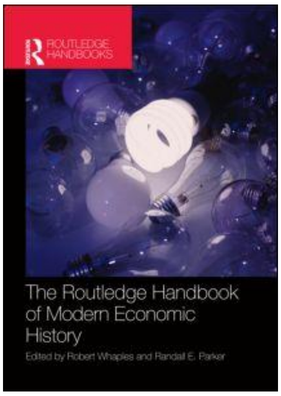

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THE EVOLUTIONARY ROOTS OF ECONOMIC HISTORY

Philip R.P. Coelho

The Mecca of the economist lies in economic biology rather than in economic dynamics.

Alfred Marshall (1890: 19)

Evolutionary biology

Evolution is the fundamental paradigm of modern biology; it lays the scientific foundations of biology beyond the visually descriptive. Evolution postulates a demand for resources by living things (organisms) that exceed the environment's capacity to provide them. The paradigm of economics – scarcity – limits an organism's ability to survive and reproduce. How well species (different organisms) adapt to the environment depends upon their genes – the building blocks of all living things. Scarcity reduces or precludes the reproduction of organisms that are relatively less effective in acquiring resources. Differential rates of reproduction ensure that the innate (genetic) traits that made organisms more effective in acquiring resources are more frequent in the next generation's gene pool. Conversely, the lack of reproduction reduces the presence in the gene pool of traits that hindered an organism's successful reproduction. There is some circularity here that is revealed in the definition of evolutionary success: survival through succeeding generations. Genes make the organism and affect all its characteristics; so, ultimately the survival (ability to successfully reproduce) of species is determined by their genes, and how well suited the genes are within the environment in which they exist.[1] Over time, the physical and biological worlds interact, producing changes in the environment to which species must adapt or cease to exist. Gene pools (the relative frequency of various genes in a breeding population) change because of natural selection, and these changes in the gene pool affect the species. Adding complexity, species can change the environment, and environmental changes may have repercussions (favorable or unfavorable) upon the species that created them.

Organisms that share enough common genes to continually reproduce are classified as belonging to the same species.[2] Another way of saying this is that a group of organisms that successfully reproduce with one another constitute a species. Still, within a given gene pool there is a sufficient variation among the genes of individual organisms (of the same species) to ensure substantial differences among organisms. For example, the domestic dog varies in size from smallest to largest by close to 100-fold (small Chihuahuas have an average minimum weight of approximately 3 pounds, while large St. Bernards have a maximum average of about 240 pounds), yet they all belong to the same species. It is necessary to point out that variation among dog breeds is not the result of natural selection; it is the result of numerous human interventions in the breeding of dogs. Regardless, within each species there are enough variations in the common gene pool to vary the characteristics of the species tremendously over generations. The results are startling; from pygmies to giants within the same species. This is also the basis for Darwinian evolution: variation through natural selection.

Natural selection leads to evolution. In successful (surviving) species, succeeding generations will be the descendants of ancestors who were able to survive the culling process of the environment, and to gather enough resources to reproduce. As noted, the genetic (innate) characteristics that facilitated the process of relative reproductive success will become more widely represented in each succeeding generation. Each generation will tend to be more genetically homogeneous as long as there are no isolated breeding populations. Countering this homogenization is the occurrence of random mutations of genes within each generation. If the net effects of the mutations assist the organism in reproducing, the mutations are pro-adaptive; if instead they reduce reproductive success, they are deemed maladaptive. Pro-adaptive genes will become more common in the gene pool as time passes, while maladaptive genes will become less frequent. But there are, as always, complications.

In sexual reproduction (many organisms are not sexual) one copy of each gene is inherited from male and female parents.[3] Human beings have two copies of each gene, but in many cases only one expresses itself in individuals. The gene that expresses itself in the individual is termed dominant; the gene that is not expressed is termed recessive. For example, in a union of a person with brown eyes with another person who has blue eyes, the resulting child has brown eyes.[4] However, the brown-eyed child will carry the blue-eye gene in its genome, and when it grows up it may have a blue-eyed child if its partner also carries that gene. Blue-eyed humans are homozygous (inherit genes for blue eyes from both parents). A brown-eyed child who is the offspring of one parent who is blue-eyed and the other who is brown-eyed is heterozygous in genes for eye color because the parent with blue eyes can only contribute the gene for blue eyes. The reason that this knowledge is relevant is because some genes that are expressed heterozygously can have beneficial effects, while if the genes are expressed homozygously they are very maladaptive. Two examples are the sickle cell gene and the Tay-Sachs gene. In a highly malarious environment, being heterozygous for the sickle cell gene is highly beneficial because it provides resistance to malaria; however, a child who is homozygous in the sickle cell gene will, in the absence of modern medicine, typically die before early adulthood.[5] A child who is homozygous in the Tay-Sachs gene dies in infancy, while people who are heterozygous in the Tay-Sachs gene are disproportionately endowed with exceptional mental powers ("geniuses"). Consequently, the specification of the *net* effects of genes is important; in certain environments even genes that are fatal homozygously expressed can have positive net effects upon a population when expressed heterozygously.

Interactions

Evolution is the story of change; but change is neither unidirectional nor simple. Change begets further change, in biology and the physical environment. For example, when the earth was newly formed the atmosphere was oxygen poor. Over billions of years living organisms (cyanobacteria are frequently implicated) through photosynthesis expired oxygen. Prior to about 2.4 billion years ago, the oxygen was sequestered in iron oxides and organic matter; when these recipients of oxygen became saturated, the expired oxygen was expelled into the atmosphere.

As the atmosphere became oxygen rich, radical changes occurred in the ecological and biological environments. Free-ranging anaerobic bacteria vanished from the earth's surface because the oxygen-rich environment that they had created over eons was inimical to their existence. An ecological niche was created and filled by oxygen-tolerant/using life-forms; these came to dominate the planet's surface. The lessons here are: 1) evolution is random and unpredictable; 2) pollution to one life-form may be paradise to another; 3) feedback effects are ubiquitous; 4) evolutionary processes are path dependent; 5) life-forms and the environment are engaged in an eternal duet, with each responding to the other; and 6) evolutionary processes work over time spans that are so long that they escape human intuition.

Evolution has no direction; it is just the unthinking process of natural selection (reproductive success) of species in environments over time. The usage of the plural, "environments," is to emphasize that environments are dependent upon evolutionary processes. Just as in history and life, there are no biological equilibria and no endings. This makes telling an evolutionary story somewhat less compelling than a narrative with heroes, villains, and a denouement. When we talk about the history of various groups, "races," peoples, and nations, it is more than a little misleading because there is just one human race. The frequencies of various genes, however, can differ among ethnic groups and the differing frequencies (caused by natural selection) can manifest themselves in visual differences that are sometimes identified with "race." The history of African slavery in the New World, racism, and regional concentration of slavery are all linked by the evolutionary heritage of the ethnic groups that came from the Old World to the New.

African slavery

Economic history places history into an economic context. The material world and humanity's ability to understand and manipulate it constrain all economic activities. The biological environment is an integral and major part of the material world. All this is common knowledge; what is less widely recognized are the profound changes that biological processes can have upon the economic and physical environments. In order to make sense of the history of African slave labor in America (the 13 colonies and, later, the United States), knowledge of the evolutionary impact of disease environments and how different populations, given their ancestral heritage, were affected by different disease ecologies is essential.

African slave labor lasted about two and a half centuries in America. Slavery and the issues surrounding it are the subject of intense debates. One important question is why American slavery was regionally specific. The South and slavery are inextricably linked, and absent the regional concentration of slavery in the South there would have been no war between North and South. Why wasn't African slavery spread uniformly about the American landscape? African slavery was tried throughout colonial North America, yet it only survived, grew, and prospered in the American South. Apparently, slavery failed the evolutionary test in the North. McGuire and Coelho (2011) argue that it failed because it was insufficiently profitable to guarantee its survival where and when it was tried in the North. Why was slavery profitable in the South and uneconomical in the North? Until recently, the commonly accepted answer to this question was climatic.[6] Because African slaves came from the tropics, they were supposedly inured to the heat, and were consequently assumed to be more productive than Europeans in hot weather. This explanation runs afoul of both physics and history. Physics because darker colors absorb more heat from sunshine, and people with darker skin pigmentation (*ceteris paribus*) are at greater risk from sunstroke. The climatic explanation runs afoul of history because in the tropics there are examples of labor of European ancestry being employed as agricultural workers; in Queensland, Australia, labor of predominately European ancestry was profitably employed in sugar cane cultivation, while in the Western Hemisphere sugar was primarily cultivated by peoples of African ancestry.

McGuire and Coelho (2011) argue that slavery was confined to the American South because those with African ancestry were more productive in the *disease* environment that eventually prevailed there. The ecology of tropical West Africa is home to a host of warm-weather diseases that parasitize human populations. Descendants of tropical West Africans are relatively resistant to these diseases because their ancestors were healthy enough to reproduce and raise their children in that disease environment. The genome of the typical European colonist was the product of a disease ecology that was deficient in warm-weather diseases, and instead the product of an environment that was replete with cold-weather diseases (influenza, pleurisy, other lung infections, tuberculosis, plague, etc.). Europeans did not have the innate defenses that tropical West Africans had to warm-weather disease because of the deleterious effects that these genes had upon populations that were not afflicted by the diseases to which the genes provided some protection.[7] The lack of any net benefits prevented these genes from becoming established in the European gene pool. When Europeans were infested with parasitic diseases, helminthic and protozoan infections that were imported from Africa with the enslaved Africans, the productivity of the European peoples declined, relative to that of people of tropical West African ancestry. Conversely, in cold-weather disease ecologies, tropical West Africans were sick more frequently and had lower productivities than peoples of European ancestries. In the tropical West African disease ecology, the side-effects of genes that endowed a resistance to cold-weather diseases were greater than any benefits these genes conferred to humans; the genes were maladaptive in tropical West Africa and could not establish themselves in that gene pool. It was not climatic conditions, but disease ecologies and ethnic differences in the susceptibility to diseases that determined the regional viability and profitability of African slavery.[8] Ironically, the American disease ecology, in turn, was heavily modified by the African slave trade. Evolution endowed tropical West Africans with genes that allowed them to survive and reproduce in the disease ecology that eventually prevailed in the South. In contrast, people of Northwestern European ancestry were relatively resistant to cold-weather diseases but had few genetic immunities to warm-weather diseases.

The differences in productivity between peoples of African and European ancestries were mirrored in the differences in infection and mortality rates for different diseases. Malaria, yellow fever, and hookworm were and are much milder when contracted by people of tropical West African ancestry; when contracted by peoples of European ancestry (in the absence of modern medicines), malaria and yellow fever are very serious diseases and frequently fatal. Helminthic diseases that are abundant in tropical West Africa have similar ethnic disparities; in early twentieth-century South Carolina, hookworm was more than twice as frequent in the white (Euro-American) population relative to South Carolina's black (African-American) population. This is even more astounding when one considers that in this era in South Carolina blacks were systematically discriminated against and routinely denied public services. Death rates (again, before modern medicine) in tropical West Africa for Europeans were typically estimated to be from the low two hundreds per thousand per year to low six hundreds per thousand per year; life expectancies for Europeans living (dying seems a more appropriate term) were around two years.[9] We do not have data for the life expectancies of Africans living there, but we know they were much higher otherwise there would have been no Africans. The data that Susan Klepp (1994) derived show that, in the cold-weather climate of Boston, Massachusetts, the life expectancies of newly imported African slaves were 12 years, while European immigrants could expect to live an additional 29+ years. These data are real and substantial; differential susceptibilities to diseases were a cause of the unprofitability of African slavery in the North, and the regional specificity of slavery.[10]

Entrepreneurship

An explicitly evolutionary approach to the history of entrepreneurship challenges the accepted canon. The conventional approach to entrepreneurship focuses on individuals or firms striving towards success. The approach explains how efforts to achieve success fared, and why they failed, succeeded, or were sidetracked. But when the future is unknown and there is no road map to follow, entrepreneurs cannot know the avenue to success.

Armen Alchian (1950) suggests an analogy: suppose people driving cars wish to leave a city but the routes they take are entirely random. Some will end up running into obstacles, some will drive into areas where there are no roads, others will be on roads where there is no fuel, and others will be lucky enough to have taken routes that are passable and are replete with fueling stations. Over historical time, we would observe that the people who had gone the furthest had acted *as if* they had a road map, when it was done entirely without conscious choice. Milton Friedman (1953) suggested another metaphor; plants act as if they want to maximize the amount of sunlight they receive. We know that the reason trees grow so high is that their genetic heritage was chosen by evolutionary processes for their relative ability to acquire sunlight. Volition had nothing to do with it. This overstates the role of chance in entrepreneurial history because humans do have memory and intelligence: copying success is a strategy that sentient beings can select. Mimicking behavior may result in success; still it does not imply understanding of why the behavior results in success. This is akin to the old story of champion pool-players acting as if they had a complete understanding of geometry, Newtonian physics, and mechanics, when they are completely innocent of such knowledge; but they do play pool superbly.

In understanding actual human behavior as distinct from the actual causes of business success, the evolutionary approach may serve better than profit maximization because profit maximization is non-operational given random processes. Even if one abstracts from uncertainty (where outcomes and distributions are unknown – what has been termed "unknown unknowns"), profit maximization is not sensible. Suppose there are two possible choices that involve different distributions of outcomes: one possible choice results in a higher mean value but it has a wide distribution of possible outcomes. The other choice has a lower mean value but a narrower set of possible outcomes. Further, suppose the distributions overlap. Which distribution is a maximum? This question does not have a meaningful answer because the choice is between *distributions*. One can reasonably ask: what is the optimal distribution? But if uncertainty exists, then profit maximization is impossible. Uncertainty (a necessary condition for the existence of profits) requires that both the distributions of outcomes and means are unknown. With uncertainty there are no criteria that can lead to profit maximization. So how can one characterize business decision making?

One solution is the evolutionary approach: to observe outcomes. Firms surviving in the competition for returns greater than costs will behave *as if* they were attempting to garner profits. To survive over time, firms must have access to resources; in a market system this means that for surviving firms expenditures have to be less than revenues. The fundamental scarcity of resources guarantees this. Each generation of surviving firms has to survive, and, assuming no change (an assumption that is demonstrably false) in the economic ecology, generation after generation of surviving firms will more closely resemble the textbook models of profit maximization.

Observing the history of firms typically means observing the *survivors* of competitions for resources; this is very like the evolutionary processes. Referring to a previous analogy, genes that impart height to trees in a jungle are pro-adaptive; we can say that the trees "want" to maximize the sunlight that they capture, but this is engagingly false. Trees have no minds; the competition for scarce sunlight selects trees for height. The genes that enable height will survive and spread through the species. This is the evolutionary process. Returning to entrepreneurs, they cannot maximize any objective function because uncertainty ensures that the knowledge necessary to maximize is nonexistent. In their ignorance, all entrepreneurs grope to find ways to survive; typically this means having revenues exceed costs. Those firms whose entrepreneurs succeed at this task may continue to populate the economic ecology; those that do not are culled from the economic landscape. Entrepreneurs do not have a text to follow; what behaviors they adopt may or may not be suitable for their environment. Surviving firms will have to acquire more resources than they expend; in market exchange the positive difference between revenues and expenditure is called profit. So passing the evolutionary test (survival) does mimic profit maximization, but is it because of knowledge, innate genius, random chance, or something else? The study of entrepreneurs is often predicated upon the genius inherent in the successful; on the other hand, a close examination of individual entrepreneurs (see Thomas [1969] on Henry Ford and the automobile) suggests that the economic ecology, luck, and slightly more talent and/or foresight are what determine success in entrepreneurship. Genius is nice, but it assures neither success nor wealth. Persistence, attention to detail, and monomania appear to be more prescriptive of success than pure genius. Nevertheless, innumerable studies (granted these are typically not in the literature of economic history) appear extolling the genius of various moguls of industry and finance.[11]

The point is that the survival of firms may be characterized by the marketplace culling unsuitable products and high-cost providers; indeed, this is the competitive marketplace. The profit maximization postulate is useful as an explanation of *why* firms survive and an *as if* prescription for the behavior of firms and entrepreneurs. The assumption that entrepreneurs want their firms to survive explains why there is a non-*ad hoc* explanation of why firms mimic other firms. In the recent past, IBM, General Electric, and Japanese industry in general have all served as models to be emulated by businesses. Why was there so much copying? Because these firms were, at the time, perceived to be highly successful and it was thought that, if firms emulated them, the imitators were more likely to prosper. Management wanted their firms to survive, and what better way to survive in an unknown environment than to imitate the successful? After all, there are multitudes of ways to fail, ways to succeed are scarce; this is why we have books and speakers extolling particular paths to success, and children of all species depend upon family instinctively copying older generations. Imitation and tried-and-true paths may not be exciting, but not being exciting is a survival strategy.

Again, many of the results of employing the survival hypothesis resemble the results of conscious profit maximization, but the stories are very different; it is not the genius of the particular individuals (like Ayn Rand's John Galt) but the environment that allows multitudes of would-be entrepreneurs to strive and succeed in the marketplace. The survival hypothesis is more dynamic than profit maximization (which is by definition part of static economic analysis) because it involves continual feedback effects, and the survival hypothesis does not depend on any single being or event (the historical equivalent of the dramatist's *deus ex machina*). Economic growth, industrial and other "revolutions" depend not on individual genius but on the economic ecology. The study of entrepreneurs focuses upon the individual; this would be analogous to studying an individual tree, like the General Sherman in the Giant Forest of Sequoia National Park. We can learn from the study of individual trees, but we learn a great deal more from studying the forest ecology that allowed giant trees to come into existence and endure. In economic history, what type of story provides more knowledge? Stories that focus on individual entrepreneurs have more drama because readers can identify with the individuals and their struggles; they do pass a market test because they are popular. Less popular are stories that emphasize market conditions, constraints, and an evolving economic ecology, but they more accurately explain the ultimate causes of the development and history of economies. There are substantive differences between the two approaches; histories that focus upon rational explanations may never be popular literature, but they attempt to explain and educate, tasks that an emphasis on the individual has yet to achieve.

Industrial revolutions

Economic history has devoted considerable attention to issues surrounding industrialization and, in particular, why England does or does not deserve to be credited as the first and prime mover in what is termed the "Industrial Revolution." Biological processes and metaphors cast these debates into somewhat different perspectives. First, *was* there an industrial revolution? If there were one, then some very perceptive observers (Adam Smith, David Hume, Samuel Johnson, and Edmund Burke, to name a few) did not recognize that they were living through a "revolution." Second, if we ask, "When did you become old?", what would the answer be? This is not a sensible question because both age and its perception are relative. A child of 3 years old thinks of a child of 12 as grown; the aging process is continual and, indeed, it never stops until death. Aging is an ongoing process that continues as long as life; dating a fixed point as old is neither accurate nor does it provide insights. We talk about the development of artists, writers, and scholars as ongoing processes; dating it as we do wars obscures the maturational process. Similarly, the transition from a primarily agricultural and mercantile society to one that had a large, if not dominant, manufacturing sector was a process that was arguably less rapid than the process of human aging. Consequently, if there were an industrial revolution, like the aging process, it was only noticed retrospectively. The impertinent, yet revealing question that the child asks – "When did you grow old?" – is in this same vein.

Whether England deserves primacy in any industrial revolution is an issue that does not concern this chapter; its concern is what the answer to this question reveals. Assuming that England was first to industrialize, does this mean that, if it had been unable (e.g. if some natural or man-made catastrophe occurred) to fulfill this role, humanity would still be confined to speed limits dependent upon animal power, or, a little bit more realistically, that industrialization would have been postponed by decades or longer? Most serious scholars do not entertain these extreme alternatives, and leave them to the authors of fantasy. If England were somehow not able, there were other candidates to lead the process, perhaps not as soon and less rapidly, but still over historic time, absent England's primacy, the economic landscape of the early twentieth century would not have been much changed.

Consider the "new economic history" and the hypothetical alternative; the importance of any single innovation, individual, or resource is of relatively small importance because there are always substitutes. Relative to gross domestic product, the assessments of the magnitude of any beneficial development are relatively small because economy-wide there are relatively good substitutes. In the case of England, there were textile industries throughout Europe where innovations were being pursued because they were perceived as potentially lucrative; in the absence of English innovations, there would most probably have been Dutch, French, Irish, Scottish, Welsh, or German innovations. This is a probabilistic statement; but consider the biological analogies – eyesight and flight have arisen numerous times through mindless evolution; so what is the likelihood that substitutes for John Kay, Richard Arkwright, and James Hargreaves (to name some of the more prominent in the historiography of the textile "revolution") would have come forth from non-English textile producers consciously seeking cheaper production techniques? Observing the history of technology, there has been no new successful technology that was the creation of one individual who had no close rivals.

Alternatively, what is so important about being first? In a competitive landscape (both biological and economic) natural selection chooses winners and losers from among the competitors. Going back to the trees seeking sunlight analogy, the genetic characteristics of the tree determine its height and its ability to garner sunlight, and these determine the growth of trees; but discovering which individual tree germinated first is a question that is relatively uninteresting. So why should economic historians be concerned with primacy? Sony was first with the Betamax, yet it was replaced by the VHS system, which was supplanted by DVDs, that are/were supplanted by other developments. The video-recording industry is illustrative; the times are changing, and this is not a new development. Still one very good reason for examining primacy is the ability to discern the background conditions conducive to economic growth; yet within the same economic ecology one would expect similar economic institutions to emerge, and, if they do not, then why they did not is an interesting question.

How did the economic ecology differ between England and its continental competitors? One difference that has been commented upon (but still deserves more attention) is that until 1844 most firms in England were unincorporated (they had no corporate charter, thus no legal identity separate from owners). Legislation adopted in 1844 changed that, but it was still 10 years later before limited liability was adopted. On the continent, corporations were more common than in England until at least the mid-nineteenth century; how was the growth of England and its firms affected by the absence of corporate charters and limited liability? Obviously it was possible to have large firms without these institutions, but what were the differential costs entailed in finding substitutes, and then working with them? Because of the rapid adoption of the corporate form and limited liability when they became available, we know that their substitutes did not function as well as the corporate form. But we do not know what the actual costs were that British firms had to bear because of the difficulties in adopting the corporate form.

Biology helps get a handle on these costs. The evolution of flight, eyesight, echolocation, and communal living all developed in entirely different species many times. This suggests that, if there is an ecological (read economic) niche, random processes and evolution will eventually fill that niche. If in the prevailing environment there is a feasible (one that can reasonably arise through random processes from the resources at hand) mechanism that provides a competitive advantage, then some variant of the mechanism will evolve. Yet there remain unanswered questions: how soon did substitutes arise and how adequate were they? Extrapolating from biology and applying it to the economic ecology, the extra costs to the British economy because of the absence of incorporation seem to have been small. Issues remain. If institutions are crucial to the development process, what is the contribution of a single institutional innovation, and, if there are many substitutes for a particular innovation, are there causes more fundamental that create the conditions for the growth of institutions?

These questions are easy to ask but hard to answer; still it appears that institutions reflect the economic ecology in which they evolved. Economic institutions, like biological species, transplanted to a foreign environment frequently have difficulties in establishing themselves.

Final comments

The epigraph of Marshall's *Principles of Economics* (1890) has inscribed on it the Latin phrase: *Natura non facit saltuum*. Roughly translated, it means: Discontinuities do not appear in nature. This means that economics is about observable reality, and there is a long lineage directly linking past to the present: history does matter. We cannot escape the past. Who we are is determined by our genes and history. Our genes are the results of a long line of evolutionary selection, going back to the beginnings of life on this planet; they were selected for combinations of traits that enhance the probabilities of survival and reproduction. The ancestral environment in which our forebears lived manifests itself in who we are; the results range from the inconsequential to those that alter history. We ignore biology at our peril because it is part and parcel of material reality. The stories of natural selection and evolution help us understand our history: past, present, and future. The biological leash that constrains humanity is a long one, but it is still a leash.

Notes

1 The "selfish gene" metaphor popularized by Richard Dawkins (1976) suggests that individual organisms are "survival machines" for genes. The implication is that genes have evolved animal bodies to carry genes forward through time. More than a few have objected to this terminology; still, the fact remains that the vast majority of genes that make people have been around for millions of years. Humans have finite life expectancies, but the genes that comprise and make individuals are potentially immortal; this gives meaning to the "survival machine" terminology.

2 "Continually" is an important condition; hybrids (a cross between two separate species – for example, a mule, which is a cross between a donkey and a horse) are usually sterile; one of the definitions of a (sexual) species is that the offspring of males and females can reproduce. A horse and donkey can mate but their offspring are usually sterile; thus, horses and donkeys are different species.

3 Sexual reproduction is important because it provides a way of disseminating genes relatively rapidly through a population and it is an additional avenue for creating genetic variations. In human history this is important because different people (ethnic groups) have different frequencies of genes within their chromosomes (chromosomes are groupings of genes; each human has 23 chromosomal pairs for a total of 46 chromosomes: 23 from each parent). Over generations, people (the individual organisms that concern us most) who are most able to survive and reproduce in a given environment will have a chromosomal heritage that is the result of natural selection in their ancestral environment. There is only one human race (*H. sapiens*); nevertheless, since the Earth's environment is not homogeneous, we neither expect nor observe genetic homogeneity among the peoples of the world.

4 This assumes the brown-eyed parent was not carrying a recessive gene for blue eyes. Even here there are exceptions; people are (infrequently) born with one eye blue, the other brown. While exceptions are fascinating to specialists, they are of lesser interest to people who just want a familiarity with the subject.

5 A child born to parents heterozygous for the sickle cell trait has a 1 chance in 4 of receiving the sickle cell trait from both parents; a child with two copies of the sickle cell trait has the genetic abnormality termed "sickle cell anemia" and, in the absence of modern medicine, will usually die before reproducing. For more about both sickle cell anemia and Tay-Sachs disease, see Wailoo and Pemberton (2006).

6 Racism (or, more broadly, xenophobia) is sometimes utilized as an ancillary, or even primary, explanation for the existence of African slavery. However, racism is neither a sufficient nor necessary condition for slavery, nor does it explain why the use of African slaves in agriculture was regionally specific during the colonial era. Many New England colonialists experimented with using slave labor in agriculture; various forms of slave labor were used throughout the New England colonies during the colonial period, although, because of fears of uprisings and high death rates, American Indian slavery diminished and was finally eliminated in the early eighteenth century. (See Mann [2011] for a general depiction of Northern slavery, and Manegold [2011] for a case history of slavery on farms in New England.) New England merchants, sailors, and speculators were heavily involved in slave trading. The evidence indicates that the regional distaste for slavery was not embedded in the colonial New England soil. There was racism in both the North and South throughout the colonial period; consequently, if racism were the cause of slavery, why did it not survive in the North? Both racism and slavery existed in the North, yet a widespread, slave-based agricultural economy did not persist because it was less profitable than agriculture based on free (non-African) labor. The attempts to establish slave-based agriculture in the North and racism's existence in the North during the colonial era illustrate the difficulties of using non-economic reasoning (racism) as an explanation for widespread African slavery persisting only in the South.

7 Recall that, on average, every fourth baby born to parents who are heterozygous in the sickle cell trait will be homozygous in the trait and, thus, doomed to an early and painful death. It should be recognized that the North American New World was sufficiently less malarious than tropical West Africa; the protection the sickle cell gene (and other genes) provided against malaria was more than offset by their negative effects. The result was that these genes were maladaptive in America. Evidence for this statement is provided by genomic research; the anti-malarial genes are expressed substantially less frequently in the contemporaneous African-American gene pool than in the present-day West African gene pool – the ancestral gene pool of most African-Americans. Conversely, genes that provide some protection against influenza are disproportionately expressed in the African-American gene pool relative to the West African gene pool, reflecting disparate evolutionary pressures of the influenza virus (see Wenfei *et al.* (2012).

8 In the Australian sugar plantations, there were much fewer warm-weather pathogens *because* there never was any consequential trade in Australia of African slaves; consequently, most pathogens that were abundant in tropical West Africa did not become established there.

9 On life expectancies for Europeans in tropical West Africa, see Mann (2011), McGuire and Coelho (2011), and Thornton (1992).

10 McGuire and Coelho (2011) provide details on the various disease environments in colonial North America.

11 See Jonathan Hughes (1986) for an explanation of why economists/historians should focus on the individual entrepreneur. The literature on the great man in business is abundant; two relatively recent examples are Chernow (1998) and Isaacson (2011).

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