feeling, allegedly to induce people into moral behavior. Yet historically, teachers have used the feeling mostly to induce people into joining a religious "faith", ministered by a priesthood that has arisen in every society. This causes acrimonious debates. People politically and educationally opposed to this priesthood try to explain why these feelings could not exist, or are mistaken for related feelings. The religious priesthood is blamed not only for exploiting a deep moral feeling, but often of creating that feeling in the first place by distortion or exaggeration.

Yet if humans evolved to maximize the options of behavior, it would only make sense that they should feel that their behavior was being constrained morally. Moral behavior forces humans to explore behavioral paths outside from those arising from genetic imperatives. This increases options, because moral constraints, rather than constraints programmed by genes, can be easily adapted. Behavior constrained by learned rather than inherited inhibition is also fit, because learning allows a much larger brain for the same density of genetic instructions. It is inflexible and genetically costly for nature to select fixed inhibitions for each behavior. For human evolution it was fit to program in a general set of inhibitions, which could be adapted to circumstances.

Historically though, explaining why feelings about moral inhibition arose was done without understanding its real cause, and this persisted even after the theory of evolution. Evolution (misunderstood) explained not moral constraints as an adjunct of brain versatility in a learning capable species, but moral-appearing constraints that were not leaned at all, but were reflex. So after thousands of years of civilization, even after the theory of evolution was discovered, humans knew that they were morally constrained, but did not know why.

This results in unconvincing explanations of religion. People require a moral explanation of the emotions that they feel, ahead of a rational explanation of the things that they believe. It does not matter if Darwin's theory can explain moral-appearing behaviors in animals. Humans feel that they are morally constrained in ways that often do not make sense in animal terms, so people are mostly not convinced by so-called Darwinian explanations of morals. This lack of conviction at alleged "evolutionary" explanations of morality is blamed on religion, as though religion had arisen *extra-potentate* to human affairs.

In addition, there does not exist religion in the imputed sense, by which people try to explain it. Someone is upset that the Catholic Church condemns birth control, or is perplexed at how people can believe in God even after science has explained that morality is disguised reflex. This is blamed on religion, which it is claimed is only an effect of the body's biochemistry. True, moods like euphoria or despair are often exploited for religious beliefs, and these moods have a natural basis in the brain's neurochemistry, regardless of which thoughts provoke them. The reason why human neurology is optimized for this range of biochemical moods is more sensibly explained by genetics than dogmas of the Church. Yet, why religion holds to its theological dogmas can no more be explained practically, by genetics or biochemistry, than reciprocal altruism can be explained by quantum mechanics. Although here too the mechanisms of one can also ultimately account for the other.

This essay too will not explain religion in detail of why any one facet of religious practice arose for any purpose (such as arranging marriages). Human behavior maximizes options when inhibitions that are called morals become constraints on behavior. These constraints override biological imperatives, forcing humans to enact some behaviors but forego others. Any theory must explain how this effect was interpreted historically, before its mechanisms were more broadly understood. So, there are three questions to be answered;

1. What was the fitness advantage in human evolution to individuals acquiring a large range of biochemical induced moods?
2. How have humans come to understand the significance of the moods to behavior in ordinary language terms?
3. Historically, what line of reasoning led humans to make ordinary language interpretations of the significance of those moods?

The first question concerns the origin of moral feelings, which is about evolutionary behavior. The second question concerns how humans explain the relationship of naturally induced mood to social behavior, which concerns ethics. The third question is an investigation into the historically derived nature of belief systems, and how these shape moral views. This question concerns the observation that historically, people first interpreted the *ethical problem* (previous chapter) via religion.

5.4.2 How Religion Arose

Humans are social animals, relying on each other for protection and support. All groups have rules, but humans not only have group rules. The human brain has a high learning ratio, which allows the species to evolve a large brain without paying the evolutionary price of needing to design each neural circuit for reflex. Just that to be effective the learning capable brain has certain transfer circuits. These do not control actions directly, but punish or reward the individual with good or bad feelings, for choices wisely or stupidly enacted. Without understanding what they are, these mood swings impute to the individual an intimate morality. It is a sense that someone or something is in control, guiding the individual about which actions to take. In a psychological sense this happens. Also from evolution, the human infant takes half a lifetime to mature. If the long years of nurturing are not to be wasted, precepts that are taught in childhood have to stick. This evolves a psychology that inhibits against abandoning early teaching. So, the individual not only encounters group rules but intimate ones as well, telling the individual how to behave.

In tribal life group and individual rules are not much in conflict, but as civilization grows tribal life is subsumed into larger organizations. As wealth and status differentiate individual roles, conflict between group rules and intimate morality within the individual intensifies. For each increase in social complexity there is an increase in complexity of the *ethical conflict* (previous chapter), which will require an explanation.

Humans by evolutionary propensity also seek an ethics to maximize options. This propensity arises from primal consciousness, as a way to group harmful or beneficial stimuli as 'pain' or 'pleasure' feelings. This enables a generalized response to varied stimuli. Millions of years later, ethics is a method for intelligent, language-capable beings to also group responses to situations. Via ethics, humans discovered that the most generalized response, to handle any situation, is to advise individuals to always act in a manner that is morally 'good', and eschew behavior that is morally 'bad'. However, while the principle of 'good' and 'bad' as moral behavior is universal in human society, how it arose was not. Before good and bad were defined in absolute terms the notion had to progress from needs of the tribe, group, and nation, till its present redefinition in terms of a universal moral good for all humanity.

Still, this has to be explained, but we still argue over how to explain it in secular terms even now, at the start of the Third Millennium. Prior to this there have been explanations about reciprocal altruism in animals, and conflict in the Freudian subconscious. Yet there was no explanation of why each individual felt that he or she was being tested over whether the person was behaving in a morally good or bad manner. It is discussed here, but we do not really have anywhere a secular explanation of why individuals should choose morally good over bad actions for its own reasons. Nobody has said before this that choosing good over bad was a human evolutionary program that *maximized* options. Nobody said that moral 'good' was a generalized response to situations that could not be foreseen, and this was fit because it maximized encephalization of the learning capable brain. Without the secular message (still not understood) a different way must be found to convey the moral concept for the first time. And this comes from religion.

5.4.3 The Religious Message

What then, is the religious message?

Primitive belief systems began with art, language, and ritual such as burial or marriage. As tribes coalesced into kingdoms the function of belief became more complex, but so did the explanations. Most tribes have animistic beliefs in which animals, plants, and objects are imbued with spirits. As agriculture begins, humans notice distinctions between objects, animals, and people. Whatever created all things, it created people differently from animals, or animals from objects, which has to be explained. As society becomes complex gradations appear among people too. Some are born slaves, others are born kings. Even so, as humans differentiate in social status they notice something else very strange. People enjoy different material freedoms, but kings or slaves equally suffer torments of the inner psyche. The force that made people different from animals, and gave them different social status, retained control over the feelings that people experienced. This has to be explained in the pre-scientific terms that people of those ages could understand, long before the theory of evolution, philosophy, or science.

Over millennia, the wise men worked it out. The "creation" was not as simple as earlier legends allowed. Instead of multiple creations by multiple gods, there was one creation, by a single all-powerful Creator-Deity called God. God alone created the heavens and Earth, and all living creatures on it. Having created all these things, god set himself a special challenge. He wanted to conduct a divine experiment. He wanted to see what would happen if He granted to certain living creatures God-like attributes of will and reason. Would creatures so divinely endowed pursue a god-like goodness, or would they degenerate into evil ways? To conduct his experiment god created humans, giving them will, reason, and freedom to choose between good and evil.

Generally, results were disappointing. Universally the new creatures pursued evil ways, bringing upon themselves strife and torment.[79] So to salvage part of his experiment god sent among humans various prophets (in one story his own son) to explain God's intent. Although humans as a whole failed god's test, by hearing his purpose explained favored individuals could still pass the test through individual salvation, by always choosing good actions over evil ones. For people who believe this, the solution to the ethical problem becomes one of making the internal moral feelings reflect the Moral Code of God.

While the religious hypothesis might appear far-fetched, it offers an elegant solution to the ethical problem, where secular explanations fail;

- Religion accounts for the universal quality of ethical feelings (which exists) by relating them to an absolute inspiration.

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[79] This is from the Bible, but it is in the Greek legends too.

- The religious explanation correctly notes the gradation in levels of consciousness between animals and people, such that only creatures with will and reason practice ethics.
- Religion provides a solution to the intimate problem of ethics, by teaching people precepts that they must follow (such as always do good) to solve ethical torments.
- Religion provides people with a purpose to life, such that regardless of which codes larger society practices the individual will always possess an intimate guide to behavior.

These guides increase options, because they allow people to respond to novel situations for which there are no prior guides. The religious explanation is also appealing because humans often feel that life is a moral test, that they are being judged by their actions, and that actions will have consequences for happiness. Significantly, religions that taught the new doctrine of a single creator-deity and moral accountability seem historically more advanced than others. Generally, societies embracing the newer explanation did well.[80]

So, the religious idea explains the moral dilemma of humans, in a way that is more elegant than secular attempts to explain inner feelings. Except the religious explanation is not a scientific explanation of morals. It might be argued, perplexingly, that the religious explanation is more relevant than social-Darwinist theories such as 'evolutionary psychology' if the only facts considered are intimate feelings. At least the religious idea focuses on real human feelings, and the torments that humans truly experience. Even so, there must be other scientific explanations of these torments concordant with evolution, free from the mythology, corruption, and other distorted features of religious practice.

5.4.4 Human Options

So when humans follow any form of ethical restraint, which includes certain religious precepts, what are they doing, really?

They are increasing options!

If we are compelled to act from impulse our behavior is constrained. We are still animals. We are back where humans were when hominids were first expelled from the ancestral forest home. Humans do not want this. Eons ago, the first step towards options was interposing an internal delay between stimulus and response.[81] Eons later, humans learned to replace natural constraints by tribal law. Even so, no matter how well tribal peoples control their behavior, they are still ruled by the laws of

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[80] Cynics have objected to this argument, by suggesting that societies utilizing the newer religious ideas were simply more organized and more ruthless.

[81] See quotes by Bronowski and others, opening Chapter 3.4

nature's scarcity. Then, in the Age of Agriculture humans learned to alter not just behavioral options, but also environmental ones. The mechanism created by the first change, tribal life, was shattered by the second one. Instead of tribal laws, individuals became members of a larger grouping, society. Within society individuals increased options, because people became socially mobile in ways not before possible.

Something else changed as well. Tribes and society have laws, and because one evolved from the other, one imagines them as the same. Yet, they are opposite. Strange as it seems the distinction is that tribal laws are real! Tribal laws are 'hard' constraints on behavior, because they reflect conditions of a struggle for survival, framed in group terms. In tribal life one either obeys the tribal laws, or not only the individual, but the whole tribe perishes. In society though, laws do not constrain individuals this way. One only has to be rich, powerful, rebellious, cunning, dishonest, or a host of things humans are good at to avoid obeying society's laws. As the Sophists explained long ago society's laws are legal fictions, for no other reason than that one does not have to obey them!

Then what laws do humans have to obey?

If a human child were raised by wolves, it must obey the laws of wolves. If it is raised in tribe 'A' it has to obey 'A's laws, and if by tribe 'B', it must obey 'B's laws. Just that laws of wolves and tribes are hard constraints; less flexible and outside the human purpose, which is to maximize options. Yet, the soft laws of society, giving maximum options are not laws at all; they are legal fictions! So, if hard laws of behavior are not sufficiently adaptable, and soft laws are fictions, what laws must humans obey to fulfill an evolutionary need of providing themselves the maximum number of options?

They must obey the laws of the inner psychology, of culture and purpose. Thousands of years ago the wise men of religion discovered these laws. In an age before science, philosophy, or universal human culture, the leap of abstraction was too great to go from primitive tribal law to modern ethics, so an intermediate explanation was used. This was the religious hypothesis, which despite variations, we can see in its true reference. This is that apart from laws of men and nature, there exists a Greater Law, to which all people must all be subservient. The Greater Law exists as a test of an individual's basic choices, to see if each of us, individuals with will and reason, will choose good over evil.

Even so, the moral test each individual faces did not come from a creator-deity. It came from a struggle eons ago, in which good and bad were measured not moralistically, but by survival. Evolution works many ways. Organisms that once ingested sulfur now breath oxygen. Creatures that once swam now run. Creatures that once crawled now fly. Science revealed these incredible transformations, but has balked at the final one.

Science struggled so bitterly to explain that the processes of evolution were devoid of morality, that it blocked itself from discovering processes whereby evolutionary forces could produce moral ones. Breaking the block comes from realizing that the evolutionary path of humans was not just physical survival and procreation, but evolving the maximum range of options that behaviors can create.

This is why humans need an ethics of choosing good over evil, because it reflects the most adaptable behavior. In survival situations morals inhibit options, but that is the point. In such situations morals can be abandoned, and frequently are! Yet if all humans are trying to achieve is to survive then the evolutionary effort of millions of years has been in vain. Instead, if the human evolutionary path was successful, far from seeking survival, humans should be facing situations in which all options are open. Humans should face situations in which the only remaining constraints on behavior are moral ones. Moral restraint gives humans the maximum options, because it can adapt a creature to the situation of having to face no hard constraints on behavior at all.

Humans place socially fabricated constraints on behavior to derive benefit from a learning-capable brain. There are no natural guides to how these constraints work. We only have looking back, historical guides the constraints took on Planet Earth. If there had arisen a single human society that did not employ religion to first explain ethical dilemma, one might claim that religion was extra-potentate to human life. Yet, religion has been universal, fulfilling social, cultural and belief-system roles. On another planet intelligent societies might have evolved without transiting the religious phase, but humans have not observed it. Evolution deposited humans on the shores of civilization, but while evolution lacks purpose, it at least obeys natural laws. Beyond evolution there are not even natural laws as guides. Humans have no analytical model of what happens, once beings acquire language, intelligence, and behavior that maximizes options. We have on this planet only an historic record. When humans formed tribes they developed belief systems. And when tribes began to form larger groupings, humans developed religions.

Religion is a complex phenomenon, indelible in human culture. We need to understand the role religion filled in human life in ages past, or fills today where religious belief is strong. We also need to explain the effect on people when religious belief collapses, without secular moral systems to take its place. In this sense the task of philosophy, or now of science, is not to produce merely dismissive explanations of the complex human religious experience.

It is to explain why.

6.0 SUMMARY AND CONCLUSIONS

6.1 Summary of the Arguments

"For I am well aware that scarcely a single point is discussed in this volume on which facts cannot be adduced, often apparently leading to conclusions directly opposite to those at which I have arrived." **Darwin**

"At any one moment one is presented with a wide variety of innovative ideas that might be followed up: not only astrology and such, but many ideas much closer to the main stream of science, and others that are squarely within the scope of modern scientific research. It does no good to say that *all* these ideas must be thoroughly tested; there is simply no time... Even if I dropped everything else in my life, I could not begin to give all of these ideas a fair hearing." **Steven Weinberg**

"Yet science seems to have driven us to accept that we are all merely small parts of a world governed in full detail … by very precise mathematical laws. Our brains themselves, which seem to control all our actions, are also to be ruled by these same precise laws. The picture has emerged that all this precise physical activity is, in effect, nothing more than the acting out of some vast (perhaps probabilistic) computation - and, hence our brains and our minds are to be understood solely in terms of such computations." **Roger Penrose**

"This kind of science goes by the name of Darwinian history, and it has been greeted with predictable ridicule by real historians. For them, wealth concentration requires no further explanation. For Darwinians, it must once have been (or must still be) the means to a reproductive end: no other currency counts in natural selection." **Matt Ridley**

"The price of these failures has been a loss of moral consensus, a greater sense of helplessness about the human condition. ... The intellectual solution to of the first dilemma can be achieved by a deeper and more courageous examination of human nature that combines the findings of biology with those of the social sciences." **E O Wilson**

"Or does Darwin's idea turn out to be, in the end, just what we need in our attempt to preserve and explain the values we cherish? I have completed my case for the defense: the Beast is, in fact, a friend of Beauty, and indeed quite beautiful in its own right. You be the judge." **Daniel Dennett**

"The world was all before them. Where to choose/ Their place of rest, and providence their guide/ They hand in hand with wandering steps and slow/ Through Eden took their solitary way." **Milton**

6.1.1 Things We Already Know

This book began from pointing out that many problems of the mind, brain, human evolution or behavior, have not so far been solved. Writers of books concerning this begin boldly enough, but their last chapter often has no real conclusion, or a weak one. Readers are entreated to believe that Darwinian forces shape human behavior merely because 'how else do we explain it?' Daniel Dennett requests that "you be the judge". Steven Pinker worries that there might be problems that a mind formed by evolution cannot solve. Some of this is just academic caution, but even so, how should this book conclude?

Well, some things are already known. Centuries ago Descartes noted that whether one is awake or asleep, 2 + 3 = 5, if that is how one defined the terms. Descartes' statement is imprecise. If the term a = a has a value 1 (true), and a ≠ a the value 0 (false), any problem that could be specified in 1's and 0's could eventually be resolved in those terms (as true or false). This would be so whether we were awake or asleep, whether we evolved or were created by God, or whether we were humans or aliens. A biological organ like the brain could not solve in a lifetime a problem it would take a trillion super-computers to resolve. However, a mind that could build a computer (human minds can) eventually can resolve all problems of this type. Evolution does not come into it.

However, evolution does come into, we might say, the facts of our existence. As far as 1's or 0's as logic, humans might all be figments of the Red King's dreams. Yet, as facts that we can measure, humans are biological organisms, formed by natural processes over billions of years of life on Earth. Now the fact that we evolved to be humans, and not fish, aliens, or angels, means that we cannot know by sentience certain things. We cannot know what it is like to be a fish, or another person, or move about in four dimensions. The fact of our evolution also stamps on our being biological motivators or regulators, such as hungers, drives, moods and emotions. So, it helps us understand our options to know why certain drives and hungers evolved the way that they did.

Even so, when analyzing human motive, one primary fact of how any organism evolved is often overlooked. Whatever an organism feels as mood or sentience, the feelings evolved at a cost, to provide a benefit to survival. If a complex sentience such as moral inhibition evolved there was more cost to evolving a complex sentience than a simple one that will merely avoid pain or gratify an urge. The corollary of this is that any sentience is a way of navigating opportunities. If we captured an aircraft with an incredibly specialized and costly navigation system, we would be curious as to what exactly this aircraft's mission was. So, if we discover an organism (ourselves) with an incredibly complex and high cost to evolve sentience, we should be curious as to exactly which evolutionary challenges this creature faced.

The controversy of complexity of sentience for cost to evolve applies especially to moral theory. Again, it is futile complaining that we might never know why humans possess a morally enabling sentience. This has been known for thousands of years! Humans have moral sentience so that they can judge morally good from wicked acts. However, knowing the reason that humans have these feelings does not make it easier to explain. Even the religious explanation of moral feelings was difficult to derive the first time, using metaphors of gods, creation, and an afterlife. The explanation in scientific terms will be difficult for several reasons. One is that there is no comparable species confronting a range of choices that humans face, for scientists to test the theories against. The other problem is the complex interaction between biology, learning, and culture, such that creatures born in human form are not compelled by any property of DNA to adopt any specific moral behavior. Still, the problem should not be insoluble. These chapters have suggested a theory of how not only morals, but feelings such as religious awe evolved. People can dispute the ideas or provide alternative explanations. The issue is not a particular explanation, but the assertion that answers can be found, ones based on evolution and real human behavior.

The conclusion of this book then, need not be that its theories are correct, in that all ideas need criticism and development. The conclusion instead is that we live in an age when much is known, so there should be no obstacle of inherent facts or logic against formulating a hypothesis of how human behavior evolved.

Let us recapitulate how the problem is approached in these pages.

6.1.2 Evolution and Behavior

The central conundrum leading to a theory concerning options is that nobody has explained how modern, complex, psychologically motivated human behavior arose by evolution. Evolutionists themselves first posed the issue. If evolution could explain behavior in animals, it only seemed that the lessons could apply to humans. And evolution did enjoy amazing success explaining behavior in animals, starting in 1859 with Darwin's own intriguing chapter on instinct.

Where evolution theory has had less success is for issues apparently not connected with behavior, such as the evolution of sex, or the stepped pattern of change. Yet, if other difficulties in evolution theory would not hold back the explanation of behavior in animals, it should not hold back its explanation in humans. Or, there should not be anything 'special' to human evolution different from animals.

These chapters have tried to explain that there were many unique aspects to human evolution. There have been no large animal species that evolved as recently or as rapidly as humans did, or none that radiated to every continent while remaining a single species, or adapted features such as language and a reasoning brain. Or while there is not much DNA difference between a chimp and human brain, the expressed effects of the differences are radical. Expanding the largely homogeneous circuits of the higher cortex does not take much change of neural DNA, which is why human brains could evolve so rapidly. Yet the large mass of free synaptic connections available, within the language and cultural context in which the human brain nurtures, results in not just a large-brained chimp, but a creature that can reason. The human brain is also bigger than required just for survival, which has never been explained. So, an ordinary transformation of brain size, speech organs, and group behavior, can result in a new creature in a phylogenic sense. Or despite genetic distances being small, human evolution at an advanced, saturated stage of life was still a radical change. This is why for human behavior one needs to consider all evolution, how it works, and not just successes explaining the pattern of behavior in lower animals.

The other point is that the biggest difficulty for evolutionary theory is explaining moral behavior, but this is a problem not just for evolution. If all that evolution theory contributed was that the motive of behavior is selfishness, this was suspected all along, but this still does not explain morality. If anything, it was hoped that evolution, being a science, could explain moral behavior where philosophical explanation had failed. But in 150 years evolution has not explained why human have morals, any more than philosophy could in 2,500 years.

Here it is argued that the 'gap' between a not quite perfected theory of evolution, and overcoming ancient conundrums such as the origins of morality, is too great to overcome in a single leap of abstraction. So, one uses an intermediate hypothesis, which works for both human evolution and modern human behavior. This is the *Theory of Options*. It argues that human behavior can be understood by considering that each individual strives to maximize his or her options in life. This hypothesis can explain a great deal of modern human behavior. One can even derive a method of counseling or psychology from the concept of options, a significant step for a theory based on evolution.

The next challenge is to explain how humans evolved. This is done by first supposing that hominids evolved along a fitness pathway that maximized the options of behavior, for the least cost to adapt. The fitness pathway requires some changes to the standard theory to explain it, but that does not invalidate the argument. All populations evolve along some type of pathway. And many facets of human evolution such as the large brain, skin, sensitive hands, posture, diet, or body covering, are difficult to explain via a 'walking chimp' type pathway. However, for any human attribute, one can inquire; "how would evolving this way maximize the options of behavior for a minimal cost to adapt?" Examining human evolution from this perspective provides many insights.

Still, the challenge is not that maximizing options can explain many human attributes, but explaining why this fitness pathway would arise at all. In one sense the mechanisms by which humans evolve should be no different to those of a mouse, an oak tree, or a lizard. But one should be careful to distinguish the mechanism from the pathway. The mechanism in evolution is maximization of the spread of DNA. The pathway is the conditions, both environmental and *phylogenic* (evolution of the species), under which favored individuals maximize reproductive fitness. If human evolution could have maximized the spread of favored DNA via an easier pathway or simpler behaviors, it would have.

Just that pathways in which simple behaviors, or simple adaptations, could be fit were already occupied. Humans evolved when advanced primate species could already adapt to their environment at the maximum rate of change that any large animal phylogeny could sustain. So, the next stage of evolution would be to move adaptation outside of biology into cultural and social forms. Any organism only has to be fitter than its rival, and change comes at a cost. Selection tends to drive organisms into specialization, because this is the easiest way to gain slight fitness for the least cost of change. However, with all the specialized niches occupied, it became fitter for hominids to specialize adaptation outside of biology, in culture and learning. Once it was easier to specialize outside of biology, within biology it became fitter to generalize for versatility. And versatile brains are motivated psychologically because as fitness costs, psychology is easier to modify than biology. Humans do not act out each biological drive impetuously, but they like to feel that they have choices.

So, the mechanism by which any creature modifies is the selective struggle and the passing on of DNA. But this mechanism, crucial at one level of explanation, does not explain all the complexities of the problem at another level. Humans evolved *as though* individuals were selected for maximizing the options of behavior, for the least cost to adapt. At one level critics can test this hypothesis, to see if it can help explain human evolution. At another level, researchers can test the idea as a separate model of psychology, to see if it can also explain how modern humans are truly motivated to behave.

6.1.3 The Use of Equations

Any theory about how evolution explains human behavior tends to end on a humanistic note. The topic begins from facts about selection or DNA, but ends with philosophical or literary arguments about ethics and human purpose. This book though, has emphasized the important role of equations, despite that no equations actually model human behavior, even in theories such as evolutionary psychology. It is even wondered why get into this highly specialized topic, which only brings further disputes over notation, qualifications, and methods of proof.

The issue, and it needs airing, is that many theorists draw freely from an authority inherent to equations, even when advocates of a view might not totally understand the equations either. The literature of mathematical biology itself tends to be cautious, but this is not how those outside the field often draw inferences. Equations show, and it always surprises, how amazingly fast a slight gain in fitness for a favored allele can spread. So the issue is not the equations, but whether rapid spread of alleles is the correct model for explaining human behavior.

There are two concerns. Firstly, even assuming that a behavior such as for cheating or aggression is expressed by a single gene or allele, it is hard to estimate the fitness value that such attributes would confer among humans, or how, among the global population such genes would spread, fix, or affect selection.[82] The inference then is that such genes might not affect selection today, but they spread when the population was small and evolving. Still, humans have only 1-2% of genes different from chimps, and many human attributes had to evolve, not just behavior. However, apart from genes, there is a 0-5% allele variety among humans that can affect temperament, and would alter by standard models among a small, evolving population. The question then is to which extent did variation stamp a permanent effect on the human temperament?

Again, individual humans have different temperaments. The problem with uncovering a general temperament, such as that humans are innately aggressive, is that it is only the reflex neurology, which expresses one behavior per allele per locus, that can be modeled in an equation. Yet in human behavior, learning dominates reflex by about 8:1, against 3:1 in chimps, or less than 1 in lower animals (such as birds) where these types of equations work best. Where reflexive behaviors can be isolated this way in chimps they exist in humans. Except very few genes for reflex altered during human emergence, in comparison to many other changes. It is the genes that enacted the gross transformations, such as increase in brain size, that are critical to human behavior.

This is the second concern. Genes that caused gross transformations of life strongly affect how humans behave, but these genes are mostly 100% distributed in modern populations.[83] However, the same equations for how alleles spread, say, from a 1% to 99% distributed, do not model how genes already 100% distributed spread further. So, reducing human behavior to how genes spread in equations concerns the less significant genes, or the attributes, of the entire human transformation.

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[82] Genes only work in an equation if they influence selection. Genes with lethal mutations affect selection, and genes that mutate as a statistical process affect the human gene mix. Or if AIDS devastated the population, a gene resisting it could spread by a standard model.

[83] It is recently suggested that BF-1 and BF-2 genes control brain size, but humans share these genes with fruit flies. Whatever the case, many gross attributes will be controlled by ancient, widely distributed genes

Even so, it is perplexing that within a small population (from 0 to 100% spread of genes), selection proved so adept at the mathematics that biologists now use. Yet selection could not solve the "math" of spread of genes beyond 100% distributed, because for humans to solve it requires an equation with $\sqrt{-1}$. Even more perplexing, from billions of years ago, selection physically did solve this problem. The majority of genes in any genome *radiate* outside of any small population under study. This could only be explained if genes already 100% spread over many populations, used new adaptations to spread further by conserving their own sequence, while forcing other genes to bear the cost of change. This way, human evolution was very successful. Some 98% of genes in the human genome found new ways to spread with their sequence unaltered, for only a 1-2% change of other DNA. Again though, while Chapter 2.4 suggests it, there are no proven equations of how this works.

There is a similar debate over whether a property such as choice can be reduced to equations. Suppose that from a given set of inputs one can get a computer to produce certain outputs. If another computer would reproduce identical outputs from identical inputs, one could not claim that the first computer made choices. Some people apply this argument if an individual acts with moral reprehension. They would claim that one need only prove that another individual under identical circumstances would act the same, to show that no choice was involved. Or one might presume there was choice, whereas if the person were following moves constrained by a Laplacian trajectory, there was no choice.

While this argument sounds recondite, present knowledge of how brains make choices is inadequate. Brains that abstract are analytical, but these depend on a program to run, and programs themselves must evolve. For analytical brains to work there must be a transformation of the type;

$$(E, d, x) \rightarrow (E, d, p, x),$$

(Where p is the electronic program E is energy, d is the design, x is the input-output. See page 132.) Yet, there is no equation of how this works, although neurology explains learning. Moreover, mathematics itself is a choice of axioms, which has been shown by theorem's such as Goedel's. (Mathematics depends on a program to isolate its inherent logic from the rest of the universe.) Brains capable of abstraction are disconnected from the outside universe too, by the synaptic mass acting as an information insulator. However, because this effect cannot be modeled by existing equations, it does not prove that choice cannot exist as a quality other than those describable within existing concepts.

The approach used here then, is to take the crucial transformation for humans, as evolution of the ability to abstract. Language, culture, and a large brain allow abstraction, but abstraction itself maximizes the options of thinking. The highest form of abstraction is organizing its processes in formal methodologies such as equations or logic. That is why, though it is a descriptive theory, this book has included certain equations, not just of evolution, but any that have led to deeper understanding. However, while existing equations can explain facets of evolution, the evolution of abstraction was itself another major transformation of life, which existing equations do not model that well.

Without equations available to explain it, the argument is forced, as in every other theory, to rely on observational descriptions of how the most complex properties of the universe; choice, morality, abstraction and options arose. So what can a theory about maximizing options say, that other explanations may have overlooked?

6.1.4 Options and the Universe

The theory in this book emphasizes the role of the individual, not in a selfish sense, but as a locus of accountability and change. Knowledge, even of how people behave, ends in choice. This precept is not new, but it is novel in a theory using evolution. Science studies nature, but without intelligent creatures in it nature does not exhibit choice in a moral sense. In the primal universe there is no choice, just as there are no naturally occurring elements with more than 92 protons, or no machines and artifacts. Such entities come into existence when creatures with culture, intelligence, and language come into existence. Choice in a moral sense only comes into existence with intelligent beings. Moral choice is an emergent property. It exists only after other properties exist first in certain relationships, but does not exist when they do not.

If anything, the very concept of evolution is that properties arise by progression. But the further the progression, often the more complex the properties become, so the harder it becomes to explain them by simple models. This is especially for explaining evolution of the very creatures, ourselves, carrying out the analysis. Daniel Dennett say, claims that all living entities, which includes humans, are "nothing but" algorithms. All he means is that life evolved by a series of algorithmic-like steps. But he infers that the algorithm itself is a physical force, like gravity, that exists independently of consciousness. All natural processes in the universe exist independently of consciousness, but analysis of those processes into symbolic rules is another emergent property, which comes into existence with intelligent beings. It is an historic process. Choice, intelligence, will, and options come into existence first. Tools of those attributes refined, such as formalized methodologies (like algorithms) come into existence as an aid to extending the range of understanding.

Perfect knowledge exists when formal logical manipulation such as mathematics becomes coincident with all the facts of our existence. Yet, such perfect knowledge would close off further choices, because it is always within the difference between facts and logic where intuition and judgment lie. If humans do not have the present understanding to close the gap, it must be sought in further knowledge. The power of abstraction comes from its generality, and the power of mathematics comes from the logical connection of its rules, plus its physical *disconnection* from the remainder of the universe. Rigorous abstraction is tautology, so outside of its physical significance, any equation can prove no more as logic than "a = a" to a being who is infinitely wise.[84] All abstraction must be verified against facts that humans can measure. This has been proven in philosophy. These chapters have suggested that the human brain evolved to work the way it does, on broadly the same basis.

The large human brain, which has never been explained in orthodox theory, did not evolve to the size it did because of the stupid peacock's tail, or so that humans could gossip about sex! Humans evolved along a pathway that maximized the options of behavior, and that pathway stayed open until a brain evolved that could fully abstract. The large brain was a critical mass of free synaptic connections that could act as an information insulator, to achieve the abstraction effect.

Human reflex, which was selected for fitness, did not evolve abstract thoughts in the higher cortex, which has a homogeneous neural circuit structure anyway.[85] Instead, reflex in humans selected for the refinement of the senses, aural, visual and tactile communication, leading to the gathering of facts for evaluating situations. The brain evolved reflex feelings for moral empathy, judgment, and emotions. From a range of information, transposed by tautology into situations about which humans can abstract, tempered by judgement and intuition, the choice of a course of action to maximize options could be made.

The purpose of knowledge, including about evolution or behavior, is to delineate for humans real choices in the most unambiguous way. Each individual, even one in deep personal crisis, has a set of options from a given point forward. This idea can be developed as a method of therapy, without negating facts about psychology already known. Every day at the home, in business, or politics, we could not understand human motives as a striving to maximize the spread of each individual's DNA. Striving to maximize options though, makes sense. Humans have options, and the deepest satisfactions will come from feeling in control of a situation, and that the choices in life are real and viable.

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[84] Notational logic can prove say, that the series $E = mc^2 + mv^2/2 + {}^3/_8\, mv^4c^{-2} + \dots$ will reduce to $E = mc^2$ for certain conditions. However, the physical significance of E, m, c and v can only be verified not via logic, but experience.

[85] The neural structure of the upper brain is highly 'proximity mapped' to specific functions, but it is not genetically mapped in the same way that the reflex neurology is. See comments at the end of Chapter 3.3, and other references.

Moreover, humans are at a point where they must maximize all their available options, if the species, or the ecosystem of the planet, is to survive. The argument begins from a premise that humans are a product of evolution, and that the biological disposition of modern humans was selected from fit ancestors. It allows too that genes strongly motivate behavior. (Or, even if motivation is more complex than genes allow, the explanation is encoded in DNA.) Yet it is also unimpeachable that most human behavior is not motivated by genes directly. It is an absolute truth too, that symbolically organized thinking, which humans use everyday, is not encoded in DNA. If it appears contradictory then, to say that human motivation arises from genes but is not directly a product of them, it is only lack of deeper explanation that makes this seem so. It is neither the facts of how humans evolved nor the facts of how they behave that are incongruous. It is how people interpret those facts.

Even then, any evolutionary explanation of abstraction, choice, or free will, still comes with a caveat. Humans evolved along a pathway that maximized the options of behavior, but any change is at a minimum cost to adapt. Because change only advances along any pathway as far as the minimum cost is met, humans never achieved complete liberation from their primal past. The final conundrum of the human condition is that we are never totally free from the forces that shaped us, but have only struck a perilous balance on the edge of that freedom. We need today a science of human behavior, because human behavior for the next few generations will determine if our species, or the planet, is to survive at all. However, we must embark on our study from concepts that balance both the perils and opportunities of our evolutionary origins. This means using all of science to reveal to humanity its real choices in the coming age. The knowledge is to confront humanity with the moral courage it needs to make those choices, in the best interests of the species.

A theory about humans maximizing options, or a variation of it, arises when science uses evolution to explain human behavior. Evolution explains how life and thought arise from mechanical processes. Yet we study these processes precisely so that we will not be trapped by them, but can modify and change. Mechanical theories of behavior do not tell us how we will behave for certain, but only how we will behave if we do not use wisely the knowledge that such theories reveal.

Knowledge increases options. Humans should seek knowledge about themselves not just in a theory of what humans are, but an argument of how humans, from all their options, choose themselves to be.

Appendices

Appendix I -Technical Background

Using Large Numbers

Books such as this invariably use large numbers, typically explained as "one with this many zeros", or other analogies. Yet, if people need to use large numbers they should learn the standard notation. Some rules are;

1. *Any number is its value in units multiplied by the power of 10*. A million has six zeros, so we write it as 10^6, one with six zeros. Three and a half million people is 3 ½ times one million, or 3.5×10^6 people.
2. *When numbers are multiplied, powers are added.* Three and a half million people with eighty thousand genes each is a total of; 3.5×10^6 times $80 \times 10^3 = (3.5 \times 80) \times 10^{(6+3)} = 280 \times 10^9$ This in turn = $2.8 \times 10^2 \times 10^9 = 2.8 \times 10^{11}$ total genes.
3. *When numbers are divided, powers are subtracted.* The galaxies move apart at 15 km/sec per 10^6 light years. A galaxy receding at 3,000 km/sec is $15 \times 10^6 \div 3{,}000 = 15 \div 3 \times 10^6 \div 10^3 = 5 \times 10^{(6-3)} =$ 5,000 light years away.
4. *When numbers are inverted, the power changes sign.* A gene mutates once every two million generations. Its mutation rate is; $1/(2{,}000{,}000) = ½ \times 1/10^6 = 0.5 \times 10^{-6} = 5.0 \times 10^{-5}$ mutations per generation.
5. *When numbers are squared, the power is doubled.* Temperature T^0K of the universe = $10^6/\sqrt{t}$ where t is years. Squaring both sides; $T^2 = 10^{(6)2}/t^{(1/2)2} = 10^{12}/t$, At $T = 1{,}000^0K$, $t = 10^{12} \times T^{-2} = 10^{12} \times 10^{(3)-2} = 10^6$ years.

Remember;

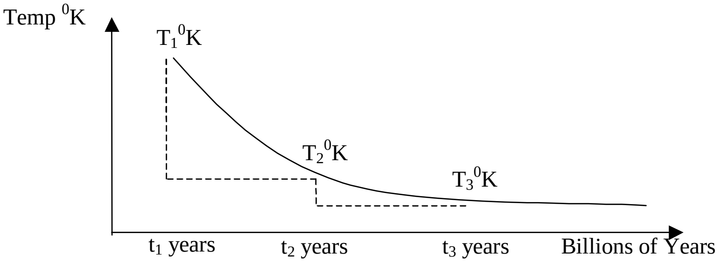
a) A million = 10^6 and a (USA) billion = 10^9.
b) Gene lengths are in bases (or base pairs, bp). A Megabase is 10^6 bp and the human genome is about 3,000 Megabase or 3×10^9 bp.
c) A light year is distance light travels in a year. The speed of light is 3×10^5 km/sec x 4.73×10^8 sec in year = 1.42×10^{14} km.
d) Nothing travels faster than light. So if the galaxies recede at 15 km./sec/10^6 light years, the furthest galaxy must be no more than $(3 \times 10^5)/15/10^6 = 2.0 \times 10^{10}$ or twenty billion light years away, though after adjustments it is less than that.
e) Absolute temperature is in ^{0}K (degrees Kelvin) which is -237 ^{0}C.

The Expansion of the Universe

Galaxies are flying apart at 15km/sec/10^6 light years (Hubble's Constant). The inverse1/H = 2×10^{10} years. Adjusted for gravity, light, and nonlinear expansion, this reduces to 1.5×10^{10} years. At that time in the past all the matter of the present universe was concentrated into a point of unimaginable density, temperature and pressure, called the 'Big Bang'. Some people question this, but;

1. Mathematical solutions to the universe yielded an expanding model, even before the measurement was observed.
2. Expansion of the universe offers the most plausible explanation of the large red-shift observed among distant objects.
3. Static models of the universe lead to irresolvable paradoxes, such as a permanently lit night sky, gravitational instability, or continuous creation of matter from empty space.
4. An explosion 15 billion years ago would leave evidence of a 2.7^0K background radiation, which has been measured.

However, the universe does not just expand, but like expanding gas in a refrigerator, it cools as it expands. For t in years and T in ^{0}K roughly; $T = 10^6/\surd t$. (Approximately, just to explain the idea.)



The Second Law.

The most misunderstood law of physics concerns three things;

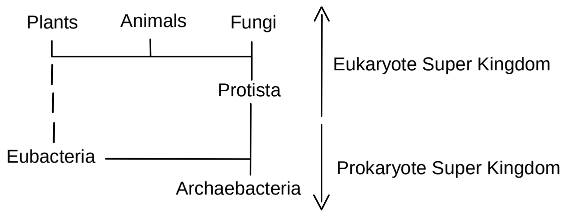
a) The <u>First</u> Law states that we cannot get energy for nothing.
b) The <u>Second</u> law states that even if there is enough energy, some of it will be lost due to inefficiency and dissipation.
c) The principle of <u>Thermodynamic Equilibrium</u> (TE, but part of the Second law) states that systems will tend towards disorder.

Total available energy in the universe is a function of its absolute temperature, but this falls over time. Today the universe is about 2.7^0K, but when Earth formed it was about 3.3^0K. So the universe has consumed $3.3 – 2.7 = 0.6$ ^{0}K of equivalent work over that time. This has gone a small part into organization that allows life. Yet if there was a nuclear war that disorganized life again, the 0.6 ^{0}K would not return to the universe as extra temperature, but would dissipate away. (The mean temperature in the universe will never increase while the galaxies expand.)

However, temperature also contains a quality called "order". This means that the temperature difference $T_2 - T_1$ between a hot body and its surroundings is available for useful work. The Second Law states that when $T_2 - T_1$ exists, the statistically likely state is that the difference will diminish over time. (A hot meal in a cold room will cool over time). The state of $T_2 = T_1$ (no temperature difference left) is called Thermodynamic Equilibrium (TE.) Life moves <u>against</u> the direction of TE, but it does <u>not</u> violate the Second Law (this is much misunderstood).

Life on Earth

Life possibly began at the same chemical composition and a slightly lower temperature than its surroundings. First life was thermophilic (heat loving) so it only had to cross a low TE barrier. (There is dispute over this. On early Earth there would be a variety of energy rich sources. It does not mean that life evolved exclusively at deep sea volcanic vents. Either way, this is bad news for those who want to discover life on cold planets like Mars.) Life moves away from TE with its surroundings by accumulating order, and this takes time. It took 3 billion years, 80% of the time life existed, or 20% of the age of the universe for life on Earth to move out from the sea. (Even then, fluids of the egg sack in modern animals are a similar chemistry to seawater, after billions of years.) Complex life only began in the last 500 myrs. Humans evolved only in the last 5 myrs, or 0.13% of the time that life existed. (In a 24-hour day, humans evolved in the last 100 seconds.)



Once an organism evolves its type spreads into all the niches that can support it. Because costs are huge and time and the resources of any planet are limited, this cycle can only repeat a few times. On Earth, there are six (some say five) kingdoms of life grouped into two super kingdoms. An early life form evolved into archaebacteria (archaea) and then into eubacteria (most modern bacteria). Archaea and eubacteria form a super-kingdom of prokaryotic cells. Protista, fungi, multi-celled animals and plants form the other super-kingdom, eukaryotes. Eukaryotes are far more complex than prokaryotes. They evolved by amalgamation of 2-3 archaea cells first into protista, while a cyanobacteria (from eubacteria) was later amalgamated into cells for plants. (*Caution:* Many diagrams show both archaea and eubacteria separately evolving from an earlier ancestor, with many more sub-branches. Plus there was much "horizontal" gene transfer in early life. Phylogenetic schemes of early life should always be checked for details against the latest findings.)

The Genetic Code

Genes consist mostly of a double helix deoxyribonucleic acid, DNA, but there are single helix ribonucleic acid, RNA, genes. DNA has four nucleotides A, C, G, and T. RNA has U in place of the T for DNA. Each letter forms a three-letter word, called a codon. It is possible early life coded only the first two letters, though there are molecular reasons for codons to be three-letter. Four letters for two places provides $4^2 = 16$ code words, so early life used 16 amino acids to build the materials of life.

Modern life uses 20 amino acids, which needs a three-letter code. Four letters in three places provides a $4^3 = 64$ word code. This makes many words redundant, with slight differences in the third letter. Redundancy of the third letter, plus that much genetic DNA is unexpressed, allows genes as DNA to mutate at a faster rate (about 10^{-7} average) than the expressed effect among proteins (about 10^{-9} average).

Genes are the code of life. Materials are polypeptides, which form proteins and enzymes, plus there are water, sugars, salts, and nutrients. This leads to debate over whether life is a vehicle just for the code to replicate, or whether the original materials of life began to replicate first and the code evolved later. It now seems that RNA evolved before DNA, and RNA or simple polypeptides might have been first life.

The "central dogma" of gene expression is that DNA produces RNA instructions. These manufacture a polypeptide string of one amino acid per codon. The "dogma" holds for simpler cells, but as cells become complex much DNA is unexpressed as RNA or proteins, and much of it is junk or non-coded. The human genome is 3×10^9 bp of DNA, but only 15% of that is genes, and only 1-2% of that DNA is expressed as useful proteins. (Roughly. Details are being revised as more is learnt about genomes. Always check against latest findings.) Some viruses use RNA code, and some viral RNA reverse translates as DNA. These effects show that evolution is more complex than at first thought.

Evolution

Evolution is accumulation of thermodynamic order over time. Total order in the universe falls with absolute temperature, but local order can accumulate. Initial accumulation is formation of atoms, stars and galaxies. This process continues pre-biotic (prior to life) up to a complexity level of amino acids. Beyond amino acids, complex forms must self-replicate, or self-renew, to maintain order against other Second Law effects. Each step away from TE presents a barrier, which must overcome. From the initial thermal soup of the universe the structure of amino acids is far from TE, so it took billions of years of stellar evolution for complex molecules to form. Order beyond amino acids is not possible until after life evolves. To send a living being into outer space is a huge step against TE that cannot be overcome by biological evolution alone, but requires social evolution.

First life could not move quickly into new surroundings at a lower temperature, without increasing internal order. It achieved this by natural selection, which is not available to non-life. For any living, self-replicating organism, there will be small fluctuations from the existing level of internal order up or down each generation. Without natural selection, mean fluctuation would result in a zero net change of order. Natural selection captures each increase in order and deletes each decrease, so that a positive net build up of order occurs over time.

Appendix II - Suggestions for Further Reading

Note: This is not an exhaustive list of books, but a sample of books in my private library. The list does not include general texts, references, or materials from periodicals and the Internet. Nor does the list include well-known, original works of philosophy, quoted in the main text. The list will be updated in future additions. Obviously, a great many original works influenced this present book, and any omissions in the following list will be gratefully acknowledged by the author.

Evolution, Monroe W. Strickberger, Jones and Barlet.
Evolution; The Four Billion Year War, Majerus, Amos & Hurst, Longman.
The Origin of Species, by Charles Darwin
The Selfish Gene by Richard Dawkins, Oxford Univ Pr.
The Blind Watchmaker : Why the Evidence of Evolution Reveals a Universe Without Design by Richard Dawkins, W W Norton & Co
The Extended Phenotype : The Long Reach of the Gene (Popular Science), by Richard Dawkins, Oxford Univ Press
River Out of Eden : A Darwinian View of Life (Science Masters Series) by Richard Dawkins, Lalla Ward (Illustrator), Basic Books.
Climbing Mount Improbable, by Richard Dawkins, Lalla Ward (Illustrator) W W Norton & Co.
Life : A Natural History of the First Four Billion Years of Life on Earth by Richard Fortey, Knopf
Darwin's Dangerous Idea : Evolution and the Meanings of Life by Daniel Clement Dennett, Touchstone Books,
The Dragons of Eden : Speculations on the Evolution of Human Intelligence, by Carl Sagan Ballantine Books (Mm)
Cosmos by Carl Sagan (Mass Market Paperback - September 1993)
Broca's Brain : Reflections on the Romance of Science by Carl Sagan (Mass Market Paperback - October 1993
Becoming Human: Evolution and Human Uniqueness by Ian Tattersall, Harcourt Brace.
Wonderful Life : The Burgess Shale and the Nature of History by Stephen Jay Gould, W W Norton & Co.
Bully for Brontosaurus : Reflections in Natural History by Stephen Jay Gould, W W Norton & Co.
Ever Since Darwin : Reflections in Natural History by Stephen Jay Gould, W W Norton & Co.
Reinventing Darwin : The Great Evolutionary Debate, by Niles Eldredge, Phoenix.

On Human Nature by Edward Osborne Wilson (Mass Market Paperback - October 1988)
Population Genetics : A Concise Guide, by John H. Gillespie, Johns Hopkins.
The Causes of Molecular Evolution, by John H. Gillespie, Oxford.
Principles of Population Genetics, by Daniel L. Hartle, Andrew G. Clark, Hardcover
A Brief History of Time by Stephen Hawking, Bantam.
At Home in the Universe : The Search for Laws of Self-Organization and Complexity by Stuart Kauffman Oxford Univ Pr (Trade)
Relativity : The Special and the General Theory by Albert Einstein Crown Pub Paperback.
William H. Calvin, The Cerebral Code: Thinking a Thought in the Mosaics of the Mind (MIT Press)
Windows on the Mind : Reflections on the Physical Basis of Consciousness by Erich Harth.
Dreams of a Final Theory by Steven Weinberg. Paperback (March 1994)
The First Three Minutes : A Modern View of the Origin of the Universe by Steven Weinberg. Paperback
How the Mind Works, Steven Pinker, Penguin
The Emperor's New Mind, Roger Penrose, Oxford.
Not in Our Genes, Rose, Kamin and Lewontin, Pelican
The Ascent of Man, Jacob Bronowski.
From Brains to Consciousness, Steven Rose, Pelican
How the Leopard Changed its Spots, Brian Goodwin, Pheonix
Artificial Life, the Quest for a New Creation, Steven Levy, Pelican
The Red Queen, Sex and the Evolution of Human Nature, Matt Ridley
Algeny, Jeremy Rifkin, Penguin
Shaping Life, John Maynard Smith, Weidenfeld and Nicolson
The Children of Prometheus, Christopher Willis, Pereseus Books
The Human Brain, Susan Greenfield, Phoenix.
The Sixth Extinction, Richard Leakey, Phoenix
Man for Himself, Erich Fromm, Fawcet Premiere
The Third Chimpanzee, Jared Diamond, Vintage
The Human Brain, Phoenix, Greenfield, Susan,
Evolving Brains, Scientific American, Allman, John

Appendix III - Table of Authorities

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