How a Few Simple Things Changed History

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What We Cover in the Course - 1

- A Few Crops
  - Wheat with a few remarks about Rice and Corn
  - Spices
  - Tobacco
  - Potato
- A Few Drinks
  - Coffee
  - Tea
  - Rum, Whiskey & Brandy

What We Cover in the Course - 2

- A Few Overlooked Technologies
  - Clock
  - Microscope & Telescope
  - Photography
  - Telegraph
  - Chemical Dyes
  - Typewriter
  - Phonograph
  - Air Conditioning

The Impact of Wheat

Wheat

What is Wheat?

- Wheat = Any of various Old World annual grasses of the genus *Triticum* that are cultivated for a cereal grain that yields a fine white flour used chiefly in breads, baked goods (as cakes and crackers), and pastas (as macaroni or spaghetti), and is important in animal feeds

Some Notes About Wheat -1

- Wheat has a complex of proteins that when mixed with water forms gluten
  - Make wheat a good source of bread
- Wheat grew on a long stalk high above the ground
  - This made it vulnerable to strong winds, hail, and heavy rainfall
- Wheat is a water-intensive crop

Some Notes About Wheat – 2

Millions of Calories per Acre

Crop	Potatoes	Corn	Wheat	Rice
Yield	9.2 Million	7.5 Million	3.0 Million	7.1 Million

Some Notes About Wheat – 3

- Most plants (wheat included) have a pod or rachis that when touched or blown by the wind shatters, scattering the ripe seeds
  - Emmer wheat had edible seeds that could blow in the wind and sow themselves
  - In some plants, a single genetic mutation creates a tough rachis or pod which makes plants unable to disperse their seeds
  - Bread wheat had a tough rachis, thus facilitating its propagation by humans

Some Notes About Wheat – 4

- Wheat was prone to genetic mutations that made wheat easy to domesticate
  - Creation of emmer wheat
  - Creation of bread wheat
  - Creation of a tough rachis
- Wheat was self-pollinating which meant that desirable mutations could easily be preserved

Some Notes About Wheat - 5

- Wheat could not be cultivated for two years running without depleting the soil
  - Thus wheat had to be rotated
    - In Southern Europe, two-field rotation
    - In Northern Europe, three-field rotation
- Wheat, if kept dry and safe, could be stored for years
  - This led to pottery, architecture innovations, and writing

Some Notes About Wheat - 6

- The history of agriculture in general and wheat production in particular is
  - A struggle against the fact that nutrient depletion, limits plant growth and crop yields
  - This struggle over time would take various forms:
    - Fallowing (the 2-,3-, and 4-field systems) & crop rotation
    - Planting legumes (17th century)
    - Natural fertilizers (manure, guano, Chilean nitrates)
    - Artificial fertilizers (late-19th & 20th centuries)

What Wheat Did - 1

- Played a major role in the development of agriculture and the emergence of urban civilizations
- Was a limiting factor that restricted economic and demographic growth
  - Gave rise to periodic famines
  - Precipitated innovations in Medieval Europe and in the 17th, 19th, and 20th centuries designed to get around the limitations

What Wheat Did - 2

- The above innovations in turn
  - Made possible economic growth
  - Led to large-scale migration of Europeans to North and South America
  - Made possible the Industrial Revolution
  - Changed the ecology of much of the planet
  - Prolonged World War I
  - Made possible the "Green Revolution" of the 20th century

Stages in the Development of Agriculture

- Hunter-Gatherers
- Domestication of Wheat
- Sedentism
- Development of Agriculture
- Irrigation & Civilization

Notes About Hunter-Gatherers - 1

- Humanity lived most of its life as hunter-gatherers
- Despite their living in harsh physical environments, they have plenty of healthy food and leisure time
  - Food supplies are abundant because food gatherers have an extraordinary knowledge of the plant and animal life in their home territory
  - Little time (15-20 hrs per week) is actually spent hunting and gathering food. Most waking hours are spent in conversation, visiting friends and relatives, and other leisure activities

Notes About Hunter-Gatherers - 2

- Food was shared, with the men hunting game or fishing and the women gathering fruits, seeds, nuts, berries, edible roots, and eggs
- Hunter-gatherers had no effective way of storing meat or food for later use
- Hunter-gatherers had to roam in search of food
  - Thus, personal possessions beyond a bare minimum was a burden
  - Necessary tools and implements were collectively owned and freely shared

Notes About Hunter-Gatherers - 3

- Hunter-gathering life requires fairly low population densities
  - Population densities of hunter-gatherer societies are typically one person or less per sq mile
  - Normally, hunter-gatherers live in small groups of 25-50 related persons
  - Populations were limited by infanticide and by mothers breast-feeding children for at least two years
    - Children normally spaced at 4-yr or greater intervals

Notes About Hunter-Gatherers - 4

- As hunter-gatherer band population increased, or the ability of the environment to support the existing population decreased, hunter-gatherers had two options:
  - Expand into previously unoccupied territory
    - This led to the great pre-historic migrations that took place in the last ten thousand years
      - From Siberia across the Bering Strait into North and then South America
      - From Southeast Asia to Australia
      - From East Asia to Polynesia
  - Become farmers and/or herders

Notes About Hunter-Gatherers - 5

- The discovery by Europeans of hunter-gatherer bands had some very interesting intellectual consequences
  - Led to the creation of the concept of the 'noble savage' living in an unspoiled Eden and unaffected by the vices of civilization
  - Led to the concept that private property was the root of all evil – e.g. Jean Jacques Rousseau
  - Led to the concept of "primitive communism" – an era devoid of class struggle and exploitation of man by man – e.g. Karl Marx & Friedrich Engels

Plant Exploitation

- In terms of plant exploitation, there is a gradation that runs as follows:
  - Foraging of wild plants
  - Tending wild plants through cultivation
  - Domestication of genetically-distinct crops
  - Selective breeding
  - Genetic engineering
- Hunter-gatherers do the first two, often practicing some form of plant cultivation

Domestication of Wheat

- Hunter-gatherers realized that:
  - Even wild wheat growing naturally on the hillsides in the Middle East could produce a harvest of up to 700 lbs of grain per acre
  - If they supported naturally-growing wild plant life by sowing, weeding, watering, and selecting it, they could produce more of it
  - Selecting wheat with a tough rachis facilitated domestication

Why Agriculture?

- Stone Age farmers in comparison with hunter-gatherers had:
  - More signs of malnutrition
  - A greater incidence of infectious disease
  - More dental decay
  - A more monotonous diet
  - Much shorter life expectancy
  - Much less leisure and more hard work
- So why abandon the hunter-gatherer life?

Factors Leading to Agriculture

- Two factors promoted the growth of agriculture:
  - Climate Change – The end of the Ice Age led to a warmer and wetter Middle East and resulted in the death of large mega-fauna.
    - This put pressure on the hunter-gatherer lifestyle
    - Expressed in the form of the "Garden of Eden" legend
  - Sedentism – The tendency for some hunter-gatherers to spend much of the year at a single camp or even take up permanent residence

Factors Leading to Agriculture - 2

- In the new climate, wild wheat proliferated
- The gathering and cultivation of wild wheat in turn encouraged sedentism
  - First during the growing season and then permanently
- Sedentism led to:
  - Permanent settlements
  - The domestication of wheat
  - Population increase
  - Accumulation of possessions and property

Out of Eden

- As in the biblical myth, humans did not choose to leave the Garden of Eden
  - Increased food supplies (largely in the form of wheat) and the resultant population increase meant that the hunter-gatherer way of life was no longer possible
- Once humans adopted agriculture, there was no going back

Where Sedentism Arose

- Sedentism and farming arose in well-watered places that offered good growing conditions and a moderate seasonal supply of birds, animals, or fish
  - Thus, agriculture arose along the banks of the Tigris, Euphrates, Nile, and later the Indus and Yellow rivers
  - This permitted the development of irrigation which in turn made possible even greater agricultural surpluses

Irrigation

- Two factors led to the development of irrigation
  - Climate Change -- Around 6000 BC, the Mesopotamian climate became hotter and drier. This made dry farming very problematic
  - Population Increase – Irrigation increased crop yields, easing the pressure of population on food resources.
- Thus, it was along the Tigris-Euphrates, Nile, and Indus that the first urban civilizations arose

Consequences of Agriculture - 1

- Creation of wheat surpluses led to
  - Permanent rectangular houses to accommodate the storage of grain and the larger families that grain made possible
  - The specialization of labor – roughly 5%-10% of the population could be diverted from farming into other occupations
  - The emergence of institutions to transport, store, and distribute surplus food

Consequences of Agriculture - 2

- Food surpluses divided humans into three major groups
  - Those who became farmers
  - Those who became pastoral nomads
  - Those who remained hunter-gatherers
- The conflict between these groups led to:
  - Farmers displacing hunter-gatherers onto ever more marginal land
  - Raids and wars between pastoral nomads and farmers

Consequences of Agriculture - 3

- Institutions to transport, store, and distribute food led to:
  - The rise of distinct social classes
    - A religious/administrative/military elite which controlled the food distribution system
    - Craftsmen who serviced the elite
    - Peasant farmers (the vast bulk of the population)
    - Slaves
  - The resultant creation of so-called “tributary” societies based upon elite expropriation via taxes and rents of the societal surplus

Consequences of Agriculture -4

- The rise of coercion within societies and war between societies
  - As agricultural societies developed institutions of control, it became possible to coerce or employ elements of the population in the building of temples, palaces, pyramids, state buildings, amphitheaters, and other architectural marvels
  - It also became possible to raise armies to both defend the society or to conquer other societies

Consequences of Agriculture - 5

- The need to inventory and record the ownership and quantity of agricultural commodities led to the invention of writing and abstract numbers
- The creation of a new “high” culture of the educated elite as distinct from the traditional “low” culture of the villages
  - The “High” culture was passed on via writing
  - The “Low” culture was passed on via word of mouth

Consequences of Agriculture - 6

- Tributary societies made possible the creation of art in all its forms and the accumulation of knowledge as well as the dissemination of both to successive generations
  - These advances, however, benefitted the few rather than the many
  - The result was a millennia-old ambivalence toward civilization which led to a nostalgia for an era in which man was uncorrupted by civilization and enjoyed a life of freedom and plenty

Consequences of Agriculture - 7

- The rise of agriculture radically changed the status of women
  - In hunter-gatherer societies, women did most of the food gathering – thus their economic roles were equal if not superior to men
  - In agricultural societies, it was men who owned the land and had the power to distribute the surplus the land produced
- The decline in the status of women went hand-in-hand with the rise of social classes and the development of writing

Consequences of Agriculture - 8

- The domestication of farm animals (who often shared living quarters with their owners):
  - Led to new foods in the form of storable milk products such as yogurt and cheese
  - Led to both leather products and woolen garments
  - Provided traction and transportation
  - Led to the emergence of a whole host of new diseases

Consequences of Agriculture - 9

- Agriculture with its corollaries of settled communities and rising population placed increasing strains on the Middle Eastern environment
  - Irrigation caused water levels in the water table to rise until the soil becomes waterlogged
  - Irrigation in areas of high water evaporation led to salinization of the soil
  - Increasing demand for lumber and firewood led to deforestation and soil erosion

Medieval Innovations

- The Medieval period saw three major agricultural innovations
  - Horse collar
  - Horseshoes
  - 3-field system
- These provided the economic basis for both the cultural advances of the High Middle Ages (12^{th} & 13^{th} centuries) and a vast increase in the population of Europe

Consequences for Medieval Society

- 12th Century Renaissance & High Middle Ages (12th & 13th centuries)
  - Increased output made possible the construction of the Gothic cathedrals, the growth of cities, and the emergence of universities
- Creation of a Malthusian trap that paved the way for the famines, wars, and plagues of the 14th century

17th Century Innovations - 1

- Dutch introduced fodder grasses for planting on fallow land
  - Fed livestock throughout the year
  - Introduced nitrogen into the soil
- Dutch introduced the turnip
  - Kept weeds under control
  - Grew on poor soil
  - Fed animals in the winter

17th Century Innovations - 2

- Clover and turnips led to a 4-field method of crop rotation which by 1750 had become standard in England
- Higher yields and the new animal fodder crops made it profitable to enclose or fence land rather than farm isolated individual strips of land
- The replacement of fallow by alfalfa and clover permitted a large increase in the number of cattle

17th Century Innovations - 3

- The Italians devised a kneading machine and mechanical press which made possible the large-scale production of dried pasta
  - This allowed pasta to take on a central role in the diet of the urban poor and peasants of southern Italy
  - Until the early-19th century, pasta was eaten either alone or with grated cheese
    - Only after the 1830s did pasta begin to be dressed with a sauce made from tomatoes & only in the 20th century did pasta with a tomato-based sauce become popular in Italy

Consequences of 17th-18th Century Innovations - 1

- Enclosure Movement displaced peasants with very small holdings and farm laborers
  - Many migrated to the newly-emerging factory towns; others emigrated to the New World – many as indentured servants
  - Removed cattle and sheep from common pastures and segregated cattle and sheep into relatively small privately-owned populations
    - Led to better diets for farm animals and made it easier to interrupt chains of infection among flocks and herds
      - This improved both animal and human health since many cattle infections infected humans

Consequences of 17th-18th Century Innovations - 2

- The large increase in the number of cattle with a resulting large increase in beef and dairy production
  - Greatly improved Northern European diets
  - Provided the malaria-carrying anopheles mosquito with a preferred source of blood
    - The malaria plasmodium did not find cattle to be a suitable host so that the chain of malaria infection was halted in Northern Europe
    - Malaria retreated to Mediterranean lands where the new fodder crops could not be produced because of summer draught.

Consequences of 17th-18th Century Innovations - 3

Increased agricultural productivity with its improved diets led to large-scale population growth in Europe

Population Growth in Europe

Year	1500	1600	1700	Mid-1700s	1800
Population (in millions)	84	111	125	145	195

Consequences of 17th-18th Century Innovations - 4

- The increase in population
  - Fostered the agricultural innovations discussed above
  - Provided a surplus labor force available for industrial employment and also for military service
  - In France, where old agricultural practices persisted, population increase contributed to the socio-economic crisis that gave rise to the French Revolution
  - Led to European adoption of such new crops as potatoes, corn, rice, and buckwheat

19th Century Innovations

- Transportation innovations that greatly reduced the cost of transporting wheat
- Industrial-milled flour which replaced grist mills
- Mechanization of wheat production
- Use of fossil manure in the form of Peruvian guano
- Large-scale importation of Chilean nitrates
- Development of phosphate fertilizers
- Beginning of the de-localization of the world food supply system

Transportation Innovations - 1

- The 19th Century saw major transportation innovations – canals, railroads, and steamships
  - These greatly reduced the time and cost of transporting wheat products
    - The Erie Canal reduced the carriage cost of a ton of wheat from 19.12 cents per ton-mile in 1817 to 1.68 cents per ton-mile in 1840
    - The canal and later the railroad also encouraged the settlement and growth of wheat production in the Middle West

Transportation Innovations - 2

- The railroad and the steamship opened up the breadbaskets of the world – the American prairies, the Ukraine, the Argentine pampas – to European consumers
  - Between 1870 and 1900, the cost of carrying grain from Chicago to Liverpool fell by nearly 3/4th
    - This hurt European agricultural interests, especially in England and Germany, and led to political conflicts between landowners and industrialists over free trade

Industrial Flour - 1

- Prior to the Industrial Revolution, wheat had been ground into flour at local grist mills
- In the first half of the 19th Century, the flour produced by industrial flour mills began to replace grist mill flour
  - Led housewives to begin baking bread and cakes (which required finely-ground flour)
  - By removing the chores involved in growing wheat (a male activity), It turned 'housework' into women's work rather than an activity shared by both sexes

Industrial Flour - 2

- The combination of Middle Western prairie-grown wheat and industrial flour led New England and Middle Atlantic farmers to abandon wheat-growing for vegetable-, dairy-, and specialty-crop farming

Mechanization of Production

- The latter half of the 19th century saw the introduction or widespread adoption of several new technologies:
  - The iron plow,
  - The gang plow (which could plow more than one row at a time)
  - The spring-toothed harrow
  - The harvester (pulled by a horse or mule)
  - The binder (which automatically tied up bunches of grain)

Mechanization's Effects

- When used together, the new technologies saved enormous amounts of time
  - Reduced the amount of labor for a bushel of wheat from 61 hours to 3 hours
- Led farms to become larger and farmers to shift to mono-cropping
- Led to large-scale economic misery and political unrest in rural areas

Guano, Nitrates, & Phosphate - 1

- As noted earlier, the history of agriculture in general and wheat production in particular is a struggle against the fact that nutrient depletion, especially of nitrogen and phosphorus, limits plant growth and crop yields
- In the 1820s, Peruvian and Chilean guano (bird droppings) began to be imported into Europe and North America for fertilizer

Guano, Nitrates & Phosphate - 2

- In 1842, John Lawes applied sulfuric acid to phosphate rock, producing a concentrated phosphate that could be spread upon the soil
- Phosphate production was greatly increased as a result of the new Gilchrist-Thomas steel making process in which the resulting slag byproduct served as the source for phosphate-based fertilizer

Guano, Nitrates & Phosphate - 3

- The creation of phosphate fertilizers along with guano and Chilean nitrates lessened a bottleneck to increased wheat production but
  - Chilean nitrates and guano could not meet the ever-increasing demand for fertilizer
  - Nitrates were not only a fertilizer but also a key component of explosives
  - The two above facts meant that when World War I broke out, European farm production was to suffer greatly
    - This had profound effects on the course and outcome of World War I

20th Century Innovations

- Full de-localization of the world food supply system
- Chemically-produced nitrate fertilizers
  - Synthetically-produced ammonia
  - Hydrogenation
    - Used to produce margarine and oils that remained solid at room temperature
- The Green Revolution

Delocalization of Food Systems

- Changes in transportation – railroads and steamships in the 19th century and trucks and airplanes in the 20th – aided by bottling, canning, and freezing, delocalized the world food supply. This had several effects:
  - It severed the links between territory and food supply and lessened seasonal variations
  - It overcame the perennial hunger of the European population
  - It imposed a greater uniformity on the diet of the industrialized world while exposing people to foreign cuisines

Nitrate Fertilizers - 1

- The Haber-Bosch process made it possible to produce synthetic ammonia from which nitrate fertilizers, explosives, and synthetic gasoline could be manufactured
  - It prolonged both world wars
  - It laid the groundwork for the Green Revolution in the latter half of the 20th Century

Nitrate Fertilizers - 2

World Use of Artificial Fertilizer

1940	1965	1990
4 Million Tons	40 Million Tons	150 Million Tons

Number of Tractors (in Millions)

Year	1930	1940	1950	1960	1970	1990
USA	1.0	1.6	3.4	4.7	4.6	4.6
World	1.1	3.0	6.0	10.0	16.0	26.0

Nitrate Fertilizers - 3

- Effects of Nitrogen Fertilizers -1
  - It allowed farmers to supply much more nitrogen to their crops
    - For wheat, corn, & rice, it meant larger seed heads which in turn meant higher yields
  - It allowed an additional 3 Billion people to eat
  - It widened the gap between rich farmers who could afford fertilizer (and tractors and other mechanized equipment) and those who couldn't

Nitrate Fertilizers -4

- Since more than half of all fertilizer applied to the soil ends up in rivers and lakes, fertilizer contributed greatly to both water pollution and the eutrophication of rivers, lakes, and estuaries
- It made food production dependent on the natural gas used to produce the hydrogen used in the Haber-Bosch process
  - Since natural gas prices are pegged to oil prices, this made fertilizer prices hostage to oil.

Farm Mechanization - 1

- Effects of tractors and other farm machinery
  - Tractors, harvesting combines, and related equipment made better sense on big fields growing single crops
    - This meant larger farms
    - This meant single crops (monoculture)
  - Monoculture meant that insects and other pests had to be controlled with chemical pesticides (since predators on pests did not find monocultures an appealing habitat)

Farm Mechanization - 2

- Monocultures depleted soil nutrients faster, so that more chemical fertilizer was required
- Mechanization virtually ended the need for working farm animals (which in 1920 had taken up about ¼th of all cropland)
  - This led to the slaughter or abandonment of hundreds of thousands of horses, mules, and oxen
  - The removal of the demand for animal feed caused wheat, corn, and oat prices to decline during the 1920s
    - This caused hard times for American and European farmers, leading to political realignment in the U.S. and right wing radicalism in Europe

Farm Mechanization - 3

- Mechanization greatly reduced the demand for farm labor, leading to both an extensive internal migration of rural farm laborers to cities and large-scale emigration to foreign countries
  - Rural Southern Blacks and Appalachian Whites to Northern cities
  - Rural Mexican farm laborers to the American Southwest
  - Emigration of Turkish, Yugoslav, Southern Italian, and Algerian peasants to Western Europe

Farm Mechanization - 4

- Mechanization made food production dependent on fossil fuels
- Mechanization favored the big grain producing countries
  - It shattered production bottlenecks in lands (such as the U.S., Canada, & Australia) where farm labor was scarce
  - It favored locales with big fields, flat farmland, and climates suitable for wheat and corn growing

The Green Revolution

- The Green Revolution had three major components
  - Extensive Use of Nitrogen fertilizers
  - Farm Mechanization
  - The development of new wheat and rice varieties with both increased yields and resistance to major plant diseases
    - This included dwarf varieties of wheat that had large, heavy seed heads and short stalks that could support the seed head

The Green Revolution - 2

- In the 19th century, the Japanese developed a dwarf variety of wheat which they crossed with American wheat strains to produce a strain by WWII (Norin 10) that had a short 2' stalk and responded well to fertilizer but was susceptible to disease
- In 1944, Norman Borlaug developed a Mexican wheat with yields 20%-40% higher than traditional varieties and was resistant to stem rust
  - It could also be planted in lowland deserts in the Winter and highlands in the Summer

The Green Revolution - 3

- In 1952, Borlaug crossed his Mexican varieties with Norin 10 and other varieties
  - In a few years, he developed wheat strains that were insensitive to day length, disease resistant, and, with nitrogen fertilizer, could double the yield of traditional Mexican varieties
    - In 1962, he released his new seeds to Mexican farmers
    - In 1963, the Mexican wheat harvest was six times what it had been in 1944 when Borlaug arrived in Mexico
  - Following his Mexican success, Borlaug took his wheat to India and Pakistan
    - Result: yields five times that of traditional Indian varieties so that India by the 1980s was a wheat exporter

The Green Revolution - 4

- The Green Revolution for a time exorcized the ghost of Thomas Malthus
  - In 1967, Peter and Paul Paddock wrote *Famine – 1975*, which predicted that hundreds of millions would starve to death in the 1970s-1980s. India would be an extreme famine basket case
    - This did not happen. In the 1980s, India was a wheat exporter
- Problems, however, developed which were to surface late in the 20th century

Green Revolution Problems - 1

- The high-yield seed varieties required artificial fertilizers, other agricultural chemicals, and large amounts of water
  - Nitrogen-laden agricultural runoff created ‘dead zones’ in some coastal areas, adversely affecting fish and shellfish populations
- High-yield crops attracted new pests, thus requiring extensive use of pesticides
  - Pesticides harmed wildlife, contaminated the soil, polluted the runoff water, and poisoned farm laborers

Green Revolution Problems - 3

- The dependence of Green Revolution crops on fossil fuels and large amounts of water makes Green Revolution agriculture vulnerable to
  - Disruption or decline of Middle Eastern oil production
  - Climate change-induced drought in grain-growing areas
    - Declining water tables in Pakistan-India
    - Depletion of the ogalalla aquifer in the Great Plains
    - Declining water flow in many of the world's rivers

Green Revolution Problems - 4

- Signs that the Green Revolution has run its course
  - A decline in the rate of growth of the food supply
    - Since the mid-1990s, the rate of growth declined to 1%-2% a year, falling behind the 2% growth in annual demand
    - India started importing wheat again in 2006
  - After years of stable grain prices, from January 2007 to April 2008, wheat prices doubled, rice prices tripled, and corn prices increased 50%
    - This reflected the growing demand of Chinese consumers for meat, rising oil prices, diversion of corn to ethanol, and drought and floods in key growing areas
    - This precipitated food riots in 14 countries