DEATH FROM A DISTANCE and the BIRTH OF A HUMANE UNIVERSE

HUMAN EVOLUTION, BEHAVIOR, HISTORY, AND YOUR FUTURE

Online endnotes

Endnotes designed for professional scholars and students.

Most general readers will not find the endnotes necessary.

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Chapter 1

The Journey We Will Take

1 The key initial theoretical work is Bingham (1999) which defines the fundamental structure and implications of the theory. Crucial recent work involves the detailed game theory of coercion (Okada and Bingham,2008).

The uniqueness of human high-momentum, aimed throwing has long been recognized and recent empirical evidence continues to strengthen the case that this is a uniquely human capability (Potts, 1988; Marzke, et al, 1988; Bingham, 1999; Cannel 2002; Chapter 7). Darwin (1871) thought that human weapon use (including throwing) might have been important to human evolution. However, the hypothesis he imagined for how this works is an example of what we now refer to as a “group selection” theory or hypothesis as we will discuss in later chapters. What matters at the moment is that we now recognize that the group selection hypothesis is extremely unlikely to be correct or important.

Over a century later, Darlington (1975) revisited human throwing in the context of human evolution, but, again, proposed a dubious group selection model for its importance. More recently, several economists have updated unlikely group selection models that borrow from Paul’s recent emphasis on the importance of throwing (Bingham, 1999) as a supporting element for group selection (Gintis, 2000 and Gintis, et al., 2003).

Calvin (1983) proposed a different hypothesis for why human throwing was important to our evolution. He suggested the specialized brain structures necessary to permit aimed throwing were “pre-adaptations” that made the evolution of elite brain function and spoken language easier – with the other unique human features resulting from our language and our new level of intelligence.

As we will see in later chapters, Calvin’s hypothesis is also very unlikely to be correct. It is logically doubtful. For example, it is unclear that elite human throwing is more cognitively demanding than any other complex, high speed animal behavior – a cheetah or hawk chase-down on a complex landscape, say. Moreover, as we will see, elite human speech and exchange of information requires the solution of the conflict of interest problem (Chapters 9 and 10). Cognitive power does not solve this problem. As well, the idea that elite throwing produced human uniqueness because it is a pre-adaptation to complex neural function accounts very much more poorly for the empirical evidence than the new theory we will explore here (Chapters 11-17).

2 For example, consider the following phenomena - things that traditionally mystify and frustrate us, evade our understanding. As these cases march across the page, be conscious that all of these previous puddles of ignorant frustration will come within our full understanding and capacity for effective action with a good theory of human biology and human uniqueness.

We all yearn to know the meaning of our lives. How did we get here, what is the purpose of the universe? Indeed, some of our greatest works of literature are endlessly read by generation after generation because they purport to answer these universal human questions.

The individual inner moral life of each of us is chaotic. We are perpetually of many minds. One of these minds aspires to the highest ethical standards, another is pragmatically aware of the "rules of the game", yet another looks to "beat the system". Our individual character is defined by how we balance these warring inner minds.

Any two humans taken from around the world at random are almost identical genetically. They are typically more similar than any two randomly chosen chimps, for example. Yet all groups of humans in the past have had no difficulty in agreeing to enslave other humans and treat them as domesticated animals. Virtually every one of us reading (or writing) this passage has ancestors who were slaves and other ancestors who were slave-owners. It is merely a question of how far into our past we have to look to find them.

We have strong, diverse, conflicting emotional feelings toward the members of our family, toward our co-workers, toward our fellow countrymen, toward the 6 billion other humans on Earth.

The same Midwestern American politician who sings in church on Sunday "Jesus loves the little children, all the children of the world" claims on Monday that it is the right of the local coal-burning electricity generation plant (a generous political contributor) to pump greenhouse gases into the atmosphere that acidify the lakes in which the children of the American Northeast used to fish and which endanger the climate for all the Earth's children. With terrible irony, this politician's grandchildren may perish with the onset of the catastrophic climate change these greenhouse gases will probably bring on or speed up before the end of this century.

Members of the Spanish Inquisition claimed to believe that they were doing a service to those whom they burned alive, saving their "immortal souls" from the consequences (ostensibly) of differences of opinion about the details of various divinities. These Inquisitors might have claimed to be quite unaware of any local social, economic or political consequences of the deaths they caused.

The Nazi regime of mid-20th Century Germany was willing to systematically gas to death millions of its citizens (ostensibly) on the basis of what was believed about differences in ancestry and in mythologies.

Nineteen young men hijacked four large jets fully loaded with fuel for transcontinental flights. They used them as incendiary weapons – flying or attempting to fly them into the Pentagon, the White House or Capital and both towers of the original World Trade Center. All nineteen were killed along with hundreds of passengers and several thousand on the ground. These young men claimed to consider themselves to be serving the very highest moral calling - as did the people who hunted down their surviving confederates.

Our contemporary economic systems have increased the productivity of an average worker in the US about 100 fold compared to that of our ancient pre-agricultural ancestors. We imagine that we "built" this economic system, yet we are unable to understand or forestall cycles of recession, inflation/deflation or to provide employment for more than about 85% of those who would prefer to work.

These and millions of like observations have traditionally been seen as "social facts" rather than biological consequences. We will argue that this perspective is wrong and self-defeating. Our theory will ostensibly illuminate the underlying biological origins of all these matters.

3 The world of subatomic particles, atoms and molecules illustrates this principle very well. We now recognize that subatomic particles have a diverse set of properties. A few of these properties determine how these particles interact with one another at moderate temperatures, such as those at the surface of the Earth, to form atoms. Moreover, the properties of atoms result from the properties of these component subatomic particles. Further still, the properties of molecules result from the properties of the constituent atoms that make them up. We continue to move up the hierarchy of complexity rather analogously to the assembly of letters into words into phrases in written language. We will argue throughout he book that this same approach will continue to apply up to and through pan-global human society.

4 For professional academics, the word *reductionist* is used with rather different meanings within the scientific enterprise than by some outside of that enterprise. We will use the word in the natural scientist's sense here. If you are a reader who has a different notion of what reductionism is, you will need to recalibrate for the purposes of this book.

This redefinition is very important for a number of reasons. One of them is that reductionism and reductionist explanation have become fighting words is some circles within the academic world. If we are to ultimately end up fighting over this word - as, in fact, we should not - we should be certain, first, that we actually do disagree. In some cases failures of mutual understanding are mistaken for disagreement.

Notice also that the highly technical arguments about reductionism between professional scientists do not concern us here.

5 When we first naively look at the properties of any level of complexity, in isolation, we are immediately overwhelmed. Consider, for example, the structure of macroscopic matter (the matter we can see and touch) at the surface of the Earth. Try to imagine that we live in a pre-scientific culture and we have no knowledge of the atomic and molecular theories of matter. We are confronted with the following observations.

Matter can apparently exist in any of three phases - gas, liquid or solid. Moreover, what appears to be a single "kind" of matter (water, say) can exist as either gas (steam), liquid (water) or solid (ice) – apparently depending on temperature and pressure.

What can we make of all this? Upon brief reflection we see that our problem is not a lack of explanations. Rather, there is a plethora of them. In fact, if we study the history of theories of matter over the last few millennia (where we have written records), we find an enormous number of proposals. A few are cunningly close to what we now know. Most are far wide of the mark, sometimes to the point of being comic.

Confronted with this "infinity of explanations", we are permanently helpless if we consider only the level of organization in question. However, if we recognize that the properties of matter must result from the properties of its components (that is, once we make the "reductionist assumption") suddenly our problem is vastly simplified. Many possible explanations for the phases of matter are eliminated and only a manageably small number remain.

This is not all. Now that we possess the reductionist assumption, our capacity to improve our understanding of the phases of matter increases with each increase in our understanding of its components parts - atoms and molecules. Moreover, we can run this understanding the other way round, as well. We can now use the properties of the phases of matter to gain further insight into its atomic and molecular components.

This still is not all. Our problem is even further simplified by continuing to make the reductionist assumption. The properties of the phases of matter result not from all the properties of atoms, but only from a small subset of those properties. This intellectual strategy turns out to be general. For example, the properties of an atom depend on only a small subset of the properties of its constituent subatomic particles, the properties of a molecule depend only a small subset of the properties of each of its component atoms and so on. Thus, as we move up the organizational hierarchy of the causal universe, our reductionist explanations do not become ever more complex and ultimately overwhelming. Instead they remain simple, always.

We are now in a position to begin to understand why reductionist explanation is everything. It not only apparently reflects how causality in the universe is organized; it also renders those causal relationships transparent and susceptible to simple description and explanation. This is an unbelievably powerful trick. We will argue that it continues to apply up to and including the level of complexity/organization corresponding to uniquely human societies.

Chapter 2

We know what life is – a special case of chemistry

1 The following story is beautifully reviewed in Peter Ward and Donald Brownlee's 2000 book *Rare Earth.*

How does Earth look to the rest of the universe?

As little as a few decades ago, many scientists made what was called the "Mediocrity Assumption" about Earth. This wasn't a conjecture that our standardized test scores were regrettably average compared to the rest of the universe. Rather, this assumption was that our planet just was not very unusual as planets go.

More recently, we've learned that the Mediocrity Assumption is very probably wrong. As we will see in moment, Earth is, in fact, shockingly unusual. Our planet is probably profoundly out of the ordinary in both its microscopic chemical composition and some of its more macroscopic properties.

This remarkable story is important to grasping the status of humans in our galaxy and beyond.

Human-like life is probably ***extremely*** unusual in the universe. The organisms of Earth evolved in a profoundly novel planetary environment, to begin with. Then we humans came along and take the business of being a terrestrial organism to a whole new level. From the perspective of our universe, we humans are unusual *squared* – the crème de la crème. We would probably occupy all the slots on an all-star team of complex galactic organisms. Among many other distinctions, we humans are probably the only organisms in our galaxy who have ever constructed a reductionist explanation of themselves – or even made a complex tool, like a pair of pliers or a folding pocket knife. It is even possible that we are the only such creatures in the *entire universe.*

Take a moment and reflect on this. Its implications could not be more important - or sobering. It is likely that we are the stewards of the galaxy or even the entire universe. The properties of this universe in the future – its "purpose", its morality, its fate – are probably ours to define.

Alas, we haggle over ownership of tiny pieces of terrestrial real estate on the time scale of decades, while an entire universe lies in a 13 billion year sleep that perhaps only we can awaken. We will have more to say about why our biology makes us so short-sighted later in the book.

Earth is a most eccentric planet in a quirky local neighborhood

How did Earth's unusual properties arise and how did these properties permit the evolution of what we think of as individual organisms? The answer to this question has several parts. To begin with, Earth is a part of our solar system organized around a star, our sun. Our solar system is a complex chemical and physical system that arose by gravitational collapse from a cloud of material produced by the explosion of earlier stars.

The chemical composition of this cloud was somewhat unusual and, thus, our solar system and our planet are unusual. The amounts of heavier chemical elements (atoms) in our solar system is substantially higher than for an average solar system in our galaxy – for reasons we mostly understand. [In this context heavier is a comparison to the lightest element, hydrogen. Heavy refers to elements like the carbon, nitrogen, oxygen, calcium and phosphorus.]

Most of the components of organisms like us are made up of such heavy atoms. Thus, our ancestors arose in an especially rich stew of what makes us up. Shortly after the birth of the universe (apparently around 12.5 billion years ago) most of the class of matter able to engage in chemistry consisted of the simplest possible kind of atom – hydrogen, containing one proton and one electron.

Here at the beginning there were essentially none of the bigger, heavier atoms. The massive clouds of hydrogen atoms present near the beginning of our universe developed local areas of higher concentration, higher density – essentially randomly or accidentally. These local concentrations apparently occurred on various scales. One scale producing massive aggregates – galaxies and galactic clusters. On a smaller scale, these local concentrations arose *within* galaxies. These local concentrations were often of a size containing enough matter to make a solar system like ours - and this is the scale we are interested in here.

These local hydrogen gas concentrations start a process of run-away gravitational collapse – each portion of the cloud pulling every other portion toward itself. As this mutual attraction continues, it results in the formation of an extremely dense glob of hydrogen near the center of the original cloud. This glob is heated by the energy released as uncountable billions of hydrogen atoms fall in, colliding violently with one another. [In the jargon of physics – potential energy (gravitational) in the original large cloud is converted to kinetic energy (heat) in the dense glob the cloud collapses into.]

Eventually, the growing glob is heated to the point that nuclear fusion reactions can occur. Notice that these reactions are NOT chemical. As we will discuss momentarily, chemical reactions involve the outer electron shells of atoms, *exclusively*. In contrast, at the colossal temperatures here, the electron shells are largely stripped away and the inner nuclei of the atoms (protons and neutrons) are smashed together with titanic violence. When this happens these nuclei are fused – joined – forming heavier nuclei.

Of course, these are the same reactions that occur in a thermonuclear explosive device – a hydrogen bomb. They release colossal amounts of new energy as a result of the conversion of a small fraction of the mass of the fusing hydrogen atoms into energy – $e = mc^2$. This huge release of energy does two things. Some of it radiates away from the hot gas glob. The rest heats the gas glob further. This internal heating encourages still further nuclear fusion reactions – a "chain reaction" is established.

This nuclear chain reaction ultimately reaches equilibrium – where the amount of energy radiating away from the glob equals the amount newly created inside the glob. The dense glob is now a stable nuclear fire. Of course, this nuclear fire is a star like our own sun - or any of the billions we can see in the night sky.

The huge quantities of energy irradiated away from these stars will be important to us a little later. A tiny bit of it turns out to be captured and converted into the chemical energy used by biological organisms of Earth to do all the things they do. However, what concerns us at the moment is the other property of nuclear fusion reactions – the creation of the heavier atoms necessary for life.

As a star burns, its hydrogen fuel is fused to make heavier nuclei. Hydrogen nuclei (protons) can only combine directly with one another in a few specific ways – making only a few heavier atoms. However, some of these heavier atoms can fuse with hydrogen and with one another, in turn - creating still other heavier atoms. The details of these higher order fusion reactions do not need to concern us here. What matters is that they mostly occur only late in the life of a star.

A star burns it hydrogen fusion fuel. This is analogous to the way a (chemical) fire burns its wood fuel. When the fuel is used up, the fire goes out. This final process in a star has two important properties. First, the higher order fusion reactions producing complex mixtures of heavier elements mostly occur here at the end.

Second, as the fusion reactions begin to die out, the heat they generate is reduced. This tremendous heat originally balanced the enormous gravitational forces of the star. (Stars are huge. You and I would weigh many, many tons standing on the surface of one of them.) When this heat is no longer produced, the star collapses under its own weight. This collapse is unimaginably violent. It produces a bounce or recoil.

Think of the star at the moment of collapse as consisting of billions of rubber balls thrown together at a single central point with ferocious speed. They are going to come bouncing back out. They do. In the case of the star, this bounce produces what we call a nova explosion - the biggest blasts produced in our universe these days. [An especially big one is called a supernova, of course.]

These explosions do one thing that matters to us here. They eject a big chunk of the matter of the original star back out into the surrounding galactic neighborhood. This includes the heavy atoms made by fusion in the star.

The heavy atoms ejected from nova explosions mix with surrounding hydrogen clouds. Ultimately they are incorporated into a new round of gravitational collapse and star formation. The heavy atoms (nuclei) from the first star are then cooked up into a still more complex mix of heavy atoms in the fires of this new, second-generation star.

Ultimately, to produce all the heavy atoms that make up the Earth - and our bodies - several rounds of star formation, death and nova explosion are required. Think about this for a moment. Look at your hand. Most of the material that makes it up spent something like 8 billion years in the unimaginably hot nuclear furnaces of several generations of stars before finding its way to Earth and finally into your body. As Carl Sagan famously remarked, "We are star dust."

At each new round of star formation, the cloud of hydrogen (spiked with some heavier atoms now) again collapses under the mutual gravitational attraction of its member atoms. The parts of this enormous collapsing cloud will have small motions with respect to one another. For example, one part might have been pushed in one direction by a nova explosion on one side of the cloud, another part in a different direct by a second nova explosion on the other side.

As the cloud collapses, the momentum in this slow, stately motion is retained. However, the smaller the gas cloud becomes as gravitational collapse progresses, the faster this motion becomes. The principle is the same as a figure skater who starts spinning with his arms and one leg fully extended. As be brings his appendages in toward the axis of his body, his rate of spin gets faster and faster until he is a blur.

This same process – "conservation of angular momentum" in the formal jargon of physics - happens to the matter in our collapsing gas cloud. The central star gradually forms from the infall of matter – hydrogen and heavier atoms. It will be spinning on its axis as a result. As well, some of the infalling matter is moving rapidly enough that it stays in orbit around the emerging, central star, never completing its fall all the way into the star. Some of this orbiting material becomes the planets around the star.

Initially, these planets have the same composition as the star. However, when they are close to the star after the ignition of its nuclear fire, the resulting heat boils off a lot of the lighter atoms (including hydrogen) and leaves a gunky residue of the heavier atoms. Earth is an example of this kind of residue.

[Notice that the planets far from our sun's heat – Jupiter, Neptune, Saturn, Uranus - have lots of hydrogen still in them. In fact, their chemical composition is very similar to the sun, itself. Jupiter, for example, fails to be a star only because it is too small – not because it lacks the necessary ingredients. These large outer planets are referred to as gas giants because of all their extra hydrogen - compared to Earth. They are *very* different in their size and physical properties than Earth and the other Earth-like planets closer to the Sun.]

So far, so good. How can we assess the chemical composition of our own solar system and compare it to others? Because of the way planets form (above), the composition of the heavy atom population in a star will tell us a lot about the composition of its orbiting brood of Earth-like planets.

We can determine the heavy atom composition of a star – even one very far away - by looking at certain details of the light it emits. When these measurements are made, they produce a rather remarkable insight. Our sun has a substantially higher level of heavy elements than most other similar sized stars. This means that the size and detailed composition of any Earth-like planets around most other stars are likely to be very different than our home planet.

The unusual composition of our solar system and our planet reflects quirky events in this little corner of our home galaxy over the last ca. 12 billion years. These unusual events were something like this. Very large stars burn their fuel much faster that smaller ones like our sun. [This results, ultimately, from the more intense gravitational heating within the larger stars.] Thus, they live short, hot lives and then explode – spreading their heavy atoms into the surrounding area. Our local environment probably had a fluky string of such large stars – like drawing the ace of diamonds several times in a row from a freshly reshuffled deck. Thus, some of the matter making up Earth was cooked in extra stellar life cycles - producing higher proportions of heavy atoms.

Whatever the precise details of the history of our local galactic neighborhood, its quirky status is very likely to be crucial to the formation of life here. Life might very well not have happened in most other solar systems.

This chemical eccentricity of our planet is just the beginning of this story. Earth is also unusual in other important ways. For example, our home is very different from the other Earth-like planets in our own solar system, Mars and Venus. They are also rich in heavy elements. But this chemical richness alone is not enough. Neither of these sister planets supports complex living organisms, like oak trees or human beings – and they do not sport a Paris or Peoria.

There is good reason to think that an amazing event in the early history of our planet is ultimately responsible for the fact that we are Terrans, not Martians or Venetians.

Early in the life of our solar system there were apparently *two* planets orbiting in the neighborhood currently occupied by Earth. [These planets (and all the large objects in our solar system) formed by gradual gravitational accretion (objects attracting one another, colliding and remaining together) from the cloud of matter left by the explosive death of earlier stars.] These two planets are sometimes called Earth Mark I and Orpheus. At some point around 4.5 billion years ago, these two planets ventured too close, ramming into one another – a truly colossal collision.

Because of the details of this event (the angle and velocity of impact, the size and composition of the two planets) the collision joined some physical components of the two planets and ejected other, different components into low orbit over the new hybrid planet – Earth Mark II. Some of this ejecta ultimately fell back into the planet and the rest consolidated in orbit (gravitational accretion, again) around the planet to produce our Moon.

The precise details of this collision are very, very important. A tiny difference in any variable – angle of impact, velocity or mass of one of the planets, for example – and the outcome would have been completely different.

So, you and I live on the new and improved version of Earth resulting from this monstrous, *and most improbable,* impact. Moreover, the presence of our large Moon and the precise details of its orbit result in a stable rotation of Earth on its axis - so that local climate at any point on the Earth's surface remains (relatively) constant over long periods of time.

As well, the chemical composition of the Earth is very different than it would have been had this collision not occurred. For example, most of the dense cores of both Earth Mark I and Orpheus were retained by Earth Mark II. In contrast, a big chunk of the lighter mantel and crust components of the two planets ended up in the Moon.

This new chemical and physical composition of Earth Mark II is probably necessary to produce the characteristic tectonic behavior of Earth – very different than Mars or Venus. Tectonic activity includes volcanism, mountain formation and the movement of the massive plates on the Earth's surface carrying the continents along (continental drift). There is good reason to suspect that tectonic activity is essential to the origin of complex life – for a variety of reasons, both direct and indirect.

All of these diverse chemical and physical properties of Earth Mark II are almost certainly essential for complex life to have evolved here. So, just how likely was this Orpheus/Earth Mark I collision? The properties of the collision probably represent something like a 1-in-a-billion shot – when all the values of angle, mass and velocity are taken into account. Moreover, the chemical composition of our solar system, unusually rich in heavy elements, probably occurs in about 1-in-a-thousand solar systems.

Thus, the likelihood of finding another planet just like Earth is the product of these two numbers. In other words, our planet is *1-in-a-trillion* shot. There are not a trillion stars in our *entire* galaxy. Our home planet is a truly cosmic long shot – like winning the lottery three weeks in a row.

Of course, there are many imponderables here. We do not know exactly how much like Earth a planet needs to be to spawn a human-like organism. Maybe planets with the necessary credentials are more common than this calculation suggests. However, we *also* do not know how truly unusual Earth is – maybe its 1-in-a-trillion-trillion!

The upshot of this is that it is at least possible (we think, likely) that we humans are alone in the galaxy or even the entire universe. We must never forget this – with all its implications for the human future.

2 Some opponents of the idea that reductionism is universal point to the behavior of subatomic particles in support of their view. It is sometimes claimed that the rules of this domain, quantum mechanics, violate causality – indicating that reductionism breaks down at this level. This way of looking at quantum mechanics is taken from the so-called Copenhagen interpretation, derived from Neils Bohr and his collaborators early in the 20th Century. It is very important to recognize that there are other, probably better ways of interpreting quantum mechanics. In particular, the "spooky" parts are more easily interpreted if we take a simple causal view of quantum entanglement and forego the insistence that the information about the breakdown of entanglement must be restricted by the speed of light.

Quite workable and realistic interpretations of quantum mechanics of this form have been proposed by Boehm among others. Discussion of these issues can be found on the excellent Stanford website http://plato.stanford.edu/entries/qm-bohm/. Also useful is Nobel laureate John S. Bell's essays in his 1987 compendium *Speakable and Unspeakable in Quantum Mechanics*.

3 See Orgel (2004) for a recent review of the chemical evolution literature and Gesteland, et al. (1999) for a recent reviews of the RNA world hypothesis for the nature of the earliest organisms.

4 The process would have worked something like this.

As we said, a polymer must leave at least two copies of itself while it is alive to qualify for the job of Universal Parent. To keep things simple, suppose that it leaves *just* two copies, no more. This might not seem like much in the vast oceans of a world – but it is. The reason is that *each* of these two copies will leave two copies of themselves – making four. Each of these four will leave two, making eight. Then eight makes 16, 16 makes 32, 32 makes 64 and so on.

This is what scientists call exponential growth. Its consequence is simple, but utterly profound. For a molecule (or a complex collection of molecules like a bacterial cell or a human being) that makes new copies of itself this way, the world is always quickly filled and, therefore, crowded.

To see this more clearly visualize a bacterial cell. This cell is stupendously tiny by our standards – a millionth-of-a-millionth of a gram or an ounce, very roughly. Yet if it makes two copies of itself each hour (as many real bacteria do) it would convert the entire mass of the Earth into bacteria in a little over a week if limitations did not intervene. Again, it does this *solely* because each new bacterium just sets about making two new copies of itself and each of those copies make two copies and so on. Exponential growth is *extremely* powerful.

The small crowded world inevitably produced by this property of living chemical systems is called Malthusian – after Thomas Malthus who first called our attention to this tendency of organisms (chemical systems) to fill their world this way.

The Malthusian world of living chemical systems creates a problem. As it fills, these organisms start to run out of things they need – things we can refer to as "limiting resources." This happens to bacteria and people in our world, for example – which is why they do not actually convert the entire mass of Earth into bacteria or people.

With these things in mind, return to our original Universal Parent molecule. It also has the problem of access to limiting resources. The Earth's oceans ultimately fill with copies of the Universal Parent. These copies use up the monomer molecules in the planetary soup necessary to make new copies of the Universal Parent.

This resource crunch produces a crucial effect when we recognize one other feature of these replicating molecules. Since they are chemical systems, replicating molecules are limited by the same physical laws as any other chemical system. One of these physical laws is referred to as the Second Law of Thermodynamics – or just the Second Law for short. It describes a profound, ubiquitous property of the universe (Alberts, et al., 2008)**.**

The Second Law can be stated in many different ways. But, one particular statement is important to us here at this moment. This form of the Second Law says that highly orderly structures require energy to build and to maintain. Moreover, to create a perfectly orderly structure requires infinite amounts of energy. Thus, the Universal Parent polymer needs access to infinite amounts of energy ***if*** every copy it makes of itself is to be identical to the original Parent.

Of course, in a finite, Malthusian world no copy of the Universal Parent can possibly have access to infinite amounts of energy. This means that the copying (replication) of the Universal Parent polymer molecule can never be perfect. Mistakes will inevitably occur. A wrong monomer (a pop-bead of the wrong color) will inevitably be incorporated into an occasional copy of the Universal Parent. In practice, some copies of the Universal Parent will be identical to the Parent and others will differ – they will contain "mistakes".

Most of these inevitable errors in copying the Universal Parent do not improve the ability of the molecule to compete for limiting resources. However, once in a "blue moon" an error creates a new version of the molecule that actually competes better for these resources. Over time, the descendents of this new, improved version displace the original version and Earth's planetary ocean has a new kind of occupant.

The process we have just described is referred to as natural selection. It is sometimes also called Darwinian selection (after Charles Darwin, of course). Since the new versions of a replicating molecule produced by this process are different from earlier ones, change produced by natural selection is also often called evolution.

Over hundreds of millions of years, many, many cycles of evolution by natural selection produced increasingly complex descendents of the original Universal Parent molecule – ultimately, 4 billion years later, including you and the authors.

5 Notice that these cooperative teams of pieces of design information also have conflicts of interest amongst their members – just as macroscopic organisms do. The ability of components of the team to manage these is crucial to the evolution of collections of pieces of design information – of "genomes" – capable of building complex organisms.

Modern genomes have inherited some of these ancient ancestral methods for managing intragenomic conflicts of interest. For example, see Bingham (1997) for a review of one of these policing systems apparently targeting parasitic transposons. The genetic recombination described in any standard genetic textbook is a second vital approach to the molecular conflict of interest problem. Recombination is a "divide and conquer" strategy preventing local aggregates of pieces of information from subverting the interests of the "coalition of the whole" represented by the genome.

6 When the descendents of the First Team originally solved this problem they obtained enormous advantages in their Malthusian world. Because these Derivative Tools did not need to be replicated directly, they were free to have much more complex and sophisticated chemical structures. They could be built from a much larger and more diverse collection of monomer units – allowing them to do more things and to do them better.

Think of this process as follows. Because these polymers also needed to be directly replicated, the monomers making up the members of the First Team were required to be very similar to one another – all spherical beads of different colors, so speak. In contrast, the individual, chemically distinct monomers making up Derivative Tools could be cubes, ellipsoids, diamonds, prickly sea urchin-shaped, Velcro-coated, etc. [See Gesteland, et al., 1999, for a discussion of the technical details of this picture.]

A polymer of the older First Team and Universal Parent type built from relatively uniform monomer units made machines like hands in oven mitts. However, the new Derivative Tool polymers (made from a more diverse, complex sets of monomer units) were like supple hands that can play a Mozart piano sonata.

7 A wrinkle is interesting. In the course of the continuing evolution by natural selection of the very first vehicles, new vehicles arose that made tools that ultimately allowed them to take the most simple and abundant tiny molecules on the surface of the earth (carbon dioxide and water, for example) and build the new monomers they needed to make new copies of themselves. Using simple sources of energy (sunlight, for example) they could build everything they needed.

These new vehicles were no longer dependent on the previously made molecules in the original planetary French onion soup. They consumed the resources of the planetary soup and evolved the capacity to make the new resources they needed. This was merely the first of many occasions in which life would transform our planet, its own home – the human revolution you and the authors are carrying out is the most recent of this chain of “biogenic” (produced by organisms) planetary transformations.

Chapter 3

The only way to win is not to play – the problem with cooperation between organisms

1 See Hrdy (1977), Grinnell and McComb (1996), Dagg, (1988), Ebensperger (1998a and b), Estes, et al. (1999), Hrdy (1999), Watson, et al. (1999), Packer (2000), van Schaik and Jansen (2000), Wolf and Dunlap (2002) and Hausfater and Hrdy (2008) for discussions of infanticide in non-human animals.

2 See Dobzhansky (1973).

3 The logic of kin-selection described in the text is an effective, efficient way to think about the problem (see Williams, 1966, and Dawkins, 1976). However, it is possible to visualize this problem in more complex ways (see, for example, Bourke and Franks, 1995) that need not concern us here.

Moreover, note that kin-selection theory probably predicts cooperation between close kin only when there close kin are not likely to compete with one another in the future (Griffin and West, 2002, and West, et al., 2002). As a result of this, we will develop the term *kinship-independent* social cooperation to include *both* cooperation between non-kin conspecifics *and* cooperation with close kin who would otherwise not cooperate because of looming conflicts of interest. See Chapter 5 for a detailed discussion of these issues.

It may enhance your understanding Box 3.1 in the text to think through the following elaborations. For example, consider another variant form of design information in the pure Indiscriminant Helper starting population. As always, this variant arises, along with many others, purely at random. We zero in on it simply to ask how well it will do in competition with Family Helper information.

Let's call this new design information variant (and the vehicles it produces) Sociopath. These individuals take *from everyone* including close kin and give back *to no one*. When they meet Indiscriminant Helpers, Sociopaths do better because they take without paying any cost to repay.

When Sociopath meets Sociopath, each does worse than Indiscriminant on Indiscriminant. But this is not enough to save Indiscriminant. Here's why. When Sociopath is rare, it almost always meets Indiscriminant information, not other Sociopath copies. Sociopaths win these interactions and grow to represent more of the population in the Malthusian world.

As Sociopaths become more common they start meeting one another more often. These interactions produce no benefit to Sociopath. However, Indiscriminant are now just as likely to meet Sociopaths as are other Sociopaths – net advantage Sociopath.

Over multiple generations, Sociopath replaces Indiscriminant. Of course, Sociopath is just the Indiscriminate Competitor we considered at the very beginning of this discussion. We saw there that Family Helper would take over the Indiscriminate competitor (Sociopath) population.

Thus, we find again, ***advantage Family Helper***.

Let's turn to our pure Family Helper population. What happens to a newly arising Indiscriminant Helper. Of course, this new individual will lose out immediately. It will give to non-kin Family Helpers without recompense, while the Family Helpers will make no such "mistake" – ***advantage Family Helper***.

Finally, consider a newly arising Sociopath in our pure Family Helper population. He may survive in the first generation because his close kin are Family Helpers who will support him. However, in all subsequent generations, the Sociopath's relatives do not help one another and they are also shunned by now non-kin Family Helpers. They are *Sociopaths*, after all. The Sociopaths quickly lose out – ***advantage Family Helper***.

4 We concur with the large majority of professional scholarly opinion that group selection *can* occur, but only under circumstances that are relatively exotic in comparison to how most large animals live most of the time. More specifically, we will argue throughout that group selection effects, if any, in human evolution are secondary and derivative. They will be unimportant (or entirely irrelevant) to our quest here.

5 We will see in Chapter 10 that our evolved human psychology makes us especially vulnerable to the fallacy – the illusion – of group selection as the basis of our social cooperation. We also tend to project this illusion onto non-human animals. It is one of most pervasive and insidious of all intellectual errors in thinking about the evolution of social cooperation.

6

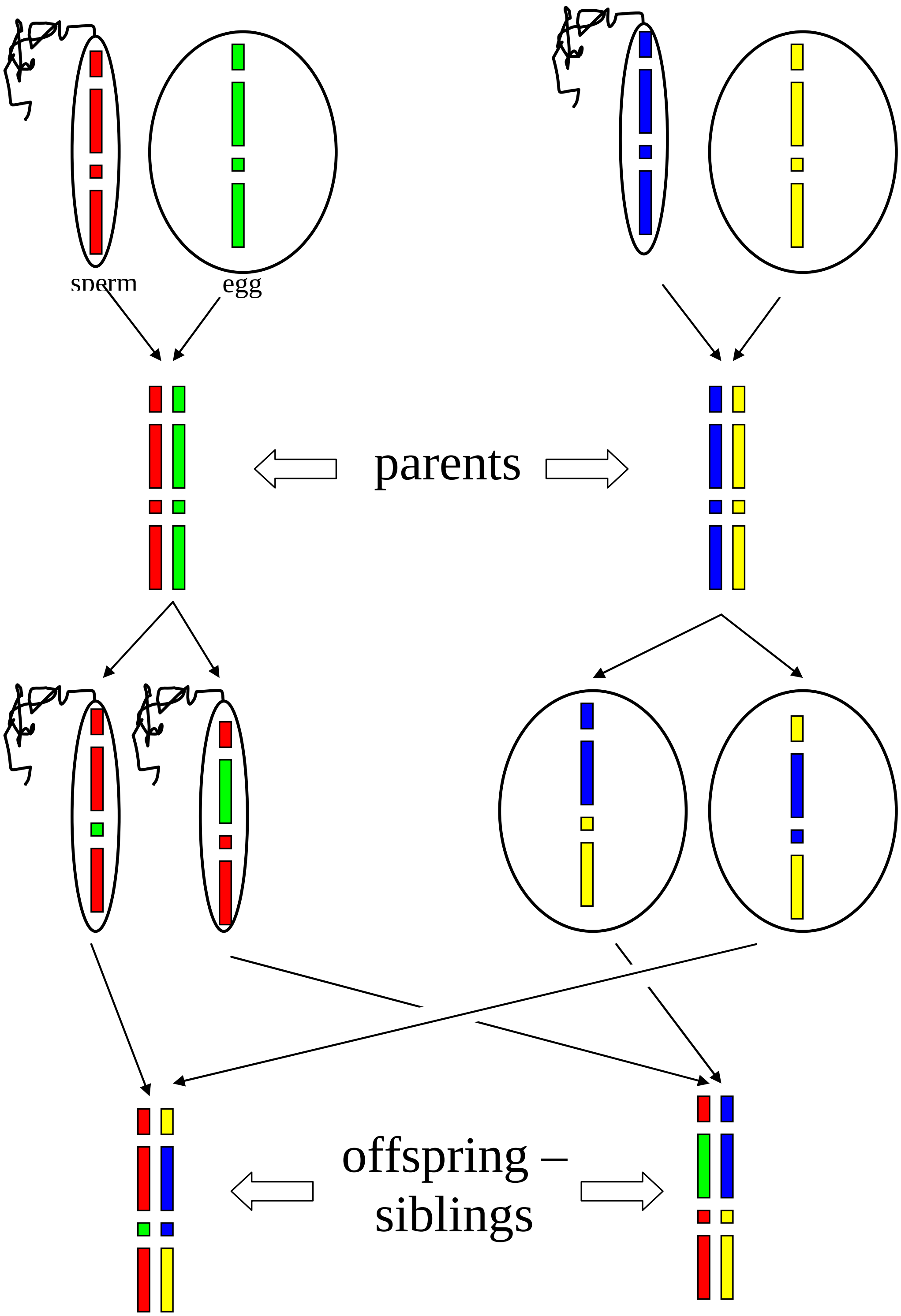


Figure OE3.1: Genetic design information in sexually reproducing organisms (preceding page).

In contemporary organisms like you and the authors design information is encoded in the sequence of the DNA polymer. Moreover, many different pieces of design information - many different genes - are strung together, one after the other, in one long DNA molecule. Each of these very long DNA molecules is packaged with a few specific protein tools to allow convenient storage, use and replication of this design information. These large packaged molecules are so big that we can see them in the conventional light microscope and they are given the technical name chromosomes. For example, the ca. 23,000 genes making up you or the authors are gathered into 23 chromosomes.

In the Figure, bars indicate genetic design information organized into only four chromosomes, for simplicity. The organisms are ***diploid*** and ***sexual***. Diploid means that each individual has two copies of each piece of design information (indicated by the two, paired bars corresponding to each individual parent or offspring). Sexual means that rather than creating offspring that are genetically identical, each parent creates a gamete (egg or sperm) that has one copy of each piece of design information – indicated by the *diverging* arrows. When two gametes, one from each of two parents, combine at fertilization (indicated by the *converging* arrows), a new diploid offspring is created receiving half of its genetic design information from one parent and half from the other.

These processes are diagrammed here for two generations of the organism (vehicle). At top are shown the egg and sperm cells that undergo fertilization to produce the parents. These gametes were produced by diploid grandparents (not diagrammed.) Each sperm and egg contains a single copy of each piece of design information that will build the organism. The chromosomes (bars) of the original gametes at the top of the Figure are color coded to allow us to follow them through subsequent events in the diagram.

Each of the two ***parents*** (male at the left and female at the right) produces two gametes by selecting randomly from among the two copies of each chromosome each has. As a result, on average, about half the information in each sperm is identical to any other randomly chosen sperm produced by the male and about half is different (line 3 of the Figure). The same applies to the eggs produced by the female.

When pairs of these gametes join in the process of fertilization, they produce ***offspring*** who are full siblings – offspring who share *both* parents. If you add up all the colored segments in the offspring you will find the following. The siblings are about 50% identical to one another. Moreover, each sibling is about 50% identical to each of its parents. [Because of additional events not diagrammed here – including recombination *within* individual chromosomes – siblings are always *almost exactly* 50% identical in real organisms.]

In the simplified cases we considered earlier in this chapter, the organisms were not sexual and, thus, the offspring were identical to their parents (except for rare mutations). In contrast, in sexual organisms offspring are only 50% genetically identical to each parent and each sibling – in the sense of having inherited the same piece of parental information – as the figure illustrates. This has important implications for understanding how kinship affects social cooperation in sexual organism. We will explore these implications in Figures OE3.2 and OE3.3 below.

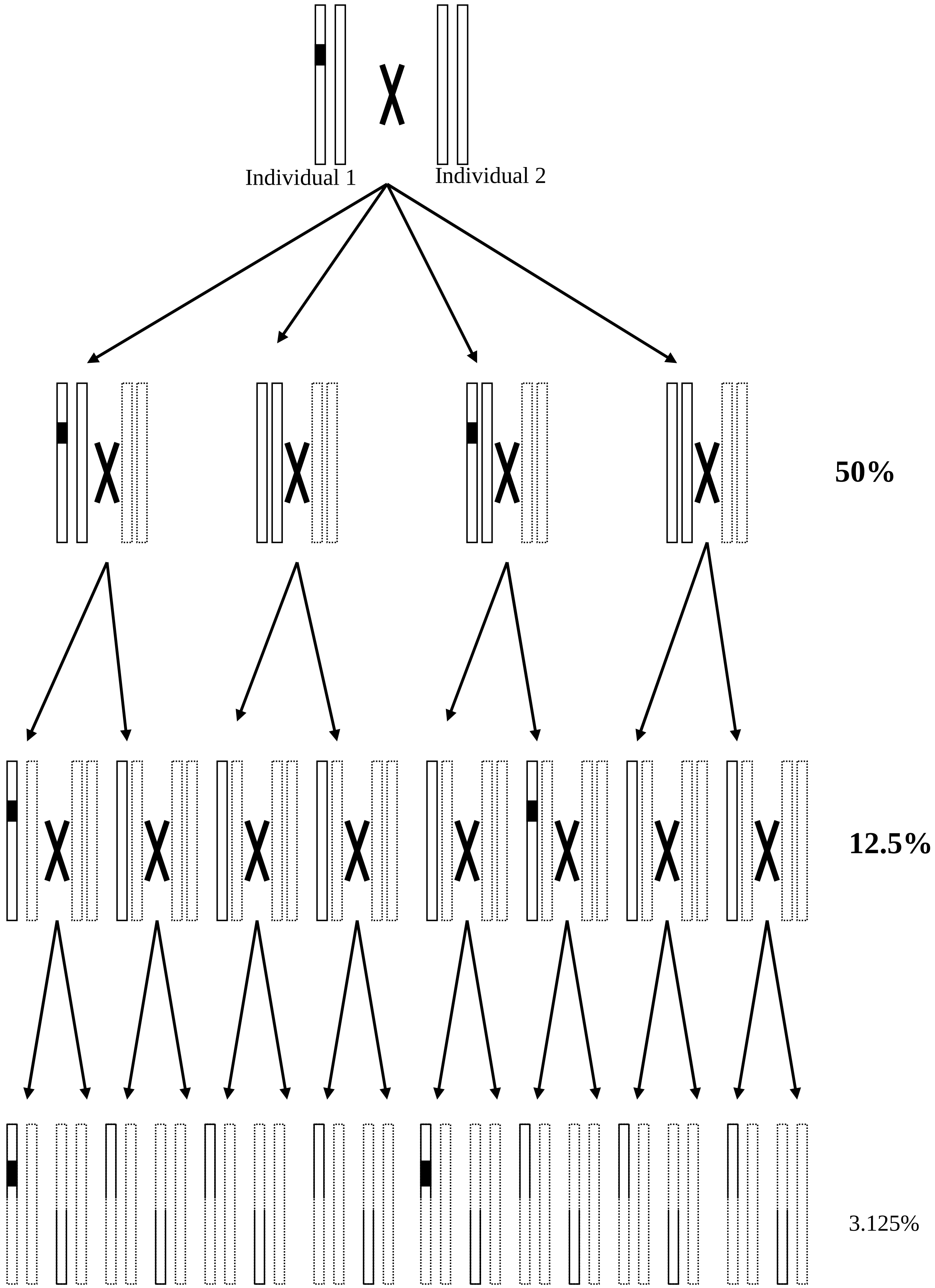

Individual 1
Individual 2
50%
12.5%
3.125%

Figure OE3.2: One approach to visualizing genetic relatedness in sexual organisms (preceding page).

The organisms our theory will be about are sexual (Figure OE3.1, above) – including humans. To understand the social cooperation problem and the unique human solution to it, we need to understand the purpose or interests of genetic design information in sexual animals. [Also Chapter 3 section entitled ***"As if" and ultimate causation, "interests" and "conflicts of interest."***] More precisely, we need to understand how a specific piece of genetic design information is shaped by natural selection to evaluate the probability that another copy of itself – identical as a result of recent inheritance from a common ancestor – is found in a second animal. If the second animal is unrelated, that probability is very low, effectively zero in most cases. However, if the other animal is a close relative, that probability becomes higher. Moreover, we can easily calculate that probability precisely and this will be important to our explorations. There are several ways to calculate and each gives the same answer. We will look at one approach in this Figure and a second in Figure OE3.3 below.

Here and in Figure OE3.3 we will artificially push all the chromosomes together end to end. This will allow us to diagram an entire set of design information – an entire ***genome*** – as a single bar. Each copy of a complete set of design information is called a *haploid* genome and the two haploid genomes making up an individual's complete set of design information is also called a *diploid* genome.

Here we will take the perspective of a specific piece of genetic design information indicated by the solid portion of the genome of ***Individual 1*** at the top of the figure. We will speak as if this piece of genetic design information were conscious and aware. Of course, in reality, it is not. However, because of the logic of natural selection for kinship-dependent cooperation, pieces of design information build animals who behave quite precisely as they would ***if*** the design information had such awareness. Thus, this metaphorical way of speaking is actually useful and remarkably accurate as a descriptive tool.

Copies of this specific piece of design information find themselves in the sibling progeny (second line) produced when ***Individuals 1*** and ***2*** mate. Each copy of this piece (solid segment) has no way of determining which parent it came from (though we know). However, as the progeny are full siblings (sibs) this does not matter. Each copy "knows" there is a 50% chance that any individual sib has an identical copy as indicated in the diagram. Natural selection will shape this (and every) piece of genetic design information to take this knowing into account, thus avoiding competition and even actively assisting sibs where the likely cost to the helper is less than half the likely benefit to the target. Equivalently, sibs have a 50% "confluence of interest".

Each of the four sibs in line 2 mates with a different individual (dotted bars) each of whom is unrelated to the sibs or to one another. This pattern of mating will frequently occur in a large population of individuals characteristic of many species of animals. These matings produce a generation of first cousins (line 3). Again, copies of our piece of design information (solid segment) find themselves in some of the cousins. Each such segment has no way of knowing which parent (from line 2) it came from. If it came from the dotted bar parent, it will not be present in any of its cousins shown here. It will have 0% confluence of interest with their design information. However, if it came from the solid bar parent, as we know it did, it will be present in 25% of the cousins. Thus, the piece of information knows there is a 50% chance of a 25% frequency of itself among cousins. This corresponds to 12.5% total or average chance. Notice that this is *fourfold* lower than the 50% confluence of interest that full sibs have.

The cousins in line 3 then mate with individuals who are unrelated to the cousins or to one another (dotted bars) and produce a generation of second cousins (line 4). Copies of our piece of design information find themselves in some of the second cousins. Each of these pieces has no way of knowing which parent or grandparent it came from. If it came from the grandparent in the first line of our figure (***Individual 1)*** - as we know it did – it will be in $1/8^{th}$ of the other second cousins. However, there is a 50% chance that it came from one of the dotted-bar individuals in line 2 which reduces this $1/8^{th}$ to $1/16^{th}$. Further, there is an independent 50% chance that it came from the dotted-bar parent in line 3 which further reduces this $1/16^{th}$ to $1/32^{nd}$. Thus, the *net* likelihood that our specific piece of information is identical with – or, equivalently, has a confluence of interest with – information in other second cousins shown is $1/32^{nd}$ or 3.125%. Notice that this is *sixteenfold* lower than the 50% confluence of interest between sibs.

The crucial lesson for us is that the probability of genetic identity between any two copies of a piece of design information - and, thus, the level of confluence of interest - drops very sharply with increased distance of pedigree relationship. Thus, if genetic confluence of interest drives the evolution of social behavior, we should expect social cooperation in sexual organisms to be restricted to very close kin – mostly sibs, parents, offspring, half-sibs (to a lesser degree) and first cousins (to a much lesser degree). As we discuss in the text, this is *precisely* and virtually *universally* what we observe in non-human animals.

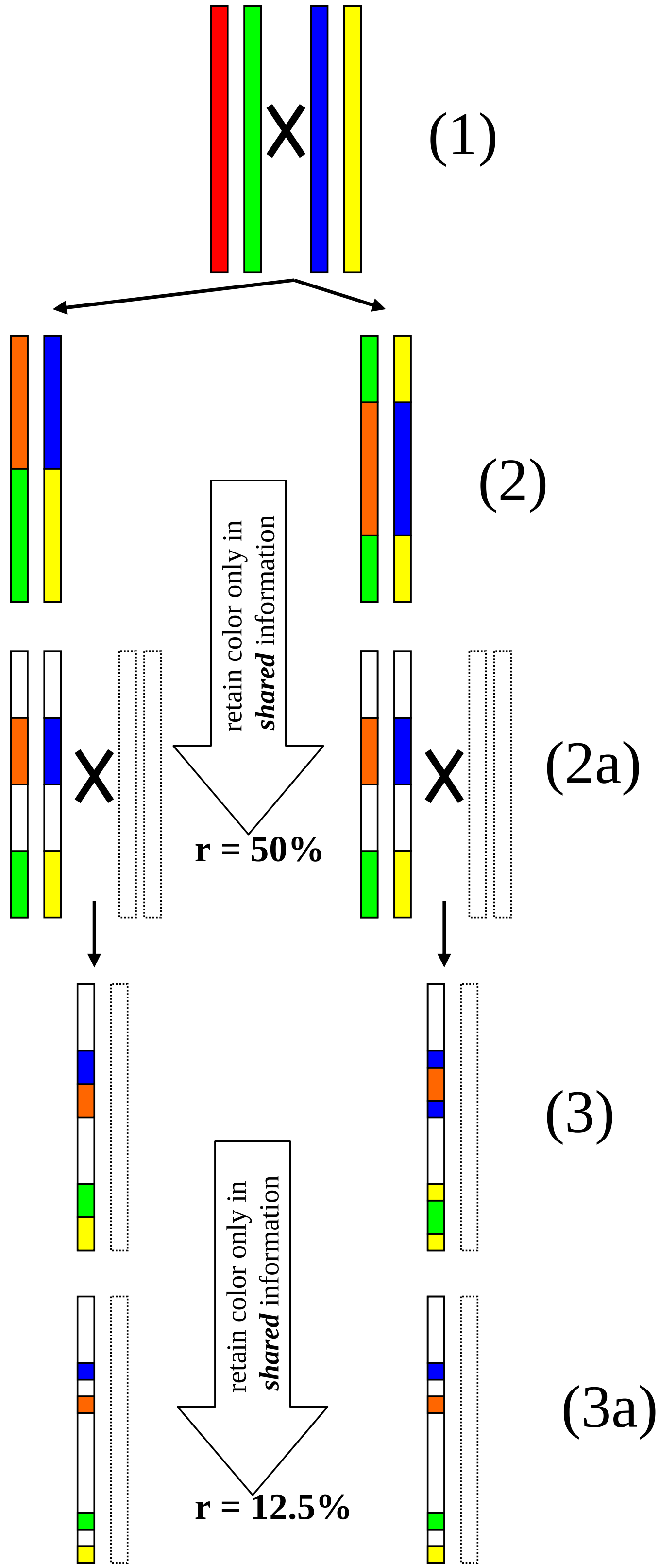

X
(1)
(2)
retain color only in *shared* information
X
X
(2a)
r = 50%
(3)
retain color only in *shared* information
(3a)
r = 12.5%

Figure OE3.3: A second approach to visualizing genetic relatedness in sexual organisms (preceding page).

Each set of genetic design information in the two original diploid, sexual parents in line 1 is coded with a different color (also see Figures OE3.1 and OE3.2 above). Each parent samples randomly from those two sets of pieces of information to construct gametes (eggs or sperm). Each gamete carries only one copy of each piece of genetic design information. For the left hand parent, for example, each piece of genetic design information in one of its gamete has a 50% chance of having been taken from the ***red*** set and 50% of having been taken from the ***green*** set.

One gamete from each of the two parents fuses at fertilization to produce offspring like the two representative examples shown in line 2. When we compare the two offspring (sibs), we see the implication of the random sampling of design information. For example, only one half of the ***red*** information in the left hand offspring is identical with the ***red*** information in the right hand offspring. The other half of the left hand offspring's ***red*** information is replaced by ***green*** information in the right hand offspring and vice versa.

Precisely the same quantitative logic applies to design information of all four colors. In line 2a we recode the information in the two offspring so that only the ***shared*** information remains colored. Thus, a clear area indicates a segment that is ***red*** in one offspring but ***green*** in the other or ***blue*** in one offspring but ***yellow*** in the other. If we add up the remaining shared colored information between the two siblings, we find that it is 50%. Therefore, the sibs are 50% genetically identical. This is sometimes called their "genetic relatedness" (abbreviated **r**).

These two sibs then mate with two individuals (dotted bars) who are not close kin either to one another or to the two sibs. The offspring of these two matings are first cousins like the two representative examples shown in line 3. Notice that 50% of the information that is identical between by the two sib parents (the colored information) ends up in each cousin. However, as before, this sampling of information is random so that only half of this information is identical between one cousin and another. In line 3a we recode the cousins genomes to reflect this. As above, only the information that is shared by the two individual cousins and is identical by descent from the original (grand)parents in line 1 remains colored.

If we add up this remaining colored information we find that it totals 12.5% of each cousin's diploid genome. Thus, the cousins have a genetic relatedness to one another of 12.5%.

The 50% relatedness of the sibs in line 2a and the 12.5% relatedness of cousins in line 3a is a direct measure of their confluence of genetic "interest". [Also see Chapter 3 section entitled ***"As if" and ultimate causation, "interests" and "conflicts of interest"***.] Selection will shape the behavior of individual animals such that one sib will help the other when the cost to the helper is less than half the benefit to the target sib. In contrast, cousins generally will help one another only when the cost to the helper is less that 12.5% of the benefit to the target cousin.

These numbers are precisely the same as those we derived in a different way in Figure OE3.2 above. Again, the most important lesson for us is that shared genetic identity (relatedness) drops sharply as a function of distance of pedigree relationship. We will use this insight to evaluate the predictions that most animal social cooperation is based on kin-selected behaviors.

7

Sex and the single organism – Bill Hamilton, kinship and cooperation

How does the sexual transmission – compared to asexual transmission - of design information change the logic of social cooperation among vehicles built by design information shaped by natural selection in a Malthusian world? The answer in the most fundamental sense is *not at all*. Family Helper still trumps Indiscriminant Helper and Indiscriminant Competitor. Kinship-dependent cooperation is the rule of the day and of the world just as our picture of life as a special case of chemistry requires that it should be.

Design information is shaped to build vehicles to value other vehicles according to how *likely* those vehicles are to have a copy of that particular piece of design information that is identical by virtue of being inherited from the same recent common ancestor. This likelihood is just exactly the relatedness we worked out footnote 6 above.

The upshot of this fact is very simple. We expect animals to cooperate with conspecifics who are very close kin (parents, siblings and offspring), maybe a little with more distant kin (cousins) and only rarely with other "non-kin" conspecific animals.

Bill Hamilton stated this principle quantitatively in what has come to be called Hamilton's Law (main text). Remember, good reductionist explanation should be simple enough to write on the front of a tee shirt. Hamilton's Law most certainly qualifies. Specifically, Hamilton's Law can be stated mathematically as follows:

$$Br > C$$

This simple inequality says that a cooperative behavior between two animals should evolve by natural selection acting on design information if and only if the following condition is satisfied. The benefit a receiving organism gains, discounted by its relatedness to the giving organism should exceed the cost of the cooperative behavior to the giving organism.

So, if some behavior costs you 1.5 units of effort and risk, but gives 4 units of benefit to another animal, you will do that behavior if that other animal is a parent, offspring or sibling but *not* if that other animal is a cousin or a non-relative. Here's how this looks when we plug these numbers into Hamilton's Law.

(siblings) $Br > C$ is $(4)(0.5)=2>1.5$

(valid inequality, behavior will evolve by natural selection)

(cousins) $Br > C$ is $(4)(0.125)=0.5>1.5$

(*invalid* inequality, behavior will *not* evolve by natural selection)

8 See Hrdy (1977), Grinnell and McComb (1996), Dagg (1998), Ebensperger (1998a and b), Estes, et al. (1999), Hrdy (1999), Watson, et al. (1999), Packer (2000), van Schaik and Jansen (2000), Wolf and Dunlap (2002) and Hausfater and Hrdy (2008) for discussions of infanticide in non-human animals.

Empirical tests: Infanticide

Return to our lions (main text). Franklin's cubs, including Minnie, are unrelated to Arthur. We expect Arthur to compete with these cubs but not with his own who are more closely related to him. Of course, this is just exactly what he does. He kills Franklin's cubs, but is a protective, tolerant father to his own.

Another example is the infanticidal behavior of animals that breed in crowded territories like the mouse-like voles of the grasslands of the American Midwest (see Wolf and Dunlap, 2002 and references therein). These animals pair up – adult male and female – and rear several litters during a summer. Voles, like most rodents, mature very rapidly. The young become independent of nursing and parental protection in a matter of weeks.

In these animals, adults of both sexes commit infanticide. Infanticide is not a male-only strategy. For example, a male will kill any pups he encounters in any nest other than the one containing a female he has mated with during the last few weeks. Only nests where he has mated recently could contain his own personal offspring – close kin carrying his design information. Likewise, females will kill pups in the nests of other females, but not their own pups.

This infanticide does two things. It eliminates non-kin pups that would grow into non-kin competitors in the highly crowded (Malthusian) world of the voles. Moreover, adults whose nests are victimized by infanticide will tend to move to other, hopefully safer, areas before attempting again to reproduce. This behavior likewise reduces non-kin competition experienced by the infanticidal vole. Notice also that killing immature youngsters is a low-risk, "cheap" strategy for mature adults. This detail will be useful in later chapters.

This fundamental pattern is seen throughout the extensive literature on this subject. Adults of both sexes kill non-kin youngsters *when* this behavior produces an increased likelihood of reproduction – replication of design information – by the adult. In other words, this behavior occurs simply because natural selection favors design information that builds vehicles that behave this way.

> There is strong evidence for this pattern of infanticide in every group of mammals and birds where it has been looked for. This includes primates, our closest living relatives. Indeed, as we will see in Chapter 4, there is even good evidence that the capacity for this kind of strategic infanticide is also part of the human behavioral repertoire.

The body of empirical evidence of this form supporting Hamilton's Law is impressive. If we look a little more closely at infanticide we can find still more confirmation.

For example, notice that parents and offspring are 50% related but they are also 50% unrelated. The child of any individual adult gets one half its design information from the *other* parent, an adult who is usually not closely related to the first parent.

Thus, Hamilton's Law predicts a limitation on the cooperation between parents and their offspring. For example, in a "him or me" situation, the parent is expected to sacrifice the offspring to save itself. Animals do this, frequently. One example will serve to illustrate this point.

A rodent mother experiences severe food shortage when her infants are too young to move. She will eat her own young before departing in search of greener pastures.

This cannibalistic mother is a good example of evidence that we might think contradicts kin-selection theory; however, it actually supports the theory once we understand it clearly. For example, we are well aware that we humans would never eat our young - even if forced to abandon them under duress. Infantophagy sounds preposterous as an adaptive act to us. However, this initial feeling of skepticism ultimately helps us see the value of this evidence.

Because rodent offspring mature in just a few weeks, the major investment the rodent mother makes is the calories she must ingest to produce the milk that nurtures the youngsters through this brief childhood. She takes great individual risk hunting for insects or seeds or other high value foods to obtain these calories. Recovering them by eating doomed offspring when food is scarce is a perfectly reasonable strategy for her.

In contrast, animals raising young who grow much more slowly invest most of their resources in protection and teaching of those offspring. The calories actually contained in the physical body of such a youngster at any moment are a negligible fraction of these resources. There is very little strategic incentive to consume the youngster under duress and it is rarely done. We humans are such long-lived animals. The Donner Party notwithstanding, we think of cannibalistic infanticide as a goofy idea – as, for us, it is.

Animals really are acting as if they are very well-informed agents deployed by their design information. This is just exactly how kin-selection theory predicts they should behave. Such realization is intellectually elegant, profoundly satisfying and ultimately crucial to our quest.

Empirical tests: Social breeding and siblicide in birds

For complex animals, especially birds and mammals, young "vehicles" usually require care and feeding to reach independent adulthood. Kin-selection theory predicts that the adult caregivers will always share design information recently inherited from a common ancestor. They will be very close kin which, of course, usually means parents (especially mothers). And this is just exactly what happens.

However, there are other candidate caregivers allowed by kin-selection theory. For example, an older sibling of a new-born is 50% related to that youngster just as its mother is. This is the same 50% relationship the older sibling would have to its *own* offspring,..

In view of these facts, what kind of animal (vehicle) do we expect design information to build? When environmental conditions are favorable for individual adults to reproduce on their own, they are expected to do so. Under these conditions, for an older sibling to help a parent raise a younger sibling would be wasted, redundant effort. The younger sibling will survive anyway and an extra copy of design information can be made in the older sibling's own offspring.

Suppose, however, that conditions are difficult – perhaps an especially densely crowded Malthusian local neighborhood. Under these conditions, much more adult effort might be required to find enough food and protect the young from unrelated and potentially infanticidal adults. A single mother or an adult pair might have trouble rearing a youngster successfully. A team, however, consisting of the parents and the older adult siblings might have a better chance of success.

Under these more difficult conditions, we predict that older siblings will often help raise their younger siblings rather than attempting to reproduce themselves. In fact, this pattern of older sibling help is just exactly what we observe. One famous example involves the bee-eaters (see Burt, 2002 and references therein). These birds nest in holes, sometimes dug in clay cliffs. The population can sometimes be so dense that the cliffs look like Swiss cheese. Thus, finding and holding on to a nest hole can be difficult – a team of adults has a better chance.

Moreover, the birds depend on the annual bloom of insects produced by the rainy season to produce a single brood each year. Hunting for enough insects is difficult and time consuming. A team of adults has a better chance of finding enough food than a lone parental pair while also guarding the nest and providing other help to the youngsters.

As we might expect under these conditions, older siblings from earlier years often help raise this year's brood. Indeed, one detail of this behavior is especially illuminating. When an older sibling is successful in setting up its own nest for the first time, its chances of success are lower. [It is an inexperienced parent and it has no helpers beyond its spouse.] If this older sibling and his mate should lose their clutch of eggs, the older sibling will return to help his/her parents raise their brood – but his non-kin mate will not.

When adults other than the parents (like our bee eater older siblings) help raise offspring, this system is referred to as social breeding. Humans are a very special kind of social breeder.

For the moment, all that is important is to notice that social breeding in non-human animals is dependent on kinship. Thus, the bee eaters and other non-human animal social breeders, are specifically *kinship-dependent* social breeders.

The bee eaters and many other birds have one last useful lesson to teach us. Recall again that even the most closely related mammals or birds are typically 50% related *and, thus* also 50% unrelated. Design information should build individual vehicles who will compete even with siblings in "him or me" situations.

This is just exactly what we see. A common reproductive strategy for birds is to lay extra eggs – "the heir and a spare", so to speak. Under unusually good conditions, there will be enough food to feed both chicks and the parent's design information gets a bonus. Further, should one sibling fall victim to a predator, a replacement is waiting in the wings.

However, in a typical year – no predator casualties, but no superabundance of food – one of the two chicks has to go. Under these conditions, the larger of the two chicks will begin pecking away at the smaller until it is dead. Indeed, in the case of predatory raptors, the stronger chick will sometimes actively prey on and cannibalize the weaker one. The parents normally stand by and do not interfere in this siblicide.

Of course, all of this bird behavior is just exactly what kin-selection theory predicts "good" bird vehicles should do. This behavior is yet more empirical verification of the theory.

9 Of course, we have long recognized why grass is green and why the sky is blue. Our eyes (and brains) assess color by analyzing the intensities of various wavelengths of light (of photons) reaching our eyes from an object – compared to the distribution of wavelengths in the background light.

Green grass results from pigments in the plant. These pigments capture solar photons for the energy to build tools and replicate design information (chemically; Chapter 2). When they do this they deplete the sunlight of some wavelengths but leave others to be reflected. Our eyes add this depleted spectrum up and call it “green”.

Blue skies result from the physics of light scattering by the molecules and particles in Earth’s atmosphere. Short wavelengths (blue light) are scattered more efficiently than long wavelengths (red light). Thus, when we look at the sky away from the sun, more blue than red photons from the sun’s light are scattered back at us and our eyes (brains) read “blue”.

The flip side of atmospheric light scattering is the red setting sun. More blue than red photons are scattered laterally away – leaving light enriched in (long) red wavelengths that our eyes (brains) read as “red”.

Chapter 4

The facts of life – kin-selected behavior in humans

1 It has long been understood that many features of individual human sexual and parental behavior look as expected if these behaviors have been shaped by the same forces of kin-selection that shape the corresponding non-human animals behaviors. For reviews and discussions see Symons (1979); Fisher (1983); Daly and Wilson (1988); Baker (1996); Baker and Bellis (1995); Hrdy (1999); Birkhead (2000); Barash and Lipton (2001); and Buss (2003).

In this chapter and in Chapters 6 and 8 we will define how our theory of *kinship-independent* social cooperation (Chapter 5) predicts and accounts for those features of human sexual/reproductive behavior that are not simply accounted for by traditional kin-selection theory. In particular, watch for the ways in humans persue individual inclusive fitness (kin-selected interest) *through* collaboration with non-kin others.

2 In pre-state and actively warring societies, non-kin infanticide rates are generally much higher and more like those of non-human animals. For example, young children were among the primary victims of the Crow Creek massacre that we will explore in Chapter 12 (Keely, 1996). The generality, we will argue, is that non-kin infanticide is suppressed in humans *if and only if* a coercively powerful local consensus exists to oppose it. (See Chapter 5 for origin of such coalitions and Chapters 6 and 8 for more of their effects.) Such a consensus exists in our contemporary state-levels cultures.

[3] What do we expect? - What are males (or females) good for?

If we are to give a theory a good test against the empirical evidence, we need two things - good evidence and clearly articulated theory. It helps to zero in on the partially distinct roles of each adult sex in reproduction. Specifically, we should ask how are male and female vehicles expected to be designed by natural selection? For mammals, like us, it seems relatively easy and straightforward to say what females are good for. They incubate the fetus, nurse the newborn and (usually more than males) are responsible to protect and teach the growing youngster. Human females are more complex than this, of course, but we are still very much like other mammalian mothers in these fundamental functions.

The effort and time necessary to contribute these motherly activities is a significant cost. This cost is referred to as maternal investment in the offspring.

Human males are a different story than most other mammals. *Unlike* most other mammals, human males are often more that mere sperm donors. We know from experience that human fathers frequently contribute substantially to their offspring beyond a haploid set of design information.

Just exactly what is the form of this additional contribution? Males can't incubate a fetus and their breasts are vestigial – not producing milk. In fact, the answer to this question is all around us. Contemporary human families probably mirror important elements of ancient ancestral families. A contemporary male often generates *resources* that can be contributed to the care, protection and teaching of his offspring.

The specific form of these paternally donated resources is situational. These resources might be animal and plant foods directly harvested or cultivated by his labor. They might be shelter and clothing produced or built by him. Or they might be some very different activity that generates a resource available to be traded for the necessary food and shelter. For example, as a university professor, Paul makes money that mostly goes in exchange for all the accoutrements of the household in which his children lived and grew.

Whatever the local situational details, human males ultimately contribute these resources to the success of their offspring. These resources cost effort and time to generate and they are referred to as the paternal investment in the offspring.

Of course, both males and females often act as bread winners, generating resources for the rearing of children. This is not merely true of our contemporary culture. It was probably generally true throughout the 2 million year history of our ancestors.

However, this fact does not change the fundamental properties of the situation. Children who are the benefactors of ***both*** maternal and paternal investment will generally do better than those who must rely exclusively on maternal investment. Paternal investment matters.

As we will see a little later in this chapter, the asymmetries in the roles of females and males in reproduction represent a selective force that has apparently shaped the minds we have inherited from our ancestors (also see Chapters 6 and 8).

However, what concerns us at this moment is that the successful rearing of the slowly developing human youngster requires the input of a lot of resources. As a result, each adult needs a substantial commitment of resources from one (or more) other adults to have the best chance of successful reproduction – replication of human design information. Thus, our minds, as proximate devices designed by natural selection, are expected to cause us to behave in ways that lead to our obtaining and defending these resources.

This simple, but utterly essential, insight is the key to understanding everything about the way human adults interact with one another as potential reproductive partners and/or potential competitors for the resources necessary for reproduction. It will give us rich insight into many of our feelings as sexual adults, as social creatures, as parents and as children.

One last issue - remember again what we said about our ethical sense in Chapter 3. We must not allow our moral reactions to behaviors to preclude our comprehension of where these behaviors come from. In Chapter 3, the issue was non-human animal behavior.

Here the issue is our own behavior. However, the stakes are the same. If we are confused by our ethical reactions to what people do, we risk failing to understand why we do these things. Ignoring or denying the biological origins of our capacity for certain behaviors might allow us the conceit of a certain juvenile moral smugness – but only at the cost of continued ignorance and moral helplessness.

Later in this chapter we will be in a much better position to place our uniquely human ethical sense firmly within the larger story we are building. For now, it is only important that we hold our ethical reactions in abeyance so they do not trip us up.

4 Also see Buss, et al (1992), Buss, et al (1999) and Pietrzak, et al (2002) for more recent explorations of some of these issues.

5 Daly and Wilson (1988).

6 See deWaal (1996) for a recent discussion of these issues.

Chapter 5

Death from a distance – the evolutionary logic of kinship-independent social cooperation

1 See Holdobler and Wilson's classic 1990 book *The Ants* for the background to these stories and many others.

2 It's enlightening to digress for a moment here. You can think of the aphids as the ants' dairy cattle. The aphids have been domesticated by the ants, so to speak. They have been genetically modified. Their feeding and reproductive behaviors have been altered, for example – by selection applied by the ants. The ants keep aphids that produce good honeydew and are easy to raise and discard those who are not. However, the ants have also been altered by selection for fulfilling their part of this arrangement. Those who fail to protect and care for their aphids are likely to starve.

In fact, we would be equally correct to look at the ants as the paid lackeys of the aphids. Of course, both views are partially correct – and incomplete.

The same complex evolutionary relationships exist between us humans and our domesticates. We might think this is not quite true. We shape our domesticates genetically, but they do not tamper with human genetics on an evolutionary timescale.

This view is incorrect. One example serves to illustrate the point. Many of us of Eurasian ancestry are lactose tolerant. We can consume raw milk and various milk products without getting severe gas, diarrhea and nausea. We can do this because we continue to express a digestive enzyme in adulthood that most mammals – and many other humans – express only when they are nursing on mother's milk as infants.

This adult expression of the lactase enzyme is the result of a genetic adaptation to consuming milk and milk products as food in adulthood. Our pastoral ancestors probably evolved this adaptation under natural selection imposed by their dairy cattle and we have inherited it.

Lactose tolerant humans can be thought of – correctly but incompletely – as having been domesticated by cows for the purposes of making more cows. This has been a very successful trick for the cows. They currently exist in enormous numbers throughout the human world. Walk through your local grocery and add up the shelf space devoted to milk, cheese, ice cream, milk chocolate, steak and hamburger – the cows' food rewards to their human business partners.

This way of looking at a grocery store or at anything else about the human condition may strike you as silly or peculiar. But it is not. It is crucial for us to develop the ability to look with this kind of detachment at biology and the place of humans within it if we are to truly understand ourselves.

3 It is also illuminating to look a little further into this kind of cooperation or business deals between members of different species. Consider bees and flowers again. What happens in the future when the bees help the flowers make more flowers? Nothing bad happens from the bee's point of view. In fact, more flowers in the future mean more food. Moreover, quite obviously, these future descendents of the flowers will not be competing with the future descendents of the bees that helped make them – and vice versa. These future bees and flowers do not need the same resources and they do not compete for mates, for example.

Thus, they do not have overt conflicts of interest. But do they have *any* conflicts of interest? Yes, they do. For example, the plant spends precious energy making the sugars that makes nectar good bee food. It would be in the plant's interest to fake this nectar by putting less energy into it, thus, fraudulently purchasing the bee's services. However, the bee has a sweet tooth. It knows good nectar from bad and does not bother with cheap, cheating flowers. The bee polices the business deal and keeps it bee-friendly**.**

Likewise, our bees are rather indifferent to transporting pollen from flower to flower. They are mostly concerned with the nectar they need. However, the plant places its stamen (pollen shedding organ) where the bee must rub against it in the process of getting the nectar. The plant is policing the bee's fair contribution to the deal.

But there's an even more important subtlety to recognize in our bee/flower business deal. A hypothetical thought experiment will highlight this issue for us. Suppose that the future flowers and future bees produced by this deal actually ***did*** come into intense, direct competition. Their business arrangement would then not only have short-term mutual benefits, it would also have future ***costs***. Let's borrow a term recently popular in the military intelligence community. We'll call these future costs of present cooperation ***blowback***.

The descendents of *this* generation of bees will often occupy the same local territory as the descendents of *this* generation of flowers – their ancestral neighborhoods. Thus, blowback would be a source of natural selection over time for flowers that could fool bees by getting them to transport pollen without giving them food that would help them make more bees (competitors). Likewise, it would be a source of selection for bees who could nip in and get nectar without picking up any pollen.

This would be an ongoing arms race with bees and plants getting ever better at fooling one another. Actually, blowback would select for the bees to find a new source of food and for the plants to find a different way to achieve pollination until the original business deal collapsed. Even more realistically, blowback means that the business relationship would never have evolved in the first place.

> Notice where we would have come to. Conflicts of interest between our imaginary competing bees and plants would have prevented the evolution of cooperation between them. Non-kin cooperation would not have evolved here because conflicts of interest would have been too great.

4 See Ratnieks, et al. (2006) for a recent review of this remarkable story by some of those who worked it out.

5 We note that Ed Wilson recently collaborated with Bert Holldobler to write a popular book entitled *Superorganism* (2009). This book sometimes slips into what appears to be the group selection fallacy. We believe that such interpretations are almost always wrong. There is a strong need to continue to put individual selection models in competition with group selection models for some of the more esoteric social behaviors of ants, bees and termites.

6 Is group selection *logically* impossible? In fact, it is not. Under the right circumstances, group selection can, in fact, work. (See Gintis, 2000, for one discussion of this issue.) However, the problem is that the circumstances under which group selection works to produce group cooperation are apparently just too unusual to occur very often (if ever) in the world of real organisms. Workable group selection models often posit conditions analogous to flipping a coin and having it stand on its edge. These are *possible* outcomes – but not likely, realistic ones.

It is a relatively easy to see why this is so using our bees and ants from the main text as subjects in a thought experiment. Suppose, at the start of the experiment, we artificially engineered the design information of worker females so that they did not police but were still cooperative as explained (raising brothers rather than sons). Under these conditions, the *individually* self-interested behavior of workers (of their design information, actually, as always), changes. Any new genetic alteration that causes workers to start raising their sons and ignoring their brothers will win out and displace our artificially constructed design information in the immediate term (the only time scale that matters for blind, foresightless natural selection). When they do this, more copies of their newly altered design information are produced (in the male offspring of the colony) relative to the design information of the other females who raise brothers instead of sons.

However, this newly available selfish strategy creates a new problem (from the point of view of the colony *as a group*). Each individual female wishes to raise her own sons (50% related) but not the sons of any of her half-sisters (12.5% related) under these conditions. Thus, the workers come into conflict over colony resources for raising males. When a worker lays a son egg in a colony cell (in a bee hive, for example), this is at the expense of the use of that same cell by another worker.

Natural selection might produce any number of solutions to this conflict depending on accident and local detail. For example, the females might strike out on their own when the time arrives in the breeding season for producing males. Alternatively, they might divide up the nest, patrolling a territory for raising sons and keeping their sisters out. [Remember that policing by destroying eggs is ruled out by our initial premise.]

Whatever the details of this thought experiment, the resulting new pattern of worker behavior will reduce the efficiency of the original "cooperative" colony. For example, females guarding son-raising territories in the colony are not helping to raise their juvenile sisters in other parts of the colony. Females in selfish colonies will leave fewer offspring overall (counting sisters and brothers raised through efficient cooperation) than females in cooperative colonies.

Our group-selection-prone minds immediately think, "That's it! This production of more offspring through cooperation is why cooperative colonies exist." However, we are wrong when we think this (usually or always). Continuing our thought experiment will help us see why.

When a "mixed" colony forms, the selfish females who raise their sons leave more copies of design information than females who raise the same number of brothers in the same colony (relatedness again). Thus, *within* the colony, the selfish strategy trumps the cooperative strategy.

As the descendents of this mixed colony disperse to set up new colonies, the selfish lineages continue to "win" *within* those new colonies just as in the original one. These mixed colonies produce fewer total offspring overall, but it does not matter. Gradually, over many generations, every colony becomes "infected' with selfish individuals who do better. Over time, the selfish strategy displaces the cooperative strategy. Natural selection produces a "race to the bottom".

Proponents of a central role for group selection in social evolution point out that there are circumstances when this does not happen and they are right. However, let's look at what those circumstances are.

The only time selfish strategies do not win (in the absence of worker policing in our thought experiment) is if the first few selfish females reduce the efficiency of the colony by a larger fraction than their selfish strategy improves their reproductive output relative to their sisters and half-sisters. For example, suppose that a selfish worker female produces 25% more copies of her own personal design information in the progeny of the colony by raising sons (50% related) rather than brothers (25%). Recall that the colony will also be raising females who will have the same relatedness to selfish and cooperative workers. Then, for the selfish strategy not to win out, her presence (surrounded by her cooperative sisters and half-sisters) would have to reduce the overall output of the colony by more than 25%.

However, notice that this first selfish female will be just one of many workers in the colony. Her selfishness is very unlikely to cut the overall reproductive output of the colony by such a large factor.

Of course, as selfish females become more common in the population of future colonies, their effect on the reproductive output of these colonies will increase. However, at this point, most of the other colonies they are competing with have also been infected with selfish individuals so that their overall output is reduced, too. The standard for "group competition" is progressively lowered – our "race to the bottom", again.

Thus, unless selfish females somehow have an out-of-scale impact on colony efficiency, group selection won't stem the tide of selection within colonies and selfishness will win.

Again, the punch line is that group selection can work in principle but the circumstances when it works are apparently too special to apply to many (if any) cases in the real biological world. Thus, group selection advantages are probably mostly (or always) *secondary consequences* of choices made on the basis of *individual self-interest*, here and, apparently, throughout biology (including human biology).

We will have much, much more to say about this later (Chapters 5 and 10, for example).

7

Proximate mechanisms and the nature of illusion

Why have we lavished so much time on the group selection fallacy? The answer is that we are all unusually prone to jump to group selection explanations of social behavior. The exact reasons for this will emerge later (Chapter 10). For the moment, what is important is that our evolved, adapted minds have built-in biases that we must deal with if we are to achieve the deeper self-understanding we seek.

In Chapters 3, 4 and 10 we talk about the fact that our minds are proximate mechanisms that are the immediate causes of our behavior – though the ultimate cause of our behavior is the natural selection pursuing ultimate goals that produced these proximate devices. What is the implication of this origin of our minds? It means that they have been engineered by natural selection to do specific things under specific circumstances – the particular circumstances under which natural selection operated to produce them in our ancestors.

This means that our minds – as beautiful and powerful as they are – can nonetheless mislead us about what is going on in the world around us. Let's get a deeper intuitive feeling for this fact by considering a case from our visual perceptual system as follows.

Relative measurements are easier to make than absolute measurements. It's easier to ask whether one stick is longer than another than to ask if one stick exactly 2.7 feet long and the other 3.1 feet long, for example. Thus, our visual systems are designed to measure things relative to one another. As a result, though we tend to feel like we have an absolute fix on the physical objects in the world, in reality, we have a mostly relative fix.

Nevertheless, in the real world, this system still almost always works superbly. Relative information tells us almost everything we need to know about the world. That's why natural selection produced the system in the first place. However, knowing how the system *really* works, we can fool it in a way that reveals its actual workings rather than our intuitive feeling about those workings. The optical illusion in Figure OE5.1 below illustrates this point.

Let three lessons from this illusion fully penetrate your consciousness and your outlook. First, our visual perception almost always reports the world to us in a way that is reliable, consistent and "realistic". Realistic in the sense that the world we "see" is well-defined when we "act" on it – a good baseball player can easily hit a hanging curveball, for example.

Second, in spite of this "realism", our minds absolutely ***can*** fool us under some particular circumstances. If we fail to recognize and accept this fact, we will run into many difficulties as we progress. Especially important to us will be the illusions that our minds occasionally throw up to us concerning the origins and logic of our ***social*** behavior. The group selection fallacy is one of these.

Third, we can actually use these occasional illusions to enrich our understanding of our social minds, turning them to our advantage just as the optical illusion above enhances our understanding of our visual system. If we are patient, relentless and honest, we can ultimately sort illusion from non-illusion – again, analogous to dissecting the optical effect in Figure OE5.1. We can escape our subjective prison and look out on that universe, our world, as knowing creatures.

Finally, with these insights in hand, be aware that the journey we will take from here forward will sometimes put us in situations that will provoke illusions about our social behavior. For example, we will find ourselves saying, "I do not think like that!" or "That is not a good description of my social behavior or social feelings!"

When we have such reactions, we must try not to be misled by them. We will try to explore the origins of these illusions as they emerge from our theory. But sometimes we must simply be patient and withhold final judgment (while never forgetting any feelings of skepticism you might have) until we have fully explored the arguments and the evidence.

Now, let's return to the question of our human behaviors, including things like our social, sexual, linguistic and ethical behaviors. These behaviors are produced by proximate mechanisms designed by natural selection.

Designed to do what? To help us navigate the human social world, with subtlety and success. Does this mean that introspection will teach us how these mechanisms actually work or how and why they evolved? Obviously, it does NOT – any more than we expect to deduce the Second Law of Thermodynamics merely from introspecting on our feelings of hunger (Chapter 2).

Instead, what we need is a theoretical understanding of how and why they actually evolved. Only this type of approach WILL give us the understanding we seek.

There is one last issue here that is unique to our social behavior in contrast to our visual perception. Though we wrote and edited these pages in isolation, you and we are really engaged in a discussion, nevertheless. All of us reading and discussing the book are participating in a highly social interaction.

Thus, our discussion of the evolution of human social behavior is being mediated by the very proximate mechanisms designed by that same evolution to permit our social behavior.

This can get a little complicated, to say the least. The opportunities for illusion here are especially great. For example, sometimes we will find that the theory we will build predicts things about our social minds that feel "wrong", embarrassing, "demeaning" or worse.

Again, we must try not to let such initial reactions cloud our long-term critical judgment. We must be patient; let the arguments and the evidence sink in. At the end of our journey, we will NOT find our humanness demeaned. On the contrary, we will find ourselves elevated as more self-aware – and more humanely self-accepting – beings.

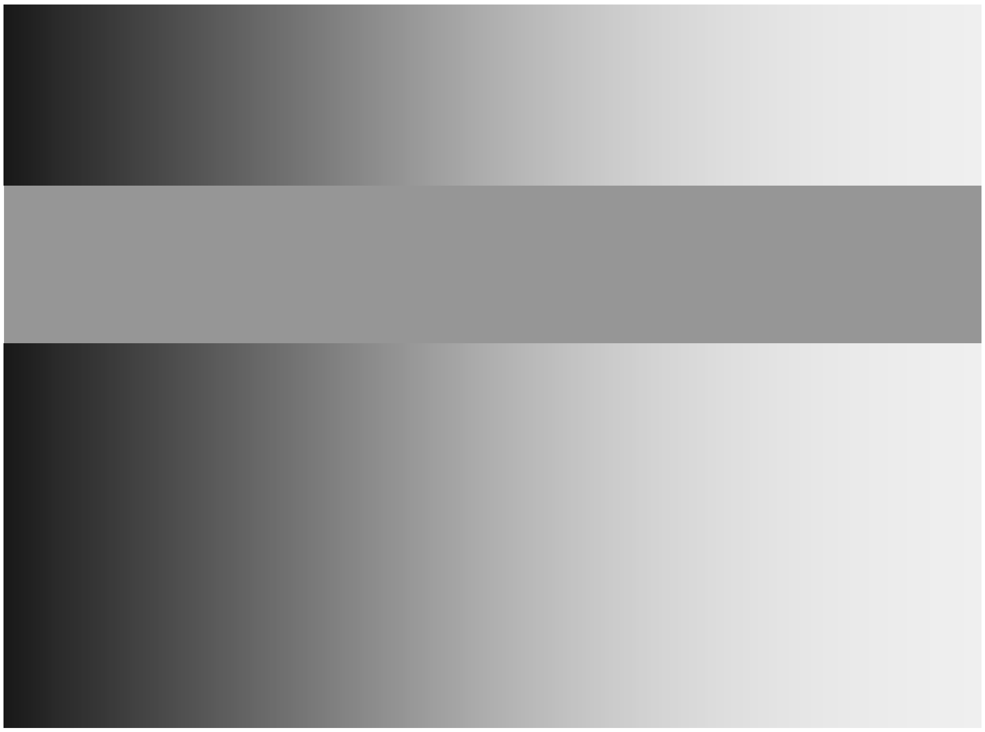


Figure OE5.1: The middle bar above looks like it is lighter at the left and gets darker as we proceed rightward. This is purely illusory. Actually the middle bar is uniform in darkness. This illusion results from the fact that the top and bottom bars *do* change in darkness from left to right and our visual system *compares* the middle bar to these. Cover the top and bottom bars to convince yourself that this is true.

We must ask ourselves two questions. First, now that we recognize the illusion, can our awareness override the proximate illusion itself? No, the illusion remains! Second, are we now actually fooled by the illusion in a conscious sense? Not really. Now that we understand we can take steps to by-pass any undesirable behavioral effects of the illusion.

Our goal must be to overcome all cases of such illusion – especially in the context of our social behavior and its evolution.

8 We believe this insight is likely to be highly general. We suggest that it applies to other animal societies, including primate troops, wolf packs and others (Bingham, Sunik, and Souza, unpublished work).

9 Sophisticated specialists will recognize that coercion by each member of the mob of workers presents a free rider problem in itself – the higher order free rider problem. There is important theoretical work remaining to be done here (Okada and Bingham, 2008 and unpublished). However, in general, those who coerce are those with the most to gain directly from ostracizing the first order free riders (sharing the food actively confiscated from would-be thieves in the example in the text).

10 For students aspiring to be investigators themselves, we encourage you to reflect at length on the *simplicity* of the solution to the human uniqueness question of problem developed in this chapter. Much of institutional science has recently come to value "complexity" in ostensibly scientific explanation (Chapter 10). Such complication is almost always a symptom of confusion (or competing motives), *not* of authentic insight.

11 Our theory is about how natural selection produced the unique animal that is us. Natural selection acts on what is present at each moment. Thus, it produces creatures that are well-designed to their environments, but also strongly influenced by their evolutionary history. For example, we all have hair on our heads instead of feathers, not because hair is better than feathers, but because our immediate ancestors were hairy mammals rather than feathery dinosaur/birds. Natural selection shaped the human "head of hair" from the hair of our mammalian ancestors.

Some interesting things about us as humans are such historical accidents. No theory of human uniqueness could (or should try) to predict these accidents. Rather, our focus is on the law-like properties of our origin and history.

This limitation should not overly discourage us, however. Science is always concerned with the law-like properties of processes and systems, not their quirky history. For example, Newtonian mechanics works very well to describe the orbits of the planets (produced by law-like processes). It cannot predict the numbers and size of the planets (produced by quirky historical accidents during the birth and early life of our solar system).

This relationship between law-like behavior at one level of reductionist explanation (of complexity) and accidental processes at surrounding levels is actually a rich topic, but one that need not concern us in this book.

12 See John Maynard Smith's classic 1982 discussion of this issue.

13 The text describes the general case for the cost of coercion. A famous specific example is Lanchester's Square Law, well known to military strategists.

The developer of this rule for artillery, Frederick Lanchester, was a remarkable early 20th Century polymath. Among other things, he was a British automobile manufacturer. [It has been suggested that Henry Ford stole most of his good ideas from Lanchester, by the way.] Among other things, he manufactured the ambulances used to haul wounded soldiers back from the front during brutal years of trench warfare in World War I.

He spent time at the front monitoring his ambulances – and feeding his relentless curiosity. One of the things he saw there were artillery duels between the British, French and American forces on one side and the German forces on the other.

He was able to work out the logic of who won such duels – in the rare circumstances where they were actually played out, rather than simply representing low-level harassment. He recognized that the risk to each artillery battery participating in such a duel was related to the ***square*** of the ratio of the number of batteries on the numerically superior side to the number on the inferior side.

Lanchester's Law was formerly known only to the kinds of people who have lunch at the "Ground Zero Café" in the center of the Pentagon. This law and its more general form (text and Figure 5.1) has a whole new importance now as we come to understand human uniqueness.

14 Though it is beyond the scope of this book to discuss the subject in detail, the uniquely human access to inexpensive coercion might reflect a massive quantitative difference rather than a qualitative difference. For example, primates with grasping hands might be able to use immobilization and forced movement of targets to gain access to effects similar to human throwing – though involving many fewer individuals and, thus, being much smaller in scale (Bingham, Sunik and Souza, unpublished). It will be of great interest to see whether some cases of limited cooperation between non-kin adult non-human animals have their origins in such effects.

15 Based on the original theoretical work of Paul (Bingham, 1999; 2000) and the game theoretical work of Daijiro Okada and Paul (Okada and Bingham, 2008).

Chapter 6

It takes a village to raise a (human) child

1 Data on sizes of humans and apes from Leonard and Robertson (1997) and Key (2000).

2 Data in Figure 6.2 from Martin (1983), Bogin (1999) and Bogin and Smith (2000). Also see following endnote.

3 Human life history has clearly been profoundly altered relative to our last common ancestor with the other apes. However, how we should interpret some of the details of these alterations remains contentious (see Smith and Tompkins, 1995; Leonard and Robertson, 1997; Leigh and Park, 1998; Bogin, 1999; Kaplan, et al., 2000; Key, 2000; Aiello and Wells, 2002; O'Connell, et al. 2002 and Ulijaszek, 2002 for recent discussions and reviews). It is currently probably *inherently* impossible to resolve these disagreements on empirical grounds alone. Conflicting interpretations of the life history evidence will persist until we have a coherent global theory allowing us to distinguish these interpretations. Ostensibly, the theory we are exploring here permits this.

Our theory appears to account for the life history evidence more completely than any previously available. Moreover, it allows us to put into perspective earlier, more local theories. Several technical issues are important for specialists at this juncture. [We also return to these points in Chapter 7.]

First, our theory predicts that the caloric needs of ancestral human mothers, babies, children and adolescents should have been provided not only by close kin but also with frequent, crucial contributions from kinship-independent social sources - from the human village (also see text and footnotes below). This pattern is observed ethnographically in contemporary hunter-gatherers (see, for example, Kaplan and Hill, 1985; reviewed in Kaplan, et al. 2000) as predicted. Notice especially that the *majority* of calories are provided through cooperation between non-kin individuals in 8/9 well-characterized hunter-gathers and a substantial minority of those calories (45%) in the remaining case in one study (Kaplan, et al., 2000; Table 2, pg. 162). Further, notice that this sharing beyond close kin can apply to diverse resources (hunted meat and gathered plant and animal resources)(see Kaplan and Hill, 1985, for a specific example; reviewed in Kelly, 1995).

Second, hunting by non-kin males often plays an important role in the provisioning discussed in the preceding paragraph. However, historically it has sometimes been argued that this male provisioning cannot have been central to early human evolution because the males who capture prey usually give it to non-kin youngsters (see O'Connell, 2002 for a review). Obviously, this objection fails to take into account the effect of suppression of non-kin conflicts of interest. Under the uniquely human suppression of conflicts of interest, the kin of provisioning males ultimately benefit (relative to individuals who are not members of the cooperative village) from the cooperative provisioning by other males. [This is, of course, merely a specific example of the indirect reciprocity postulated by Alexander (1987) to be the unique element of the human social adaptation. Our theory allows us to account for Alexander's important empirical suggestion.]

Third, it has also been argued that male provisioning through hunting and/or scavenging cannot have been central to early human evolution because the day-to-day variation in yield is too high (reviewed in O'Connell, et al., 2002). In effect, a glut of calories would sometimes be available but, at other times, individuals (including mothers and babies) would starve while awaiting the next kill. However, this objection does not exclude the hypothesis that foraging by non-kin males (hunting/scavenging) was central to human evolution. It merely says that such cooperation was probably not sufficient *alone* to sustain evolutionary change in human life history. The ethnographically observed pattern is precisely that predicted by our theory. Our theory requires only that the *aggregate* yield of *all* the cooperative human village's efforts should be sufficient to support the altered human life history. In fact, it is (see, for example, Kaplan and Hill, 1985; reviewed in Kelly, 1995 and Kaplan, et al., 2000).

Finally, it has been argued that cooperative provisioning by non-kin males did not evolve to support human reproduction directly (including provisioning of mothers and youngsters) – even though it has that effect. Rather, it is produced by sexual selection on males to "show off" (reviewed in O'Connell, 2002). This is based, in part, on the (fallacious) kinship argument of the preceding paragraph. However, this claim is also based on the observation that males behave (and seem to feel) as if they are showing off when they hunt. This second argument confuses proximate and ultimate causation. The subjective experience leading to a behavior bares no necessary relationship to its ultimate strategic (evolutionary) rationale. [Of course, any behavior or anatomical feature with adaptive significance can *secondarily* become a target for *sexual* selection, as well.]

4 There are occasional cases of systematic rearing of non-kin youngsters. These rare cases include adaptive errors (conspecific parasitism). As well, they include cases where the adopted youngster is actually captured for future service, either as a caregiver or mate to youngsters who are kin to the adoptive parents. In other words, these cases do not represent large-scale kinship-independent cooperation *in the face of conflicts of interest* that we will see in human social breeding. See Avital and Jablonka (2000) for a recent review of these animal cases.

5 Does the chimp Flo in the main text story need any social support to give birth to Flint and to rear him? Yes, she needs just a tiny amount of backhanded social support and that's all she gets. It works like this.

Flo is surrounded by the dozen or so adult males of her troop. They do not make any contribution whatever to feeding her or giving her shelter. However, she mated with a number of them and they tolerate her presence and that of her offspring because they cannot be sure (unconsciously, of course) that the offspring are not their own (kin-selected behavior; Chapter 3).

Moreover, these males may protect Flo's offspring from infanticide by the most non-kin adult females occupying her troop – again, this is a kin-selected behavior by the males.

Finally, these males have a selfish interest in policing their territory to keep unrelated, competing males out. [These males are usually related to one another. Even though there are apparently exceptions to this relatedness, the *probability* of relatedness is sufficiently high that male cooperation is probably mostly kin-selected.] In the process of keeping these males out, they inadvertently prevent the presence of males who have not mated with Flo. Such males (unrelated to Flo's offspring) are precisely those with an incentive to kill Flo's newborns, committing self-interested infanticide perfectly analogous to the lion case (Chapter 3).

That's it. Flo's social support consists of a few indifferent males who accidentally protect her from other indifferent males. Otherwise, essentially she is completely on her own.

6 We use the word village metaphorically for any unit of human kinship-independent social cooperation. It can apply to a traditional village of small family homes and public facilities (likes stores, libraries and churches). However, it can also apply to larger human aggregates, like a modern city or even the global village. As we will see later in the book, villages of radically different size (a local town and the global village, for example) result from the same underlying processes and have very similar fundamental logic.

Finally, the word village can also apply to ancient, pre-historic human aggregates of diverse forms. For example, such an ancient human village might consist of family units of hunter-gatherers that forage alone and gather together with other family units only in the evenings or only on certain days of the year. This ancestral human village might be permanent, semi-permanent or changing in location each day.

This universal human village will have diverse features that are defined by local cultural accidents and adaptations. However, human villages will share two properties – always and everywhere.

First, they will include multiple adults of one or (usually) both sexes who are *not* close kin. Second, the village adults (including non-kin adults) will cooperate in a way that supports all the members of the village and even in circumstances presenting potential conflicts of interest. This cooperation can take many forms, including the sharing of collaboratively generated resources (hunted food, say) and cooperatively held information and know-how. It can also include the systematic sharing of individually gathered or hunted foods as a strategy for risk management over time. (For discussions of the fundamental ancestral case of cooperative human food foraging see, for example, Winterhalder, 2001; Kaplan and Hill, 1985; Kaplan, et al., 2000; reviewed in Kelly, 1995).

Second, some or all adult members of the human village will always be armed to permit them to project coercive threat. This armament might consist of throwing stones, bows and arrows or sophisticated handguns – but it will always be present *without exception*. Moreover, massively large human villages (the global village, for example) will include members (themselves aggregates, like nation-states in the global village) that have the technology to project coercive threat on the scale of this massive village. It is this access to relatively inexpensive coercion that is the *sine qua non* of kinship-independent social cooperation (on any scale) as we saw in the Chapter 5 and will explore throughout the remainder of the book.

7 Compartive life history data are from Martin (1983), Bogin (1999) and Bogin and Smith, (2000).

8 Based on data reviewed in Aiello and Wells (2002), a chimp mother will need about 400-500 extra calories each day when she is lactating while a human mother will need 700-800 more calories per day. Moreover, a human female needs another extra 600-700 calories each day just to sustain her larger body, independently of the needs of her oversize, big-brained infant. [Calories are used here as a dietician would use the term. For a chemist these calories are actually kilocalories.]

9 See Chapter 8 for a discussion of the very broad range of ancestral human sexual behaviors.

The empirical evidence also strongly supports the central role of the village in our life history. For none of us in the contemporary world did our parents raise most or all the food we ate through our childhood, for example. Moreover, this remains true among contemporary hunter-gathers who live much more like our remote human ancestors. Especially important is the fact the hunter-gather children receive most of their calories from adults other than their parents. [A beautiful example of this can be found in the classic paper of Kaplan and Hill (1985). Reviews can be found in Kelly (1995) and Kaplan, et al. (2002).]

It has also been suggested that it was grandmothers (rather than husbands) that allowed the uniquely human life history to evolve (see O'Connell, et al., 2002 for a recent review). As discussed in Chapter 8, this theory is based on the observation that human life history redesign includes the extension of life after reproductive age (including post-menopausal life in human females). The idea is that design information that built individuals who lived longer and used that longer life to help provision their (kin) grandchildren would have done better.

Notice first that our theory can account for the extension of post-reproductive life as an *effect* - rather than as a *cause* as assumed by the grandmother hypothesis. For example, the vastly expanded role of culturally transmitted information in the human adaptation predicted by our theory (and observed empirically) is potentially important. This information continues to be acquired throughout life so that older individuals know more than younger ones. Such older individuals are in a position to help cooperative coalition members (including kin) through providing this information (and its fruits).

In contrast, the hypothesis that grandmothers are a *cause* of human life history change (and human uniqueness, more generally) is much less capable of predicting the empirical evidence than our theory. For example, it fails to predict that humans are the first animals to develop "grand mothering" on a large scale – this is merely assumed *a priori*. Further, it fails to account for life extension in males as well as females. Finally, the ethnographic evidence indicates that grandmothers are rarely a source of substantial caloric support (Kaplan, et al., 2000).

10 We are not surprised to see that the optimal levels of body fat for this purpose correspond fairly well to those of Playboy centerfolds. Reproductively robust females were the most successful mates for ancestral males and we contemporary males have apparently inherited the genetically constructed portions of their minds determining their tastes in females – proximate mechanisms win out.

11 The ethnographic record of the simplest human villages sometimes describes the cooperative aggregates that support human mothers and their babies, infants and children as extended families. It is important not to be mislead by this phrase. We might erroneously think that these human cooperative aggregates were merely kin-selected. They are not. Extended human "families" typically include individuals who are so distantly related (second cousins, for example) that they would be treated as non-kin by non-human animals. As well, these aggregates typically contain very distantly related or fully non-kin adults (mates) of one or both sexes.

The upshot of this is simple. Human extended "families" actually embody substantial kinship-*independent* cooperation.

12 The fossil record is still too fragmentary to give us a complete picture of the chronology of human life history evolution (see Smith and Tafforeau, 2008 and references therein for recent discussions). However, the information we do have is consistent with a relatively rapid emergence of "babyhood", "childhood" and "adolescence" in early Homo – with the duration of these stages then subsequently expanding over the next ca. 1.0-1.5 million years to produce something resembling the "modern" human life history by 500,000 years ago (or, perhaps, earlier).

13 One of the complexities here is the fact that adolescence is ***very different*** for males and females. One of the upshots of this is that 16-year-old girls and 16-year-old boys do not have a lot in common. The girls often consider the boys as just "too immature", as they are, in fact.

14 The much higher quality of the human diet in comparison to the other apes is reviewed in Leonard and Robertson (1997). See Susman (1987) and Aiello and Wheeler (1995) for a discussion of the role of dietary quality on the evolution of gut and brain anatomy. Other useful recent reviews of the evolution of human diet are Key (2000); Vasey and Walker (2001) and Ulijaszek (2002). A more general review of gut evolution and diet as well as of the gracilization of the human chewing machinery can be found in Wood and Richmond (2000).

15 Our small guts and gracile chewing apparatus could, in principle, reflect a specialized hunting adaptation that could have evolved under individual and kin-selection. [See Blumenschine, et al., (2007) for a recent discussion of human scavenging and Bramble and Lieberman (2004) for an example of a proposal that early humans might have been elite hunters.] Professional devotion to meat eating might conceivably produce these anatomical changes (though not the other life history changes discussed above). However, we believe that adaptation to the yields of highly efficient, kinship-independent cooperative foraging is a more likely explanation for human anatomical changes than a more specialized dedication to carnivory.

Chapter 7

Throwing strikes on the village commons – the planet's first remote killer and first kinship-independent social cooperator

1 See Vrba, et al. (1995) and Bromage and Schrenk (1999) for discussions of African climate change.

2 It is illuminating to reflect on interactions between sibling species when they come to occupy the same territories. As a result of the extensive similarities they will usually have inherited from their recent common ancestors, individual members of new sibling species will often compete for resources. This competition can have one of two outcomes.

First, the two species might compete so extensively that all the members of one of them perish. This happens when individual members of one species consistently win in competition for resources – territory, feeding sights, etc. Over time, members of the less successful species leave fewer offspring and the more successful species members leave more.

Over many generations, the less successful species finds itself in losing competitions with the more successful species more and more frequently. The end result is inevitable. All available space and resources are captured by members of the more successful species. Finally, inevitably, the last members of the less successful species cannot find mates or food or space. This species is now gone forever.. The process is referred to as ***extinction.*** In fact, extinction can occur for any of a number of different reasons and the above example is only one.

Alternately, the two new sibling species may be different enough from one another that each can avoid competition with the other just enough so that both can survive indefinitely. When this happens, new selective events tend to further reduce competition between members of these two new species, over long periods of time. Their behavior and anatomy will eventually tend to ***diverge***.

The reason for this divergence is obvious. Members of each species who make choices of territory, food sources, birthing sites, etc that allow them to avoid competition with the other species will leave more offspring that those individuals who fly directly in the face of this competition. These different choices will often be the consequence of different alleles at genes influencing behavior. "Competition-avoiding" design information will do better. Its vehicles will leave more offspring than the alternative. The two species will evolve to reduce competition in this way. In other words they will evolve to fit different niches in the available environment.

Over many generations, these sibling species can become quite different as a result of these selective forces.

A real example will help to visualize this type of event more clearly. Think of the three surviving East African big cat predators - lions, cheetahs and leopards. These cats are very similar to one another in overall body plan because they all descended from a relatively recent common ancestor. However, individuals from each species hunt mostly different prey and live in ways that minimize their competition with members of the other two big cat species. For example, lions mostly compete much more intensely with other lions instead of with cheetahs and leopards. This is the expected result of the processes we have been describing.

3 See Lee and DeVore (1969), Potts (1988), Aiello and Dean (1990), Wood (1992), Alcock (1993), Walker and Leakey (1993), Tattersal (1995 and 1998); Walker and Shipman (1996), Darwin (1998/1871), Klein (1999 and 2009), Boesch and Boesch-Acherman (2000), Stanford and Bunn (2001) and Wood and Collard (1999) for earlier discussions of hominid phylogeny. See Wood and Longeran (2008) for a recent review.

4 There is now a massive literature on this subject. Some details – like whether new species emerge in explosive turnover pulses or more gradually – remain in dispute. However, major elements of the picture of climate drying (with cycles of more and less extreme dryness) appears clear. See Reed (1997), Wynn (2004) and Bobe and Behrensmeyer (2004) and references therein. Moreover, the volumes edited by Vrba, et al. (1995) and Bromage and Schrenk (1999) are very useful.

5 Reviews of African climate change during the times that interest us can be found in Vrba (1995), Bromage and Schrenk (1999), Reed (1997), Bobe and Behrensmeyer (2004) and Wynn (2004).

6 This specific scenario for the emergence of "power scavenging" is built around suggestions from the seminal work of Blumenschine and colleagues (see Blumenschine, et al, 2007, and references therein), Marean and colleagues (see, for example, Marean and Assefa, 1999), Bunn and colleagues (reviewed in Stanford and Bunn, 2001) and others. Also see deHeinzelin, et al. (1999) and Dominguez-Rodrigo and Pickering (2003). This work, in turn, was motivated by the longstanding intuition – beginning with Darwin (1998/1871) - that hunting or scavenging must have had some role in the emergence of humans.

The importance of hunting/power scavenging to human life history redesign is discussed in Aiello and Wheeler (1995), Kaplan, et al. (2000) and O'Connell, et al. (2002).

7 See Alcock (1993), Krebs and Davies (1993) and Dugatkin (1997) for reviews of the fundamentals of non-human animal cooperation.

8 Reviewed in Boesch and Boesch-Achermann (2000).

9 See Schick and Toth (1993) and Savage-Rumbaugh and Lewin (1994) for charming discussions of these studies by the people who actually did them.

10 See Aiello and Wheeler (1995) for development and review of gut size and diet.

11 See Potts (1988) and Schick and Toth (1993) for authoritative reviews of the earliest simple flake stone tools beginning around 2.5 million years ago. See Isaac (1987), Potts (1988) and Cannel (2002) for discussions of possible thrown missiles in the form of manuports. See Walker and Shipman (1996) and Asfaw, et al. (1999) and de Heinzelin, et al (1999) for recent reviews of early fossil prey bones discussions. See Asfaw, et al. (1999) and de Heinzelin, et al (1999) for discussion of *Australopithecus garhi*, a candidate for a "late garhi" from our example here. See Aiello and Dean (1990); Klein (1999 and 2009); McHenry and Coffing (2000) and Wood and Richmond (2000) for discussions of the *Homo habilis* record. There is some controversy about stone tool marks on putative fossil prey bones at 2.3 mya, but none for prey bones at 1.9 mya and later (R.Blumenschine, personal communication). However, the 2.5mya dates for the first sharp stone tools appear relatively certain.

12 This evidence is fragmentary and modest. The OH7 hand bones have an enlarged joint between the metacarpal and trapezuim of the thumb somewhat human-like and the apical tufts are a little bigger than australopiths (Tocheri, et al., 2008). However, the OH7 hand is distinctly different that the modern human hand and it seems likely that

The OH8 foot has some properties that look a little more like the human than the australopith foot that could reflect adaptation to throwing. (Kidd, et al., 1996).

13 Reviewed in Falk, et al. (2000).

14 Whether these two femurs – KNM-ER1472 and 1881 – and the 1470 skull are from the same species are conjectural. Though this possibility is certainly credible (Day, et al., 1975), there remains debate. See Wood and Richmond (2000) and McHenry and Coffing (2000) for the current status of the debate over these two femurs.

The cranial volumes of some other later australopiths (the robusts and *Australopithecus africanus*) appear to increase a little (ca. 25%) relative to earlier australopiths (reviewed in Falk, et al., 2000). These slightly australopith cranial volumes remain in the range of other apes and it is likely that they should not be considered as the incipient steps of the much more dramatic cranial expansion seen in early *Homo* (main test Figure 7.4). However, note that it is remotely conceivable that throwing evolved around 2.5 million years ago in several australopiths (presumably in response to climate change) and that several lineages began "exploring" the evolutionary options this opened.

On this (unlikely) view, late australopiths are showing the very first signs of cooperation-dependent life history change and, thus, on our theory, should show significant redesign for elite throwing. The evidence from the South African fossil hand and foot bones apparently from robust australopithecines (*Paranthropus sp*) could be interpreted in this way (reviewed in Aiello and Dean, 1990).

Again, this less likely alternative interpretation of the hominid fossils between ca. 2.5 and 2 million years ago would also be consistent with the theory we are exploring here.

15 See Leakey and Walker (1993) for a detailed description of this remarkable fossil.

16 Fossilization of bones can happen is a number of ways. In general, fossilization occurs when the bone is buried in silt, mud or soil and when water percolating through the soil carries dissolved minerals. It works as follows.

Most of the hard part of bone, itself, is a mineral – built up from calcium and phosphorous and a few other atoms. Some of the mineral components of bone can slowly dissolve in water – like a sugar cube in a cup of coffee. However, these soluble (dissolvable) bone components can be replaced with different atoms or small molecules from the water-borne minerals. These replacement atoms and molecules are less easily removed again later by water than the bone components they originally replaced.

These newly added minerals make the bone harder and more resistant to later deterioration than the original bone. In effect, the original bone is a (comparatively) soft rock which is turned into a much harder rock by fossilization. What is most important about fossilization, is that this replacement is generally precoise. New atoms are added only by replacing original bone atoms – the new atoms are *not* caked onto the outside of the bone, for example.

Thus, the fossil is often an excellent, very detailed replica of the original bone. In other words, a fossil can give us a very precise picture of the skeleton of an animal that lived millions – or even hundreds of millions – of years ago.

17 One example will suffice to illustrate the general principle (see Klein, 1999, for a review of additional details). Soils and minerals contain the element potassium. Most of the Earth's potassium exists in a stable isotope with a mass or weight of 39 atom mass units. But a small amount is a radioactive isotope of atomic weight 40 units.

Isotopes are atoms that have the same number of protons and electrons and, thus, the same chemical properties. However, they have *different* numbers of neutrons and, therefore, different atomic weight – Potassium-40 has one more neutron than Potassium-39, for example. The extra neutron in Potassium-40 makes is atomic nucleus unstable – hence, the radioactivity we are going to make use of.

When an atom of Potassium-40 undergoes radioactive decay it produces an Argon-40 atom. [Actually it produces either Argon-40 or Calcium-40. However, the *fraction* that becomes Argon-40 is constant and can be more easily measured than Calcium-40.]

This is useful because of the properties of argon. Argon is an "inert" element. That means that argon does not form chemical compounds with other atoms. It's always free. Moreover, argon is a gas. Thus, it floats away whenever it is not trapped inside some kind of container, like solid soil. This is especially true at high temperatures, where gas molecules are moving around very rapidly and violently.

This becomes useful because all the tiny pores inside a particle of dirt, dust or sand act as containers to trap argon. However, when the particle is heated, these containers tend to rupture and release their argon into the atmosphere. All the argon is boiled off, so to speak.

When the resulting Argon-free hot particle cools, it will slowly start accumulating new Argon-40 from new radioactive decays of Potassium-40. As long as it is not violently heated again, it will accumulate a little more Argon-40 each year – year after year, century after century.

We can come along hundreds of thousands or millions of years later and measure the amount of this Argon-40 (relative to the amount of Potassium-40) and determine how long ago the grain of sand or dirt was last heated.

How does this help us? Where will grains of sand or dirt be violently heated? One common way this can happen is when the grains are blown out of a volcano as a component of volcanic ash. When a volcano erupts it will often spread a thin layer of ash over thousands of square miles of area around the volcano.

This ash layer will be deposited at a specific time point in the sedimentary sequences accumulating at the bottom of lakes, for example. When we come along millions of years later and examine this sedimentary sequence we can tell exactly when its component layers were laid down on the basis of the Potassium-Argon-determined age of the volcanic dust layers that are part of the sequence.

18

The Glen Iris Gorge in Fletchworth Park in upstate New York is a spectacular example of sediments laid down long ago, then uplifted and cut through by a contemporary river (TOP frame). Paul is standing by the gorge in the MIDDLE frame. The BOTTOM frame is a close-up of a segment of the sediments.

These sediments were laid down at the bottom of an ancient sea (several hundred million years ago). This stratigraphic sequence records some of the events in the early evolution of fish. In the main text we make use of much younger sedimentary sequences to explore the evolution of humans over the last several million years.

Photos by P. Bingham and Z. Zachar.

19 Main text Figure 7.3 is based on diverse sources. See especially Aiello and Dean (1990), Johanson and Edgar (1996) and Klein (1999 and 2009) for reviews. Also see Johanson, et al (1982) for Lucy details and Walker and Leakey (1993) for Nariokotome details.

20 Aiello and Wheeler (1995).

21 See Wood and Longeran (2008) and Robson and Wood (2008) for recent reviews of hominid (hominin) phyologeny and life history, respectively. Details of hominid phylogeny and classification of early human-like hominids is controversial. Likewise, the life history of *Homo* appears to continue to have changed significantly throughout the ca. 2 million years since the origin of this clade. Finally, note the lack in the earlier published work of a useful, credible theory for uniquely human life history evolution. Our theory potentially sheds substantial new light on all these issues. Specifically, human life history redesign is expected to emerge from novel social cooperation (Chapter 6) emerging, in turn, from new access to inexpensive coercion (Chapter 5). Moreover, this characteristically human life history redesign is so massive that it is reasonable to suppose that it was only achieved by an extensive series of adaptive (genetic) changes, each dependent on changes that went before. Such a vast redesign process might have taken significant time and produced different “grades” of humans while underway.

Also see Falk, et al (2000).

22 See Schmid (1991) for a detailed discussion of the comparative trunk shapes of australopiths and Homo. See Aiello and Wheeler (1995); Wood and Richmond (2000) and McHenry and Coffing (2000) for additional discussions. The body shape of the Nariokotome fossil in particular is discussed in detail by Alan Walker and Christopher Ruff in Chapter 11 of Walker and Leakey (1993).

23 See Stern and Susman (1983) and Susman, et al, (1984).

24 In addition to the pelvis described in this section, there are a number of additional morphological characteristics that can be interpreted as evidence of the evolution of human throwing. However, detailed treatment of these is probably better left as additional opportunity for more sophisticated professional anatomists to test the theory. Examples include the human shoulder (reviewed on pages 351-371 of Aiello and Dean, 1990), the leg and knee (reviewed in Chapters 21 and 22 of Aiello and Dean, 1990), the hamstring muscle attachments to the pelvis and lower leg (reviewed on pages 411-413 and 453-454 of Aiello and Dean, 1990) and the inner ear (possible important to feedback control of the violent throwing motion; Spoor et al, 1994; Spoor and Zonneveld, 1998).

25 Reviewed in Marzke, et al. (1988).

26 Reviewed in Aiello and Dean (1990).

27 We know that some of these muscles are involved from the electromyography discussed in references below. In other cases, like the obliques, we are reasonably confident of their involvement in view of their size and positioning.

Useful references on human throwing muscles specifically are Stern (1972), Stern, et al. (1979), Marzke, et al (1988) and Young (2003).

Useful general references on human anatomy are Aiello and Dean (1990), Snell (1995), and Agur, et al., (1999).

28 See Stern (1972), Snell (1995) and Agur, et al. (1999) for descriptions of the unique features of the human gluteus maximus. Farfan (1995) reviews some of the evidence that this and other trunk muscles are "over-sized" in humans. Farfan interprets these muscle hypertrophies as adaptations to "heavy lifting"; however, they are equally well interpreted as adaptations to the violence trunk motions involved in elite throwing.

29 Modern human anatomical data can be found in Snell (1995) and Agur, et al., (1999). Fossil hominid anatomy is reviewed in Aiello and Dean (1990) and Klein (1999 and 2009). Nariokotome pelvis reconstruction is based on Walker and Leakey (1993). Australopith (Lucy) pelvis reconstruction (using mirror image replacement and other pelves to fill in missing elements) is from Johanson, et al (1982) as described in Johanson and Edgar (1996). Data on other hominid fossil pelves and lower limbs can be found in Day, et al. (1975), McHenry and Corruccini (1976), McHenry and Corruccini (1978), Kennedy (1983), Stern and Susman (1983), Rose (1984), Susman, et al., (1984), Kidd, et al. (1996), Asfaw, et al (1999), McHenry and Coffing (2000), Lordkipanidze, et al. (2007).

30 The attachment of the uniquely human gluteus maximus muscle to the underside of the pelvis fills a region of attachment on the bone. This edge of this region of attachment is visible on the bone as the "posterior gluteal line" (Agur, et al., 1999). Though this line is delicate enough not to fossilize very well, there is evidence that it may be missing or placed indicating a smaller attachment site in australopith pelves (reviewed in Stern, 1972).

31 See Marzke, et al. (1988) for electromyography on the gluteus maximus muscles during throwing and other activities.

32 At this writing, electromygraphic measurements have not yet be done on these muscles during throwing to our knowledge. Such studies would be of great interest.

33 See Stern and Susman (1983) and Susman, et al, (1984).

34 See Susman (1998) and Marzke and Marzke (2000) for recent pithy reviews.

35 Work on the evolution of the human hand was pioneered in its modern form by Napier (Napier and Tuttle, 1993 and references therein). Reviews of much of the early work can be found in Aiello and Dean (1990). Also see Snell (1995), Susman (1998), Agur, et al., (1999) and Marzke and Marzke (2000). An excellent review of the state of the art at this writing is Tocheri, et al. (2008).

36 See Tocheri, et al. (2008) for an incisive, critical review of these issues and limitations.

37 Data on modern human hand structure is in Snell (1995) and Agur, et al. (1999). Modern ape hand structure is from authors' images of casts and from Tocheri, et al. (2008). Fossil hominid hand structures are reviewed in Aiello and Dean (1990), Napier and Tuttle (1993) and Tocheri, et al., (2008). Stuctures of *Homo erectus* (Dmanisi) distal phalanges are from Lordkipanidze, et al (2007). Details of hominid hand structures can be found in Susman and Creel, (1979), Johanson, et al. (1982), Susman (1994), Ohman, et al. (1995), Susman (1995), Marzke, et al (1988), Susman (1998), Cannell (2002), Grine (2005), Marzke (2005), Moya-Sola, et al (2008).

38 See Agur, et al. (1999) for basic anatomy, Aiello and Dean (1990) for overview of evolutionary anatomy and Tocheri, et al., (2008) for our current picture of these muscles.

39 Marzke, et al. (1998), reviewed in Tocheri, et al., (2008).

40 Reviewed in Aiello and Dean (1990) and Tocheri, et al. (2008). See Lordkipanidze, et al. (2007) for two of the best examples of early *Homo* apical tuft enlargement. Also see Susman and Creel (1979), Stern and Susman (1983) and Shrewsbury, et al (2003). Note that baboons also show some expansion of the apical tuft, though no other apes do (reviewed in Tocheri, et al.; 2008). Thus, this expansion probably reflects adaptation to delicate manipulation more generally, including but not restricted to elite throwing.

41 See Napier and Tuttle (1993) for the updated version of Napier's classic discussion of earlier hypotheses for what the human hand is designed to do. See Marzke (2005) for a recent, expert and agnostic review of this approach.

42 Modern foot anatomy can be found in Snell (1995) and Agur, et al. (1999). Fossil hominid foot anatomy is reviewed in Aiello and Dean (1990) and Klein (1999 and 2009). Also see Lordkipanidze, et al (2007) for a review of *Homo erectus* (Dmanisi) foot bones.

43 There is some question as to whether early australopiths might have been able to use there feet for climbing a little better than modern humans (though certainly not like chimps)[See Stern and Susman (1983) and Susman, et al, (1984)]. However, this need not concern us here.

44 First, Neandertals have a robust, human-like first metatarsal (reviewed in Aiello and Dean, 1991). This demonstrates that human-like metatarsals are probably more than 500,000 years old – consistent with the requirements of our theory.

Second, the ca. 1.8 million year old Dmanisi *Homo erectus* finds have yielded a modern looking first metatarsal. (See the cover story in the April 2005 issue of National Geographic or Lordkipanidze, et al., 2007, for images of this first metatarsal.) Notice that

Lordkidpanidze, et al. (2007) interpret the Dmanisi postcranial remains as adaptations to locomotion; however, they are equally well interpreted as adaptations to elite throwing.

45 Bramble and Lieberman (2004).

46 Reviewed in Aiello and Dean (1990), Chapter 12.

47 See Aiello and Dean (1990) for a review of the early work. See Lordkipanidze, et al., (2007) for review of the powerful evidence from the Dmanisi *Homo erectus* fossils. Larson and colleagues (Larson, 2007; Larson, et al., 2007; and personal communication) have argued that early Homo shoulders were substantially different from later human shoulders, including limited range of motion behind the plane of the body. It will be of great interest to assess why such an odd arrangement might have evolved. We note that the power for human throwing comes predominantly from the trunk muscles. Arms with various different patterns of motion around the shoulder joint might serve to allow elite aimed throwing.

48 Bingham (1999).

49 See Gabunia, et al. (2000), Rightmire, et al. (2006) and Lordkipanidze, et al., (2007) for discussions of the Dmanisi site. Some details of the manuports at Dmanisi also come from the authors' personal conversations with Phillip Rightmire and Reid Ferring.

50 See Gabunia, et al. (2000) and Rightmire, et al. (2006) for a reviews of Dmanisi crania.

51 See footnote 49 above. See Potts (1988) for discussion of manuports in the African record.

52 Heinrich (2002) and Bramble and Lieberman (2004).

53 For example, the details of redesign of the inner ear system for monitoring balance and movement in humans (Spoor and Zonneveld, 1998) is very plausibly interpreted as part of the adaptation for stabilizing the head (the elite aiming system) during the violent human throwing motion.

54 Heinrich (2002).

Chapter 8

Promiscuity and monogamy – sex and family life in the uniquely human village

1 The suggestion that promiscuity might be a route to life insurance has been made previously in different theoretical contexts. See, for example, Angier (1999) page 383.

2 Our understanding of the evolutionary logic of females creating paternity uncertainty to control risks of male infanticide owes an enormous debt to one of the great primatologists of the late 20th Century, Sarah Blafer Hrdy. Hrdy's vast monograph *Mother Nature* is an excellent entrée into this literature and to the history of our growing understanding of these issues – and the controversy this understanding inevitably produces.

3 The variance of male reproductive success will decline in a monogamous mating systems relative to a promiscuous mating system. However, the *average* male reproductive success will not change, ceteris paribus.

4 See the introductory chapter to Beckerman and Valentine (2002) for a review of these cultures and their time depth.

5 See Beckerman and Valentine (2002), Crocker and Crocker (1994) and Crocker (1990).

6 Beckerman and Valentine (2002).

7 Crocker and Crocker (1994). Bill Crocker's description of his initial difficulties in getting accurate information on Canela sexual practices (pgs. 143-144) are enlightening about why ethnographers sometimes fail to get good information in this context. Also see Crocker (1990).

8 See, for example, Fawcett (1915), Shostak and Nisa (1981), Beidleman (1971), Marshall (1976), Tonkinson (1991), Lessa (1966), Chagnon, (1992) and Balikci (1970).

It is also noteworthy that one adaptive response to very high paternity uncertainty is to reckon economic kinship through the maternal linage (maternity is never in doubt, paternity always is). This pattern is seen in the Canela and in numerous other promiscuous Amazonian cultures (Beckerman and Valentine , 2002). It is also common in some of the promiscuous cultures referenced in the preceding paragraph. In view of this, it is attractive to assume that many or most matrilineal societies are (or were recently) promiscuous. The frequency of such matrilineal societies is apparently high (Murdock and White, 1969). It is also important to be aware that there are other possible responses to paternity uncertainty – for example, setting up mating systems so that local males are always closely related. Thus, the frequency of matrilocality/matrilineality may underestimate the fraction of pre-state cultures that practice *de facto* promiscuous mating.

Finally, it will be of great interest to determine if the superficial complexity of human kinship systems (see, for example, Morgan, 1877; Murdock, 1949; Malinowski, 1962) can be more clearly understood in light of the theory we are exploring here – as "enforceable" alternative adaptive responses to paternity uncertainty.

9 See Symons (1979), Fisher, (1983 and 2004), Angier (1999), and Buss (1994) for reviews of these issues.

10 See Harcourt, et al. (1981) for non-human ape testis size. See Simmons, et al. (2004) and Simmons and Jones (2007) for human testis size and for evidence that testis size correlates with sperm number at ejaculation. See Baker and Bellis (1995) for a provocative (and sometimes controversial) review of this issue.

11 In view of the ethnography of the Canela and others (above) we might have anticipated a larger effect on testis size. However, work in non-human primates indicates that female manipulation of male opportunities can limit the extent to which larger testis size is a good investment for males (Schulke, et al.,2004; Snook, 2005). We will argue in the text below that ancestral human females may, indeed, have exercised the kind of large effect that would have limited male opportunities to compete simply by producing more sperm.

12 See Gallup, et al. (2003 and 2006) and Simmons and Jones (2007) for discussion of the penis in this role. Also see Baker and Bellis (1995).

13 See Gallop, et al., (2006) for discussion of the evidence that human copulation has these adaptive purposes.

14 See Hrdy (1977) and Hrdy (1999).

15 Levin (2002) and Lloyd (2005). Levin's argument is that rapid intake of seminal fluid into the cervix would defeat capacitation necessary for subsequent fertilization. In our view, this argument is not persuasive as sperm must remain quiescent in some unknown location, gradually releasing and being capacitated in order to cover potential times of ovulation. Leaking from intact seminal droplets in the cervix would appear to be as likely a solution to this problem as any other currently known or suspected. This is a subject that would benefit from much additional study.

Ultimately, the major source of skepticism about claims that the female orgasm is adaptive result from confusion about what adaptive outcome it might have been designed to achieve (see, for example, Lloyd, 2005 and Wallen, 2006). Our theory provides a robust new proposal for this mechanism – paternity control under promiscuous mating. It will be of the great interest to see if new investigation informed by new theory might be more productive.

16 See, for example, Baker and Bellis (1995); Hrdy (1999).

17 See Baker and Bellis (1995).

18 Reviewed in Lloyd (2005).

19 Reviewed in Symons (1979). Also see Barash and Lipton (2001) and Wilson (1982).

20 Though it is beyond the scope of this book, the pervasiveness of homosexual behaviors and orientation in humans is of great interest. At present, we lack efficient access to the systematic ethnographic data we would need to get a clearer picture here - though such data may exist buried in documents readily accessible only to specialists. Future investigation would certainly be rewarding.

We note that one classic model for homosexuality is that it produced adults who contributed disproportionately to the rearing of the offspring of their siblings and other close kin in the ancestral environment. Especially under conditions of intense demographic competition, such an approach might well have been successful. In the context of the cooperative human village, stronger lineages would still have prospered.

A related model is suggested by our theory. Lineages that produced stronger contributors to the larger kinship-independent social enterprise might well have been rewarded by the ancestral human village in ways that redounded to the reproductive advantage of lineage members. Production of dedicated specialists (including leaders) who were divorced from the daily demands of parenting might have had this adaptive effect.

The prevalence of homoerotic behavior in (otherwise heterosexual) adolescent males is also of considerable interest in view of our theory. Conceivably, this represents harnessing the proximate mechanisms of sexuality to formation of powerful cooperative coercive (even "military") alliances in the ancestral past.

21 Reviewed in Hawkes (2003).

22 Crocker and Crocker (1994).

23

The fossil record and human mating behavior

Behavior does not fossilize and most of the elements of uniquely human sexual anatomy are soft tissues (again, no fossils). In spite of this limitation, the fossil record has several elements of important insight for us here.

As we have already seen in Chapter 6, our theory predicts the correlation we observe in the fossil record between the radical redesign of the human skeleton for elite aimed throwing (allowing inexpensive conjoint coercion) and the equally radical remodeling of our life history (as assessed by fossil brain size).

Moreover, we are now in the position to understand a second feature the fossil record of our past. There is fossil evidence that the australopithecine (presumptive) ancestors of the first humans were highly sexually dimorphic, while, in contrast, humans have been much less dimorphic from or very near the beginning of our genus, *Homo* (reviewed in Aiello and Dean, 1990). What this means is that australopiths were more like gorillas, where the males are nearly twice as large and heavy as females – a male is the proverbial "900 pound gorilla".

In contrast, from at least African *Homo erectus/ergaster* – Nariokotome boy and his contemporaries ca. 1.6 million years ago (Chapter 7) – humans were much less dimorphic, as we are today. Human males are slightly larger and stronger, *on average*, than human females, but there is substantial overlap – with some females being larger and stronger than some males. Thus, humans are relatively *monomorphic* sexually. If the first monomorphic human evolved directly from a highly dimorphic australopith, this is a rather dramatic feature of the human story. Does our theory account for such a radical, rapid change?

Apparently, it does. Here are the issues. Sexual dimorphism usually arises when there is strong sexual selection on males. Males take on extra properties in order to compete better for mating opportunities. One form of this competition is when males fight among themselves for mating opportunities. Under these conditions, larger, stronger males generally do better.

This sexual selection drives up male body size. However, factors like food availability (vulnerability to starvation) and basic body design dictate an optimal body size for individual members of a species. When males are under sexual selection to increase in size, they generally increase beyond this optimal size. As a consequence, their long-term health and longevity is commonly compromised. This compromised health can only be sustained in the face of natural selection when such oversized males get enough extra mating opportunities to offset their reduced life expectancy. Thus, when this sexual selection for individual "combat dominance" in males is removed or relaxed, we anticipate that sexual dimorphism should rapidly recede.

With this in mind, notice the logic of conflicts in humans. Combat dominance does ***not*** come from individual strength, but from the ability to mobilize numbers of elite throwing ancestral conspecifics who "agree with your position". Indeed, a single large, strong male who attempts to assert his dominance based on individual strength is easily overpowered by a set of others possessing elite human throwing skills. Ten Rockettes armed with throwing stones defeat Arnold Schwarzenegger in direct combat.

Thus, the ancestral human village will be substantially democratic from the point of view of mating opportunities. Oversized males will not do better and their overly large size will become pure liability. Sexual dimorphism is expected to rapidly recede on our theory.

Thus, as predicted by our theory, fossil evidence for elite aimed throwing arises together with (or immediately precedes; Chapter 7) the rapid loss of sexual dimorphism in the human lineage.

Chapter 9

Voices from the past: The evolution of 'language'

1 See, for example, Whitten, et al., (1999) for the specific case of chimps and Avital and Jablonka (2000) for a general review.

2 von Frisch's classic work from the 1940's is reviewed in Hauser (1996). Also see Gould and Towne (1987).

3 Gould and Towne (1987).

4 See Hamilton (1996) for a review.

5 See, for example, FitzGibbon and Fanshawe (1988).

6 See, for example, Rafaeli (2005).

7 See Maher (1996) for a biography describing Stokoe's remarkable career. Anyone contemplating a career in science and wishing to generate fundamentally new insight, rather than merely being a successful technical bureaucrat within institutional science, should read and internalize the lessons from Stokoe's life. They are the same lessons taught by the lives of other real scientists, like Barbara McClintock, George Williams, Albert Einstein and Charles Darwin, by the way.

Sign language continues to be a powerful tool for the rules and cultural evolution of languge. See, for example, the work on newly evolved sign languages (Sandler, et al., 2005; Meir, et al., 2007; Aronoff, et al., 2008).

8 The idea that language is merely one element to a more complex adaptation to information exchange has been proposed by others (see, for example, Moll and Tomasello, 2007). Our theory provides the first credible explanation of why such evolution should have occurred uniquely in the human lineage.

9 There is now a substantial body of evidence that the other great apes have comparable abstract symbolic skills to Koko. See, for example, Savage-Rumbaugh and Lewin (1994) for a sympathetic discussion of one of these studies.

10 Reviewed in Kobayashi and Kohshima (2001).

11 See Pinker and Jackendoff (2005) for a recent review by two gifted contemporary linguists who would support the claim that language might, indeed, look like (and be) an evolved device.

12 See Pepperberg's 1999 mongraph.

13 See Pinker (1994) for an excellent general review. The complexities of processing in both top-down and bottom up modes are profoundly illuminating about minds work. This subject is beyond our scope here. However, Wray (2002) and Wray and Grace (2007) fir discussions of formulaic speech adds substantially to our tools for thinking about this important feature of language comprehension and production.

14 Biederman (1987).

15 See, for example, Stringer, et al. (2007).

16 The hierarchically nested structure of bird and whale song are classic examples of the non-human property (see, for example, Suzuki, et al., 2006 and Plamodon, et al., 2008, and references therein).

17 See Herrenstein and Loveland (1964) for an early classic paper and Makino and Jitsumori (2007) for a recent review.

18 See Plotkin (1994) and Csziko (1995).

19 See chapters in Heyes and Galef (1996) for a detailed discussion of these issues.

20 Note that Moll and Tomasello (2007) recently reached the same conclusion on the basis of empirical evidence about non-human animal capabilities.

21 See Heyes and Galef (1996); Avital and Jablonski (2000); Fripp, et al. (2005); Matosova, et al., 2007.

22 See Zentell (2006) for a recent review of these issues.

23 See, for example, Call, et al. (1998) and Call and Tomasello (2006).

24 Moll and Tomasello (2007) reach the same conclusion the basis of the empirical facts of the animals' behaviors.

25 Miklosi, et al (2003 and 2007).

26 Savolainen, et al (2002).

27 Topal, et al (2006)

28 Kaminski, et al., (2004).

29 Reviewed in Pinker (1994).

30 Reviewed in Ruhlen (1994).

31 See Fordham (1999) and Palacas (2001) for discussions of Ebonics in context.

32 It is highly conspicuous that sign languages tend to be more "transparent" in the relationship between meaning and sign (see, for example, Sandler, et al., 2005). Indeed, very large populations of humans with loosely interconnected social systems (discussed in Chapters 11 and 12) apparently have a global "lingua franca" in sign, but mutually incomprehensible local speech dialects. See Wurtzberg and Campbell (1995) for the pre-contact Native North American sign language case.

33 Souza and Bingham, unpublished work.

34 See Klein (1999) and Klein and Edgar (2002), for an examples of belief in very recent human language evolution.

35 Figure drawn from various sources, including Aiello and Dean (1990), Snell (1995) and Agur, et al. (1999).

36 Also see, for example, Heim, et al (2002)

37 See, for example, Lieberman (1996) and Klein (1999). See Lieberman (2007a and b) and Boe, et al. (2007) with associated commentary for a detailed discussion of the current state of thought about Neandertal speech. Our theory clearly favors the view of those phonologists who believe that Neandertals were capable of human-like articulate speech.

38 Alemseged, et al. (2006).

39 See Gallese, et al., (2004), Gallese (2007) and Iacoboni, et al. (2005) for reviews of the original mirror neuron work.

40 Arbib and Bota (2003) for issues of homology between monkey and humans brains.

41 Taglialatela, et al. (2008).

42 Reviewed in Arbib (2005) for a recent review and debate. Also see Hewes (1973 and 1992) for discussion of the original proposal of this hypothesis.

43 See Kimura (1993) for a review of Doreen Kimura's ground breaking work in this area. Also see Horwitz, et al. (2003) for a discussion of recent work.

44 See Tobias (1987) for a review of this crucial work, including Tobias' own seminal contributions. Also see Broadfield, et al., (2001) for a recent analysis of an early *Homo erectus* endocast with strong, clear images.

45 This discussion draws on Okada and Bingham (2008) and unpublished game theoretic work by D. Okada and P.M. Bingham.

46 D. Okada and P.M. Bingham, unpublished.

Chapter 10

Wisdom of Crowds – Implications of uniquely human information sharing

1 But see Plotkin (1994) and Czisko (1995) for reviews of one especially appealing general model for how an important component of brain information processing works.

2 This fundamental insight is core of what is sometimes called evolutionary psychology. This important body of early work has made many vital contributions. Evolutionary psychology has always been limited, however, by not understanding "the purpose for which [the human mind] was designed", to borrow Williams' famous words. We argue that the theory we are exploring here gives us that purpose, allowing a new scale of investigation of the human mind. For readers interested in early evolutionary psychology, Barkow, et al. (1992) contains an excellent set of foundational specialist discussions. See Wright (1994) and Pinker (1997) for excellent general accounts of the early work.

3 Recent attempts to explain the evolution of this moralistic quality of humans in the specialist scientific literature have coalesced around two very different approaches. One of these invokes "altruistic punishment" as an element of the evolved human social adaptation (Gintis, 2000; Fehr and Fischbacker, 2003; Gintis, et al., 2008 and references therein). The alternative approach proposes that humans do not normally punish (a post facto act) but rather are usually ostracizing *prospectively*. Past events are relevant only in forecasting future behaviors to be preempted and proscribed. Moreover, humans engage in this prospective ostracism only in pursuit of instantaneous self-interest, *not* altruistically (Bingham, 1999 and 2000; Okada and Bingham, 2008). This self-interested ostracism approach is the theory we are exploring in this book.

4 See Martin, et al. (2005) and Jerison (1963 and 1985) for synopses of the brain/body size picture.

5 We do not understand all the limitations on the capacities of genetic design information, but they probably include the costs of accurately copying all this information tens of billions of times in the course of building our bodies and minds. Recall that each of the cells in our bodies and brains must have a complete, functioning set of all this genetic information.

This limitation is compounded and aggravated by the complex, innovative, improvisational nature of human intelligence. Genetic design information responds to novelty on the time scale of many generations, not "on the fly" in real time as our minds do. Our social, political, and economic environments are changing constantly with new adaptive opportunities arising at a rapid pace. The massive amounts of information required to store all possible human contingencies of contributing to and utilizing our environments – from being a WNBA shooting guard to an American Supreme Court Justice or a Bordeaux vintner, for example – is probably not within the capabilities of genetic information

6 See Lander, et al. (2001) and Venter, et al. (2001) and Mural, et al. (2002) for the early foundational work. The editorial discussions in these issues of Nature and Science are also of considerable interest. The scope, ease and precision of large scale sequencing has continued to grow explosively – improving by orders of magnitude - but the goals remain the same. Our challenge is understand what genomic information can tell us about the human condition and what it cannot tell us. There remains much naïveté on this score.

7 The generic mammalian appearance of the human genome (endnote 6 above) does not unambiguously falsify the proposal that the human genome contains vastly more or different genetic information. For example, we could argue that new information comes from an as yet unrecognized properties of the human genome. Extensive new alternatively spliced mRNAs producing a combinatorial explosion of new potential complexity is an example. However, we note that hypotheses of this type are ad hoc at present. Moreover, they are gratuitous and unnecessary on our theory – and, we think, most unlikely to be correct.

8 See, for example, Whiten, et al. (1999) for a review of the chimp case.

9 See Joseph Terkel's (1996) richly beautiful, elegant study of rat culture.

10

What do we know and when do we know it

Armed with this picture of human intelligence and with our understanding of language from Chapter 9, we can gain a very new perspective on the development of the individual human mind. Remember that we argued that language is probably not special. Its structure likely reflects the underlying organization of the ancestral animal mind – refined and redeployed for the uniquely human scale of information sharing. Language is a window into the mind rather than a quirky add-on widget. Thus, our acquisition of the culturally transmitted parts of our language should be paradigmatic of our acquisition of many other pieces of our cultural heritage.

What features and details of the language we speak most naturally - our "first language" - are genetically determined and what parts are determined by cultural information? Most linguists and biologists, including the authors, believe that some basic properties common to all human languages probably reflect genetically controlled structure and constraint. However, most of the properties our languages that we are aware of (words and meanings and many of the rules of expression, for example) are clearly controlled by culturally transmitted information.

For example, both authors are fluent speakers of their common first language, English, while neither of us speaks or understands Japanese. However, had we been adopted at birth by a Japanese family we would speak fluent Japanese and, possibly, no English. This natural experiment is performed millions of times around the world every year. The result is not in doubt.

Now, reflect for a minute on how you learned your first language. How did you acquire this language? Who taught you? In fact, of course, you cannot answer either of these questions from your own personal experience. First language acquisition begins shortly after birth and is largely complete by the time we begin to form lasting conscious memories.

Traditional linguistics has viewed this well-known sequence as idiosyncratic to language. Clearly, we believe it is not. Instead, language acquisition is probably merely a particular example of a much more general case. On this view, language is paradigmatic of our acquisition of most of the enormous repertoire of culturally transmitted information producing our uniquely human minds. This includes vast amounts of information about the world that we subjectively feel as if we know intuitively – so much information that we cannot yet begin to identify and sort it from our genetically encoded repertoire. This information almost certainly includes attitudes, perspectives, ethical values, unconscious analytical and social skills - among many, many other things.

When we learn these things is almost certainly during the period in our development between birth and formation of our first conscious memories. How we learn these things (again, as with language) we cannot answer from personal experience. We learn all of these things naturally and on the fly just as we acquire our first language. We do not know how much influence our parents have as opposed to all the other adults and children in our human villages – entering either in person or through electronic communications channels.

Thus, in very profound ways, we may already be shaped as individuals by the time we reach four years of age. This conclusion is an inevitable implication of the generalization of language acquisition to culture acquisition. Even though both authors have lived on Long Island, New York for the last 25 years, Joanne spent her early childhood on Long Island and Paul in the American Midwest. Each of us still speaks our native English with recognizably different accents to this day. This utterly prosaic story illustrates the issue. As with the languages we acquire in childhood, the same process applies to most of the repertoire of cultural information we acquire. If we seek to influence fundamental elements of a child's cultural repertoire, the point when they start school (even as early as 4 years of age) may be far, far too late.

Likewise, the skills we consciously learn in school (algorithms for manipulating numbers and the letters of our written languages, for example) may actually be the tip of a vastly larger (mostly unconscious) iceberg of skills.

It will be of the greatest interest for developmental psychologists to continue to learn more about what really happens to the mind of a young human between birth and ca. 3 years of age. The answers may allow us to improve human lives in the future, enormously.

11 The fundamental logic (the game theory) of individually self-interested coercive ostracism of thieves on the scale of modern economies is a little more subtle that in the ancestral village as described in Chapter 5 (Daijiro Okada and Paul M. Bingham, unpublished work). However, notice that the law enforcement (coercive ostracism) sustaining the contemporary world involves compensated professionals at its most immediate, rubber-meets-the-road level – it consists of many *self-interested* acts just as it apparently did 2 million years ago.

12 See, for example, confabulation in split brain patients as documented in studies by Michael Gazanaga and his colleagues (Gazzaniga, 2000 and 2005).

13 There is a truly massive literature on human ethical and political psychology dating back to Aristotle and beyond (key word search for "ethical philosophy" on Amazon produces more than 3,000 hits, for example). Spinoza, Hume and Adam Smith are of particular historical interest. Huxley's and Williams' work (Paradis and Williams, 1989) is biologically substantive. It is also noteworthy that from the beginning of recorded public ethical codes, they are concerned with the conflict of interest problem and, in particular, its control in the context of economic mechanisms providing *indirect access* to culturally transmitted information. (see *Code of Hammurabi*, for example).
Of contemporary ethical philosophers, Peter Singer (1981) and economist Amartya Sen (1999) come closest to grasping the authentic human condition, in our view.
We believe that a new generation of ethical philosophy is absolutely essential, now that we have a much stronger theoretical grasp of the human condition.

14 See Durham (1991) for a review of the early currents of this thought. See Blute (2006) for a recent overview of the state of the art and references to the extensive work in the "memetic information" tradition.

Much additional clarification is needed for this body of work to reach its potential. For example, we note that potential conflicts of interest exist between *any* two pieces of information building a vehicle/organisms, genetic and/or cultural information. It is not only the case the cultural information has conflicts with genetic information. Rather, each piece of cultural information has potential conflicts of interest with every other piece of cultural information and with every piece of genetic information.

Finally, each piece of genetic information has potential conflicts of interest with every other piece of genetic design information. The conflicts of interest between different pieces of genetic design information are managed by systems that suppress and manage cheating (reviewed in Bingham, 1997 and Burt and Trivers, 2006). We anticipate that the resulting "cooperative genomes" of genetic design information (building the substrate in which cultural information is stored) are in a relatively powerful position relative to culturally transmitted information. If so, genetically built minds are well position to manage conflicts with (and between) pieces of cultural information.

Finally, public doubting in an animal with access to inexpensive conjoint coercion is an excellent way for an array of "cooperative" cultural information to police invasions by parasitic cultural information. This is expected to allow the accumulation of massive, relatively reliable, adaptively useful cultural repertoires. This role of doubting in policing parasitic information should be recalled any time public figures or institutions attempt to suppress public doubt or ask us to "submit to authority" or to have "blind faith."

15 From Gould (1997).

16 A popular notion has been that culturally transmitted information will often behave "parasitically" vis a vis its vehicles (see the final chapter of Dawkins' 1976 *Selfish Gene* for the seminal articulation of this view). Of course, this will happen just as it also happens with some individual pieces of genetic design information. However, "cooperative" genomes evolve when the capacity for genetic parasitism is managed – yet another example of the central role of control of conflicts of interest in the emergence of biological complexity (Bingham, 1997; also see endnote 14 above). Thus, we anticipate that culturally transmitted information will be highly adapted to manage parasitic information, permitting an adaptive suite of cultural design information to arise, persist and grow. The process of public doubting (main text) is almost certainly one of the culturally (and genetically) transmitted strategies for managing conflicts of interest between pieces of cultural information.

17 See Armstrong (1993) for a brief general review.

18 See, for example, Roberts (1993).

19 A crucial issue for future investigation is whether any belief system (secular or theistic) that suppresses public doubting can ever be the basis of authentic democratic seizure of a human enterprise. The Great Awakenings in American political history (see, for example, Stearns, 1970) might be especially interesting cases to investigate with this issue in mind. Our theory clearly predicts that no belief system that suppresses democratized public doubting can ever support humane cooperation (also see Third Interlude and Chapters 13-15 and 17).

20 Tilly (2006 and 2008); Gazzaniga, 2000.

21 Our theory sheds considerable possible light on the genetic evolution of the modern human brain. However, it is beyond our scope here to discuss this complex issue in detail. See Deacon (1997) and Allman (1999) for overviews of the evolution of human brain anatomy, though from very different theoretical perspectives than ours.

Chapter 11

The human mastery of Earth begins – The behaviorally modern human revolution and the first information economy

1 Stringer (1993); Shreeve (1995); d'Errico, et al. (1998); Gamble and Gamble (1999); Klein (1999 and 2009); McBrearty and Brooks (2000); Bar-Yosef (2002); Klein and Edgar (2002); Mellars (2005 and 2006); Hovers and Kuhn (2006); Zilhao (2007), Teyssandier (2008).

2 See, for example, Mithen (1996) and Klein and Edgar (2002).

3 See Lieberman (1998 and 2007) and Klein (1999) for discussions by prominent partisan of language-late views.

4 The possibility that the behaviorally modern human revolution might have been cultural rather than genetic has recently been considered by archaeologists on empirical grounds. The first modern version of the proposal we are aware of was by Bar Yosef in the 1990's – reasoning by analogy with his field work on the later agricultural revolutions (reviewed in Bar Yosef, 2002). In 1998, d'Errico and colleagues suggested that Neandertals might have been "acculturated" during this process - on the basis of archaeological evidence.

Since the original *theoretical* prediction that the behaviorally modern human revolution was purely social/cultural in nature (Bingham, 1999), this possibility has received extensive additional empirical attention. See, for example, Mellars (2005); Zilhao (2007) and Finlayson and Carrion (2007) for recent reviews and criticisms of some of these empirical issues.

5 See the chapters in Hovers and Kuhn (2006) for robust recent views of the various points of view among specialists in this area. The insight offered by our theory puts these scholarly debates in a new context and offers the opportunity of improved perspective both on available evidence and new professional analyses that might be fruitful (main text).

6 Bridges, et al. (2000); Baugh (2003); Shea (2006); Whittaker and Kamp (2006); Rhodes and Churchill (2009).

7 Shea (2006).

8 See Brooks, et al. (2006) for a recent review of this point of view.

9 We believe this initial treatment in the main text is likely to contain many of the essential features of the complete answer. However, this is one of many issues that are illuminated by the theory at its present state of development, but that will benefit much more attention, thought and empirical investigation – probably by many thinkers and scholars - to bring us to a point of extremely high confidence in all the details.

10 This is an area that will repay the detailed attention of professional game theorists in the future, in view of our new theoretical grasp of the essential issues. We suggest the outlines of one plausible approach to this problem in the main text here.

11 This is another problem that will reward detailed new attention from ethnographers and game theorists in light of the new perspective of our theory.

12 It will be of very great interest for specialists in the archaeology of trade to look for diagnostic patterns predicted by the hypothesis the conflicts of interest and their management are the decisive considerations here – as our theory predicts.

13 Stringer (1993); Shreeve (1995); d'Errico, et al. (1998), Gamble and Gamble (1999); Klein (1999 and 2009); Bar-Yosef (2002); Klein and Edgar (2002); Mellars (2005); Hovers and Kuhn (2006); Mellars (2006); Zilhao (2007).

14 Chatters, et al (1995); Pacheco (1996); Dancey and Pacheco (1997); Bridges, et al. (2000); Bernardini (2004); Carr and Case (2005); Abrams (2009); Coon (2009).

15 Altman, et al. (1987); Lourandos (1997).

16 Reviewed in Gamble (1999); see, especially, pages 296-299.

17 Reviewed in Lourandos (1997).

18 Reviewed in Bar Yosef (2002).

19 For a sober review of the elements of this literature most relevant to us here see Smith (1999). Though the ethnographic and paleo-behavioral archaeology literature is empirically rich (if uneven), it has been accumulated in the absence of a clear theory of the logic human social behavior. Our theory apparently provides a new theoretical framework that should allow this vast body of evidence to be rethought and reinterpreted. This endeavor is beyond the scope of this book. However, we make a few relevant observations.

Most importantly, much of the interpretation of this information to date has been badly clouded by confusion of proximate and ultimate causation – by assuming that what people overtly claim to believe is what matters most in understanding their behavior. As we discussed in Chapter 10, this assumption is almost never valid. When we make this fundamentally flawed assumption we are immediately doomed to swim with the red herrings. Among many other debilitating effects of this approach is the assumption that each society has its own idiosyncratic internal logic that cannot be predicted or analytically understood on first principles – rather, mere “thickly” described. Equivalently, societies are presumed to be inherently self-referential, with no universally predictable properties at the levels of concern to cultural anthropologists. Again, we suggest that this is an utterly false picture.

On the contrary, on our theory, all human beliefs are ultimately just the rules of the local cooperative enterprise – an enterprise whose fundamental features are always universal and predictable. For example, as bizarre, arbitrary and self-referential as local “social acts” might appear to be, we predict that this strangeness merely constitutes proximate persiflage (Chapter 10). These acts are always designed for the immediate pursuit of self-interest through acquisition of socially attainable assets – access to coercive power as well as mates and material assets. This can take various forms, including recruiting coercive allies and agreeing to exchange material assets, among many other related things.

Finally, the empirical quality of the ethnographic record must also be subject to persistent questioning. For example, field workers sometimes assume that their informants are telling them the truth about what matters to these informants – things like who their leaders are, what their leader's powers are and what the purposes of this or that "ceremony", "ritual", "object" or "act" might be. To get a feeling for how implausible this assumption can be in the case of the "simple" societies we are concerned with here remember that these "subjects" were under siege by the powerful states sending out their "armies" of priests and scholars. Now, consider how likely you would be to tell to the truth about the most intimate workings of your local culture to a representative of a powerful extraterrestrial civilization in the process of colonizing Earth. Of course, the answer is "not bloody likely."

20 Many ethnographers on the ground have observed symbolic objects being used as currency at many places around the world. However, anthropologists have not stopped to ask what this means for the nature of money or of the behaviorally modern human use of such objects.

Many cultural anthropologists will object to this proposal as grossly over-simplified and inconsistent with the ethnographic record. We argue that this objection is ill-conceived – resulting mostly from the proximate/ultimate confusion that plagues much of cultural anthropology (also see preceding endnote). An example will illustrate what we mean. Does a "made guy" paying "vigorish" to a mob boss' loan shark have all kinds of complex thoughts about the "social significance" of what he is doing? Absolutely. Does that mean the money he uses for this purpose is not merely currency? Absolutely not.

21 See Ofek (2001) for a beautiful exposition of the possibility that "market" behavior might be an ancient part of the human adaptation. Of course, our theory now gives the ability to understand why this might be true. Humans are predicted to be both the "pedagogical animal" and the "economic animal" on our theory (Chapter 10).

22 We note that ostensible differences between "ceremonial" and "economic" exchange may be more apparent than real (reviewed in Altman, 1987). This is an issue that would repay critical expert reexamination.

23 We believe the implications of the theory discussed in this chapter may help focus attention on approaches most likely to yield a robust and general theory of "money" (Spector, Bingham, Souza, Okada, unpublished work).

24 Chatters, et al. (1995); Pacheco (1996); Dancey and Pacheco (1997); Bridges, et al. (2000); Bernardini (2004); Carr and Case (2005); Abrams (2009); Coon (2009).

25 Reviewed in chapters in Pacheo (1996).

26 An important theoretical issue for future attention is all the possible "functions" of ritual. For example, acquiring detailed knowledge of ritual practice imposes a substantial opportunity cost. Would-be free riders are less likely to be willing to pay such costs under risk of early ostracism. Thus, ritual observers are "pre-tested" for their social strategies. We will discuss these issues in more detail in Chapter 12.

Chapter 12

Neolithic and "agricultural" revolutions: Humans "settle down"

1 Bar Yosef (2001), pg. 5.

2 Behaviorally modern humans (Chapter 11) sometimes domesticated plants. In contrast, many plants were domesticated by later Neolithic cultures. It will emerge through this chapter that "agricultural" revolutions are not an *effect* of plant domestication, but of an increase in social scale. This increase in social scale then sometimes engenders a new round of plant domestication. See Smith (2001) for a review of plant domestication without associated up-ticks in complexity or intensification.

3

Adaptive revolutions – how fast should they be?

If a new coercive technology produces an increase in the scale of social cooperation as our theory requires, how fast will the predicted ensuing adaptive revolution be? This timing or rate is not explicitly predicted by the theory; however, we can make some good educated approximations.

On the one hand, humans are conservative in the short-term. They are loathe to throw out an adaptation that has been working and many self-interested individuals have benefited from the old ways. They will use their coercive means and political power to cling to these ways. This unwillingness to change will slow things down to some unknown extent.

On the other hand, the never-ending conflicts of interest that are merely managed – but never eliminated – in human cooperative enterprises mean that there will always be individuals looking to beat or change the system, to gain advantage, to (subjectively) "make a difference" or "change the world", to "get rich quick" and so on. This result of the conflict of interest problem will therefore produce a relentless drum beat of trial and error, including the use of any new coercive means that might come along. This creative ferment will speed things up to some unknown extent.

In view of our ignorance here, two things can assist us in our predictions and the testing of those predictions. First, we know from all our knowledge of human behavior evidenced in contemporary societies, ethnographic records, and older historical documents, that the creative ferment in human cultures is powerful and relentless. No human cultures are really "stable" on time scales longer than a few generations – even when their *net* adaptive sophistication is not increasing (Third Interlude).

Second, we have our own, contemporary world. As we will see in Chapter 14 the "modern economic miracle" begins sometime around 250-300 years ago. At the inception of this process we walked on foot and rode horses. At the end, we walk on the Moon and ride in jumbo jets. Yet, during this time, people all around the world mostly thought of themselves as just building incrementally on what they learned from their parent's generation, often seeking to "preserve" a "way of life."

Thus, we expect that new adaptive revolutions will be moderately slow (sometimes even subjectively) on the scale of individual life times, yet blindingly fast on the time scale of centuries and millennia. We will see many indications that this empirical prediction of rate of "historical" change is accurate, here and in later chapters.

4 See, for example, Solecki and Solecki (1970) and Campana (1979). Reviewed in Farmer (1994) and Bar Yosef (1998).

5 Elston (1979). Also see Chang (1977) pgs 68-79.

6 Blitz (1988). Also see additional references below.

7 Blitz (1988).

8 Walde (2006).

9 See chapters in Knecht (1997), Hughes (1998) and Edelmann-Nusser (2006). Also see Hamilton (1982), Hamm (1989), Bradbury (1985), Hardy (1992) and Crosby (2002). Authors have carried out substantial personal experimentation with bows, as well.

10 See, for example, Childe (1952).

11 For specialists we note that we are sympathetic to some, but not all, elements of "agency" and "post-processual" approaches to archaeology (see Rowley-Conwy, 2004 and Dobres and Robb, 2005, for discussions). Human beliefs matter and they shape history.

However, agency and post-processual approaches sometimes mis-apprehend the role of belief in human society and history, we argue (also see Fourth Interlude and Chapter 10).
First, the relationship between historical change and the content of belief involves a crucial proximate/ultimate distinction. The behaviors that belief actually produces – not the detailed content of belief – is what matters.
Second, we reject a key view of some practitioners of these approaches - that the human beliefs that shape history have a large component that is inherently unpredictable (that is, whose generated behaviors are unpredictable). On the contrary, we argue that the component of human beliefs that shapes important historical processes is quite predictable (again, the behaviors they generate are predictable). Indeed, these beliefs are shaped by selection on culturally transmitted information to fulfill self-interest as constrained by local ecology/demography and, more importantly, by the crucial uniquely human concern – availability and deployment of coercive means. In contrast, the unpredictable elements of human belief shape history only marginally and secondarily, we argue. [See the sections near the end of the chapter on "ritual" for our theory's interpretation of the more extravagantly unpredictable components of human belief.]

12 Reviewed in Bar Yosef (1998) and Twiss (2007).

13 See Byrd (2005), for example.

14 Reviewed in Bar Yosef (2001).

15 Reviewed in Bar Yosef (1998).

16 Reviewed in Twiss (2007).

17 Reviewed in Henry (1989) and Smith (1995).

18 Reviewed in Price (1987) and Rozoy (1998).

19 See Elston, et al (1979) and Chang (1977) pgs 68-79 for the timing of the bow in East Asia. See Shelach (2006) for discussion of pre-agricultural sendentary settlements in

China. See Smith (1995), Crawford and Shen (1998), Linduff, et al. (2002) and Shelach (2000 and 2006) for dating of plant domestication in China.

20 See Smith (1995) for a review.

21 Reviewed in Smith (1995).

22 Below is an example of a ca. 1000 year old timber preserved in an exquisite stone wall in the present day ruins of the Chaco Canyon structure Pueblo Bonito. (Photograph by P. Bingham)

23 There is a long former history of scholarly bickering about the coming of the bow to North America (reviewed in Hughes, 1998). However, in the last ca. 20 years we believe a strong coherent picture has emerged from independent studies at many sites across the continent (also see references below). The bow apparently arrives in the upper continent (northern Great Plains) by around 100AD/CE and diffuses down and across the entire continent by 400-700CE. See Cordell (1997) and chapters in Reed (2000) for recent reviews of the evidence for the bow in the Southwest. See especially Gieb and Spurr (2001) for discussion of the possibility that the very first bows may have entered the Southwest around 100-200CE, though the weapon does not come into wide use until about 400CE. See Justice (1987 and 2002) for North American point typologies and classification details.

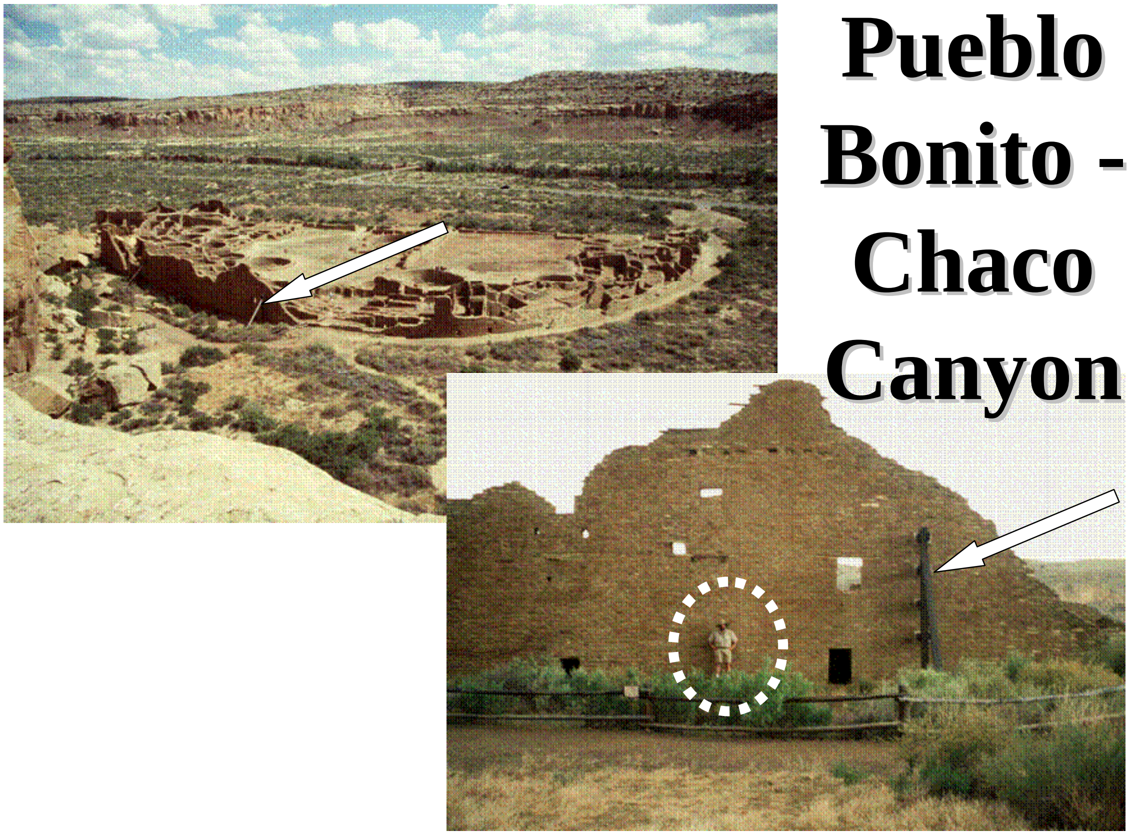
24 See chapters in Reed (2000) for a collection of recent expert reviews of the chronology of the early emergence of sedentary hamlets and villages in the Sourthwest immediately following the coming of the bow.

25 See calculations of stored maize and surplus generation on pages 151-155 of Altschul and Huber (2000) and pages 171-173 of Gilpin and Benallie (2000).

26 See Windes and McKenna (2001) for a marvelously illuminating description of some phases of Anasazi construction work. Windes and Ford (1996) review the definitive dating of the construction phases of the Bonito ruin.

27 See chapters in Part II of Wills and Leonard (1994) for discussions of the forms of aggregated sedentary settlement in the later Pueblo phases of this expansion of the scale of social cooperation in the Southwest. We will return to other details of these societies later in the chapter.

Also shown below are images of the contemporary ruins of Pueblo Bonito with one of the authors (PB) circled in dashed white as a scaling object. (Photographs by P. Bingham and Z. Zachar)



Pueblo Bonito - Chaco Canyon

[28] See Linda Cordell's review of Gwinn Vivian's amazing studies of Chao irrigation on pages 286-288 of Cordell (1997).

[29] See Adler (1996), Cordell (1997), Reed (2000), Mills (2002) for recent overviews of this massive, elegant body of archaeological insight.

[30] Reviewed in Blitz (1988), Seeman (1992; pgs 41-51), Muller (1997), Hughes (1998), Milner (1998), Nassaney and Pile (1999), Bettinger and Eerkens (1999) and Bridges, et al. (2000).

31 General references to the large body of brilliant work on the Mississippian culture include McNutt (1996), Emerson (1997), Fowler (1997), Muller (1997), Pauketat and Emerson (1997) and Milner (1998).

32 See, for example, Dancey (1992), Ahler (1992), House, (1996), Lewis (1996), Morse and Morse (1996), and Smith (1996).

33 There is considerable scholarly debate about exactly what is going on in some areas of the Midwest and Southeast during the era in question. In addition to the technical limitations mentioned in the main text this initial post-bow era is very heterogeneous across the vast area. Though there is extensive evidence for increased scale of organization of settlements and groups of settlements early in this process – corresponding to the Late Woodlands as defined by Midwestern archaeologists – this trend apparently differs from place to place.

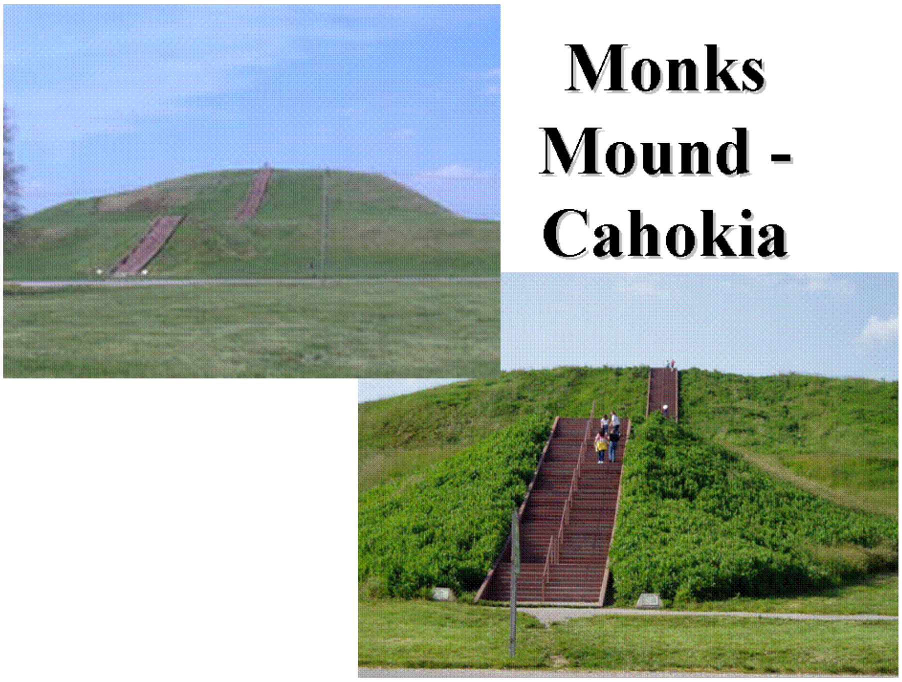
It is especially noteworthy that the disruption of the "Hopewell Interaction Sphere" is sometimes used as a marker for the beginning of this era. We emphasize that this continent-wide trade network would have been interrupted by spotty local introduction of the bow – before the bow spread throughout the entire region. Notice especially that the cases of early nucleated villages used in the text are cases where arrowheads are part of the site content.

To get a feeling for the range of expert opinion on this subject compare George Milner's (1998/2006) account (pages 173-175) with Nassaney and Cobb's (1991) (Chapter 10).

Finally, note, however, that this brief, locally complex period is followed rapidly by the emergence of unambiguously more complex and sedentary Mississippian adaptation throughout this region (main text below).

34 Reviewed in Pauketat (1994), Lindauer and Blitz (1997), Muller (1997), Milner (1998/2006), Pauketat, et al. (2002), Cobb (2003) and Schroeder (2004).

35 Below are two views of Monks Mound at Cahokia, near present day St. Louis, Missouri, USA. Notice the people on the modern staircase as scaling objects. (Pictures by P. Bingham).



36 For reviews of this large, elegant body of work see Erlandson (1994); Arnold, et al (2004); Kennett (2005); Rick, et al (2005); and chapters in Arnold (2004). Note that all the references throughout this section are suffused with theoretical views on the evolution of "complexity" with which we mostly disagree. However, the empirical content of the archaeology is outstanding.

37 Reviewed in Arnold, et al (2004), Rick, et al (2005) and Kennett (2005). Also see chapters in Arnold (2004).

38 Reviewed in Arnold, et al (2004) and Kennett (2005; pgs. 185-187).

39 Kennett and Kennett (2000).

40 Reviewed in Arnold (1992), Arnold et al (2004) and Kennett (2005; Chapter 7).

41 Arnold (1995). Tomol basics reviewed in Arnold and Bernard (2005). Evidence that economically intensified use of the tomol begins around 500AD/CE is in Bernard (2004). Note that there is evidence that the tomol was actually made earlier than 500CE (Gamble, 2002). Though this claim is controversial, our theory suggests, indirectly, that is it reasonable. The very strong archaeological signal of the tomol is likely to reflect its expanded use in economic intensification supported by bow-based coercion, not necessarily its original invention.

42 See, for example, Coupland (2004) and Glassow (2004) in addition to the references above.

43 See Walde (2006) for a recent review of this important, newly emerging body of work.

44 See Flores (1991) for a review.

45 Reviewed in Walde (2006) pg 303.

46 Verbicky-Todd (1984). Also see Chapter 8 in Pringle (1996).

47 Reviewed in Walde (2006) pg 300.

48 The Calusa of southwest Florida are one dramatic example. These complex hunter-gatherers show a dramatic increase in settlement size and economic intensification based on marine fish beginning around 500AD/CE (see Widmer, 1988; Marquadt 1992). This is precisely the timing our theory predicts assuming that the bow reaches Florida as expected in the larger context of the weapon's continent dispersal. Moreover, the Calusa were using the bow at European contact based on ethnography. However, the published work on the transition from the atlatl to the bow is inadequate to allow us to use the Calusa as a direct test of our theory at this time. We look forward eagerly to the Calusa specialists' input on this vital issue.

49 Overviews of this massive, important body of work can be found in Matson and Coupland (1995), Ames and Maschner (1999) and Sassaman (2004).

50 Reviewed in Ames and Maschner (1999), including pgs 200-211.

51 Reviewed in Ames and Maschner (1999), pgs. 159-160 and. 216.

52 Several pieces of evidence – for example, local Australian cases (Lourandos, 1997) and the famous Poverty Point site in North America (Gibson, 2000) – suggest that behaviorally modern humans can reach significant local population densities without Neolithic levels of cooperation/intensification when appropriately lush local resources allow (also see Chapter 11).

53 Notice, for example, that the changes in village structure attributed to warfare in Chapter 8 of Ames and Maschner (1999) are just as likely to include responses to new cooperative opportunities – with warfare being only one of these.

54 See, for example, Wirtz and Lemmon (2003) for a climate-based model which attempts to explain the large time difference between the New and Old World.

55 See following references for reviews of the work focusing primarily on North America. Haas (1990); Bamforth (1994); Keeley (1996); Haas and Creamer (1997); Martin and Frayer (1997); LeBlanc (1999); Milner (1999); Turner and Turner (1999); Schaafsma (2000); Smith (2003); and Milner (2005).

56 See Malthus, et al. (1992) for a reprint of Malthus epoch-making 1798 essay on the tendency of human populations to grow until restrained by the "four horses of the apocalypse" – war, pestilence, famine and disease. As we discussed in Chapters 2 and 3, we now recognize that this is a very general principle for all organisms for all time – human or non-human.

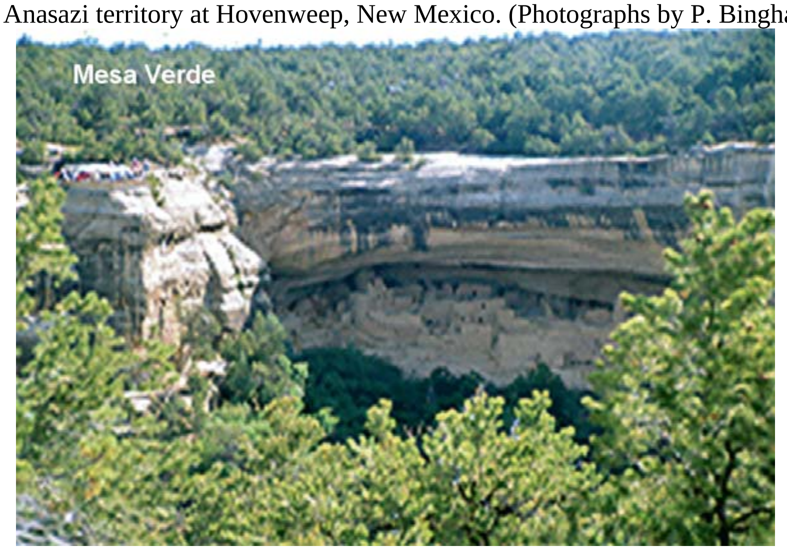
57 The nature of this violence is shocking, but possibly illuminating. It consists of the brutal massacre of local homesteads and small settlements – sometimes with evidence of cannibalistic consumption of the residents, men, women and children (see White, 1992; LeBlanc, 1999; Turner and Turner,1999; Chapter 25 in White, 2000; Lekson, 2002). This kind of violence is what we might expect for extreme ostracism of a free riding family unit within a Neolithic cooperative adaptation. For example, if family units attempt to change allegiances to a competing local social unit, this kind of reaction might be anticipated.

Organized criminal activities or chronic, unmanageable conflicts of interest (Box 12.1; main text) are also expected to generate archaeological signals of this kind of violence.

Notice especially that the conscious rationales by the perpetrators of such violence – witchcraft, etc – are merely the proximate mechanisms initiating the behavior, *not* its ultimate adaptive motivation.

58 Reviewed in Hass (1990), LeBlanc (1999), Lekson (2002).

59 Immediately below is a village of stone buildings constructed *within* an easily defensible cave site at Mesa Verde, New Mexico. The second image below is a defensive outpost along an Anasazi territory at Hovenweep, New Mexico. (Photographs by P. Bingham).



60 Axtel, et al. (2002) and references therein.

61 Reviewed in Bamforth (1994), Keeley (1996).

62 Reviewed in Keeley (1996).

63

Hierarchy and chiefs - Conflicts of interest are managed, not eliminated

Our theory makes a perfectly clear prediction. A workable new weapon system *will* allow conflicts of interest to be *managed* on a new scale. However, this new weapon will *never eliminate* those conflicts of interest.

This fact predicts that the internal social structure of Neolithic societies or bow-based MPUs will be constantly riven by small subunits seeking – consciously or not – to exploit the "coalition of the whole," the MPU in their own interests. Of course, obviously parasitic subunits - extortionists, say - will generally be subdued, ostracized or killed by the conjoint self-interested actions of their potential targets, preempting the losses the parasites would otherwise impose and confiscating the parasites' liquid assets.

More difficult are small groups who offer "services" to the MPU in return for "compensation." One of the useful adaptive features of larger MPUs is that individuals can acquire specialized skills that serve the interests of others providing broad indirect access to the fruits of specialist knowledge held directly by a only few individuals (Chapter 10).

Such "public services" might include things like military leadership or "government" – coordination of cooperative undertakings of various sorts.

For the moment the question is how this will play out? This is an urgent subject for much further investigation, but we can probably define the outlines of the equilibrium that might be reached. Subgroups that can provide some facsimile of a valuable service will acquire assets in compensation for that service. If the service seems extraordinary, the compensation may be, as well. Moreover, assets so acquired can be used to reward supporters of this arrangement.

Over time this process will result in some level of inequality of access to wealth *within* the MPU. Indeed, individuals who are members of especially successful subgroups will be able to extract more wealth from the coalition of the whole in return for ostensibly visible public service. If such subgroups go too far they will be sanctioned or expelled by the coalition of the whole. However, if they are judicious – presumably including the delivery of at least some tangible service – their "exalted" status will be tolerated.

This perspective on the origin of elite members of Neolithic societies is most likely correct. In a bow-based culture, coercive threat is very widely distributed. It is not possible for a small subgroup to "subdue" the coalition of the whole. "Leaders" and "public servants" are always ultimately answerable to the self-interested members of the coalition of the whole.

This may seem like a rather arcane discussion. But it has an important purpose. One of the most durable ideas in archaeology and ethnography is that Neolithic societies emerge when "chiefs" arise to run them. The notion, in part, is that only with a central command can complex economic intensification occur. Wealth differentials in the archaeological residue of mature Neolithic cultures – bigger residences, more extravagant burials and the like – have long been taken as empirical support for the existence of chiefs in this sense.

On the basis of the argument above, we believe this view is fundamentally mistaken, backwards actually. Our theory leads us to concur with those anthropologists and archaeologists who think Neolithic societies were *relatively* democratic. The amazing adaptive feats achieved by larger human aggregates are no more likely to be the products of "chiefly" control than are centrally planned economies to out-perform market economies.

Put differently, Bill Gates and Steve Jobs live in exceptionally large, expensive houses. We do not conclude from this picture that they run our society – though, of course, they would if we tolerated it.

This is not a trivial technical issue. This is about the fundamental source of human adaptive creativity. Our creativity lies in the mutually self-interested, coercively managed sharing of all our diverse skills and insights, not in submitting to "expert" guidance. We are empowered by "wise crowds", not specialist opinion (Chapter 10).

It will be of the greatest interest to determine whether the ethnographic and archaeological record can be mined to better support/falsify this prediction of our theory.

"Styling" – uniquely human use of tools and gewgaws

Our improved grasp of the role of culturally transmitted information under ongoing Darwinian selection gives us insight into another superficially "non-adaptive" feature of human economic products and tools. These products tend to have quirky local styles. This quirkiness, in part, simply reflects a historesis effect. Tools and strategies are adapted from those we already have. Thus, their contemporary shape is not only a product of these adaptive function, but also of their historical origin. [The analogy we have used before is that we have hair on our heads, not feathers because our ancestors were haiy mammals not feathery dinosaurs. Our hair does *not* necessarily imply that hair is adaptively "better" than feathers. So it is also with our economic tools and strategies.]

However, our theory of ritual also gives us further insight in the conspicuous styling of artifacts so characteristic of humans. Another way to fulfill the identifier requirements mutually imposed by MISA members on one another is for everyone to use and wear public tools and ornaments possessing conspicuously arbitrary – or even mildly maladaptive – MISA-specific variations in form. This serves precisely the same functions as public declaration of belief. It will also contribute to driving the continuous generation of new styles as MISAs diverge both within MPUs and after MPU fissioning. Thus, again, our adaptation to living in uniquely human cooperative MPUs – managing conflicts of interest *within* them and executing conflicts against competing MPUs – accounts for another of the otherwise strange elements of the archaeological record.

Anthropologists have long recognized empirically that the things we wear and carry are related to what we subjectively experience as social identity. Our theory now gives us strong new insight into why such identity is so central to our sense of ourselves and our feeling of social connection.

64

The bow and "money"

A feature of human economic behavior that contemporary academic economics mostly stipulates in lieu of understanding is money. [For a richly engaging, iconoclastic and illuminating discussion of how much modern economic theory *does not* know about theories of money see the various chapters in Wray (2004). The substantive claims in the text about contemporary theories of money are based on the review chapters in this book.] We touched on this subject in Chapter 11, but the archaeology and ethnography of the Neolithic revolutions give us the insight we need to go further.

Traditional theories of money are generally either vague or treat money as a recent invention of the state. Neolithic societies show us clearly that money is much more ancient than the state. They also guide us toward some potentially useful, concrete, specific views.

It's useful to begin with the empirical record of Neolithic "money." Every studied Neolithic culture produced objects that have little or no inherent adaptive value. They could not be eaten or made into a weapon or turned into shelter, but they were made in large numbers and widely circulated (reviewed in Spielman, 2002, for example). A shockingly universal practice in Neolithic cultures on every continent was the production of highly manufactured beads from marine animal shells. Moreover, we know from the ethnographic record that these objects were sometimes used as currency in exchange. [See Blackburn's chapter (pgs 225-244) in Bean and Blackburn (1976) for one of many examples of "shell bead money." See Douglas (1958) for a very different physical kind of money.]

In view of our much clearer understanding of the Neolithic societies emerging through a new scale of coercive control of conflicts of interest, we can now extend our model of money or currency from Chapter 11. Specifically, currency arises at first as a mnemonic or record keeping device that allows a transaction spread over a great distance or a long period to time to be decomposed into two immediately reciprocal transactions at each end of the interval. As we said in Chapter 11, we give you a bead for a chicken today and you can recover 10 potatoes from us months later in exchange for those beads – the beads have allowed us to exchange a chicken for some potatoes across a long time interval.

Our theory lets us see this model of money in much more detail when looking at the more complex human Neolithic adaptation. In the Neolithic village we use money and we are property owning citizens. If we refuse to give you the promised potatoes for the currency (shell beads) you demonstrably hold, we declare ourselves to be free riders. It is now rationally self-interested for others to help you seize our property to settle our debt to you and to compensate these others who helped you for their coercive risks/costs.

Thus, the "debt" represented by the currency you possess is enforceable and collectable. In turn, the currency has the value represented by that collectable debt. The rest is easy. You can exchange the currency for something a third party considers to be worth our 10 potatoes. This third party can do the same with a fourth party and so on. In fact, we need never see this bead again and you are indifferent as to whether we do or not. Someone will show up at our door some day in the future with a bead seeking 10 potatoes. We give the potatoes in exchange for the currency. You have been compensated for your chicken long ago and we have collaborated in a "public market."

As we saw in Chapter 11, for an object to function as money in a public market it must be non-counterfeitable. The object need have no intrinsic value except it that must be more costly for you to make a "fake" copy of the object than it is to obtain an authentic copy in return for something of value you produce.

Objects manufactured with expert labor from difficult-to-obtain and highly idiosyncratic, easily recognized materials – drilled, smoothed beads from sea shells are a perfect example – are just the non-counterfeitable objects we need.

This trick is actually childishly simple, but highly effective. Money emerges from an enforceable social exchange. Money is a simple product of the human strategy of management of conflicts of interest.

Don't 'show me the money' – it's not about that

We are now in the position to come full circle and ask whether the human economic exchange we discussed earlier is really the point of what people mostly do with money and assets. In other words, are people really "rational economic actors" most of the time? Anthropologists have long argued that often we do *not* appear to be rational economic actors. We want to argue that this view is wrong – but not for the usual economist's reasons, rather for a new reason predicted by our theory.

A lot of human "economic activity", in fact, does not look like "good business." Much Neolithic exchange was probably "customary" rather than overtly "market-like." [This includes things like the famous Pacific Northwest potlatches but also donations and tithes to local "temples" or individual "dignitaries" (or from same) – among many forms.] This customary exchange takes many different forms. For example, members of a Neolithic social unit - an MPU - will sometimes gather for massive seasonal feasts to which each household will contribute food from the surplus generated by their intensified economic activity, their work. [Examples are reviewed in Mills (2002),. Pauketat, et al. (2002) and Spielmann (2002).] These contributions will generally be specified by longstanding convention rather than by any local market at the feast. Moreover, the overtly material benefits obtained at the feast by household members may or may not directly justify their contributions to the feast.

These details have long been recognized to imply that customary exchanges have additional social functions. The challenge has been to understand what those additional, "non-economic" functions are. The temptation has been to settle for purely proximate explanations. People "feel" closer to other members of their society when they "feast" together, for example. We could interpret such events as "bonding" exercises. However, these explanations are precisely analogous to explaining that an animal or a person eats because she/he feels hungry. These are really restatements of the question masquerading as answers.

Our theory strongly suggests a different way of looking at the "non-material" elements of human exchange. This view then apparently lets us grasp some or most of the ultimate logic of these behaviors.

Because continued membership in a decisive local coercive aggregate is as vital to us as food and water, we will undertake many actions and expenses to maintain this membership. Much of our "customary" exchange is actually paying membership dues to our indispensable coercive aggregate. We are incentivizing others for their continued willingness to collaborate with us in the mutual coercive enforcement on which we all depend. Actually, it is probably more accurate to say that we are publicly demonstrating that we possess the "assets" and "property" that makes us vulnerable to self-interested enforcement actions of others and, thus, that we are "made" members of the self-funded coercive coalition.

Put differently, "customary" exchange is just as economically rational as mundane "market" exchange. It's just that we are buying a different kind of commodity in each case. The commodities purchased through market exchange might be useful to a non-human animal. The commodity purchased through customary exchange is uniquely human.

65 There are a few visionary exceptions. See Alchian and Demsetz (1973); Demsetz (1996 and 2002), North and Thomas (1977) and the collection of papers in the June 2002 issue of the Journal of Legal Studies for discussions of the evolution of property law by economists. These represent important first steps, but are still rather naïve in their lack of grasp of the central role of self-interested coercion.

66 Reviewed in Holliman (2004).

67 Yellowtail, et al (2007).

68 This effect is so profound that some have suggested that ritual caused the Neolithic (see, for example, pgs 3-20 in Price and Brown, 1985 and Cauvin, 2000). Reviewed in Aldenderfer (1993).

69 Mississippians are reviewed in Pauketat (1994) and Pauketat, et al. (2002), for example. Anasazi ritual is discussed in Mills (2002), for example.

70 Reviewed in Holliman (2004) and Corbett (2004).

71 We can get in touch with how important identifier beliefs are to us by looking at how attacks on them affect us emotionally. To get a feel for this, choose the *identifier* category below that best fits you and feel your reaction to an attack on those identifier beliefs. [Notice that identifier beliefs do not have to be false. Rather, there veridical relationship to the material world is merely irrelevant.]

Identifier 1 – Christian: Christ was an inept revolutionary who failed in his attempt to subvert Roman control of his local area. Some of his followers made the best of his failure and the Greek, Saul/Paul, used the resulting belief system to build a larger cult. This cult went on to be sufficiently successful that, ultimately, Roman Imperial functionaries found it expedient to co-opt the cult to better govern underclass members of the late Empire. Over 1.5 billion people still profess to accept the identifier beliefs of the various MISAs derived from this enterprise. The traditionally committed members of these MISAs regard their values as the values of their states, their MPUs, and themselves and their disciples – called laity - as the proper rulers of those states.

Indentifier 2 – Moslem: Mohamed had a psychosis that caused him to believe he was being spoken to by an imaginary sub-diety (an archangel). He used the products of these delusions as a pretext to recruit a criminal gang who ran a very successful extortion racket parasitizing trade routes in the Arabian peninsula. This criminal enterprise became so successful that it was able to expand – ultimately conquering a big chunk of Eurasia. Over 1.5 billion people still profess to accept the identifier beliefs of the various MISAs derived from this enterprise. The traditionally committed members of these MISAs regard their values as the values of their states, their MPUs, and themselves and their disciples – called believers - as the proper rulers of those states.

Identifier 3 – Agnostic materialist: Modern "science" arose, in part, as an attack by increasingly powerful non-elite members – the rising "middle class" - on hierarchical early modern states. Its focus on "empirical" evidence was designed to discredit the "theistic" identifier beliefs of the privileged and assist devotees and practitioners in gradual capture the state. Members of the contemporary MISAs derived from this enterprise still insist on the priority of empirical evidence over "revelation." and they, themselves, determine the rules whereby such empirical evidence will be used. The traditionally committed members of these MISAs regard their values as the values of their states, their MPUs, and themselves and their disciples – called students - as the proper rulers of those states.

Chapter 13

Elite body armor: Hierarchical coercive power and the archaic state

1 From period Spanish reports as quoted in Hass and Creamer (1997), page 243.

2 As recounted by Roberts (2004), pgs. 86-90.

3 Roberts (2004), pgs 203-204.

4 There are, of course, cases where we do not yet have enough information to make a judgment. Investigation of these cases will be especially interesting to follow in the future. However, we note that some archaic states were once widely believed to emerge for reasons other than new coercive means – sometimes called "warfare" in archaic state archaeology. These included the Mesoamerican Maya and the South American Moche, for example. However, the evidence is now strong that these two states are the products of new coercive technologies (Webster, 2000; Quilter, 2002). Our theory predicts that the same pattern will follow as other under-investigated cases become better documented. Examples of these under-studied cultures include the Harappan (Kenoyer, 1998 and 2003) and Minoan (Tattaron, 2008) civilizations.

5 Reviewed in Smith (2005).

6 Reviewed in Freeman (1996).

7 See, for example, chapters in Culbert and Rice (1990) for the Mesoamerican case and Healy, et al. (2007) for a recent example from this region. See Chapter 6 of Moseley (1992) for a review of the South American case. See Trigger (2003) pgs 307-312 and 396-399 for reviews of the early Old World and general cases.

8 There is an immense literature on settlement organization in urbanized archaic states. See Wenke (1999) pgs 404-408 for a brief review. See Chapter 13 in Marcus and Flannery (1996) an example analysis of the pristine archaic Zapotec state.

9 See Stanish (1997) for a characteristic example. The well-known Roman road system is another, of course.

10 The question of how archaic state "economies" function in detail remains an active, contentious area of research. See Trigger (2003) for an excellent review of the level of "commercialization" in a collection including some original "pristine" states. See Hirth (1998) and Minc (2005) for examples of some recent thought in this area.

Our theory apparently does not predict these details. They appear to be historical accidents of the experiences and belief systems of the founders to archaic states – which become institutionalized as the state consolidates.

However, we believe that two things are likely to be general. First, humans are probably highly adapted to exchange (Ofek, 2001). Our theory predicts that this behavior will have evolved as a direct consequence of control of conflicts of interest beginning around 2 million years ago. Thus, humans in all archaic states will engage in some form of market behavior. However, the scale of this behavior – local communities versus state-wide – will be strongly effected by what is permitted by the elite warrior class. Second, whatever the scale of market behavior permitted by the elite warrior class, this group will generally hold itself aloof from labor and commercialism as lower class activities.

One last element of this story is of potential interest. It appears that the extent of urbanization – formation of cities – in archaic states may correlate with the level of commercial activity permitted by the elite warrior class - see, for example, Trigger's (2003) discussion of Inca versus Aztec urbanism. If this pattern is general it would represent both a highly useful empirical insight and a rich clue to the adaptive purpose of urbanism more generally.

11 The insight that something that can be called "warfare" is somehow related to the rise of early states in an old one – dating, at least, to Homer, Herodotus and Aristotle. Many contemporary scholars have also considered the issues (see, for example, Caneiro, 1970 and 1981; Webster, 1975; and Gilman, 1981). The limitations of these early pictures is their failure to grasp many crucial elements of the internal logic of this process and, even more importantly, its inherent connection to the larger 2 million year human story. Our theory predicts these earlier insights and local theories and much more.

We note also that Carneiro's (1970) concept of "circumscription" as causal of the state probably does not generalize in the way that a complete theory should. As humans fill the Malthusian landscape their choices to "vote with their feet" are eliminated – they are almost always circumscribed in practice. Circumscription has been part of the human story for 2 million years, not a recent cause of the rise of early states. Indeed, the population growth associated with many early states is probably an *effect* of their improved economic performance, not a *cause* of their original existence.

12 Though we are fans of Timothy Earle's impressive body of work and thought, his failure to fully grasp how central coercive threat is to human social organization is paradigmatic of entire subcultures in archaeology and anthropology. When we criticize his approach to this issue we are really criticizing this entire – flawed – intellectual approach to power. In his otherwise beautiful, illuminating 1997 book *How Chiefs Come to Power* Earle says the following. "Inherently warfare [read coercive power] is limited in its effectiveness as a power for central control. Although military force may create a broadly integrated polity, it can as well dissolve it by intrigue, coup and rebellion. To be effective as a power of centrality, coercive force must itself be controlled…" (pg 106).

The fundamental mistake here can be thought of as the "functionalist" error. It is intimately related to the "group selection fallacy" in biological thought (Chapters 3 and 10). It is assumed that societies "seek" to evolve toward order because order allows greater "safety" and "economic productivity." In fact there is not the slightest reason to believe that this is true. The adaptive potential of "order" is not sufficient to bring order into existence – or to cause it to "evolve". The world produced by natural selection does not work that way. Many alternatives come into existence as a product of the Second Law, but only the most adaptive in that environment remain for us to see. No "seeking" is done – only elimination through trial and error. Moreover, our theory predicts – and, we argue, the empirical evidence indicates – that societies have only that order which the pursuit of individual self-interest generates as a byproduct.

Thus, we would rephrase Earle's comment as follows. "Coercive violence may create a broadly integrated polity and it can as well dissolve the polity by intrigue, coup and rebellion. It does either or both these integrative and disruptive things according to how coercive power is distributed and used in pursuit of self-interest - *and for no other reason*. Coercive power is never controlled except by countervailing coercive power – even when this lack of control produces poverty and chaos."

13 See, for example, the tiny fraction (ca. 0.4%) of the population represented by the top Inca hierarchy (Moseley, 1992; pg 9). See Hassig (1988) pggs 28-29 for the Aztec case. See Turnbull (1996) for the Japanese case. See Webster (2000) pg. 8 for the Mayan numbers.

14 The technical game theory of elite coercion involving body armor and shock weaponry is challenging and complex (Okada, Souza and Bingham, unpublished work). Further complicating this analytical problem, archaic states develop multiple layers of warriors – super-elites, elites, sub-elites, commoners with some military training. An immense amount of work remains to be done – important work that will yield many new insights. Moreover, much of the rich episodic complexity of large archaic states – like the Roman and Islamic Empires or Inca and Aztec states – emerges from these second order complexities. They will be rich fodder for future work.

However, we believe that our grasp of the most fundamental issues is sufficient at this stage in the analysis to outline some of the most general and basic properties of archaic states as they are predicted by our theory. Most importantly, the empirical record is sufficient to test the most central predictions of the theory – that archaic states emerge from the self-interested application of new coercive means.

Finally, in writing for a general audience we will make liberal use of terminological simplification – for example, the Triple Alliance in the area of the Valley of Mexico will simply be referred to as the Aztecs.

15 Quoted in Turnbull (1996) pg 10.

16 Though much further theoretical and empirical work remains to be done on understanding all the details of elite coercion, we can already get a sufficient level of insight to be extremely useful at this point in the analysis. Our treatment in this chapter is based on our current level of insight.

17 For readers who are skeptical that this is a plausible scenario for the local emergence of archaic states, we note that this is a remarkably good description of the rise of the Viking states in Northern Europe between ca. 700-1200CE (reviewed in Hedeager, 1994).

18 See Roberts (1993) for a crisp, trenchant review of the Old World archaic states. See Moseley (1992) and Trigger (2003) for discussions of selected elements of the New World archaic states.

19 Hardin (1968).

20 Also see Hedeager (1994) for a review of one economically well-documented case of such an expansion – the early Viking states.

21 An important secondary source of archaic state instability is the diffusion of new military technologies beyond the frontiers of such states. This technical diffusion is probably inevitable and allows the formation of completely independent competing states.

These "barbarian" states will grow in wealth both internally and, often, by trade with the original state. Ultimately, they must either be co-opted to the elite of the original parental state or grow into a hostile competing power. Co-optation is more practical early in the cycle of state development, hostile competition more likely as the state matures into its late crisis (main text).

22 Reviewed in Marcus (1998).

23 Reviewed in Moseley (1992) and Bauer (1996).

24 See Gernet (1996) for the Chinese evidence. See Wardman (1982) for the Roman case. See Lucero (2003) for the Mesoamerican Maya case. See Trigger (2003) for reviews of the Mesopotamian and Egyptian cases.

25 Accusations of "human sacrifice" have used since at least Roman times as tools to diminish and discredit "barbarian" or "pagan" political opponents (see, for example, Rives, 1995). These accusations are salient and politically useful because of their shock value. This is cause for concern that such reports are often fictional or exaggerated. However, we note that a precisely countervailing bias also arises. Defenders and partisans of specific ancient cultures will tend to minimize or reinterpret – as "symbolic," for example – any suggestions of human sacrifice in the historical record.

Our theory is clear. Archaic states will *always and everywhere* make use of overt public cruelty as projection of decisive coercive threat. Moreover, religiously rationalized "human sacrifice" or legally justified, overtly cruel "execution" are likely to be the most common forms of this elite public threat.

Clearly continued, sober scholarly attention to this issue is called for.

26 Like the issue of human sacrifice, itself, the question of whether sacrificed or executed people were cooked and consumed has been a source of great and continuing scholarly controversy (see, for example, Arens, 1979 and Obeseyekere, 2005). We note that the countervailing tendencies to exaggerate or suppress "cannibalism" are the same as those for human sacrifice (preceding endnote). Continued, detached scholarly attention is called for.

However, we note that whether cannibalism, *sensu stricto*, actually occurred in some archaic state public rituals is not an important concern for us here. Only the overt public cruelty necessary to project powerful coercive threat matters.

27 We have a number of independent contemporary sources on the human sacrifice practiced by the Aztecs. The details are not in serious doubt. See, for example, Diaz (1963) for a modern translation of Bernal Diaz' contemporary account.

28 Reviewed in Futrell (1997).

29 See Garnsey (1970), especially Chapter 4, for a detailed discussion of Roman legal penalties and their differential application to commoners and elites.

30 See Jaspers (1953); Eisenstadt (1982); and Armstrong (1993).

31 It is very hard for us to accept this picture of our political/social behavior. Indeed, even professional scholars – who are ostensibly trained to be skeptical and open – find it difficult or impossible to believe that the "right" in human affairs is exclusively determined by access to coercive threat – by power.

Our theory clearly suggests an answer as to why this point is so elusive for us.

We have each been unconsciously trained from birth – by the reactions of all those around us, mostly, themselves, unconscious – in the ways of human social power. Most important among these lessons is that public argument is a contract negotiation which is always an ethical argument – what "should" we do. This ethical framing ostensibly respects the coercive power of everyone else involved in the negotiation. Indeed, if we attempt to argue from an arbitrary position of personal power, we are asserting our individual prerogatives over the other parties to the negotiation, who will unite against us and resist.

This universal training makes it emotionally uncomfortable for us to occupy an intellectual position, as scholars, that asserts that only coercive power matters. We – mostly unconsciously – assume that others will unite against us if we take this position and we shy away.

Moreover, having this experience, we understand that the socially powerful must also make the pretense of respect for the other parties to a negotiation. We unconsciously confuse this awareness of cosmetic nicety for the assumption that the pretense is the real negotiation. When this is done, a fundamental mistake is made. A public pretense is mistaken for an ultimate cause.

These considerations apply to us as we grow up as relatively socially powerful individuals – as many of us have. However, we sometimes also experience the role of powerlessness. The hypothesis that power is decisive is emotionally painful to us from this perspective and, again, we reject the hypothesis of power for intellectually irrelevant reasons.

If this argument is essentially correct – and we believe it is – it follows that the route to a more humane future is an understanding of the rules of human coercive power that will make it possible for us to exploit those rules to produce the outcomes we jointly choose and that are universally humane (Chapter 17).

32 The written "history" of these states includes occasional claims of control by elite economic interests controlling and even disadvantaging elite warriors (reviewed in Gilman, 1981). Reviewing these issues in detail is well beyond our scope here. However, we suggest that such claims are exaggerated and, even where true, transient. The Roman case, again, is apparently illuminating. Any wealth advantage gained by the senatorial class at the expense of the Roman legions was short-lived. The seizure of the Roman state by the "emperors" was arguably actually a seizure by the legion, by elite warriors (Freeman, 1996).

33 As mentioned in general above, Eurasian cases where a lesser role for coercive force is sometimes claimed to be involved are always the less well investigated - the Angor civilization (reviewed in Higham, 2001 and Coe, 2003) is an excellent example. Our theory clearly predicts that such cultures will ultimately prove to have been dominated by a warrior elite – just as the "peaceful" Maya (reviewed in Webster, 2000) and Moche (reviewed in Quilter, 2002) in the New World ultimately proved to be most likely dominated by warrior elites.

34 Gernet (1996).

35 See Morton (1994) for the general Japanese historical context. See Turnbull (1996 and 1998) for details of the Japanese Iron Age weaponry traditions.

36 See Trigger (2003) for a discussion of varying levels of archaic state commercialization.

37 See Polybius' account (translated in Polybius, et al. 1979), for an early, but surprisingly "contemporary" example. Polybius was originally brought to Rome as an aristocratic hostage. However, he ultimately ingratiated himself into Roman society and was richly rewarded – predictably becoming a Romanophile.

38 We borrow Patrick Kirch's (1982) succinct description of this landscape as "transported." See Kirch (1984) for a detailed discussion of the geology and early history of Hawaii. Also see Kirch and Sahlins (1992) pgs 45-46.

39 Reviewed in Kirch (1990); Kirch and Sahlins (1992); Earle (1997); and Kolb and Dixon (2002).

40 See references in preceding endnote. By far the most useful reference to Hawaiian archaic state ethnography is Valero Valeri's remarkable 1985 book *Kingship and Sacrifice: Ritual and Society in Ancient Hawaii* – still in print at this writing. Though the subject of Valeri's book is ostensibly narrow – ritual – he gives us heart-wrenchingly clear insight into the elite warrior society of Hawaii before European contact, in all its beauty and horror.

41 Webster (1998) pg. 312.

42 There has been extensive confusion about the term "chiefdom" between different academic subcultures as we also mentioned in Chapter 12. Our theory contributes substantial clarification here. First, some cultures regarded as chiefdoms are arguably quasi-democratic – like the bow-based Chumash, Anasazi and Mississippian cultures of Chapter 12. We propose that the appearance of stratification in these cultures mostly represents differential wealth accumulation from entrepreneurial activity – analogous to wealth accumulation in modern democratic states. This stratification is subject to constant social monitoring and even confiscation by a democratic consensus.

In contrast, other cultures also sometimes classified as chiefdoms – like the Hawaiian "kings," for example – are based on elite access to coercive threat through armored warriors. Stratification in these chiefdoms is largely impervious to democratic monitoring. Moreover, as we argue in the main text, this type of chiefdom is indistinguishable in every sense from a small state.

Lastly, the term chiefdom is problematic for another reason. It implies that the chiefly individual is the central issue – he/she in general is not. Rather, in hierarchical states there is a heavily armed elite which gathers around individual political entrepreneurs who become kings if the elite cadre is successful in seizing the local state. Thus, the elite warrior cadre is the central issue – never the king.

In view of these considerations it might be wise to consider abandoning the term chiefdom altogether. For example, social systems like the Chumash and the Anasazi might simply be called "Neolithic economies" while chiefdoms like Hawaii are merely small archaic states.

43 Kolb and Dixon (2002); Kirch (1984; Chapter 8).

44 Kamakau (1961), footnote on page 77.

45 For discussions of prehistoric Hawaiian agriculture, see Kirch and Sahlins (1992) volume 2, pgs 170-174; Earle (1997) pgs 33-46.

46 Valeri (1985) pg. 154.

47 Valeri (1985) pgs. 159-160.

48 Valari (1985) pg 161.

49 Valeri (1985) pgs 336-338.

50 Kamakau (1961) as quoted in Earle (1997).

51 Quoted in Valeri (1985) pg. 231.

52 Valeri (1985), pg. 157.

53 See Valeri (1985) pgs 50 and 161, for example.

54 Dinning (1980) quoted in Kirch (1991) pg. 132.

55 See Hassig (1988 and 1992).

56 See Hassig (1988 and 1992).

57 See Hassig (1988 and 1992); Webster (2000); and Quilter (2002).

58 See Benson and Cook (2001) and Smith and Schreiber (2006).

59 We also face an additional, related technical problem. Though detailed discussion of these issues is beyond our scope here, several fundamental points can be made.

Coercive management of conflicts of interest by elites can ultimately operate at a fairly large scale – like the Romans or the Inca. However, this large scale requires the assembly of a great deal of know-how about how to create and (temporarily) sustain a very large political economy. Moreover, the scale of such large political economies is expected to be limited by local ecological carrying capacity.

Thus, we anticipate that very large archaic states will require time – precise duration unpredictable – to coalesce from smaller early archaic states. Moreover, these large states are apparently always fundamentally agrarian (for reasons we will discuss further in Chapters 15 and 17). It follows that large archaic states will arise only where local ecology permits relatively extensive agricultural intensification.

These expectations seem to be sound extensions of the fundamental theory and the empirical evidence is consistent with them. Notice, especially, that learned skills for large scale political economy building and the nature of local ecology are causal only in a secondary derivative sense. Possession of elite coercive power – and the ensuing management of conflicts of interest on a new scale – is the overarching, primary cause.

60 As mentioned, the Harappan (Kenoyer, 1998) and Minoan (Tattaron, 2008) civilizations are especially attractive cases for future analysis. Many of the archaeologists studying these very early archaic states argue against a central role for elite warriors. If they are right our theory is wrong (or, at least, incomplete). However, we suggest that they will probably prove to be wrong and that elite warriors are central even to these earliest states.

Note also that these earliest archaic states may have been produced by relatively small elites, relative to the commoner population. Under these conditions, elites would have had limited ability to systematically subjugate the larger commoner population. Such small elites might have acted more to police larger markets than as the dominating daily influence in local residential communities. Policing *within* local communities might still have relatively democratic, Neolithic-like (Chapter 12). Under these conditions, elites would have left a relatively modest footprint in the iconography and rituals of daily life.

However, as elite military technology improved and wealth from elite control accumulated, such relatively small, “innocuous” elites are expected to be transient. Intrusive, domineering, heavily armed elites are expected to grow and become characteristic of archaic states.

61 Reviewed in Yoffee (1995), Stone (1997) and Adams (2006).

62 Aitchison (1960) pgs 18-49.

63 Reviewed in Gabriell and Metz (1992). Also see Moorey (1986) for a discussion of scale armor somewhat later in the Southwest Asian record.

64 Reviewed in Hassan (1988), Bard (1994) and Wenke (1999).

65 Cattle in late Predynastic subsistence reviewed in Holl (1998); McDonald (1998); Wendorf and Schild (1998); and Garcea (2004). Ritual significance of cattle in early Dynastic cults reviewed in Wengrow (2001).

66 Reviewed in McDermott (2004).

67 Reviewed in Collis (1984).

68 Reviewed in in Drews (1993).

69 See Morton (1994) and Omoto and Saito (1997) and references therein for reviews of the early Japanese Iron Age. See Gernet (1996) for a review of the Chinese evidence.

70 Hassig (1992); Webster (2000) ; Webster (2002); and Spencer and Redmond (2004). Also see Chapters in Brown and Stanton (2003).

71 Reviewed in Quilter (2002) and Arkush and Stanish (2005).

72 See Dillehay, et al. (2007) and Balter (2007) for South American cotton domestication. See Coe (2002) and Marcus and Flannery (1996) for early Mesoamerican weaving.

73 See Chapter 13 in Sharer and Traxler (2006) for a review of Mayan human sacrifice. The Moche story is reviewed in Bourget (2001) and Verano (2001). Also see Quilter (2002).

74 Reviewed in Pozorski and Pozorski (2005).

75 Reviewed in Moseley (1992) pgs 123-136.

76 See, for example, Bourget (2001) and Verano (2001) for examples of the South American evidence.

77 Reviewed in Marcus and Flannery (1996), pages 128-130.

78 See Smith (1995) for the North American domestications by pre-Hopewell populations. See Dillehay, et al (2007) and Balter (2007) for discussions of the South and Mesoamerican cases.

79 See Moseley (1992) for a review of the South American picture. See Flannery (1976), Marcus and Flannery (1996) and Coe (2002) for reviews of the Mesoamerican case.

80 Reviewed in Marcus and Flannery (1996) and Coe (2002).

81 Reviewed in Moseley (1992) also see Stanish (1997) for an interesting specific example of the development Inca roads. See Trigger (2003) for a discussion of Inca commercialization.

82 Reviewed in Berechman (2003).

83 Trigger (2003); Stone (1997) and Stone and Zimansky (1994, 1995). But also see Darnell and Manassa (2007) for a review of evidence for a relatively central role of elite warriors from the beginning of the Egyptian state. Notice especially the role of these warriors in internal policing and "religious" ritual as described in Chapter 6.

84 Hassan (1988) and Bard (1994).

85 See the elegant studies of Stone and Zimansky (1994 and 1995) on canal systems as integrated elements of Mesopotamian towns.

Chapter 14

Modernity emerges from the barrel of a gun, Part 1 - artillery stabilizes the hierarchical state

[1] See Kuykendall (1957) volume 1, Chapters 2-4 and Kirch and Sahlins (1992) volume 1, Chapters 1-2 for reviews of the coming of the Europeans to Hawaii and the subsequence consolidation of the Hawaiian kingdom.

[2] Approximately $1.20/day in 1990 dollars (Maddison, 2001 and 2005).

[3] Direct economic data go back no further than ca. 2000 years (reviewed in Maddison, 2001 and 2005). However, there is no evidence – archaeology, for example – and no theoretical reason to believe that an average more remote ancestor was any richer than the average denizen of first century Rome.

[4] Based on contemporary per capita GDP figures from the American Central Intelligence Agency (https://www.cia.gov/library/publications/the-world-factbook/rankorder/2004rank.html) or, alternatively, extrapolating from Maddison (2001) pg. 28.

[5] Data on historic life expectancy from Maddison (2001) page 29 and contemporary US life expectancy at http://www.cdc.gov/nchs/data/statab/lewk3_2003.pdf.

[6] Mao Zedong is the famous Chinese communist autocrat. He apparently made this comment in 1927 during the Chinese Civil War (Schram, 1994, pg 128).

7 See Chapter 2 in Hall (1997) and Kelly (2004) for reviews of our current knowledge of the transfer of gunpowder to Europe in the 12-13th Centuries and the early European refinement of this technology. See Buchanan (1996 and 2006) for specialist discussions of some of the many remaining issues in this area.

8 Reviewed in Chapter 2 of Hall (1997).

9 See Porter (1994) and Hall (1997) for two useful reviews of the emergence of gunpowder technology. Hogg (1997) contains some useful images.

10 Our theory predicts that modern states arise as a result of the characteristically human application of a new coercive technology to the pursuit of self-interest. That technology is gunpowder weaponry and elite interest groups who win local gunpowder competitions caused most of early history to be written. Thus, many of the more ostentatious "historical" cases of gunpowder's use will appear to be events we have come to call and think of as "war." Indeed, many of us have historical beliefs about the wars – of "liberation", of "revolution" – that ostensibly produced the societies we occupy. These beliefs are rich and emotionally salient for us.

Moreover, military historians have long recognized an empirical connection between what they call war – as a matter of professional practice – and the rise of modern states. From this source some of us have also acquired scholarly beliefs about war.

If we are to understand our theory's predictions about gunpowder-based coercion in the course of recent human history, we must sweep away or substantially revise most of these beliefs about war. We must come to see these events as merely examples, among many others, of characteristically – as in 'what we have been doing for ca. 2 million years' – human exploitation of a new coercive means in pursuit of self-interest, nothing more, nothing less. Moreover, the most important applications and implications of gunpowder weaponry are often not war *sensu stricto*.

It is useful to begin to revise our views here by looking more carefully at what military scholars call war and to contrast it with the picture our theory provides. In doing this we will begin to position ourselves to use the truly gigantic body of scholarship on "war and the modern state."

The best of these studies are richly brilliant in empirical content. [See Tilly (1992) and Porter (1994) for two outstanding monographic reviews of this immense body of work. See chapters in Rogers (1995) for a sample of vigorous scholarly debate of this way of looking at the early state.] However, this work has severe – even fatal - theoretical and conceptual limitations. It is shot through with group selectionist thinking (Chapters 3 and 10) and deep confusions of cause and effect – including proximate/ultimate confusions (Chapters 3 and 10).

For example, group selectionist thinking is flagrant in the reification of "ruler" and the "state" – as if rulers ran the show as individual decision makers or, even more egregiously, as if states were coherent entities with minds and wills. [Inca kings were nearly as useful as mummies as they were in life (see, for example, Chapter 5 in D'Altroy, 2002) as are thousands of wholly imaginary deities. This is a most illuminating insight into the role of individual rulers, even ostensibly absolutist ones.] Further, for example, war is imagined as the product of decisions by individual rulers at one extreme or entire states at the other – extreme reification again.

Even more disastrously, war is seen as mostly attempted territorial expansion or resistance to same, by rulers or states – with its social consequences following the practical/adaptive constraints of achieving victory in such competitions. This mostly confuses effects for causes.

Our theory's predictions are quite clear – allowing us to get a much simpler and usable picture. The primary impact of coercive means – including weapons of war – is in the day-to-day management of conflicts of interest *within* social aggregates. Indeed, the most important applications of gunpowder coercion will be everyday law enforcement events – either passing unremarked or actively hidden to discourage emulation of law breakers.

However, even large-scale events that we might wish to classify as overt war represent an extremely heterogeneous collection. To see how this helps us it is very enlightening – and not too artificial - to look at exactly what kinds of coercive violence our theory predicts in the world of modern states as these social aggregates emerge from the self-interested application of gunpowder weaponry.

First, some events that historians refer to as wars are the acts of coercive violence inevitably associated with the initial consolidation of a new scale of social cooperation - enabled by the self-interested application of a new coercive technology. Thus, the "War(s) of the Roses" are not the same the thing as the combat associated with the French Revolution, say.

Second, other wars are the violence associated with ongoing large scale policing of social aggregates after they consolidate – again, in immediate pursuit of individual self-interest. Thus, the English Civil War and the American Revolution are not the same thing as World War I, for example.

Third, the effective scale of social cooperation cost-effectively supported by the self-interested use of gunpowder weaponry is not infinite (main text below). Thus, once the maximal sustainable size of these gunpowder-enforced aggregates is reached, the different aggregates – "states" - will have conflicts of interest that cannot be suppressed or managed. They will engage in occasionally violent competition – endlessly, perennially – until some later coercive technology is developed that permits these conflicts of interest to be controlled (see Box 12.1 for the theory of war and Chapter 16 for policing on the intenational scale).

This ceaseless competitive bickering between states is the story of large portions of the globe from about 1500 to 1918. These conflicts are also often called wars – but, again, World War I is not the same thing as the French Revolution.

A related, especially pernicious intellectual error concerns how we think about the social implications of gunpowder weaponry - thinking that wars between modern states occur *because* gunpowder weaponry gives combatants a chance of success, as military historians sometimes do.

Our theory predicts that this enabling role of gunpowder is secondary, relatively unimportant. The primary or prior role of gunpowder in modern state war-making is the internal suppression of conflicts of interest – allowing, in turn, a war machine to be built and maintained.

Put differently, state war-making is a massive cooperative project, profoundly susceptible to subversion by free-riding – tax avoidance, draft evasion or cheating on military contracts, to name three of thousands of cases. Thus, before gunpowder weapons can ever be brought to bear in state-level warfare they must *first* be used to sustain the cooperative enterprise that is the state itself. It is this state-sustaining function that is most important in understanding the emergence of the modern world.

In summary, on our theory, military historians are right to think that gunpowder weaponry has something to do with the rise of the modern state. However, they are mostly mistaking a secondary use of this weaponry – cooperative war-making – for its primary consequence, the consolidation of the state in the first place.

11 There is a massive literature seeking to explain the modern states as emerging from the administrative and logistical *requirements of* gunpowder weaponry rather from the *consequences of* the use of gunpowder (see McNeill, 1982; Porter, 1994; and Rogers, 1995 for several examples, among many). This work is often of very high quality in its reporting of the empirical record. However, it fails in providing a credible theoretical understanding of the underlying processes. For example, it is flagrantly group-selectionist (preceding endnote). It assumes that massive sets of individuals cooperated to produce an outcome (military effectiveness) because that collective outcome was ultimately beneficial. This approach ignores the free rider problem and is simply incoherent as we have discussed. Further, for example, it is not at all clear that the administrative requirements of putting massive legions in the field at the height of Roman Imperial dominance was any less that for early modern armies. Yet, the Roman Empire was short-lived while the early modern states we stable and grew vastly more powerful than the Roman could have imagined – features predicted by our new theory.

12 See Hassig (1988) Chapter 16, Smith (1996) Chapter 11 and Chipman (2005) for discussions of the Spanish conquest and subsequent events. Notice Cortes' focus on wealth but his extensive sexual exploits with Aztec women (see, for example, Chipman, 2005, pg. 51).

13 See Chapter 16 in Hassig (1988) and Chapter 11 in Smith (1996) for reviews of the Spanish conquest of Tenochtitlan.

14 See Chapter 11 in Smith (1996) and Chipman (2005).

15 See Meyer (1993), Morton (1994) and Chapter 1 in Jansen (2000) for reviews of pre-Tokugawa Japan.

16 See Turnbull (2003) Chapter 5 for a recent review of our current understanding of gunpowder in early Japan.

17 See Morton (1994) and Jansen (2000) for general surveys of the Tokugawa era.

18 See Maddison (2001) pages 252-258 for a review of Tokugawa economic performance. Note that Maddison emphasizes the stability of the Tokugawa era and is growth. However, this growth is virtually nil by the standards of modern democratized" states (see Maddison's Table B-21 on page 264, for example) as we will discuss in Chapters 15 and 17.

Chapter 15

Modernity emerges from the barrel of a gun, Part 2 – handguns democratize the modern state

1 See Hall (1997) and Turnbull (2006) for well-annotated and very readable reviews of the empirical scholarship on early European gunpowder technology and "state building" – empirical reporting not too heavily distorted by specific theoretical lenses. See Porter (1994) and Tilly (1992) for discussions with stronger theoretical bias – biases we mostly don't share. Finally, see papers in Rogers (1995) and Buchannan (1996 and 2006) for scholarly discussions of various specific technical issues.

2 See Tilly (1992), Porter (1994) and Roger (1995) for reviews of this traditional perspective.

3 Crisp, informative overviews of an especially well-document, paradigmatic case, the War of the Roses, are available online at this writing, including the Wikepedia account. Also see Gillingham (1981), Goodman (1981) and Cunningham (2007).

4 This simple, powerful insight was originally proposed by Frederick Lane (1958) and subsequently developed by others.

5 Quoted in Turnbull (2006) page 170.

6 Quoted in Turnbull (2006) page 250.

7 See pages 227-234 in Hall (1997) for an illuminating description of this process by the mid 16th Century.

8 Supplementary Weapons Figures:

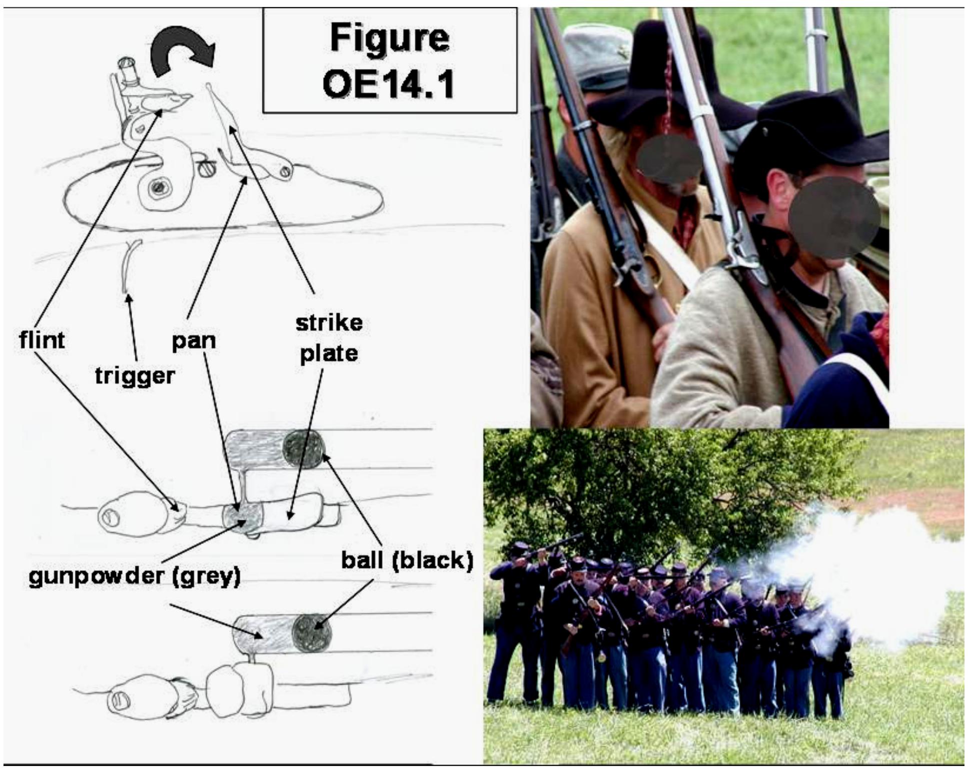


Figure OE14.1: LEFT: The firing system of the flint lock is illustrated at left. At the top is a side view of the central portion of the weapon. When the trigger is pulled a spring mechanism drives the rotating flint holder forward violently as indicated by the curved arrow. The flint impacts the strike plate and tiny pieces of flint are driven off as sparks. The strike plate rotates around the screw at its base (as illustrated in the two top views of the mechanism at bottom) and sparks are driven downward into a small puddle of gunpowder in the pan, igniting it. The powder in the pan is connected by a narrow channel bored into the muskets barrel to the main powder charge that has been loading through the mouth of the gun barrel off the figure to the right. This main powder charge is packed tightly with a small piece of cloth or paper wadding (not shown in the figure) and the ball or projectile. The ignition burns through the tiny channel igniting the main charge tenths of a second after the initial flint strike – driving the ball out of the musket at extremely high velolcity. (See Chapter 5 in Hall, 1997, for additional dicusssion of early muskets.)

RIGHT TOP: Contemporary reenactors of the American Civil War carry a later (19th century) version of the musket in which the flintlock firing mechanism has been replaced by a similar, but more reliable mechanism.

RIGHT, BOTTOM: Contemporary reenactors of the American Civil War discharge a volley of musket fire and prepare to reload.

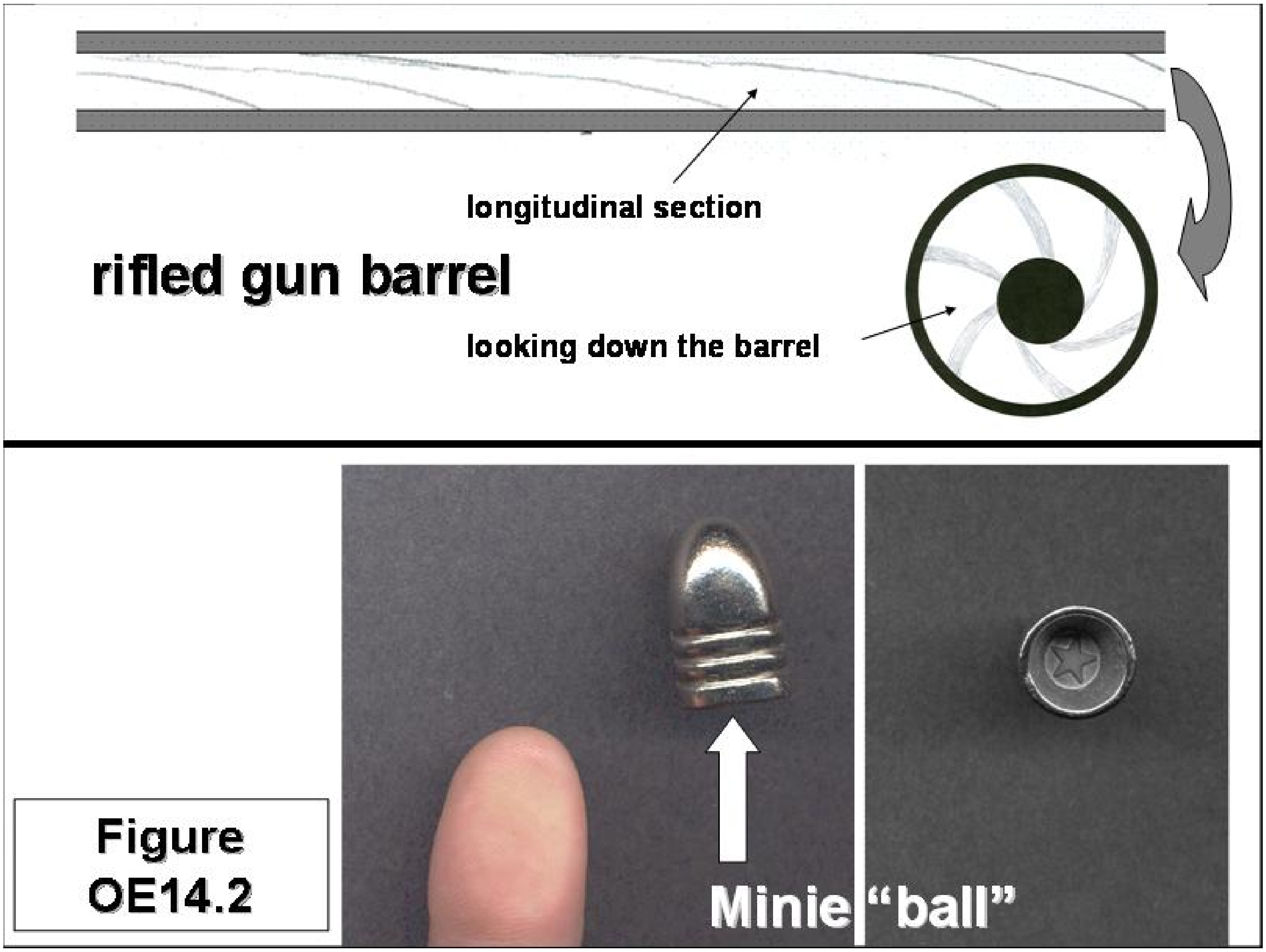


Figure OE14.2: TOP: Rifling revolutionized the accuracy and effective range of the musket in the mid 19th Century. Riflings are tiny sharp ridges spiraling down the inner surface of the barrel as indicated in the images. The rifling spun the slug leaving the gun producing gyroscopic stabilization much truer flight.

BOTTOM: The original practical rifled muskets needed to be rapidly loaded down the muzzle under fire. This was achieved by the invention of the Minie round or ball. Shown is a life-sized steel replica of the lead Minie round. The back of the round and the direction of its flight are indicated by the white arrow. A back view of the round is show at right. It hollow back allowed the base of the round to expand when the powder charge exploded behind it. Thus, the round could be slightly smaller than the musket barrel diameter – dropping easily down the barrel at loading – yet firmly grip the rifling of the barrel as it exited the weapon at firing.

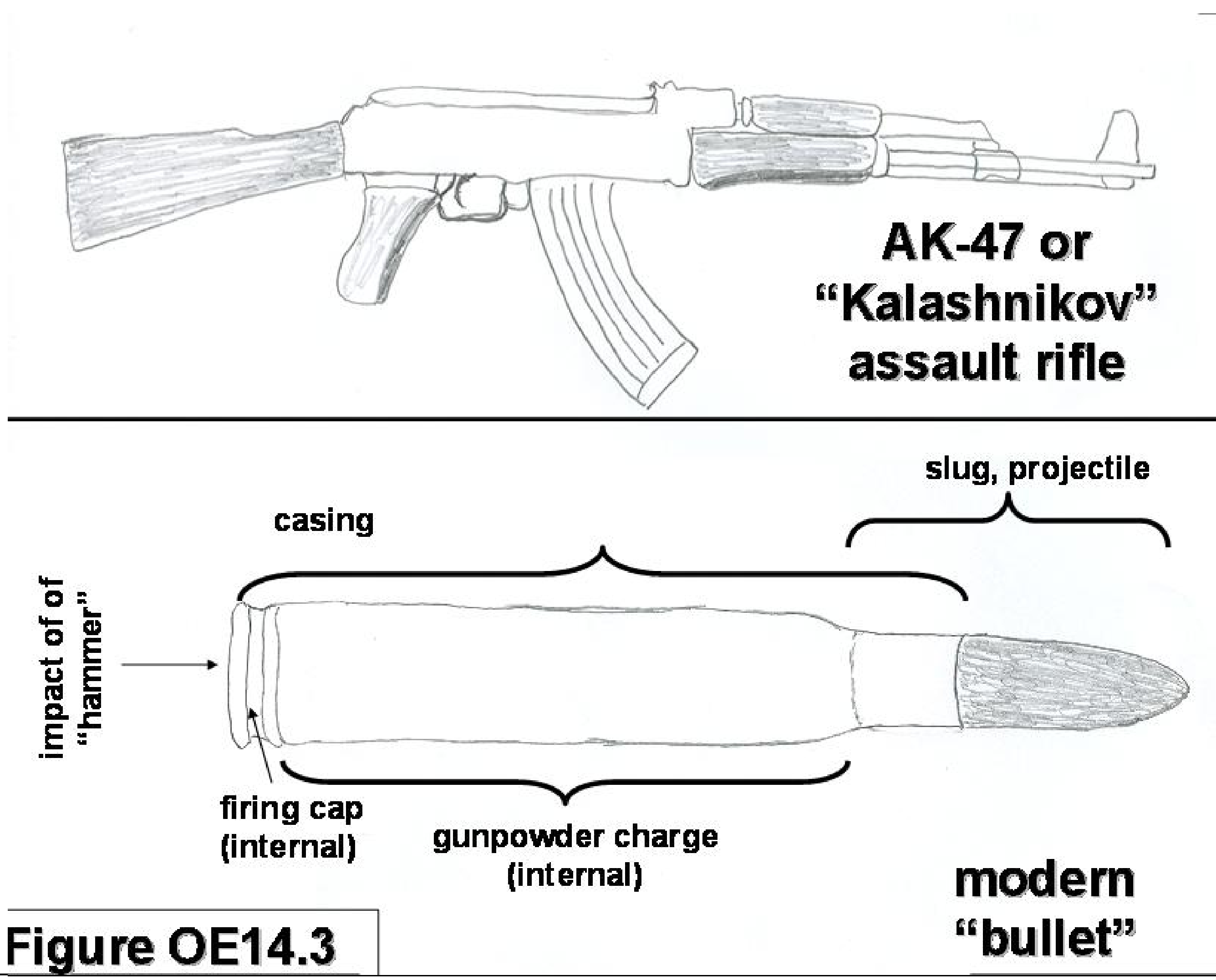


Figure OE14.3: TOP is a modern assault rifle. Pulling the trigger releases a firing pin or hammer which strikes the back of the bullet in the chamber (below). This fires the round and the exploding gas behind the slug is also used to cycle the mechanical-spring mechanism – discharging the spent casing (below) and driving a fresh round into the firing chamber. On automatic mode the next round is fired and the cycle is repeated as long as the trigger is depressed. This weapon can fire 5-10 rounds per second on automatic. The long crescent clip underneath the weapon is a spring driven device to feed bullets into the firing chamber on demand. This clip will hold 30 rounds. Larger clips holding up to ca. 55 rounds are widely available (Google search "AK-47 clip" to get a feeling for this).

Like all modern guns, Kalashnikov has a rifled barrel and using advance third generation gunpowder. Thus, it has great range, accuracy and killing power. The Kalashnikov is famous for its robust, simple, reliable design. Often told stories describing digging up buried Kalashnikovs during excavations of old battle sites, banging them against a tree to clear debris and firing them – as is (see Kahaner, 2007, for the history of the Kalashnikov, including this story on page 52).

BOTTOM: A generalized modern bullet or cartridge. All elements of the projectile and propellant are sealed (weather proof) and self-contained for easy loading for firing – even automatic firing as above. The casing is typically a brass alloy designed to have just the right thermal properties to transiently expand and occlude the back of the firing chamber at discharge, then rapidly recover its original size to allow easy removal of the spent casing. Slugs generally consist of lead, often jacketed in a harder metal – though many variations on this theme are in use.

9 See preceding endnote and Chapter 5 in Hall (1997) for detailed discussions of these issues.

10 See, for example, Brown (1980) and Brown (1991).

11 Israel (1995).

12 See Rothman (2005) and pages 422-496 in McDougall (2004) for a review of the big cotton slavocracy.

13 See, for example, references to Nat Turner in Burton (2007).

14 See especially Hopcroft (1999) for a discussion of the British-continental distinction. See Schama (2000), volume II for a succinct summary of early modern British history. See Gillingham (1981); Goodman (1981); Western (1993); and Cunningham (2007) for more detailed discussions of early modern British history. See Doyle (2002) and Price (2005) for succinct reviews of early modern French history.

15 In addition to Galvin (1989) see Malcolm (1994). Also see Malcolm (2001) and Lindgren (2005) for discussions of the now-discredited alternative view that the 18^{th} Century North American colonists were not heavily armed.

16 Reviewed in Chapter 6 of Schama (2001), volume II and in Chapter 8 of McDougall (2004).

17 See Martin and Lender's (2006) excellent review of these issues.

18 See Chapters 13 and 14 in Burton (2007) for a brief recent review of the late 19th Century portions of elite manipulation of the North American economy. See Zinn (1995) and McDougall (2004) and for a more general discussion.

19 See Chomsky (2003) and Higgs (2004) for two examples among thousands of the skeptical criticism American citizens routinely heap upon their government and politicians.

20 Lincoln purportedly said this in an 1856 speech, though we have not seen a transcript of that speech.

21 See McDougall (2004) for an outstanding overall review of the current state of scholarship on the rise of the North American state. See Watson (2006) and Chapter 7 in Zinn (1995) for reviews of "Jacksonian Democracy" in the early 19th Century America. See Chapter 5 in de Soto (2000) for an insightful review of the emergence of American property law from the self-interested assertiveness of an armed, disrespectful electorate.

22 Burton (2007).

23 See McPherson (1991), Wills (1992) and Fletcher (2001) for discussions of the central importance of the American Civil War.

24 See the early chapters in Hobsbaum (1975) for a review of the Crisis of 1848.

25 The American Civil War has other important lessons for us. African Americans fled the collapsing South during the war and large numbers fought and died in the Union infantry (see, for example, DeAngelis,2003). However, after the war the commitment of the Union government – controlled by European Americans – to African American enfranchisement was minimal.

Local white Southern elites had lost their control over overtly enslaved labor and they needed a replacement. Human coalitions use identifier information to define their members – and, equivalently, their non-members. Exploitative elite coalitions, in particular, have the problem of distinguishing their members from their prey – coherently and with transparent mutual consent.

Most commonly elaborate sets of cultural traits – identifier beliefs – are the basis of such distinctions (Chapters 10 and 12). However, "racial" traits are also convenient and reliable. Thus, "whites" could readily form a coherent dominant coalition preying on "blacks" – as they, in fact, did (reviewed in Foner, 1988, Leman, 2006 and Chapters 11 and 12 in Burton, 2007).

Whites used their superior coercive power – they disproportionately controlled the manufacture and distribution of weapons – to systematically disarm African American militias. Local white coercive organizations – including the KKK and White League - waged a campaign of pervasive intimidation and terror to subdue African Americans and deprive them of political power.

This coercive campaign was ultimately successful, by ca. 1875. Local laws were enacted and enforced that effectively deprived African Americans of the political franchise they ostensibly held under the 13th, 14th and 15th Amendments to the American Constitution, passed at the end of the Civil War. This new white-dominated political/economic system – called the "Jim Crow" system in American historical jargon – thrived to the benefit and/or indifference of European Americans for the next 90 years.

It is especially crucial to notice that the local economic system in the Jim Crow US was determined *not* by formal legalities – like the Constitution – but by distribution of access to coercive threat. Constitutions matter only when they are defended by self-interested coercive threat.

During World War II many thousands of African Americans were trained in the use of contemporary weapons. Empowered, this generation began to agitate for the actualization of the political rights ostensibly guaranteed by the American Constitution. Their political actions included putting large numbers of people in the street in marches – implicit threat. It also included projection of more overt threat by some political entrepreneurs leading the struggle (Google "Huey Newton", "Bobby Seale" and "Black Panther Party" to see examples of public displays of threat).

This exchange of threat and renegotiation of social contract beliefs reached a local peak in the 1960's. Voting rights acts and new enforcement created a substantial increase in African American economic and political participation. The struggle for full economic enfranchisement continues – notably including an overlay of the threat of violence reflected, for example, in contemporary hip-hop music, among other venues.

With the ferment of global democratization through the last several centuries the rights of half the world's people – women – were often discussed. [See Chapter 2 of volume III of Schama (2000) for a discussion of an early important example of this in the writings of Mary Walstonecraft – who happens also to have been the mother of Mary Shelly. See Ward, et al (1999) for reviews of the lives of American pioneers, including Elizabeth Cady Stanton and Susan B. Anthony.] However, little was achieved of lasting substance.

By the late 19th Century guns had been refined to the point that the opportunity costs of their use were extremely low – self-contained cartridges eliminated the complex drill of muzzle loading, "keeping your powder dry" and so on. Moreover, the weapons were lightweight and inexpensive. Thus, all adults – women and men alike – now had equivalent access to the decisive local coercive threat these weapons represented.

Into this environment was born a young woman in the US state of Ohio, Phoebe Ann Moseley (See Cooper, 1927 and Warren, 2005). Her anecdotal story is illuminating about the human psychology of her era. She grew up shooting for economic reasons – providing game to local restaurants to help with family support. She grew so skilled that she began to win public shooting matches against seasoned professionals – one of whom would become her life-long spouse and manager.

Her success brought her to the attention of the great showman and entrepreneur William "Buffalo Bill" Cody. She became one of the stars of his traveling "Wild West" show – an extremely popular attraction of the time. Moseley is widely regarded as having been one of the greatest shots of all time. She could hit impossibly small targets at great distances, shoot moving targets out of the air and shoot from horseback with spectacular skill.

Under her stage name – Annie Oakley – Moseley went on to be an international superstar, comparable to a David Beckham or a Kobe Bryant today, for example. She played to huge crowds around the world – even meeting European royalty. It is, of course, of more than passing interest that public shooting was a very popular form of mass entertainment in this era and that Moseley's skill could make her a global celebrity. Our theory predicts that this was – mostly unconsciously – an ongoing public exploration of coercive power and ensuing renegotiation of enfranchisement.

In addition to her public appearances, Moseley trained women to shoot – thousands, she claimed – many of whom trained others. This continued throughout her life. Six years before her death the 19th Amendment to the American Constitution was passed – its first sentence reading "The right of citizens of the United States to vote shall not be denied or abridged by the United States or any State on account of sex".

Consider the following. For the ca. 5500 years since the founding of the first archaic states women were never politically enfranchised in any state anywhere. This is predicted to emerge from two interacting factors. First, locally decisive coercive weaponry imposed physical demands and opportunity costs that made them more readily accessible to those playing male roles in reproduction and being physically larger. Second, sex is a conveniently transparent identifier, essential to the functioning of exploitative elite coalitions – precisely analogous to the case of skin color above.

In the late 19th Century new locally decisive coercive weapons became available that gave women fully equal access to coercive threat. *Within a single life time* of the wide availability of these weapons, women became politically enfranchised *for the first time in thousands of years*. Women were now in a much improved position to renegotiate operative social contracts.

This is a remarkable temporal correlation – one our theory predicts. If you feel intuitively that a causal connection between access to coercive threat and enfranchisement here is unlikely, we suggest that your intuition is misleading you.

Another American event from the early 20th Century further illustrates this continuing democratization. In Ludlow, Colorado the business interests of elite capitalist John D. Rockefeller ran a coal mine worked by mostly immigrant workers exploited rather badly. [See pages 346-349 in Zinn, 1995.] With support of the nascent United Mine Workers, the Ludlow miners struck. They were immediately evicted from their lodgings in the "company town" and erected at tent city nearby. They were harassed initially by paid goons – "detectives" from the Baldwin-Felts Agency – and eventually by the state's national guard troops deployed by the governor at the behest of the mine owners.

A raid of the tent city resulted in the killing of several individuals including men, women and young children. The striking miners were armed and took to the hills, pursuing a local civil war with the national guard troops now being actively funded by the

Rockefeller interests – the Colorado Coalfield War, it was called. The miners were able to hold their own in skirmishes.

This local civil war was ultimately suppressed when the American President, Wilson, sent in Federal troops to disarm both sides. Fewer than 200 people were killed. Notice how different this was than murders of untold thousands of disaffected workers and peasants by contemporary elite interests throughout Eurasia – including the ostensibly democratic Red Army of Trotsky and Lenin in the decade immediately following Ludlow (reviewed in Chapter 5 of Ferguson, 2006).

The United Mine Workers went on to successfully unionize American miners. The Rockefeller interests spent a generation trying to undo the public relations damage from this event.

26 See Chapter 5 in Ferguson (2006) and Chapter 2 in Hobsbawm (1994) for reviews of these events from two very different perspectives and sympathies.

27 Reviewed in Doyle (2002).

28 Of course, colonial powers – like the British against the Zulu's, for example – used these weapons and their terror to subdue massive local prey populations. However, Trotsky and Lenin were the first to use them as the basis of a self-sustaining modern terror state.

29 The Russian civil war has several other useful lessons for us.

First, the tremendous global power of the ostensible ideals of Bolshevik Revolution attest to the universal demand – through the present – for democratic empowerment. This massive demand remains a formidable potential source of coercive/political power – though a source of power, when disarmed, susceptible to being exploited and betrayed by heavily armed elites.

Second, the Russian civil war began in an environment where coercive power was highly concentrated. There was no simple, direct path to redistribution of coercive power and it remained centralized. The only immediate question was who would capture this elite power. Once captured, it was utterly inevitable that this elite power would be used to serve the interests of those who held it, as it was.

Notice especially that humans never willingly surrender any coercive power they hold. Coercive power is the most precious adaptive asset a human can own and our evolved psychology makes it utterly impossible for us to willingly surrender it. Our use of coercive power can only be restrained by others who also hold coercive power – there is no alternative. By the end of the Russian civil war, Trotsky, Lenin and the Red Army confronted no competing source of coercive power inside of Russia.

Notice also that it may even have been that some members of the Trotsky/Lenin/Red Army elite actually believed in the Bolshevik or "Communist" ideals they espoused to commoners in the course of gaining power. But any such belief is quite irrelevant. Beliefs do not dictate the course of history, coercive power does – everywhere and always.

Third, the success of the Bolsheviks in the Russian civil war illustrates another important principle. Even when a large commoner class is disarmed, they are not entirely without coercive recourse, in view of their numbers. Thus, appeal to commoner interests – even meeting some of them – will be vital to seize and maintain elite power. We expect – and reading the daily paper confirms – that even the most egregiously murderous contemporary authoritarian regimes have learned this lesson.

Fourth, notice one last implication of these facts. Had some other faction – "tsarist", say – won the Russian civil war, the outcome would have been essentially the same. We might have called the resulting state "fascist", say, rather than "communist", but it would have been a distinction without a difference. The publicly espoused beliefs of elite power matter hardly at all in how that power is used.

Put differently, the ostensible goal of a revolution – its public "social contract" beliefs – are quite irrelevant to its outcome. It matters not a wit whether the goal is "socialism", "liberation", "democracy", "decolonization", "religious/moral rectitude", "divine right" or any thing else we might imagine. The only thing that matters is the distribution of the access to political – read coercive – power. Everything else is merely persiflage and window dressing. All attempts to right the wrongs of elite power by seizing elite power will fail – everywhere and always, if our theory is correct.

The question becomes, then, how can we authentically democratize the many elite-controlled states that still exist on the Earth? This is, without doubt and by far, the single most important question facing us as citizens of the contemporary global human community. We will return to this vital matter in Chapter 17. We will argue that there are ways, there is real hope.

30 See Jansen (2000) for a well-annotated review of the massive body of scholarship on the history of Meiji and modern Japan.

31 See Craig (2000) for a detailed review of recent scholarship and Jansen (2000) for an excellent contextualized overview.

32 Reviewed in Chapter 8 of Ferguson (2006). Also see the review in Chapters 15-18 of Jansen (2000).

33 Quoted on page 290 of Ferguson (2006).

34 Reviewed in Ferguson (2006).

Chapter 16

The pan-human population takes full ownership of planet Earth – aircraft, nuclear explosives and the emergence of the pan-global human village

1 These figures are from atomicarchive.com. Though there is some controversy about the exact death toll – and subsequent deaths as an indirect result – the fact that the number killed was unthinkably enormous is not in serious dispute. A Google search of this topic gives a good reading of the persistent controversy about these death tolls.

2 Death toll estimates range from 25,000 – thought to be the most realistic – upwards to much higher estimates. A Google search of this topic gives a good reading of the persistent controversy about these death tolls.

3 Note that the global "free trade" of the late 19th Century was based, in large measure, on the British Empire, directly and indirectly. This Empire, in turn, was based on an inherently temporary and unstable military ascendancy of Great Britain and did not last.

4 Though we have high confidence in this fundamental conclusion, this problem needs much more extensive analytical treatment. For example, a detailed game-theoretic analysis of the actions of state-level entities will be of the greatest interest. We have made some progress on this problem (Bingham, Souza and Okada, unpublished work). We hope and expect that others will also take on this crucial issue.

5 See Chapters 2 and 6 in Kramer (2007) for a detailed account of the World War I case.

6 See Johnson (1998) pgs 780-783 for specific production figures. See Ferguson (2006) Chapter 15 and Zinn (1995) Chapter 16 for two overviews of American industrial might in World War II.

7

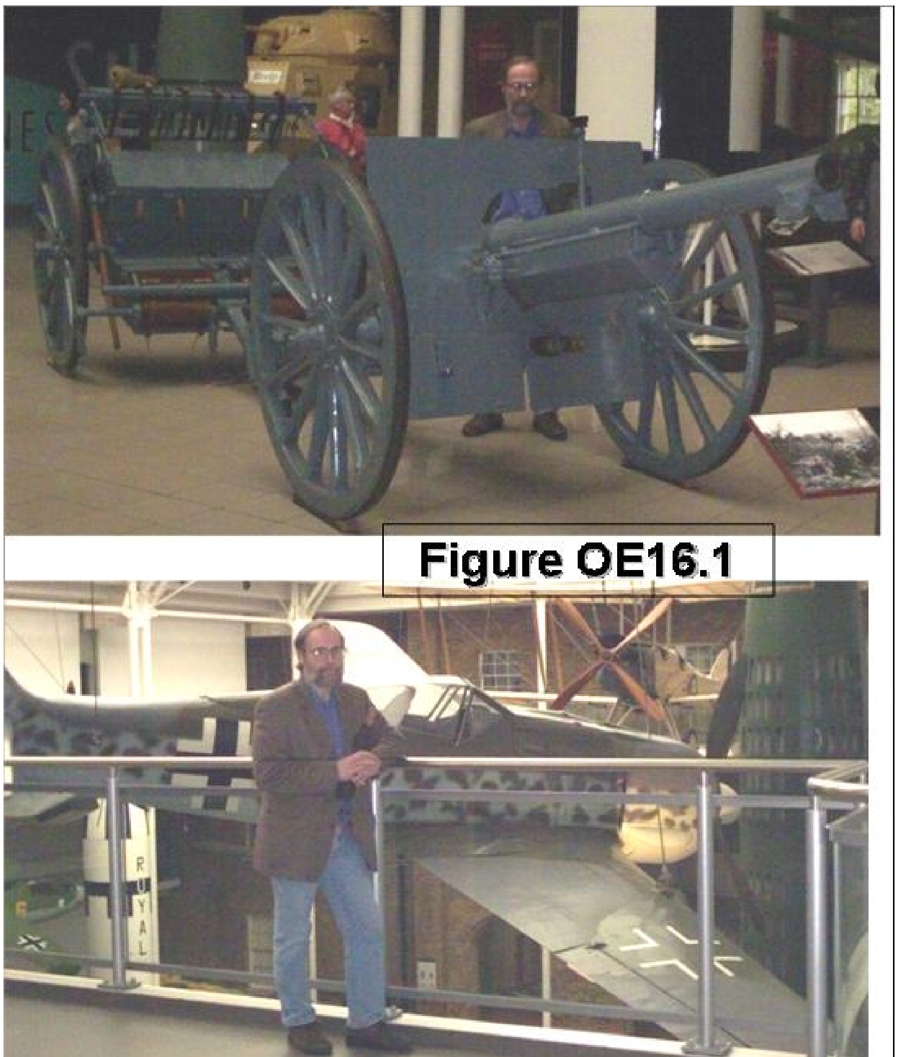


Figure OE16.1: Paul examines a World War I artillery piece (French-75; top) and a World War II vintage fighter (bottom) in the London War Museum. (photographs by Joanne Souza)

Figure OE15.2: One of the authors examines World War II vintage fighter aircraft at the Palm Spring (California, USA) museum.

[8] See Murray and Millet (2000) for a detailed discussion of Allied tactical and strategic use of aircraft in the context of complete battle planning. See Bergerud (2000) for the details of Allied aircraft performance and properties.

[9] See Ferguson (2006) Chapter 4. See Chapters 2 and 5 in Kramer (2007).

[10] See Ferguson (2006) for a general discussion. See Bergerud (2000) and Sparpe, et al. (2001) for a description of the aircraft.

[11] See Johnson (1998) pgs 780-783 for specific production figures.

12 See, for example, MacNamara (1983); Jervis, (1988); Cimbala (1996); and McCGwire (2006).

13 See Wight (2006) for a pentrating, illuminating discussion of the run up to the World Trade Center strikes on September 11, 2001 in New York.

Chapter 17

Final considerations -A humane future from our evolutionary past

1 Maddison (2001 and 2005), Chapter 10 in Clark (2007).

2 See Chambers and Mingay (1966) and Overton (1996) for discussion of the "modern agricultural revolution" in England.

3 For reviews, see, for example, Rosenberg and Birdzell (1986); Maddison (2001, 2005); Mokyr (2002); Bernstein (2004); and Clark (2007).

4 See Chapters 15-17 in Clark (2007) for a review of the relevant economic analyses.

5 See, for example, North and Thomas (1973); Rosenberg and Birdzell (1986); and Maddison (2001, 2005). Notice that none of these historical economists grasps the central causal role of self-interested coercion in these "modern" processes; however, Douglas North has come closest to beginning to explore this issue.

6 See pages 340-370 in Clark (2007) for a review of this particular example of the democracy effect on worker productivity.

7 See Schama (2000) volume III.

8 The trans-national support of individual contributors to the formal knowledge enterprise has been especially important over the last century. Individual investigators in authoritarian social systems can sometimes make contributions – most often "theoretical" contributions that depend on information imported from democratized social systems and that require relatively little of the know-how more widely available to enable experimental science in democratized societies. However, these individuals can gain substantial primary and secondary return from their work through the institutions of democratized states. For example, Albert Einstein was able to emigrate from Nazi Germany to the US and many scholars routinely leave authoritarian cultures for more rewarding positions in democratized cultures.

9 Again, we propose several working hypotheses for the psychological origins of gun control views. Those who favor broad citizen access to coercive means (within the US) are predicted to include individuals who perceive themselves as members of a potentially powerful majoritarian interest group. In contrast, those who favor restricting citizen access to coercive means include those who perceive themselves as elite benefactors of the contemporary status quo (government officials, university professors, corporate executives, etc) or as vulnerable minority targets of a potentially hostile majoritarian interest group.

Notice especially that these predictions are apparently orthogonal (or even actively contradictory) to the interpretations of some psychologists studying this phenomenon (see, for example, Kahan and Braman, 2003). Resolving these *apparent* contradictions will be of the greatest interest.

One example will illustrate our concerns with the present data. Kahan and Braman (2003) use survey assays yielding the result that individuals who are "egalitarian" in their attitudes are more likely to favor legal restriction of access to coercive means. Superficially, this can be construed as contradictory to our predictions. However, we note that individuals who consciously think this way may actually feel unconsciously powerless and vulnerable, invoking egalitarianism to recruit new allies. Moreover, they may support gun control (unconsciously) to reduce the coercive advantage of a majoritarian coalition by which they feel threatened. It should be possible to design experimental psychology and other studies to distinguish between these interpretations.

We emphasize, again, that we are agnostic about legal restrictions on the public transportation of guns by non-professional users (Lott, 2000; reviewed in Kahan and Braman, 2003). Private weapons in crime control is *not* relevant to our discussion, only private access to weapons for the ultimate ability to "police the police" (and the military).

10

"Difference", hate, war terrorism and human political psychology

The whole aim of practical politics is to keep the populace alarmed (and hence
clamorous to be led to safety) by menacing it with an endless series of hobgoblins,

most of them imaginary.

H.. L. Mencken

We humans probably did not evolve cooperation primarily as a result of conflict with other human groups as naïve group-selectionist theories have proposed (Chapter 5). However, our ability to cooperate in large groups makes aggressive competition with other groups an occasional adaptive choice or necessity. Indeed, the needs of intergroup competition have probably been one of the persistent selective forces on the individual members of our lineage for the last 2 million years – among a number of other selective forces, of course (see Box 12.1).

Our political psychology apparently bears the imprint of this persistent selection. We are extremely susceptible to seeing other groups – distinguishable in various ways, but especially by distinct identifier beliefs (Chapter 12) – as threatening and hostile. They usually were in the ancestral past. Let's call this evolved fear "xenophobia" here.

Xenophobia is just as susceptible to being manipulated by self-interested political entrepreneurs as is, say, our sexual psychology by advertisers. When done effectively, manipulation through xenophobia is incredibly effective. All of us – authors included – are very vulnerable to having our judgments distorted in this way. And would-be political manipulators are very well aware of this.

Our new theory puts us in a much better position to understand why this is so. For example, clearly, any Darwinian excuse for elite domination or hierarchical control is largely self-justification by those who have managed to seize local coercive dominance. Help against external danger from "others" is simply an example of such self-justification. It mostly works because sometimes it has a grain of truth – usually because of the machinations of analogous self-interested entrepreneurs on the "other" side. These perverse self-justifications usually exploit the intense emotional reactions we all have to people with different identifier and social contract beliefs.

It is also useful to note that this reaction to difference is easier to exploit if it is coupled with some physical traits – sex or "race" – that are conspicuous. Indeed, as far as we are aware, every sexist and/or racist belief system in all of human history has simply been a tool and a mask for elite political control – no exceptions. This same rule applies to ideological purity – where cultures with different political or religious beliefs are portrayed as evil and threatening. Likewise this pretext is always and everywhere a tool of elite control.

As all of us members of the pan-global human community become more self-aware we will become much harder targets for such self-interested elite political entrepreneurs.

11 Contemporary readers at this writing will remember the Enron, Worldcom and subprime lending debacles as just some of the latest in the endless playing out of this process – in these particular cases revealing hole in financial regulation and corporate governance "social contract beliefs".

12 Also see Chapter 5 in de Soto (2000) and discussions in Chapter 15.

13 See the Afterword in Watson (2006) for a recent synopsis of the Age of Jackson. See Burton (2007) for a synopsis of the Age of Lincoln.

14 Below left is the front view of the Seventh Regiment Armory building in contemporary Manhattan. At right Joanne stands in front of the massive wood doors protecting entry to the building.

15 See Beatty (2007) page 206.

16 Quoted on page 309 of Beatty (2007).

17 See Forbath (1989) for a review of these events.

18

The logic of "robber barons" and "organized labor" in the late 19th Century US

This American story has specific additional lessons for us. However, most readers will find it a struggle to look at these lessons objectively. All of us (authors included) have intense ethical beliefs about the growth of modern economic systems – but we must try to set them aside for a moment.

First, the great capitalists of the late 19th and early 20th Century US (Rockefeller, Carnegie, et al) created powerful new cooperative entities – corporations. Of course, corporations are merely one specific instantiation of the fundamental human unique – non-kin cooperative coalitions.

On the one hand, the owners and investors in these corporations pursued profit – often ruthlessly. This ruthlessness certainly included their treatment of their workers. On the other hand, these corporations brought incredible new wealth to many Americans – first in the form of cheap kerosene and transportation and, ultimately, in the form of cheap and plentiful food, housing and other goods. Big capital has no difficulty providing a compelling ethical rationale for its behavior.

Thus, whether we consider these corporations "good" or "evil" largely depends on our point of view. They were the products of human pursuit of self-interest, by all parties involved, as allowed and enabled by the coercive environment. This coercive environment included both the formal law and the informal coercive threat all parties could bring to bear (Beatty, 2007).

You might be thinking that capitalists and consumers were pursuing self-interest but laborer were merely seeking a "living wage" or a "decent living" – to use two common phrases from the labor movement. No doubt many workers felt this way precisely – at least consciously. However, organized labor – just like organized capital – pursues the interests of those who control its coercive assets. This may include individual workers or it may be weighted in favor of political entrepreneurs who manage labor's coercive means. In either event, however, labor – again, just like capital – will rationalize its self-interest as ethically compelling. Unchecked this would extend to extravagant wage rates and benefits with extremely high prices for the consuming public.

The point is simple. Labor, capital and consumers all represents collections of self-interested individuals. How their pursuit of self-interest is policed and managed by the democratized coalition of the whole determines how we all live.

How such events can be more humanely managed in the future is a crucial question for all of us – specialist and citizen alike. However, again, these events are simply the human trick – pursuit of self-interest in a managed environment. They will be the story of our future just as they have been our past. To build a more humane future we must understand them and manage them transparently but wisely.

Several considerations are useful grist for out common thinking mill. First, though exploitation of labor and corrupt manipulation of government were involved in the growth of massive enterprises like Standard Oil and Carnegie Steel, they also brought low-cost commodities to American consumers as we have seen. Can we create a better environment in the future where such radical improvements in productivity can be achieved without some of the toxic side effects?

This seemingly prosaic little technical question is one of the most profoundly important in the universe and for the next million years of the human future. It can be restated as follows, making its importance more clear. How can the ancient human cooperative adaptive trick best be deployed on the massive scale of state-level and planetary cooperative coalitions? The wealth, comfort, safety and insight our descendants enjoy will be almost totally determined by how we answer this question.

Second, it is illuminating to contemplate how democratized coercion can turn the "sow's ear" of extravagant wealth concentration into the "silk purse" of public good. It has before and it can again.

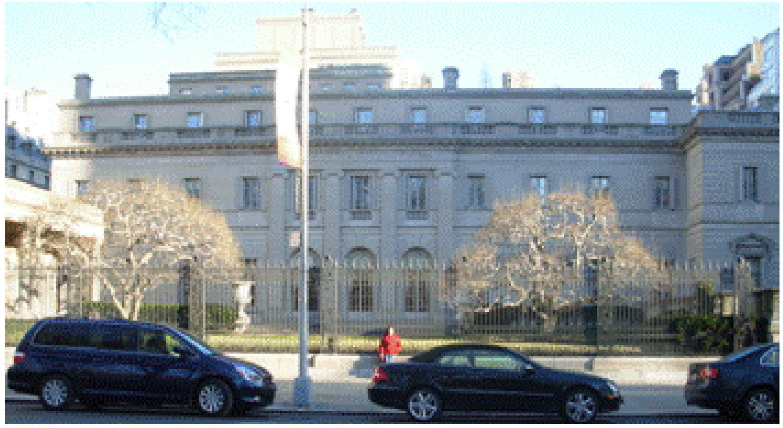
For example, Clay Frick built an extremely successful business supplying coke to the early steel manufacturers, including Carnegie – eventually even becoming a Carnegie partner. He eventually built for himself and his family a "home" on millionaire's row in Manhattan (5th Avenue, facing Central Park). He collected huge quantities of some of the most beautiful art in the world. His collection is worth hundreds of millions in today's dollars and his home is actually a spectacular, monumental museum-like setting (see image below).

His descendents subsequently donated this "museum" and its contents to the public. You can walk through the amazing Frick Collection today. It is telling that the Frick Collection is just a few block northeast of the 7th Avenue Amory (endnote 14 above) dedicated to projection of coercive threat in defense of business interests.

Further, for example, Carnegie and Rockefeller donated huge sums to the public good. Indeed, the life of one of the authors (PB) was touched repeatedly by Carnegie's legacy. First, Paul developed his avid reading habits early in life almost exclusively in a "Carnegie Library" in the tiny Midwestern town of Waveland, Indiana. His life would almost certainly have turned out profoundly differently without that library. Second, Paul then went on to make major scientific contributions in collaboration with colleagues at the Carnegie Institution in Baltimore, endowed by its namesake. Finally, as residents of New York, both authors have enjoyed the great music and entertainment still on stage at Carnegie's "Hall" (image below).

Could these same social benefits have been more humanely (or more efficiently) produced in some other way? Again, this is a vital question for the human future.

[Pictures by P. Bingham and J. Souza.]




CARNEGIE HALL
CARNEGIE HALL

19
See, for example, Popper (1945).

20

"High" democracy and wars of conquest

We have been implicitly assuming that war will not erupt between the democratized states. Is this foolish, naïve optimism? Our theory suggests that it is not.

In Chapter 16 we discussed the emergence of the contemporary pan-global human world as predicted by our theory. However, to fully understand what our theory has to say about the likely human future, we need to look at some important details of how nations behavior within this global world.

In principle, the United States could easily scale up its military investment and treat Iraq as a wholely owned tributary state. But it won't – in part, because the American electorate does not see its interests served in this way. This illuminates an important feature of highly democratized states in the way they control their coercive assets – traditionally called "civilian" control of their "military."

Foreign conquest is costly for the society as a whole, though potentially profitable for a small "military" elite subculture. States like the US make their military decisions based more on the benefits to the society as a whole than to small elites.

Similarly, for example, the US could, in principle, probably exploit its military advantages to conquer Canada. But, to Americans and Canadians alike, this sounds more like the punch line to some joke than a real prospect. Both Canada and the US are high-functioning democracies. The advantages to a typical US citizen of conquering Canada would be far outweighed by the costs of mounting and sustaining this enterprise.

On our theory this is fully predictable. The key issue is the cost-benefit ratio of projection of coercive threat. As we saw in earlier chapters, this ratio is profoundly influenced by who accrues the benefits of coercive acts. This, in turn, is determined by who ultimately controls coercive threat.

To discuss how this works, it is useful to define a term – "high" democracy and "highly" democratic states. Professional scholars have invested much effort in trying to come up with a clear definition of "democracy". As useful as these attempts have been, we suggest that our theory brings new clarity to this issue. We predict that the level of democracy is directly determined by only a single factor – the fraction of the members of a state that ultimately control locally decisive coercive threat. Other traditional "measures" of democracy are useful only to the extent that this capture this variable or its consequences.

For example, measures of voting franchise and fraction of the population participating in voting are traditional measures which do not capture much of what is important. Voting is quite irrelevant when elites are able to manipulate either electoral choices or outcomes.

In contrast, the existence of authentic competitive multiparty electoral politics correlates well with distribution of access to coercive power. Real multiparty politics reflects a powerful electorate managing competing political entrepreneurs – rather than vice versa.

In "high" democracies, the coalition of the whole controls coercive threat – even if it is usually projected in day-to-day practice by professional specialists, soldiers and police. Under these conditions, the benefits of coercive acts must accrue to the coalition of the whole in excess of their costs for coercion – including "war" – to be viable, that is, "politically realistic." Most wars of conquest would not meet that criterion.

In contrast, when coercive power is controlled by a small minority, the benefits of coercive acts preferentially accrue to this small minority while many of the costs can be fobbed off on the remainder of the – coercively controlled – home population.

Our theory predicts that the logic of aggressive state-level coercion – wars of conquest – is transparently simple. Specifically, expensive wars of conquest against relatively developed "peer" nation-states will almost never be undertaken by highly democratic states, but will sometimes be undertaken by states where coercive assets are controlled by small elites. We suggest that the historical record very strongly supports this prediction.

First, highly democratic states – like the US – often waged wars of conquest that were potentially cheap and lucrative. For example, these include the wars of conquest of the North American continent in forming the US – all waged against vastly inferior forces, like Native Americans, in pursuit of rich returns accessible, at least in part, to the coalition of the "white" whole.

Second, however, costly wars of conquest against peer states in the modern era were launched exclusively by states in which coercive assets were under elite control - Nazi Germany and Imperial Japan, for example (main text).

It is especially enlightening to notice the striking similarity in the well-documented expansion of the ostensibly republican French state under the Directory and Napoleon, the Nazi state and the Red Army under Lenin/Trotsky. Each of the three coercive enterprises paid public lip service to very different "political" and "ethical" goals; however, the underlying economic and institutional logics were essentially indistinguishable. Each state was dominated by a powerfully coercive military under nearly exclusive elite control. Each took extravagant risks and incurred exorbitant costs to generate possible benefits preferentially for a small elite.

This is our crucial first step toward understanding the future. In light of this implication of the theory and of the empirical evidence, the still-ongoing global struggle for democratization really matters. It is the most vital issue for the human future. The 2 million year human story is in the midst of its predictable next phase – the consolidation of pan-global cooperation sustained by relatively inexpensive coercive threat of global reach. This insight has pervasive practical import for the human future as we will see.

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