Attitudes, Aptitudes, and the Origins of the Great Enrichment.

Joel Mokyr
Departments of Economics and History
Northwestern University.

Presented to
New Economic School
September, 2020

NORTHWESTERN
UNIVERSITY

A Naïve Question

With the current wave of protests against racial injustice and discrimination and the BLM movement, here is a really naïve question:

WHY, really, isn't it the other way around? Why didn't black people have white slaves? Why did we not see African and Asian colonial empires exploiting Europeans?

In the past 400 years Europeans have dominated, subjugated, enslaved, and exploited much of the rest of humanity in multiple ways. The remnants of that asymmetrical relation are at the foundation of today's race relations.

NORTHWESTERN
UNIVERSITY

Not just in the US

Other Western hemispheres nations see the same, such as Afro-Brazilians.

Even in Europe, where black slavery was never introduced on a large scale, we observe the same, e.g. in France and the UK where people of African and Asian descent are discriminated against and disadvantaged by white people, from mortgage lenders to police brutality.

This is not just *racism*, though obviously there is a relation. Racism just means disliking others who don't look or sound like you; I am talking about racism coupled to *inequality (*and *asymmetry)*. They are related, since racism usually → inequality, but formally they are <u>not</u> the same.

NORTHWESTERN UNIVERSITY

But why?

But what is the source of this inequality?

There is nothing inherent in "white-ness," or European culture (e.g., Christianity) or geography (much less bogus theories based on genetics) that would explain it. The evidence for that is decisive:

It had not always been so. In the year 1000 AD Christian Europe was an ignorant, impoverished, violent backwater, whereas the worlds of Islam and the Song dynasty in China at roughly that time were sophisticated and literate societies that made major advances in medicine, math, engineering, philosophy, literature, and so on.

Rather than worry about the "Great Divergence" we should discuss the "Great Reversal".

NORTHWESTERN
UNIVERSITY

- Since it is not biology or geography, it must be history.

- Somehow, "white" people (i.e., Europeans) acquired a mysterious advantage over brown and black people that allowed this inequality to emerge. It create early colonialism modern imperialism and the gaps between the incomes of white as opposed to non-white peoples, both within and between economies.

- The great irony of history: Europeans were able to colonize, subjugate, enslave, and exploit people elsewhere in the world. Yet the descendants of these subjugated people are today far richer than their ancestors thanks in large part to European knowledge. The historical watershed has been dubbed by Deirdre McCloskey the "Great Enrichment" --- emphasizing the world-wide rise in living standards.

- All the same, the racial divides are still there as the persistent legacies of the Great Reversal.

If the origins of the Great Divergence, the Great Reversal and the Great Enrichment had to be summed up in one word, what would it be?

Knowledge.

Yet there is no European advantage here, say around 1250 AD. Other civilizations at that time were more advanced in science and technology, had a better educational infrastructure, higher literacy, and more human capital.

NORTHWESTERN
UNIVERSITY

But by the eighteenth century, at the onset of the Industrial Revolution, the gap was there:

Dr. Samuel Johnson's fictional Abyssinian prince Rasselas asked his philosopher friend in 1759

"By what means are the Europeans thus powerful; or why, since they can so easily visit Asia and Africa for trade or conquest, cannot the Asiatics and Africans invade their coasts, plant colonies in their ports... the same winds that carry them back would bring us thither." The answer that was provided was: "they are more powerful than we, sir, because they are wiser; knowledge will always predominate over ignorance. But why their knowledge is more than ours I know not." (emphasis added).

NORTHWESTERN UNIVERSITY

Did Europeans "know more"?

- What mattered was not just the level of human capital and knowledge, but what *kind of* knowledge emerged, which questions intellectuals were interested in, and how much of an impact they had on the world of production.

Either way:

- The answer to prince Rasselas's question can be summarized by two words: **Attitudes and Aptitudes.**

- These were the results of changes that occurred in Europe in the three centuries before Dr Johnson wrote these words.

NORTHWESTERN UNIVERSITY

Brief digression:

What does it mean for a *society* to "know" something:

Definition: Social knowledge is defined as the union of the knowledge of all members. Can knowledge be effective, that is, change behavior?

The effectiveness of some subset of knowledge depends, among other things, on three factors:

1. Density: what proportion of people know a relevant piece of knowledge?
2. Access: how costly is it for someone who does not possess the knowledge to acquire it?
3. Tightness: how strongly do people believe that what they know is true? Do they trust the "authorities" who tell them it is?

In the three centuries before the Industrial Revolution, the factors affecting knowledge growth changed

- During those centuries, Europeans developed both attitudes and aptitudes that drove them to acquire the kind of knowledge that gave them an advantage in certain capabilities that ended in “white domination” entailing slavery, colonialism, and a huge economic gap in income and living standards between West and East.

NORTHWESTERN UNIVERSITY

The argument I will make has two parts: Attitudes and Aptitudes.

NORTHWESTERN
UNIVERSITY

Part I: Attitudes.

NORTHWESTERN
UNIVERSITY

Culture and Progress

Attitudes: It is hard to think that the growth in useful knowledge happened independent of epistemological beliefs, preferences, and values--- that is, *culture.*

Between 1450 and 1700, improvements were taking place in the European **cultural** environment in which the idea of "progress" and the willingness to challenge and control nature to improve the human condition became part of the dominant culture.

NORTHWESTERN
UNIVERSITY

Three important attitudes:

1. **Skepticism**. By 1450 Europe had rediscovered the learning of ancient Greece and Rome. They realized there was a lot of wisdom and learning there. But then they realized there was a lot of error as well.

Medieval European intellectuals --- with some notable exceptions --- believed strongly that classical knowledge, especially the great philosophers and scientists Aristotle, Ptolemy, Pliny, and Galen was sacrosanct. But then doubts crept in. By 1500, such criticism had become more common. By 1700 Copernicus, Galileo, Descartes, Newton and many others had created a new science, dismissing the classical "canon" at times with contempt.

NORTHWESTERN UNIVERSITY

The skepticism could border on disrespect

In the middle of the sixteenth century, the French philosopher Pierre de la Ramée (1515-1572) already wrote freely "on the errors of Aristotle".

By the early seventeenth century Francis Bacon insolently wrote that "[the Greek writers of science] certainly do have a characteristic of the child: the readiness to talk with the inability to produce anything; for their wisdom seems wordy and barren of works" (Bacon [1620] 2000, aphorism 121, p. 59).

The English physician and physicist William Gilbert in his *De Magnete* (1600), a widely admired and pioneering work in its time, announced from the onset that he was not going to waste time on "quoting the ancients and the Greeks as our supporters, for neither can paltry Greek argumentation demonstrate the truth more subtly nor Greek terms more effectively, nor can both elucidate it better. Our doctrine of the loadstone is contradictory of most of the principles and axioms of the Greeks."

Without skepticism, there could be no progress.

Sacred Cows were slaughtered:

All knowledge, both new and old, was contestable ("*in nullius verba*").

By the mid seventeenth century, even the holy bible itself did not escape dispassionate textual analysis from such heterodox intellectuals as Spinoza and Hobbes, despite fierce indignation by devout clerics of various stripes.

NORTHWESTERN
UNIVERSITY

Traditionalists resisted fiercely

In the late seventeenth century both France and England witnessed a *querelle des anciens en des modernes* — a battle between the ancients and the moderns.

The moderns won this war hands down: by the seventeenth century, first Galileo and then Newton and their contemporaries had hammered the last nails in the coffin of ancient physical science.

It was more than physics. The Florentine physician Francesco Redi (1626–1697) showed convincingly that the Aristotelian belief in spontaneous generation of plants and insects was false and earlier William Harvey (1578-1657) showed the same for the Galenic model of blood circulation.

NORTHWESTERN
UNIVERSITY

This outcome is symptomatic of European exceptionalism

In other civilizations --- China, Muslim, India --- the traditionalists basically won the day. The same was true for Jewish civilization in Europe before 1750.

In those civilizations, the iron grip of the tenacious past and what best could be called “intellectual ancestor worship” kept blocking intellectual innovation. Rather than testing and criticizing traditional knowledge, intellectuals engaged in exegesis and philology, arguing about what ancient sages “really meant.”

NORTHWESTERN UNIVERSITY

European Skepticism explained

There were various reasons for the emergence of this skepticism, but we don't really know which of them was most important.

Perhaps by 1450 Europeans were less committed to ancestor-worship because they lived in small nuclear families. Perhaps the forces of reaction had a harder time coordinating the suppression of heretics because of the polycentric nature of European politics.

By 1500, the global voyages started to make people realize that the world was not quite what the Greeks had described. This was reinforced when new scientific instruments came online after 1600.

NORTHWESTERN
UNIVERSITY

2. **Open-ness**. Europeans from early times on were willing to learn from other civilizations and readily adopted (or stole) their ideas, then went on to improve upon them. After 1500, when they started traveling around the world, they adopted and learned how to make Indian cottons, Chinese silks and porcelain, and grow many crops from the Western Hemisphere.

Their objectives were quite explicitly to learn and then copy and adopt new forms of technology and medicine. This is known as the "Columbian Exchange." They did this in addition to forcibly converting others to Christianity, pillage their gold and silver, steal their lands, and enslave them if they could in order to grow the crops Europeans desired.

NORTHWESTERN
UNIVERSITY

Open-ness to foreign ideas was striking:

The appreciation of foreign information by Europeans had already manifested itself in the high Middle Ages.

Europeans happily adopted windmills, paper, and decimal numerals from the Muslim world.

The names of medical authorities such as Al Razi (Rhazes) and Ibn Sina (Avicenna) were latinized, and medieval medicine never hesitated to adopt their writings as the core of the medical canon for centuries knowing full well that they were Muslims.

NORTHWESTERN
UNIVERSITY

- Equally striking was the willingness of European theological writers to study and learn from the philosophical writings of Ibn Rushd (Averroes), whose work influenced Thomas Aquinas, or study the astronomy and optics of Ibn al-Haytham (Alhazen).
- Europeans freely conceded the foreign origins of their use of "Arabic numerals," drank beverages that had alcohol in them (derived from the Arabic al kohl), and taught their children algebra (from the Arabic al jebr). They also grew turkeys under the mistaken belief that turkeys came from the middle east or India, sipped tea from chinaware, grew corn (maize), potatoes, wore damasks and calicots, and practiced a technique of black laquer known as "Japanning."
- As many scholars have noted, this route was mostly one way. After 1200, there was little in Western culture that Islam adopted before the nineteenth century unless it was for a highly specific purpose, and some key inventions (e.g. printing) were resisted for centuries. The same was true for China and Japan after 1600 or so.

The most striking example: cotton

Cotton is an entirely-imported raw material.

Europeans imported cotton cloth from the Middle East, then India.

But then they started spinning and weaving and bleaching and printing cottons themselves, importing the raw materials. And they got good at it eventually: that is a standard part of the Industrial Revolution.

As a recent author (Hahn, 2020) neatly summarized it: “European fabric producers competed with Asian specialty textiles ... until the substitute obliterated the industry it was designed to imitate”

NORTHWESTERN
UNIVERSITY

European Open-ness

Despite being just as religiously bigoted and racist as anyone else, Europeans were willing to adopt foreign ideas and studied foreign civilizations and languages.

One example: In the year 1613 Leiden University established one of Europe's very first chairs of Arabic Language and Culture. Its first occupant, Thomas Erpenius (Thomas van Erpe, 1584-1624), laid out the rationale in his inaugural lecture 'Arab culture has a world of wisdom to teach'.

NORTHWESTERN
UNIVERSITY

Why was this?

One explanation is competition. Europe was deeply fragmented among different fault lines, and competition with other Europeans meant that every unit had to run to stay in place lest others got ahead of them.

The fragmentation was along many lines: dynasties, states, cities, universities, religions.

If knowledge was useful in some way, it was important to get it to maintain the country's competitive position.

NORTHWESTERN
UNIVERSITY

3. **Neophilia.** European elites developed a taste for the new and the unfamiliar and rewarded intellectual innovators. People who came up with new ideas (in the arts as well as sciences) were rewarded and enjoyed high status. None more so than the great Isaac Newton who became a national hero. But many others as well.

Many leading scientists ("natural philosophers") became celebrities and often landed posh and comfortable "patronage" positions. This implied that intellectuals were expected to be "useful" in providing knowledge that helped their patrons: medicine, navigation, ballistics, engineering as well as astrology.

NORTHWESTERN
UNIVERSITY

It is a good example of the blessings of a well-functioning market

In Europe, the market for ideas was highly competitive. Intellectuals competed with one another for patronage jobs. Courts and Universities, on the demand side, wanted the most famous and illustrious scholars to signal their greatness, but also, as noted, to render certain services like tutoring their children or medicine.

The reputation of scholars among peers was often the critical signal; to attain such a reputation, they had to be innovative.

NORTHWESTERN UNIVERSITY

- As a result, many radical new ideas were proposed between 1500 and 1750. Some were developed by Europeans themselves, some adopted from elsewhere.

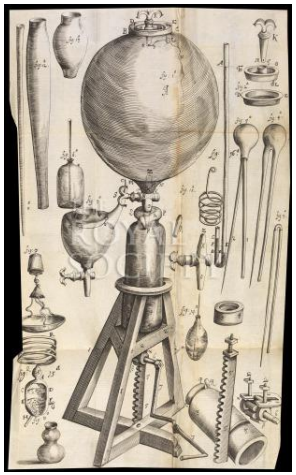
- Not all these new ideas were good. Many of them were bogus or just mistaken. Fake news and pseudoscience were at least as common then as now. Astrology and numerology were popular. Yet there was clear progress toward ideas that worked.

- But whenever possible, knowledge that worked was put to good use, far more than anywhere else.

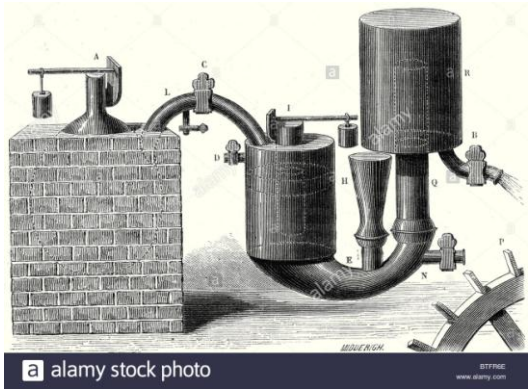
NORTHWESTERN
UNIVERSITY

An example is the realization that contra Aristotle, a vacuum could exist. Hence the sequence:

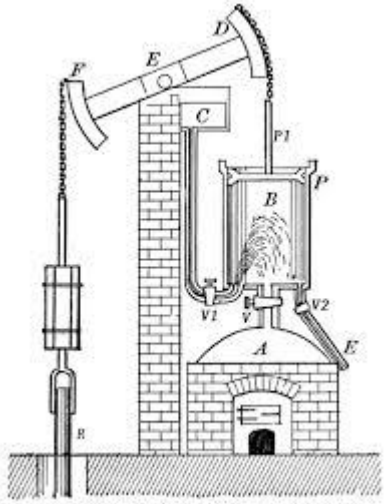
Torricelli, 1643



Boyle, 1660



Papin, 1690-1707



Newcomen, 1712

NORTHWESTERN UNIVERSITY

What explains European neophilia?

All societies have some people who think outside the box. But outcomes differed because incentives and risks differed.

Being innovative and iconoclastic in all societies carried risk of being accused of heresy, apostasy, blasphemy, witchcraft and the like.

It surely did in early modern Europe which persecuted many innovators (and executed a few).

But to be successful on a Continent-scale, reactionary policies required coordination by the entities that enforced conservative policies. Lacking that, intellectual innovators could play competing powers against one another and move between different political entities. Many did.

NORTHWESTERN
UNIVERSITY

Two examples:

Tommaso Campanella (1568-1639)

Accused of heresy by the Inquisition, he was sentenced to life imprisonment in 1599 (for anti-Spanish activity rather than for heresy) and spent twenty seven years in a Neapolitan jail. However, his conditions there were sufficiently benign (thanks to the protection of Emperor Rudolph) that he could write seven books in jail, including his celebrated *City of the Sun* (1602) as well as a pamphlet defending Galileo during his first trial in 1616. He spent his last years in France, where he was received at the court of Louis XIII with marked favour and protected by Cardinal Richelieu and granted a liberal pension by the king --- no doubt as an enemy of the Spanish Habsburgs.

NORTHWESTERN UNIVERSITY

Jan Amos Comenius (Komenský)

(1592-1670)

Famous progressive philosopher and follower of Francis Bacon and educational reformer. One of the most footloose European intellectuals of all times, he escaped religious intolerance and benightedness by moving from his native Moravia to Poland, England, Sweden, and Hungary, and died in Amsterdam.

NORTHWESTERN UNIVERSITY

The rise of intellectual tolerance

As a result, the persecution of “deviants” slowly faded and in the eighteenth century it was little more than window-dressing. This is not so much because rulers became more tolerant and enlightened but because it was pointless.

NORTHWESTERN
UNIVERSITY

Part II: Aptitudes

NORTHWESTERN
UNIVERSITY

What constrained the effectiveness of new ideas?

Not all new ideas, even if they were in principle sound, could be realized.

Leonardo Da Vinci drew hundreds of pictures of technological ideas.

NORTHWESTERN UNIVERSITY

Other inventions that actually worked could not be commercially realized or “scaled-up”

Cornelis Drebbel’s submarine, 1620

Blaise Pascal’s mechanical calculator, 1642

NORTHWESTERN UNIVERSITY

Why not?

One answer: inadequate workmanship and materials.

These were a form of knowledge (primarily tacit) or competence.

One could summarize it as “aptitudes”

NORTHWESTERN
UNIVERSITY

Here too, Europe slowly gained an advantage

- Even as late as c. 1400, compared to Europe, the Chinese still had superior technological capabilities in shipbuilding, navigation, metallurgy, hydraulics, textiles, printing, weapons, and engineering. But Europeans were already catching up.

- By the time the first Jesuits arrive in China in 1582, they noticed how backward China was in some technological areas (Matteo Ricci). Many of the skills the Chines used to have had deteriorated or were lost (e.g. clock making, shipbuilding).

- All the same, around 1550, Asia still had a highly skilled class of artisans who produced many of the luxury goods Europeans sailed around the globe to get.

NORTHWESTERN
UNIVERSITY

By 1700 or so, European artisans were quickly improving

- This is particularly true in Britain, where artisans made high quality clocks, telescopes, instruments, pumps, and after 1712 steam engines.

- But on the Continent too:

Vaucanson's Duck (1731)

Cremona violin museum (c. 1720)

NORTHWESTERN UNIVERSITY

The growth in the quality of workmanship and materials in the preceding centuries helps explain the timing and location of the Industrial Revolution

(Why did none of Leonardo's inventions ever became a reality but James Watt's did?)

To be poetic about it, one could say that

The difference between

Leonardo and Watt

Was that Watt had Wilkinson

and Leonardo did not

John Wilkinson, ironmaster, 1728-1801
(painted by Gainsborough 1776)

NORTHWESTERN UNIVERSITY

Artisanal Progress in Europe

- **Watchmaking:** A perfect example of continuous improvement in artisanal competence is the eighteenth century watch industry. Without any discrete macro-invention in the eighteenth century, the real price of watches fell by an average of 1.3 percent a year between 1685 and 1810 (Kelly and Ó Gráda, 2017), the result of an increasingly finer division of labor and learning by doing (micro-inventions).
- Another example is in the **small arms industry**. Hoffman (2015) shows the secular decline in the prices of firearms due to the growth in total factor productivity. He estimates a rise in total factor productivity of pistols at 1.1 percent a year (1556-1706) relative to a low-tech product such as spades. This, as he points out, is an underestimate since it does not account for quality improvements in muskets and pistols.

NORTHWESTERN
UNIVERSITY

Yet in the absence of major macro-inventions, technological advances would have run into diminishing returns

- Major breakthroughs, some informed by formal knowledge and some not, increased the rate at which artisanal knowledge could advance and opened new areas of artisanal activity.

- In that sense formal knowledge from natural philosophy and practical mathematics was complementary to the mostly tacit skills of the best craftsmen and engineers.

NORTHWESTERN UNIVERSITY

In these advances, the upper tail of the human capital distribution (UTHC) was decisive.

- Adam Smith expressed this when he noted that “to think or to reason comes to be, like every other employment, a particular business, which is carried on by very few people who furnish the public with all the thought and reason possessed by the vast multitudes that labour.” The benefits of the “speculations of the philosopher ... may evidently descend to the meanest of people” if they led to improvements in the mechanical arts (Smith, [1776] 1978, pp. 569–72).

NORTHWESTERN
UNIVERSITY

Materials mattered in addition to mechanical competence

One such advance: better steel, which was used to make the tools that mechanics had to use.

Benjamin Huntsman, a Sheffield clockmaker, perfected in 1740 the so-called crucible process, which made it possible to make high- quality steel in reasonable quantities. Huntsman's process was superior in that it produced not only a more homogeneous product (important in a product such as steel, which consisted of about 2 percent carbon mixed in with the iron) but also removed impurities better because it created higher temperatures.

Crucible steel is one important technological catalyst that economic historians have tended to overlook. Steel was essential in the production of machine parts, cutting tools, instruments, springs, and anything else that needed a material that was resilient and durable.

NORTHWESTERN
UNIVERSITY

Friedrich Engels even attributed the development of England's industrial might to Huntsman's discovery, by virtue of the high quality tools and machinery it made possible.

“For the greater purity of the materials placed at its disposal, and the more perfect tools, new machinery and a minute division of labor, the metal trade of England now first attained importance.”

The Condition of the Working Class in England (1844), p. 12

NORTHWESTERN
UNIVERSITY

Mechanical skills were part of the knowledge that Dr. Johnson was talking about

The success of Europe in generating this knowledge was due to the basic notion that artisans and scientists should talk to each other and cooperate. Science and mathematics were supposed to serve practical purposes.

Isaac Newton himself said that geometry “was devised, not for the purposes of bare speculation, but for workaday use” which meant that its techniques should be such that “any practitioner should find them readily applicable in his measuring.” The same was true was the calculus that he helped invent, and which was found to be useful in many applications.

NORTHWESTERN UNIVERSITY

The "Industrial Enlightenment"

Many eighteenth century scientists were themselves deeply interested in practical problems and had no qualms in getting dirt under their fingernails.

No "ivory towers" for them! Think of the chemist Joseph Priestley who discovered oxygen in 1774. But he also invented carbonated ("sparkling") water and the pencil eraser.

Progress through Knowledge could have been their slogan. There was a deep complementarity between *savants* and *fabricants*. At times, of course they were the same person.

NORTHWESTERN UNIVERSITY

One Example of a typical "Industrial Enlightenment Man":

René Réaumur, 1683-1757

Trained as a mathematician, a leading life-long member of the French *Académie Royale*, but also interested in:

- Iron and Steel (first to suggest the chemical properties of steel)
- Porcelain and glazing
- Egg incubation
- Entomology and pests (and their significance to agriculture
- Meteorology and temperature measurement
- Showed the feasibility of glass fibers
- Suggested paper to be made from wood
- Proved that the strength of a rope is larger than the sum of the individual strands of the ropes.

NORTHWESTERN UNIVERSITY

In Britain, this connection between scientists and industrialists was socially engrained

Most famous:

Lunar Society of Birmingham

NORTHWESTERN UNIVERSITY

In short: there was an "Industrial Enlightenment"

Modern Economic Growth was driven by a combination of **attitude** ("culture") and **aptitude** ("skill"). Both of these were greatly transformed in early modern Europe and created the background for the Industrial Revolution.

The genius of the Industrial Enlightenment was not just to believe in Progress but to actually suggest a way in which it was to be achieved and carry it out.

There were two main components of this: the advancement of technology through skills and knowledge, and the improvements of the institutions that constituted its environment. In both of these areas, there were major changes between 1760 and 1830.

NORTHWESTERN
UNIVERSITY

So now the question you all have been waiting for:

That's the past:

What about the future?

Can Progress continue?

NORTHWESTERN
UNIVERSITY

Clouds on the horizon:

- Is the future of progress assured? In terms of our ability to develop new technology, the answer is almost surely yes.

- But progress also depends on the right institutional and political environment.

- There is no guarantee that these will continue to progress and they may be regressing.

NORTHWESTERN
UNIVERSITY

Among the institutional features that are important:

- economic liberty and mobility
- relatively free (but not unregulated) markets
- the rule of law and a civil society
- effective supply of public goods
- low rent-seeking and corruption
- a balance of power and constraints on the executive
- tolerance of dissent and “others”
- a free and open press
- human rights and social justice

NORTHWESTERN
UNIVERSITY

The great danger:

Unbalanced growth: continued expansion of useful knowledge that is not accompanied by institutional progress could create unprecedented hazards to humanity.

We routinely speak of technological *progress* but institutional *change*. Perhaps for good reason.

NORTHWESTERN
UNIVERSITY

"Institutional progress" vs technological progress

As Freud expressed it in his *The Future of an Illusion*, "While mankind has made continual advances in its control over nature and may be expected to make still greater ones, it is not possible to establish with certainty that a similar advance has been made in the management of human affairs."

That is the understatement of the century!

NORTHWESTERN
UNIVERSITY

Thank you

NORTHWESTERN
UNIVERSITY