

2005 Congress of Neurological Surgeons Presidential Address

Homogeneity and Heterogeneity: Lessons from Nature and Society

Nelson M. Oyesiku, M.D. Ph.D., F.A.C.S.

First, a warm welcome to all our members, domestic and international, who have come to Boston for the 55th Annual Meeting of the Congress of Neurological Surgeons (*Fig. 1.1, A and B*). It has been a wonderful opportunity to serve as the President of the Congress of Neurological Surgeons (CNS). I am indebted to my parents and extended family for their incalculable lifelong influence. Thanks to my wife and children for giving me the time, latitude, and support to get through my assignments. Thanks also to the many individuals who offered me the opportunity to get into the field of neurosurgery in the first place: Robert Jones and Howard Richter, then of Lankenau Hospital in Philadelphia—RKJ and HAR, and Loren Amacher at the University of Connecticut-Hartford Hospital; from Emory University, George Tindall, Suzie Tindall, Roy Bakay, Austin Colohan, and Dan Barrow, who has been more a brother than a colleague; Don Wigston, my Ph.D. thesis advisor who introduced me to the rigors of basic research, and, finally, my partners and support staff at Emory.

Within the Congress past and present, there have been many, too many to mention, who were responsible for supporting me in the CNS. I thank my executive committee and the CNS staff for their dedication and volunteerism. Thanks also to the joint section, AANS, and CNS leadership for their collegial approach to advancing the cause of organized neurosurgery.

In my Presidential Address, I will share with you some observations regarding homogeneity and heterogeneity. I will examine these concepts from the standpoint of Mother Nature and Society. I will confine myself to the topics of Ecosystems, Geography, Genetics, Biodiversity, and the Physical World of Elements, and I will examine different civilizations. Finally, I will make a case study of the United States and then close with a few lessons.

What do we mean by the concepts Homogeneity and Heterogeneity?

Homogeneity is the quality of being similar or uniform and heterogeneity is the quality of being diverse or incomparable.¹

I will use these concepts and look to ecosystems and geography. My thesis is quite simple: ecosystems provide the environmental goods and services upon which human life depends. Ecosystems are varied and preservation of the variety is necessary for the preservation of species, which is essential to survival.²

Ecosystems vary from sandy beaches to lush rain forests and dry deserts, each with unique species. The greatest biological diversity is found in the tropical regions of the world, with large concentrations in rain forests, coral reefs, lakes, and the deep sea. Rain forests occupy only 7% of the land area, yet they contain the majority of the Earth's species. The Amazon River, the second longest river in the world, carries 20% of the Earth's fresh water. The associated rain forest is the size of 48 of the 50 states in the United States and contains more species of plants and animals than any other place on Earth (*Fig. 1.2*). An area the size of Ireland is destroyed in these forests every few years, and at the current rate of deforestation, 17,000 species will go extinct every year, which is more than 1000 times the rate before man arrived on the planet.³

Common to four continents are large expanses of wetlands. These areas support numerous plants and animals adapted to the unique conditions. A great example of this ecosystem is the Florida Everglades, another is the Pantanal Wetlands of South America, considered to be the world's largest wetlands.⁴ Not only do these wetlands harbor species diversity, they also protect man's habitat by providing an environmental buffer, for instance every 2.5 miles of wetlands reduces the storm surge by one foot, a fact we were painfully reminded of in the recent environmental catastrophe in the Gulf coast region of the United States.

Mediterranean ecosystems number only five regions in the world; they are rare and highly distinctive and harbor 20% of the Earth's plant species. The Mediterranean region of



FIGURE 1.1

South Africa is particularly distinctive because it is the smallest and richest unit of the world's six floral kingdoms. The diversity of plants here is mind-boggling. More than 8000 species of plants occur in the area, 5000 of which do not occur anywhere else in the world.⁵

Alteration of ecosystems is the greatest threat to the richness of life on Earth. Experts think species extinctions are occurring at the fastest rate in human history (Fig. 1.3). Consequences include the loss of species that could provide future medicines, crops, and biotechnology research, as well as major climate disruptions.²

I will now examine the influence of geography on human interactions. As noted by Jared Diamond, Professor of Geography and Physiology at the University of California, Los Angeles, geography presents people with more or less natural resources and, secondly, geography shapes or limits opportunities for cultural interaction and the advancement that comes out of that interaction.⁶ I volunteer two exceptions: first, the so-called "resource curse," notably endemic to some third world nations of Africa and the Middle East; and the second through converse observation, how some have made do with less resources, at least starting out,⁷ with the United Kingdom and Japan being good examples. These exceptions justify two of my favorite contemporary quotes. The first is attributed to the United States Supreme Court Chief Justice, John Roberts, who, in response to a speech writer who proposed that President Reagan say the United States was "the greatest nation God ever created," countered "God creates things like the heavens and the Earth, and the birds and the fishes, but not nations."⁸ The second equally thought provoking quote is that of the political economist Jude Wanniski, who states that "Economies are driven not by the dollars in peoples' pockets but by the ideas in their heads".⁹ With that minor digression, I will now press my

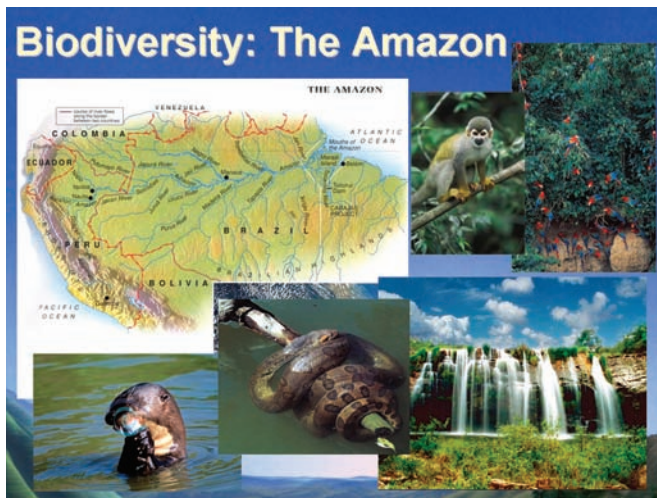


FIGURE 1.2

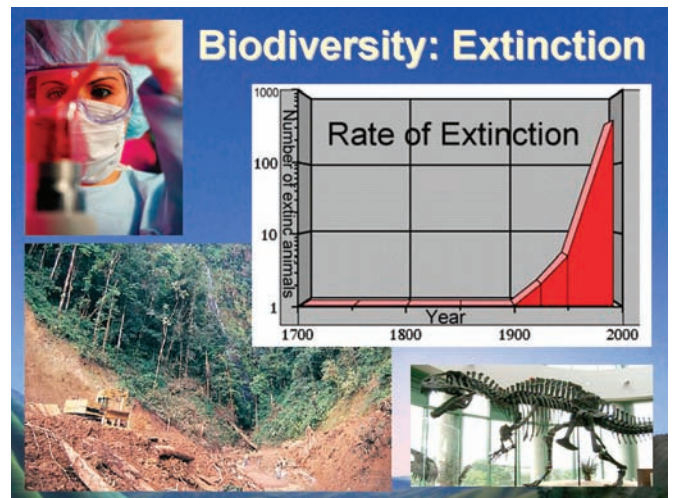


FIGURE 1.3

argument—small, isolated islands in the sea have rarely been sources of major advances. There are islands on land as well. In places where fertile soil exists only in isolated dispersed patches, there tend to be isolated, fragmented cultures. Voyages of exploration are facilitated by convoluted coastlines with harbors and inlets that shelter vessels from the open sea.¹⁰

Waterways have played a major role in the evolution of nations. Virtually every major city on Earth is located on either a river or a harbor. Whether it is a great harbor, such as Sydney, Singapore, or San Francisco, or London on the Thames, Paris on the Seine, or numerous other cities on the Rhine or Danube (Fig. 1.4). New York is fortunate to have both a long, deep river and a huge, sheltered harbor. Conversely, there are entire nations in Africa without a single navigable river.¹⁰

The most famous ancient civilization on the continent of Africa arose within a few miles on either side of Africa's longest navigable river, the Nile. Even today, one of the largest cities on the continent, Cairo, is on that river. The great West African kingdoms around the River Niger and the long-flourishing East African economy based around the great natural harbor on the island of Zanzibar are further evidence of the role of geography in promoting human interaction.¹⁰ Only recently has sophisticated transportation, including high speed railways, automobiles, and airplanes, made possible those cities, such as Atlanta, that are exceptions to the rule.

None of these geographical features in themselves create a great city or develop a civilization. That is the work of humans. Indeed, many economies have been ruined by government policies. Nevertheless, differences in geography have been important in promoting human interaction and cultural advancement.¹⁰

Now let us examine biosystems. Approximately 1.5 million species have been described and at least twice that number of species remain unknown. Invertebrates make up about 99% of all animal species, and most of these are insects (Fig. 1.5). By almost any standard, insects are phenomenally successful. They were the first animals to invade the land and, later, the air. Coincidentally, but not surprisingly, they are also the most heterogeneous group. By some estimates, approximately 900,000 insect species have been identified, and entomologists believe a full tally would be in the millions. By comparison, taxonomists know of only about 4000 species of mammals. According to experts, the biological success of insects is due to an exceptional talent for evolving new traits and becoming new species.^{11,12}

Biological diversity is important to human welfare for many reasons. Crops come from wild species, and the high-yielding hybrids of modern agriculture depend on revitalization from wild genetic stock. Plants are the basis of approximately 25% of prescription drugs. For example, the rosy periwinkle, native only to the tropical forests of Madagascar, is the origin of vinblastine and vincristine¹³ (Fig. 1.6). Another example is the Pacific yew, the bark of which produces the anti-neoplastic drug, taxol.¹⁴ Other notables are belladonna, the active ingredient of which is atropine, and foxglove, from which digitoxin is derived.^{15,16}

Exotic animals also produce unique drugs, for example the Brazilian arrowhead viper that inhabits the Amazon rainforest produces toxins that inhibit angiotensin converting enzyme (ACE). This discovery led to the development of Captopril and other ACE inhibitors that are used to treat hypertension and are some of the best selling drugs in the world.¹⁷

Yet another example from the 5000 species of amphibians: in the tropical rain forests of Central and South Amer-

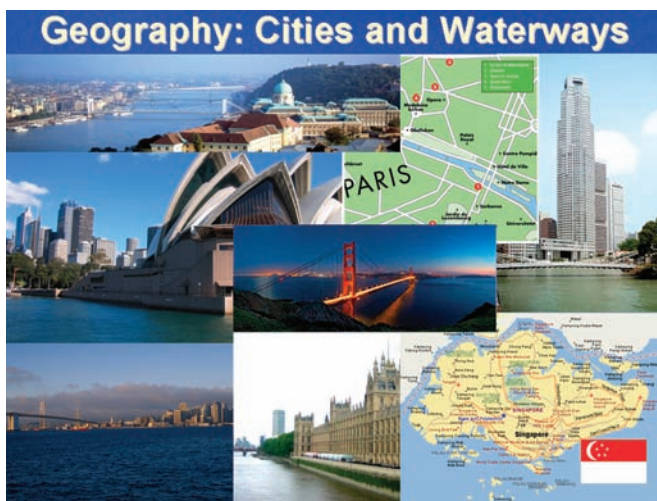


FIGURE 1.4

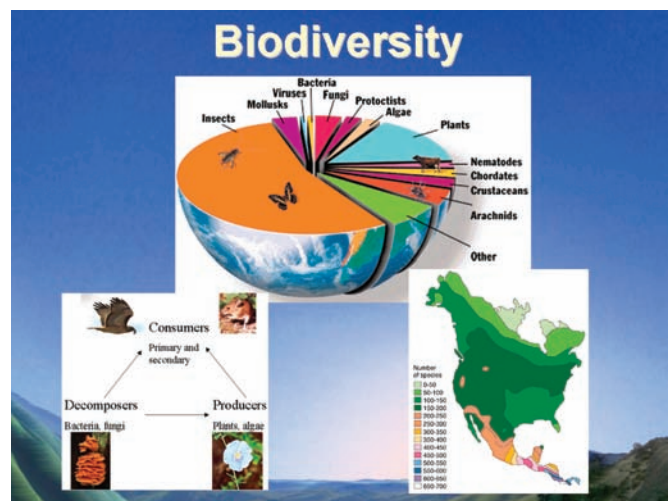


FIGURE 1.5

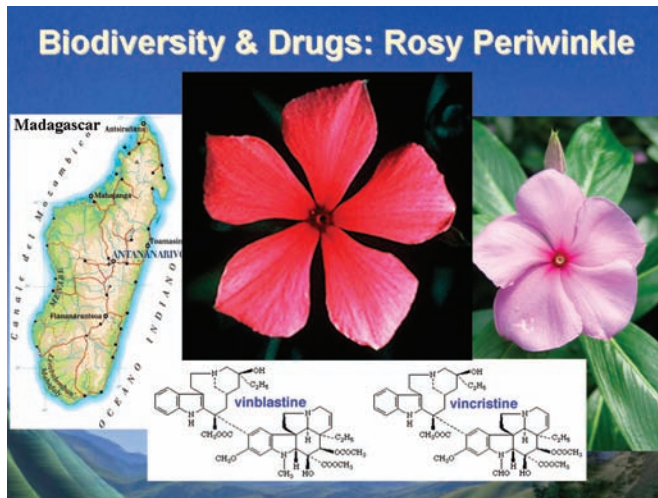


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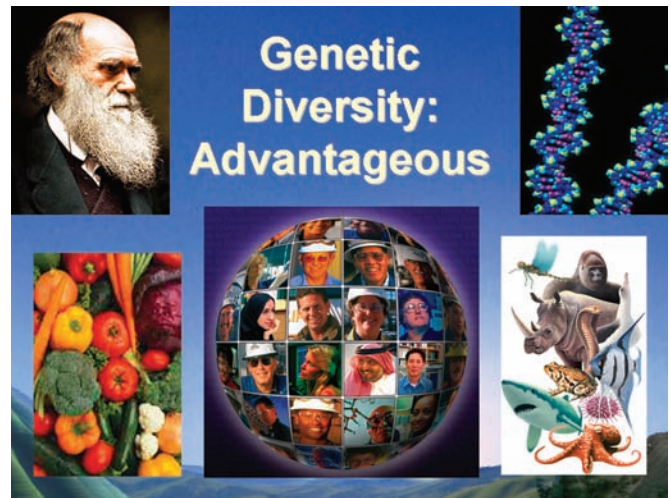


FIGURE 1.7

ica, there are species of tree frogs that secrete deadly toxins that are used by the native people as a hunting weapon. Abbott labs have isolated one of these alkaloids, which is 200 times more potent than morphine, but without the problems of dependence and withdrawal.^{18,19}

In considering heterogeneity within genes, with regard to genetic diversity, it is actually the variation in alleles that is critical. Alleles are different versions of the same gene expressed as different phenotypes. New alleles appear by mutation, genetic drift, and selection. If one has two different versions of a gene, the individual is heterozygous; if the two alleles are the same, the individual is homozygous. The measure of heterozygosity is a good indicator of the genetic variability and genetic health of a population. Predictably, the greater the genetic diversity, the better the chance that some individuals will have a variant that is suited for a new environment and that offspring will be produced to continue the population (*Fig. 1.7*). Genetic diversity is the most basic component for long-term species survival.²⁰

Consanguinity and endogamy lead to increased genetic homogeneity that, if repeated for many generations, leads to a greater incidence of recessive disorders, decreased fertility, and survival. On the contrary, introduction of new traits usually provides biological advantages.²⁰ Transgenic plants have been successfully developed to provide pest resistance, longer shelf life, disease resistance, and resistance to herbicides.²⁰ In fact, so important is the preservation of variant forms of life and species that it has been handed down by divine decree in the biblical story of the deluge, Noah's Ark.

Moving from the biological world to the world of elements, a cursory examination of the periodic table shows again the extraordinary heterogeneity of Mother Nature²¹ (*Fig. 1.8*). It is also obvious that, as with biosystems, there is merit in harnessing the advantages of differences by forming

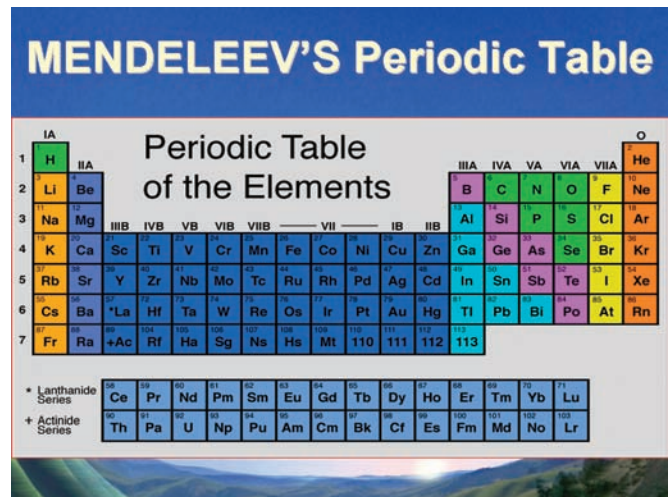


FIGURE 1.8

compounds and alloys with properties that are more desirable than their components.

Consider the alkali metals in Group 1 and their close cousins, the alkaline Earth metals of Group 2. They are all highly reactive and are rarely found in elemental form in nature. And, what would we do without the ionic salts they form with halogens or the hydroxides they form with water? Looking further, we encounter the transition metals, a paradigm for the virtues of capitalizing on differences. A few important examples:

- 1) Copper is undoubtedly an important element, but it is even more worthy as one of the components of bronze (copper and tin)—a combination so significant that it gave birth to the Bronze age. Bronze made tools, weapons, and armor that were harder and more durable than copper.

2) Zinc forms a wide variety of alloys, including, of course, brass (an alloy of copper and zinc). The malleability and acoustic properties of brass have made it the metal of choice for musical instruments as well as innumerable other uses. Brass was known to man since prehistoric times, long before zinc itself was discovered.

Of the post-transition metals, aluminum merits special mention because, in terms of quantity or value, the use of aluminum exceeds that of other metals, except iron, and it is important in virtually all segments of the world economy. Although the pure metal is malleable and an excellent conductor, it becomes stronger and harder when alloyed. These alloys have better mechanical properties.²² A final example is steel, a metal alloy whose major component is iron, with carbon being the primary alloying material that provides hardening. Nickel and manganese add tensile strength; vanadium reduces metal fatigue. Chromium and nickel are added to make stainless steel that resists corrosion and staining.²³

I will now review observations in society over centuries of human history. The entire history of the human race has been marked by transfers of advances from one civilization to another. Who would believe that the birth of agriculture occurred in today's troubled land between the Tigris and Euphrates, and not in today's bread basket of the Great Plains of the United States? As early as 8000 BC, the people of Mesopotamia, the Babylonians and Assyrians, had begun the march to written numbering, language, map-making, wheeled vehicles, and pottery²⁴ (*Fig. 1.9A*).

Greece is called the cradle of Western civilization, and for good reason. Science is full of contributions from Greek civilization—Pythagoras and his theorem, Euclid and geometry, and Archimedes, who was the first to calculate the value of π and a geometric series and also described the laws of buoyancy. In medicine, we still refer to the Hippocratic Oath, which, along with Galen and Herophilus, laid the foundations of medicine. The art and architecture of ancient Greece greatly influenced Western art (*Fig. 1.9B*). One of my favorites, Aesop, wrote his Fables in the 6th century BC. The works of Socrates, Plato, and Aristotle defined classical thought, and who has not read or heard a tale of Greek mythology, or not heard the music and voices of Maria Callas, Vangelis, or Nana Mouskouri? Greek culture was more than cerebral—the Olympic Games originated in Greece.²⁴

The Romans took over Greek civilization and adapted Greek culture. The Romans were some of the greatest builders of the ancient world. They improved on the arch by inventing the dome. Romans made concrete and Roman architects built huge structures, such as the Coliseum. To connect the empire with Rome, they built miles of roads and distributed water by aqueducts. Under Pax Romana, Latin stretched to all parts of the empire, and was the basis for the

Romance languages of French, Spanish, Portuguese, and Italian. Even German and English include words from Latin. Most European languages use the original Latin alphabet. This was, however, borrowed from the Greeks, who got it from the Phoenicians. During Pax Romana, there were 200 years of peace, law and order, and good government (*Fig. 1.9C*). As the authority of the Roman Empire declined, its territories were sacked by succeeding waves of so-called “barbarians,” bringing forth the Dark Ages.²⁴

Although the lights went out in Europe, the Dark Ages were marked by scientific and artistic advancement in centuries of Islamic civilization and culture between the 8th and 15th centuries. The conquest of Spain by Moslems in the 8th century made Spain a center for the diffusion of advanced knowledge of the Mediterranean and the Orient. Indeed, much of the philosophy of ancient Greece first reached Europe in Arabic translations, which were then retranslated into Latin or other vernacular. The Arab world enhanced and developed the arts and sciences and preserved the libraries of the Greek, Roman, and Byzantine cultures²⁴ (*Fig. 1.9D*).

Cultural advancement was by no means restricted to the West. Paper and printing, for example, originated in China centuries before they arrived elsewhere. So did the magnetic compass, which made possible the great age of exploration (*Fig. 1.9E*). During the first millennium B.C. through the middle of the second millennium A.D., before the discovery of the sea route to India, the Silk Road was a vast network of trade routes that linked the people and traditions of Asia with those of Europe. These historic routes served as a major conduit for the transport of knowledge and material goods between East and West, and were the first major global exchange of scientific and cultural traditions.²⁴

With the transfer of civilization from the Arab Empire, Europe emerged from the Dark Ages. Literacy increased and there was a radical change in the rate of inventions, economic growth, and greatly improved ships, all of which made possible the Age of Exploration, marked by the pioneering journeys of the great explorers.²⁴

While it is true that the discovery of the New World brought about a new civilization, it is not to say that complex society did not already exist there. Mexico had been the center of a succession of Indian civilizations for more than 2500 years; the Mayan and Aztec cultures had developed pottery, mathematics, metal works, and urban planning, and their capital was a marvel of engineering. Furthermore, in South America lay the empire of the Incas, master builders and farmers with their showpiece of Machu Picchu.²⁵

The so-called “Dark Continent” gave birth to the dawn of humanity, and Ancient Egypt was an advanced culture that arose 5000 years ago in the Nile River Valley and thrived for more than 2000 years. The ancient Egyptians created the world's first national government, basic forms of arithmetic,

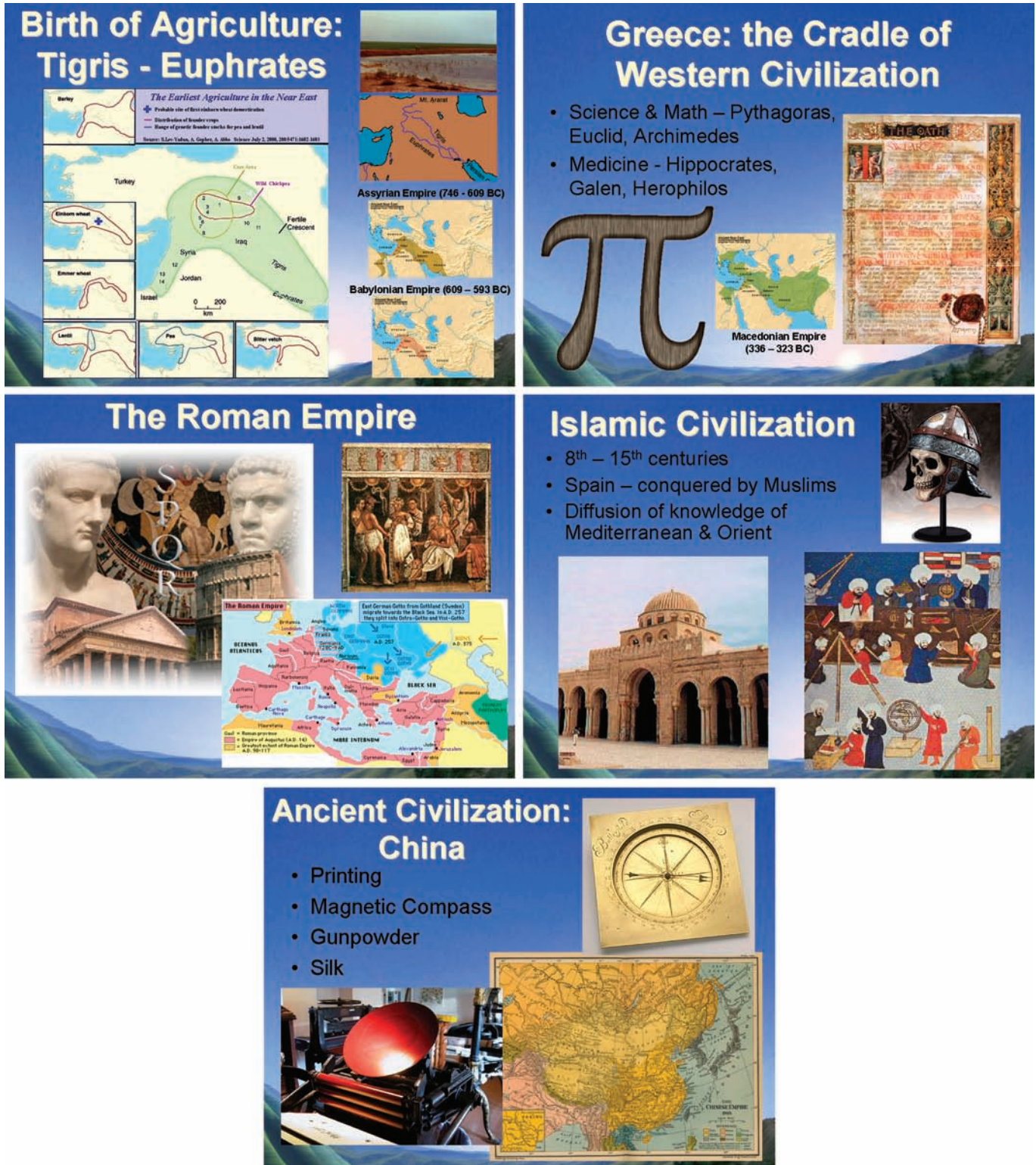


FIGURE 1.9

and a 365-day calendar. They invented hieroglyphics, papyrus, and built great cities and, of course, the pyramids.²⁶

Later civilization on the African continent was highlighted by the empires of Mali, Songhai, and Ghana who were notable for their wealth, stability and scholars.²⁶

During the Age of Exploration, the Renaissance began in 15th-century Italy, with an explosion of knowledge in science, art, and architecture. The Renaissance spread north out of Italy, arrived first in France, and then spread to the Low Countries and Germany, and finally to England and Scandinavia by the late 16th century.²⁴

In Northern Europe, the Renaissance was embellished on and supplanted by the thinkers of the Age of Reason and the Enlightenment in the 17th and 18th centuries. These movements provided a framework for the American and French Revolutions. The 200 years between 1600 and 1800 brought about a scientific revolution with the likes of Kepler, Bacon, and Galileo, and it presaged the industrial revolution, which was a period of major technological, socioeconomic, and cultural change.²⁴ This was, of course, led by Great Britain with the introduction of steam power and powered machinery. The impact of this change on society was so enormous that it can only be compared with the Neolithic revolution, during which mankind developed agriculture and abandoned the nomadic lifestyle. The mechanical and scientific inventions changed everything and made Great Britain very wealthy. At its height in the late 19th and early 20th centuries, the British Empire included territories on all continents, and comprised about one-quarter of the world's population and area. The outstanding impact of Rule Britannia was the dissemination of European ideas, particularly British institutions and culture, and English as a lingua franca.²⁴ Like the Greeks before them, the British Empire also brought many games, including my favorites of cricket, golf, and football.

The Second Industrial Revolution (1871–1914) was prompted by developments in the chemical, electrical, petroleum, and steel industries that further transformed the world. These were primarily driven by Germany and the United States.²⁴ The rise of the United States continued through the “American Century,” and today Pax Americana has replaced Pax Romana.

Clearly, civilization has changed hands many times. The historian Herodotus noted in the 5th century BC that “human prosperity never abides long in the same place”.²⁷ Karl Marx made similar observations. Cultures have enriched each other, and no culture has grown great in isolation, but a number of cultures have made historic and even astonishing advances when their isolation was ended.²⁸

Although mankind's cultural diversity is still strong, it seems anachronistic at a time when globalization is sweeping the world.²⁹ From Miami to Manila, people seem to eat the same foods, watch the same films, and drive the same cars.

People eat Peking Duck in Pittsburgh, drink Heineken in Hanoi, and stay in Hilton Hotels in Cairo²⁸ (Fig. 1.10A). Together, the different cultures of the world make up an intellectual and spiritual web of life, an “ethnosphere” that envelops the planet (Fig. 1.10B). The ethnosphere is a vast archive of knowledge and expertise. It is a catalogue of man's imagination and is humanity's greatest legacy.³⁰

The United States is undoubtedly the world's most heterogeneous society in people and materiel. Coincidentally, but perhaps not surprisingly, financial historian Professor Niall Ferguson of New York University in his book *Colossus*, notes that the United States is also the wealthiest, most powerful, and most influential nation we have ever seen.³¹ Indeed, the very motto of the country, “*E Pluribus Unum*,” or “Out of many, one” recognizes the heterogeneity of the American people.²⁸ It reflects the Founders' strong determination to create a single united country from the original 13 colonies.



FIGURE 1.10

The peopling of North America began with migrants from northeast Asia in successive migrations over the land bridge across the Bering Strait to Alaska. The arrival of Columbus launched a frenzy of exploration. Mass immigration from Europe, Asia, and Central and South America, as well as the conquering and purchase of Mexican, American Indian, and Native Alaskan lands, and the importation of Africans, brought new peoples into America.²⁴ Later, in the late 19th and early 20th centuries, more ships brought Northern Europeans from Ireland, England, Germany, and Scandinavia who were fleeing starvation, feudalism, and social upheaval, including Jewish families from Romania, Russia, and Poland being driven out by pogroms. Other immigrants streamed out of Southern and Eastern Europe. They all headed to the United States where they heard the promise of jobs, freedom, and fortunes.²⁴ In the 100 years before 1924, when immigration law became restricted before being relaxed again in the mid-1960s, 34 million immigrants landed on American soil. United States census figures show that the proportion of foreign-born people in the United States population reached 11% in 2000, the highest it had been since 1930.³² According to 2004 data, California, Texas, Hawaii, and New Mexico are all majority-minority states, as is the District of Columbia. Five others states—Maryland, Mississippi, Georgia, New York, and Arizona—are next in line with minority populations of about 40 percent.³² In spite of all of this, America is still undergoing profound demographic shifts (Fig. 1.11).

Within this structure is the promise of the American Dream, which has served as a reliable and unifying national ideology, defined as the promise that all Americans have a reasonable chance at success as they define it.³³

From the standpoint of physical and natural geography, the United States comprises seven broad divisions with an

extensive inland waterway system and has a broad range of climates. Economically, there is little doubt about superpower status, as computed by the gross domestic product. The United States remains the world’s largest economy and has more than 20% of the gross world product. The mineral and agricultural resources are tremendous and the country is a large exporter and importer of goods. America’s heterogeneity has translated into economic hegemony within one of the bastions of the modern economy—information technology. Consider the founders of Intel, Google, Sun Microsystems, Oracle, Computer Associates, Yahoo, eBay, and numerous other successful ventures.

Although all these facts translate into “hard power,” a more subtle, but equally important, kind of power is “soft power,” which, according to Joseph Nye, former Dean of the Kennedy School of Government at Harvard “is the ability to get what we want by attracting others and getting them to want the things we want,” whereas “hard power” is “the ability to coerce others by using carrots or sticks as bribes or threats.” In other words, “If I can get what I want because you want it too, it saves me a lot of carrots and sticks.”^{33,34}

Popular culture the world over celebrates American values and is a strong part of United States dominance by projecting “soft power.” American brands, such as Levi’s, Mickey Mouse, Coca Cola, McDonalds, CNN, MTV, and a galaxy of stars, all dot the world media landscape, in effect pre-programming people to accept images of American society and reinforcing its attraction. It is not an exaggeration to say that the world watches America on cinema and television. There is probably no greater stage and no greater example of the power of America’s heterogeneity than in the projection of America’s soft power, that is to say, its standing as a contemporary cultural superpower.^{33,34}

FINALLY, WHAT LESSONS CAN WE DERIVE FOR OURSELVES?

Lesson 1

Heterogeneity is the spice of life and is one of nature’s enduring principles. It generates the best traits and, on that score, trumps homogeneity. Neurosurgery as a specialty includes many different subspecialties—pediatrics, peripheral nerve, tumors, stereotactic/functional, cerebrovascular, spine, etc. All of these have their unique features. As we have seen with Mother Nature and society, this heterogeneity equals strength. Take the best traits from each, put them together, and you have a great specialty.

Lesson 2

To harness the advantages of diverse systems or peoples, they must be united and driven by common purpose or balkanization and fission will result. To quote Yeats “things will fall apart because the center will not hold. . . .”³⁵ Con-

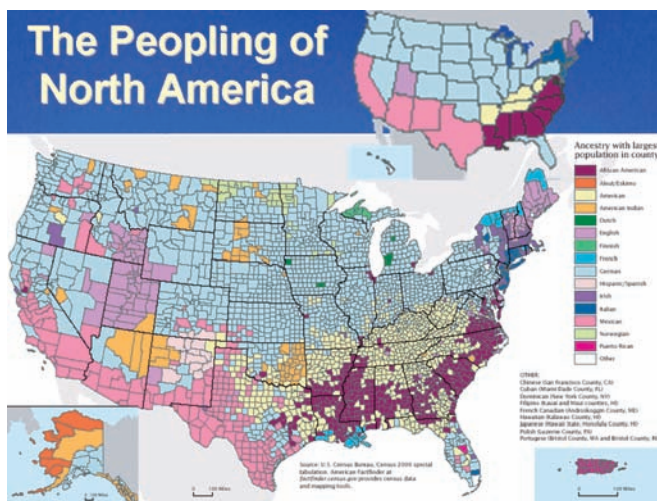


FIGURE 1.11

sider the words of others who have examined human interactions:

Whether you are working on a constitution:

“We must all hang together, or assuredly, we shall all hang separately.” ~Benjamin Franklin³⁶

Or coaching football teams:

“People who work together will win, whether it is against complex football defenses, or the problems of modern society.” ~Vince Lombardi, legendary NFL football coach (1913–1970)³⁷

Or marshaling tribes of desert Bedouins:

“Me and my brother against my cousin, me and my cousin against the clan, me and the clan against the infidel.”

Lesson 3

Interaction between peoples, the exchange of ideas, and the enrichment that comes of it invariably leads to advancement. Travel, as Mark Twain said in 1867, “is fatal to prejudice, bigotry, and narrow-mindedness. Broad, wholesome, charitable views of men and things cannot be acquired by vegetating in one little corner of the Earth all one’s lifetime”.³⁸

Consider the changes wrought by the great explorers. Today, globalization has come to epitomize this phenomenon, with air travel, internet, and free movement of goods, money, and people. The CNS, true to its charter as an international neurosurgical organization, continues to expand and maximizes the advantages of interaction.

Lesson 4

Size does not always mean strength. Because you are outnumbered or outgunned does not mean you are outsmarted. Resource-poor does not mean failure, and resource-rich does not mean success. It is how one uses resources that makes the difference. We have seen numerous examples of great powers that started out small or under-resourced.

Neurosurgery is a small specialty with finite resources and we are assailed by great forces around us. However, I submit that all that is necessary for us to prevail, in the words of that great Admiral Horatio Nelson, is that every man do his duty.³⁹

Thank you for the opportunity to serve as the president of the CNS. It has truly been an honor and a privilege, not to mention a joy. I thank all of you friends, colleagues from all over the world who have come to make this Annual Meeting a terrific event. I leave the CNS in good hands with people who will continue the ideals and mission of this great organization. And now it is time to say goodbye.

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