Cultural Evolution

Next Factor in Drake Equation: f_c

- f_c: fraction of planets with intelligent life that develop a technological phase, during which there is a capability for and interest in interstellar communication
- No significant biological evolution in last 40,000 to 200,000 years (maybe 6000 yr)
- Evolutionary Takeover
  - Cultural evolution instead of biological
  - Much shorter timescale

What is Cultural Evolution?

- No longer changes in genes (biological)
- Extra-somatic information
  - Information stored outside the body
- Changes in knowledge of group
  - Passed on by learning from others
- Parallels to sexual reproduction in bio evol
  - Allows combination of “lessons learned” from many individuals
  - And correction of mistaken ideas

Example

- Culture in primates other than humans?
  - Differences in behavior of groups
- Example: Orangutans in Kluet swamp in Sumatra
  - Make and use tools (bark-stripped twigs) to get honey and seeds from fruit
  - Genetically similar group across Alas river do not
  - River too wide to cross
  - Key feature is high density: observe each other's behavior and learn

Van Schaik, Sci. Am. April 2006

Concepts

1. Timescales
2. Origin of agriculture
3. Extra-somatic information storage
4. Tools, technology
5. Interactions: written language, cities, taxes, classes, technology
6. Interest in communication
7. World view evolution
8. Coupling between technology and world view

Timescales

- On next slide (which we will look at in more detail later) notice the timescales
- MUCH shorter than the previous kinds of evolution
- And accelerating!

Time	Information	Technology	World View
2 Myr ago		Stone tools	
??	Oral Language	Collective hunting	
10000 BCE		Agriculture	
6500 BCE	Clay tokens	Cities	
6500 BCE		Wheel	
4000 BCE		Copper tools	
3000 BCE	Clay tablets		Oyster World
3000 BCE	Syllabic alphabet		
2800 BCE		Bronze tools	
1500 BCE	Letter alphabet	Iron tools	
500 BCE			Natural Philosophy
200			Ptolemaic Model
1456	Printing Press		
1540			Copernican Model
1610		Telescope	Kepler, Galileo
1665			Newton
1700s		Industrial Revolution	
1859			Darwin
1895	Radio		
1924			Other galaxies
1936	First TV Broadcast		
1950s	Computers	Transistors, microchips	Miller-Urey
1960			First Search for Signals
1990s	Internet		

Importance of farming

- The rise of civilizations all based on farming
- Understand origins of agriculture
- How likely to arise?
- Did it arise **independently** more than once?

Agriculture

- Arose independently in different regions
  - Perhaps 10 different origins
  - First in Sumeria
  - Corn (maize) in Mesoamerica most remarkable
    - Major modifications from wild ancestor
  - Provided settled lifestyles, surpluses, specialization, central states

Agriculture leads to higher level political organization

	Band	*Tribe*	*Chiefdom*	*State*
Religion				
Justifies kleptocracy?	no	no	yes	yes → no
Economy				
Food production	no	no → yes	yes → intensive	intensive
Division of labor	no	no	no → yes	yes
Exchanges	reciprocal	reciprocal	redistributive ("tribute")	redistributive ("taxes")
Control of land	band	clan	chief	various
Society				
Stratified	no	no	yes, by kin	yes, not by kin
Slavery	no	no	small-scale	large-scale
Luxury goods for elite	no	no	yes	yes
Public architecture	no	no	no → yes	yes
Indigenous literacy	no	no	no	often

A horizontal arrow indicates that the attribute varies between less and more complex societies of that type.

J. Diamond, Guns, Germs, and Steel

TABLE 14.1 Types of Societies

	Band	*Tribe*	*Chiefdom*	*State*
Membership				
Number of people	dozens	hundreds	thousands	over 50,000
Settlement pattern	nomadic	fixed: 1 village	fixed: 1 or more villages	fixed: many villages and cities
Basis of relationships	kin	kin-based clans	class and residence	class and residence
Ethnicities and languages	1	1	1	1 or more
Government				
Decision making, leadership	"egalitarian"	"egalitarian" or big-man	centralized, hereditary	centralized
Bureaucracy	none	none	none, or 1 or 2 levels	many levels
Monopoly of force and information	no	no	yes	yes
Conflict resolution	informal	informal	centralized	laws, judges
Hierarchy of settlement	no	no	no → paramount village	capital

J. Diamond, Guns, Germs, and Steel

Information

Genes $\longrightarrow$ 10^{10} bits (or less)

Brains $\longrightarrow$ 10^{14} bits

$\hookrightarrow$ 1400 cm^3 in humans

$\Downarrow$

Extra-somatic information

leads to communication: information passed between individuals.

Allows **societies** to evolve.

Oral language	400,000?	Cooperative hunting?
Oral historians	30,000?	Traditions and Lore
Clay tokens	~ 6500 BCE	Sumeria (record keeping)
Clay tablets	~ 3000 BCE	Business, Taxes
Paper	~ 100	China
Printing press	1456	Europe
Radio	1895	Italy
Television	~ 1936	First “strong” broadcast
Computers	~ 1950’s	
World-wide-web	~ 1990’s	

Written Language

- Played key role in expanding knowledge
- Could be stored outside **any person's** body
- Developed first in Sumeria
  - Clay tokens to keep accounting
  - Clay tablets

Clay Tokens and “Vase” to hold them

Evolved into Clay Tablets

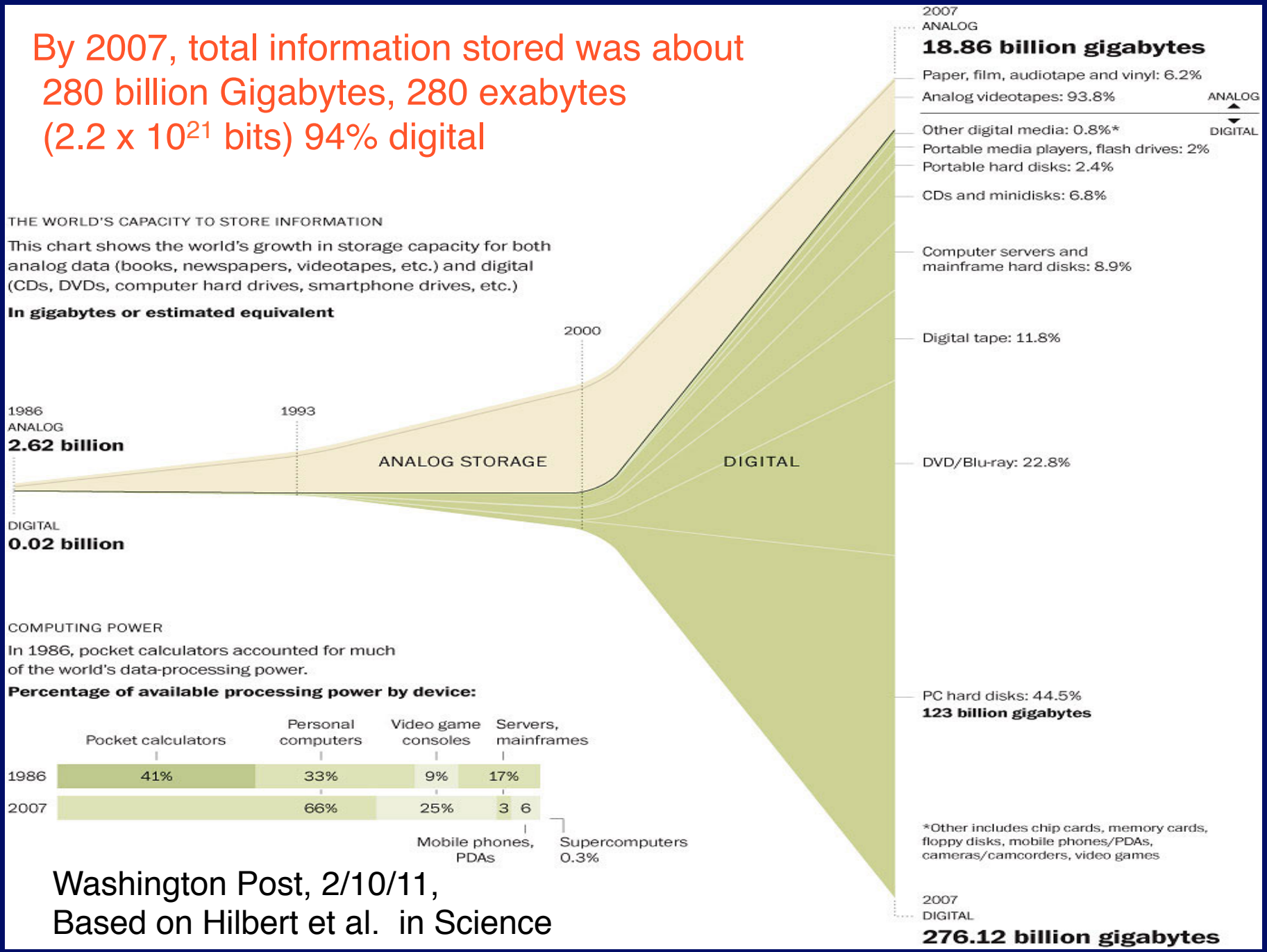
To Printing Press to Computer screen

Incipit epistola sancti ihoronimi ad paulinum presbiterum de omnibus diuine historie libris capitulū primū.

Frater ambrosius tua michi munuscula pferens: deuotissimas trās: ñ a principio amicicie nr fidē: pfectā: et iam fidā: et veteris amicicie nouā: pferebant. Ea cra mō illa necessitudo ē: et xpi glutino copulata: ñiu non vsitas ro familiaritas: nō pānis tantum corpoz: nō fabula: et palpās adulatiōs: sed dei timor: et diuinaz scripturaz studia conciliant. Legim⁹ in veteribus historijs: quosdā lustrasse: plurimas: nouos adisse plos: maria trāsisse: ut eos quos ex libris nouerant: corā ñ: viderēt. Sicut pitagoras memphiticos vates: sic plato egipti: et architā tarentinū: eudoxus oram ytalie: que quondā magna grecia dicebat: labo riosissime petijt: et ut qui acheruis mīst erat: et potens: animos doctrinas achademie gignasia plenabāt: fieret pegrinus: atq discipulus: malēs aliena necesse discere: ñiu sua ipudēs ingeri. Denīq cū trās quasi rore orbe fugientes plequit: capt⁹ a piratis: et venūdatus: ortāno cuidā cinico paruit: duct⁹ captiuus vinct⁹: et seruus. Tamē quia plus maior cuiusq se fuit: ad orum linū: lacedemoniosq eloquētie fontē manauit: de vltimis hispanie galliarūq finibus: quosdam venisse nobiles legimus: et quos ad scribendū sui roma nō reperat: unus hoīs fama pduxit. Ea buit illa etas inaudītū ōnibus seculis: celebrandūq miraculū: ut urbē tantā ingressi: aliud extra urbem quererent. Apollonius siue ille mag⁹ ut vulgus loquitur: siue pthagoricus tradunt: inierant pisas: pānium: tantalū: albanos: scithas: massagetas: opulentissima indie regna penetrauit: et ad extremum lassimo physon amnē trānauit: ad bragmanas: ut hyarcam in chrono scdm̄ aurea et de tantali fonte poraretur: inter pauca discipulos: de natura: de moribus: ac de cursu diuq et side: audiret docerent. Inde p elamitas: babilonios: chaldeos: medos: assirios: parthos: syros: phenices: arabes: palestinos: egiptus ad alexandriā: pergit: ad ethiopiā: ut gymnosophistas: et famosissimam solis mensam videret in fabulo. Inuenit ille vir ubiq; q discere: et semp profectus: semp se melior fieret. Scripsit super hoc plenissime octo voluminibus: philostratus.

Quid loquar de secli hominibus: cū apls paulus: suas electōis: et magistr gentiū: qui de conscientia trā i se hospitis loquebat: dicēs. An experimentū quaritis eius qui in me loquit xp̄s. Post damasci arabiāq lustrata: adiit ihrosolimā ut videret petrū: et mānsit apud eū diebus quindecim. Hoc eū milicio ebdomadis et ogdoadis: futur⁹ gentiū pdicator instruendus erat. Cuiuscūq post ānos quatuordecim assumpto barnaba et tito: egressus est cū apls euāgeliū: ne forte in vacuum curreret aut cucurrisset. Habet ecclia ḥd latinis exemplis: viros actus: et in aures discipli de auctoris ore manantes: foecundos sonāt. Unde et eschines cū rodi legisset: et legeret

By 2007, total information stored was about 280 billion Gigabytes, 280 exabytes (2.2×10^{21} bits) 94% digital



Washington Post, 2/10/11,
Based on Hilbert et al. in Science

Information and Intelligence

- Can we think of extra-somatic information as intelligence?
- Collective “intelligence” of the species
- But cannot be assimilated by any individual
- The concept of a “meme” as a unit of cultural information (can mutate and evolve…)
- Collective knowledge does lead to ability to engage in interstellar communication

Tools and Technology

Stone

Oldowan	2.4 Myr	H. habilis
Acheulian	1.6 Myr	H. erectus
Mousterian	200,000 yr	Neanderthals
Paleolithic	90,000 yr	H. sapiens (Africa)
Paleolithic	40,000 yr	H. sapiens (Europe)
Pottery	7,000 BCE	
Wheel	6,500 BCE	Sumeria

Oldowan Tools (H. habilis)

- OLDOWAN TOOLS (left to right): end chopper, heavy-duty scraper, spheroid hammer stone (Olduvai Gorge); flake chopper (Gadeb); bone point, horn core tool or digger (Swartkrans).

From http://www.handprint.com/LS/ANC/stones.html

Acheulian (H. erectus)

- ACHEULIAN TOOLS (left to right): cleaver stone (Bihorei oest, France); lanceolate hand ax (Briqueterie, France); large hand ax (Olduvai Gorge).

Mousterian (Neanderthal)

- MOUSTERIAN TOOLS (left to right): cutter or point, Levallois core and point, Aterian point with base tang, double-sided scraper (various sites in France).

Upper Paleolithic (H. sapiens)

- UPPER PALEOLITHIC TOOLS (left to right): biconical bone point, Perigordian flint blade, prismatic blade core, Soluterean Willow leaf point, double-row barbed harpoon point (various sites in France).

Tools and Technology

Metal

Copper Tools	4,000 BCE
Bronze Tools	2,800 BCE

(bronze is a copper alloy: arsenic, tin, …)

Iron Tools	1,500 BCE
Industrial Revolution	
Mass Production	

Silicon

Transistor	1948	U.S.
Microchip	1959	
Internet	1990's	

Metal Tools

Copper

Bronze

Iron

The Importance of Iron

- Iron played crucial role because of strength
- But late because it requires very high temperatures to ‘reduce’ to elemental state
  - And addition of carbon to make an alloy
- In 1800 BCE, 40 ounces of silver to buy one ounce of iron!
- By 600 BCE, one ounce of silver bought 2000 ounces of iron

From The Substance of Civilization by Stephen Sass

Uniqueness

1. Agriculture

   At least 5 (and maybe 10) independent origins

   Southwest Asia, China, Mesoamerica, Andes, Eastern U.S.

2. Written language

   2-4 independent origins

   Sumer, Mesoamerica, China(?), Egypt (??)

   Only after farming

From Guns, Germs, and Steel Jared Diamond

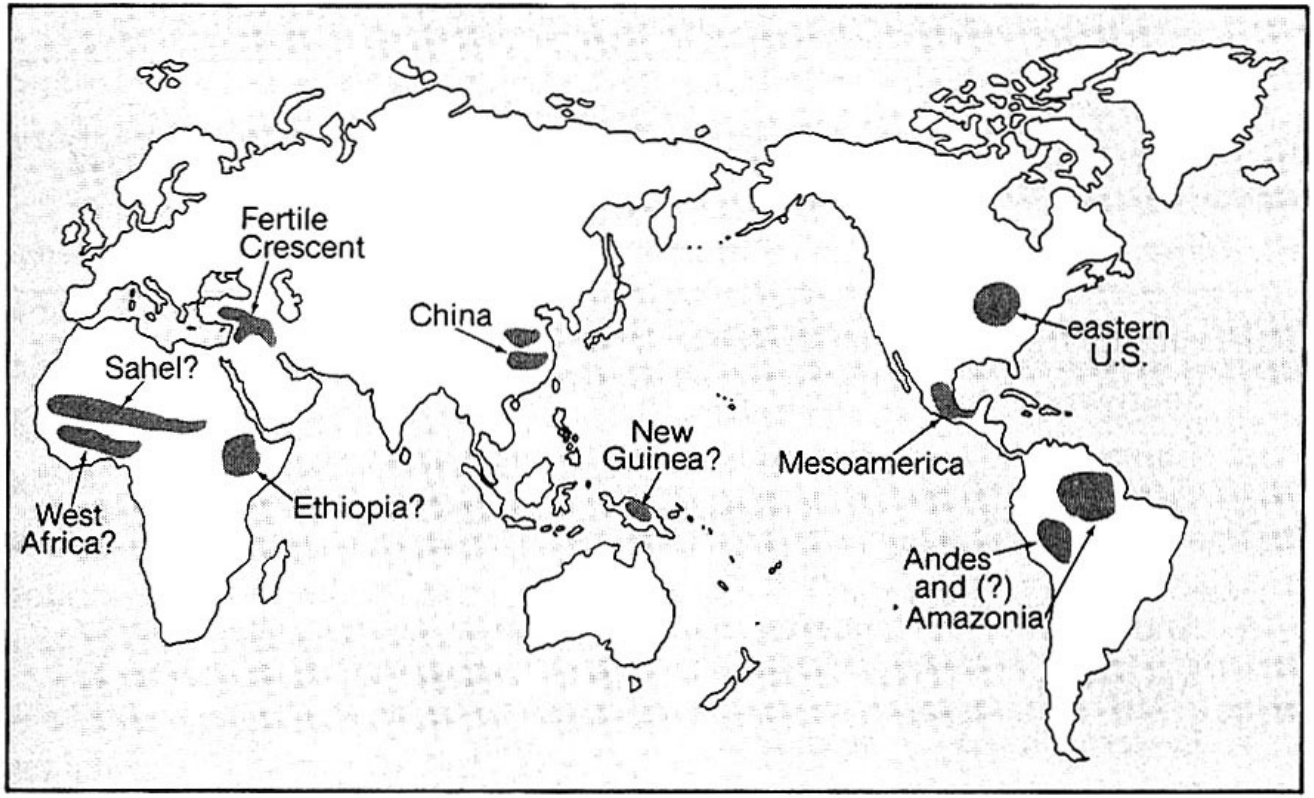


Figure 5.1. Centers of origin of food production. A question mark indicates some uncertainty whether the rise of food production at that center was really uninfluenced by the spread of food production from other centers, or (in the case of New Guinea) what the earliest crops were.

From Guns, Germs, and Steel Jared Diamond

TABLE 5.1 Examples of Species Domesticated in Each Area

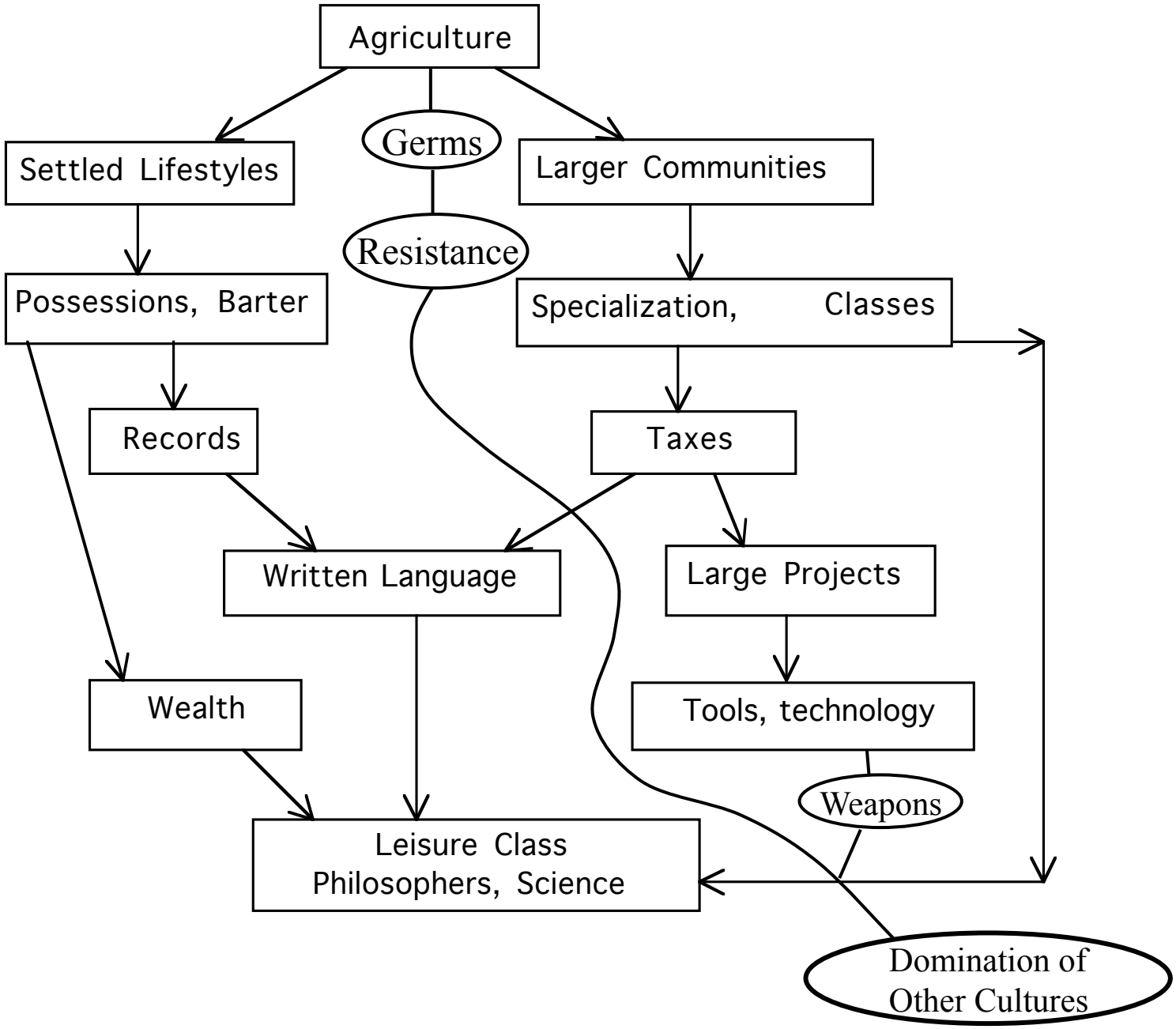
	Area	*Domesticated*		*Earliest Attested Date of Domestication*
		Plants	*Animals*	
	Independent Origins of Domestication			
	1. Southwest Asia	wheat, pea, olive	sheep, goat	8500 B.C.
	2. China	rice, millet	pig, silkworm	by 7500 B.C.
	3. Mesoamerica	corn, beans, squash	turkey	by 3500 B.C.
	4. Andes and Amazonia	potato, manioc	llama, guinea pig	by 3500 B.C.
	5. Eastern United States	sunflower, goosefoot	none	2500 B.C.
?	6. Sahel	sorghum, African rice	guinea fowl	by 5000 B.C.
?	7. Tropical West Africa	African yams, oil palm	none	by 3000 B.C.
?	8. Ethiopia	coffee, teff	none	?
?	9. New Guinea	sugar cane, banana	none	7000 B.C.?
	Local Domestication Following Arrival of Founder Crops from Elsewhere			
	10. Western Europe	poppy, oat	none	6000–3500 B.C.
	11. Indus Valley	sesame, eggplant	humped cattle	7000 B.C.
	12. Egypt	sycamore fig, chufa	donkey, cat	6000 B.C.

Uniqueness

3. Centralized states, specialization
   Several independent origins
   Only after farming

4. Metal use
   Near East
   New World (Andes) mostly decorative

5. Industrial Revolution, modern electronics
   (no test possible - all world in contact)


Agriculture
Germs
Settled Lifestyles
Larger Communities
Resistance
Possessions, Barter
Specialization, Classes
Records
Taxes
Written Language
Large Projects
Wealth
Tools, technology
Weapons
Leisure Class
Philosophers, Science
Domination of
Other Cultures

Questions

How does cultural evolution differ from biological evolution?

Does “natural selection” operate in cultural evolution?

If so, is technology an “advantageous trait”?

Is “cultural evolution” a valid description of “history”?