Today in Astronomy 106: civilization
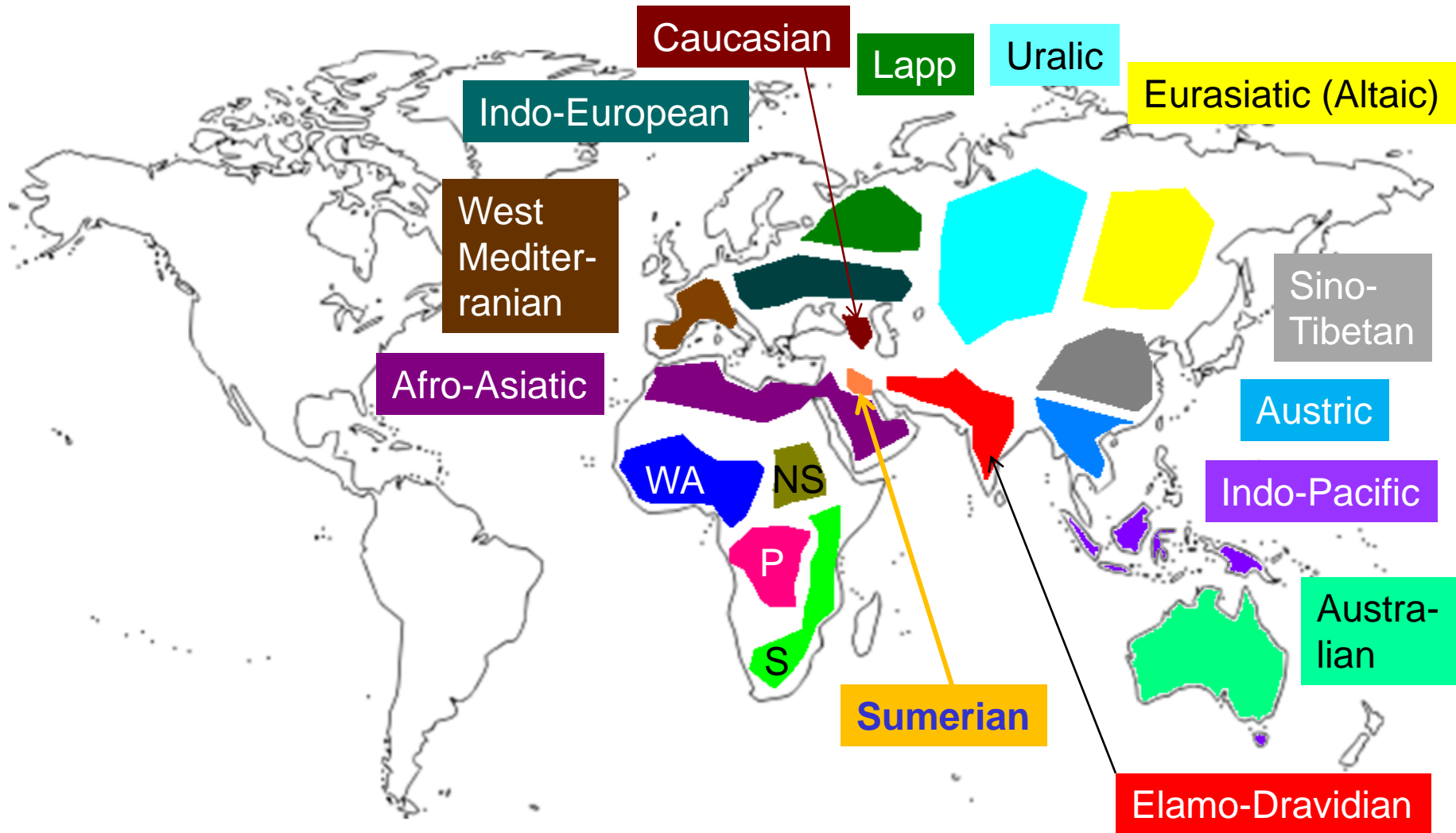
❑ The spread of *Homo sapiens*.

❑ Languages and extra-African races.

❑ Luck of the draw: distribution of plants, animals, and mineral resources, and which peoples were favored thereby.

❑ Sumer: the invention of agriculture, the invention of Invention itself, and a fundamental change in the mechanism of evolution.

Terracotta figurine, Ubaid culture, c. 6000 ya, probably from Ur. (US Department of State)

The ethno-linguistic groups, c. 15000 ya

Caucasian

Lapp

Uralic

Eurasiatic (Altaic)

Indo-European

West Mediter-ranian

Sino-Tibetan

Afro-Asiatic

Austric

WA

NS

Indo-Pacific

P

S

Austra-lian

Sumerian

Elamo-Dravidian

The Neolithic (new stone age)

By about 10,000 ya,

❑ *H. sapiens* had been active in Africa for almost 200,000 years and had built up the four different sub-Saharan races that exist today.

- Originally, as we have seen, each with its own language group.

❑ the earliest Eurasian establishments of *H. sapiens* had thousands of generations in which to become accustomed to the resources presented by their homelands…

- and by then had begun to differentiate into race-like groups as well as language groups, even though large genetic differences hadn't had time to happen.

Neolithic (continued)

❑ *H. sapiens* had only recently colonized the Americas. Their first acts were to eat the remaining horses and mammoths.

Richer homelands of course endowed some of the groups with advantages that sped them toward sophistication. Special opportunities to make or take:

❑ Abundant and tasty animals that don't mind being around humans.

- **Domestication**, both to provide food sources more reliable than the hunt, and eventually to provide beasts of burden. Not just taming…

- That's a two-edged sword: more intimate contact with animals meant more crossing over of animal **diseases**. Hinders but also builds immunity in survivors.

Neolithic (continued)

❑ Carbohydrate-rich food that can be stored for months without spoilage.

- Domestication here means determining the right seeds for edibility and high productivity, planting, and selecting seeds of the best outcomes for replanting.

❑ Useful minerals: rocks, gems, and eventually metals.

- Stone tools predominated for a long time even after the appearance of metal ones.

- Copper is the first "domesticated" metal: colorful ores, low melting point, easy to cast or to hammer.

- Bronze – a lower-melting-point copper alloy – is harder and holds an edge better, and was possible to make inadvertently while smelting copper. A new age.
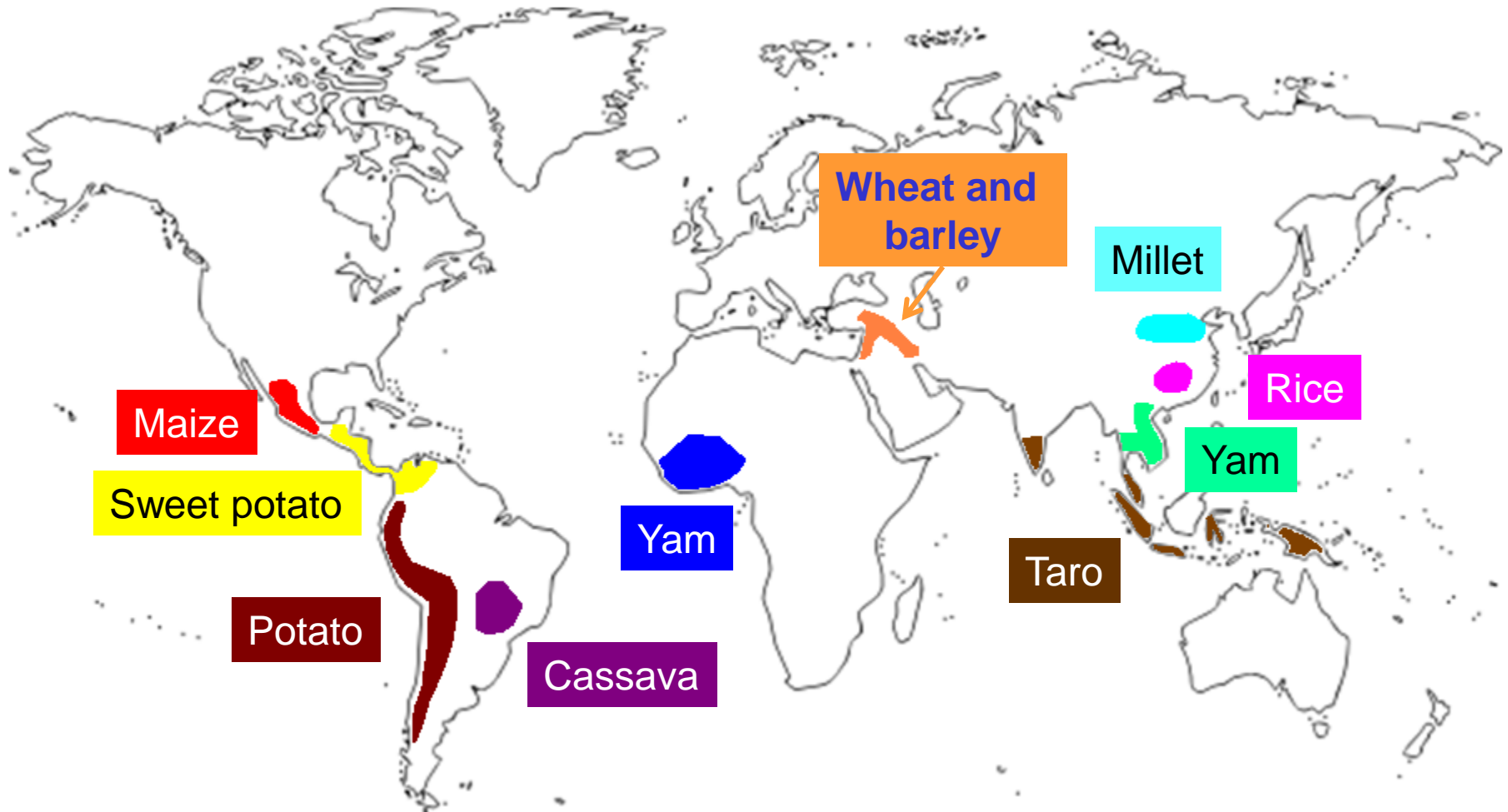
Mid-lecture Break

❑ Homework #5 will hit WeBWorK tonight; it is due at 5 PM, Wednesday, 14 April 2010.
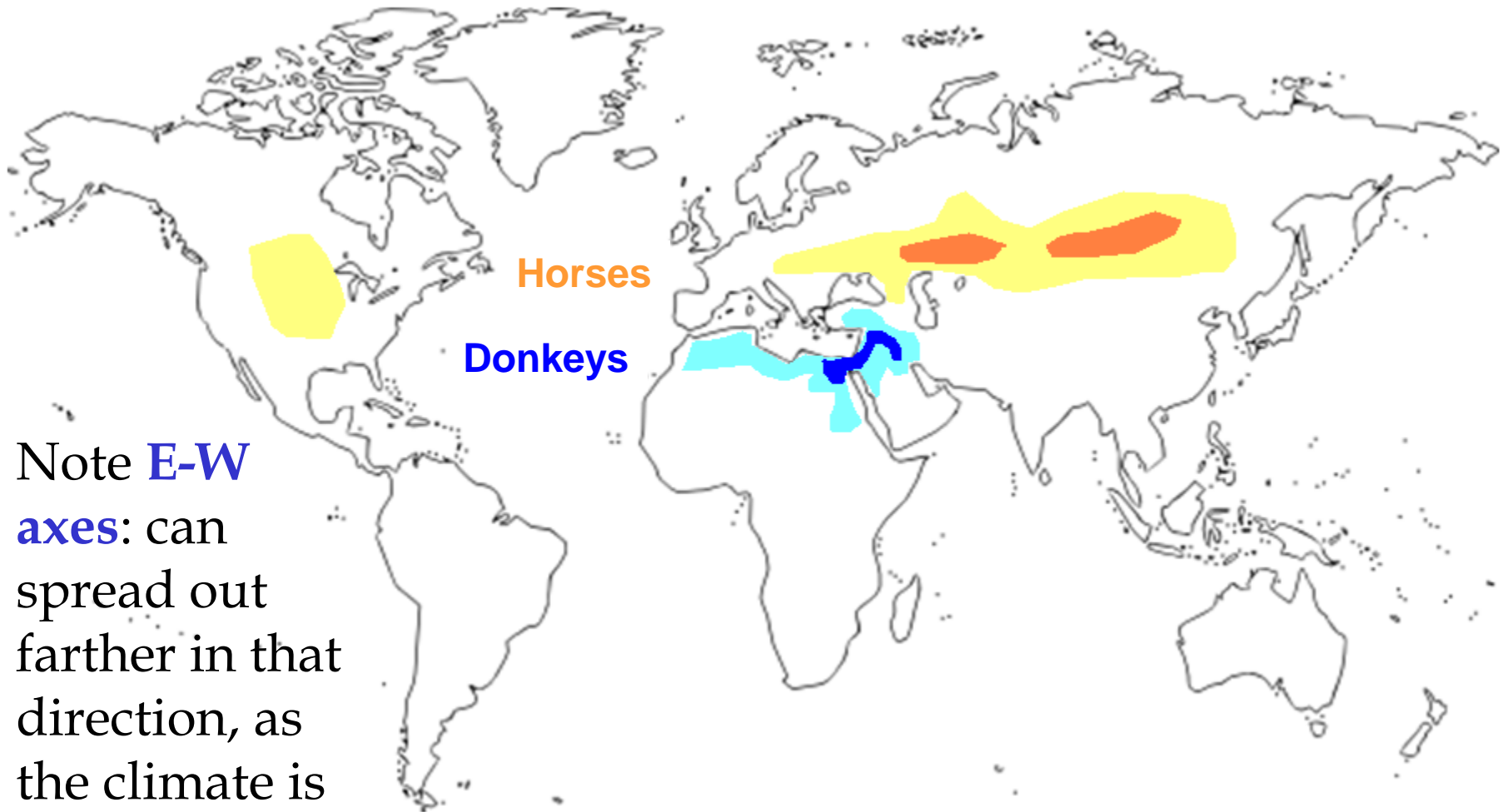
❑ No recitation today.

Part of the Stele of the Vultures, which commemorates a victory in battle by Eannatum of Lagash, c. 2600 BC (Musée du Louvre).
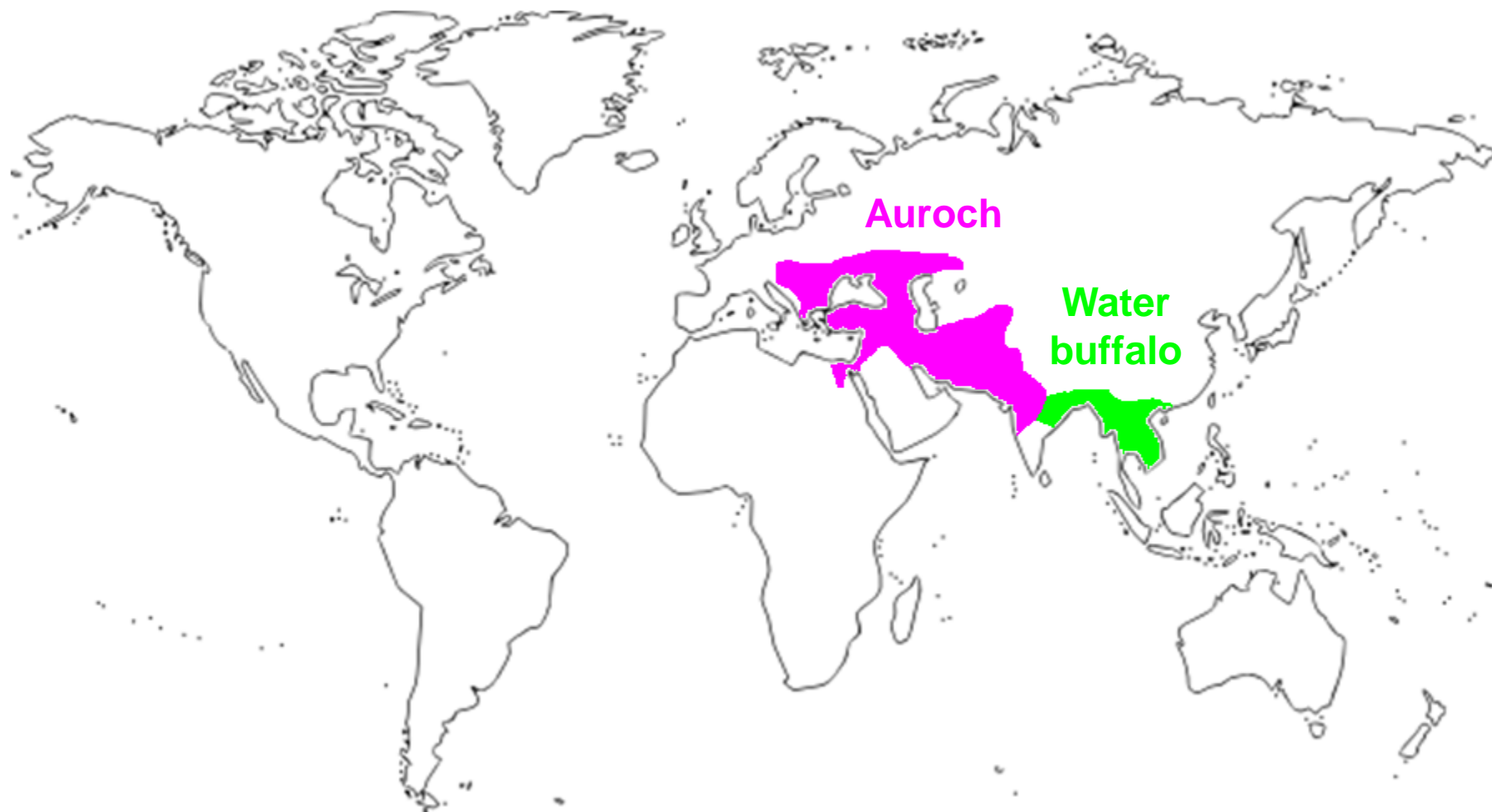
Native ranges of the staple carbohydrate crops

Native ranges of large equines

Horses

Donkeys

Note **E-W axes**: can spread out farther in that direction, as the climate is the same.
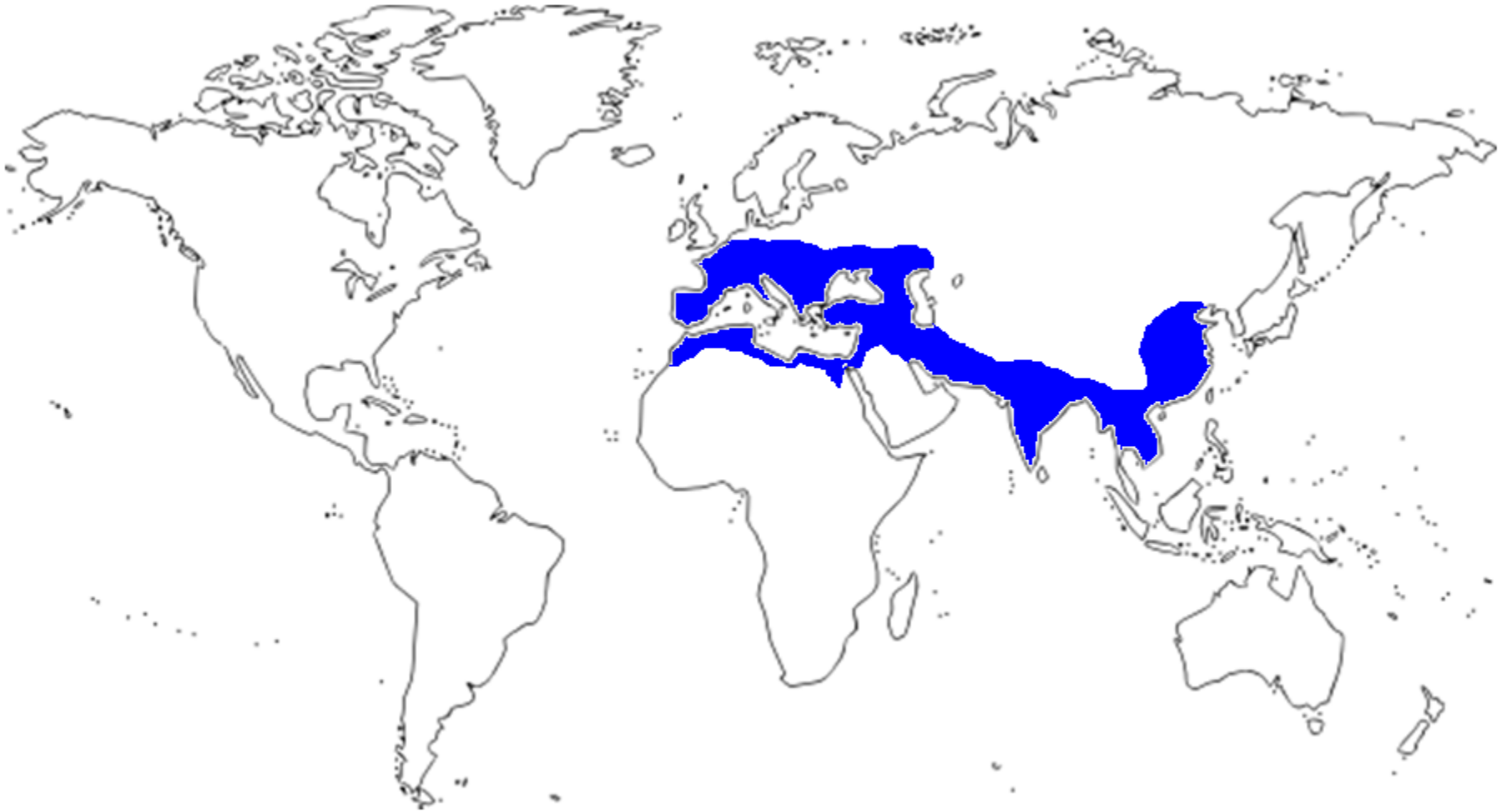
Light = low density, dark = higher density

Native ranges of large bovines

Aurochs are (larger) ancestors of cattle and oxen; extinct by 1627 AD.

Native range of swine

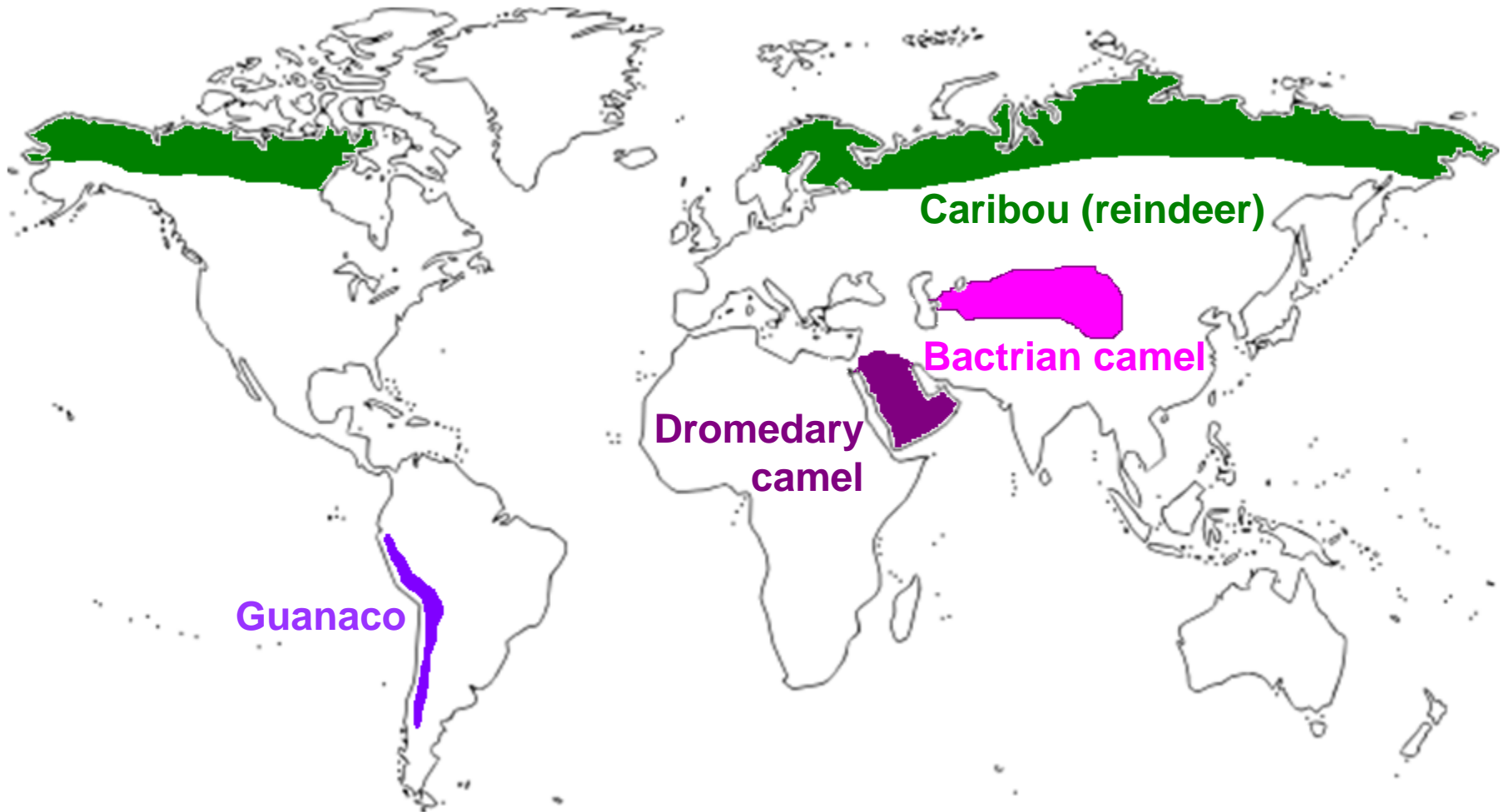# Native range of common ("bezoar") goats

Native range of common ("mouflon") sheep

Native range of other large mammals

Caribou (reindeer)

Bactrian camel

Dromedary camel

Guanaco

Easily-accessible copper and tin

Tin deposit (major/minor)
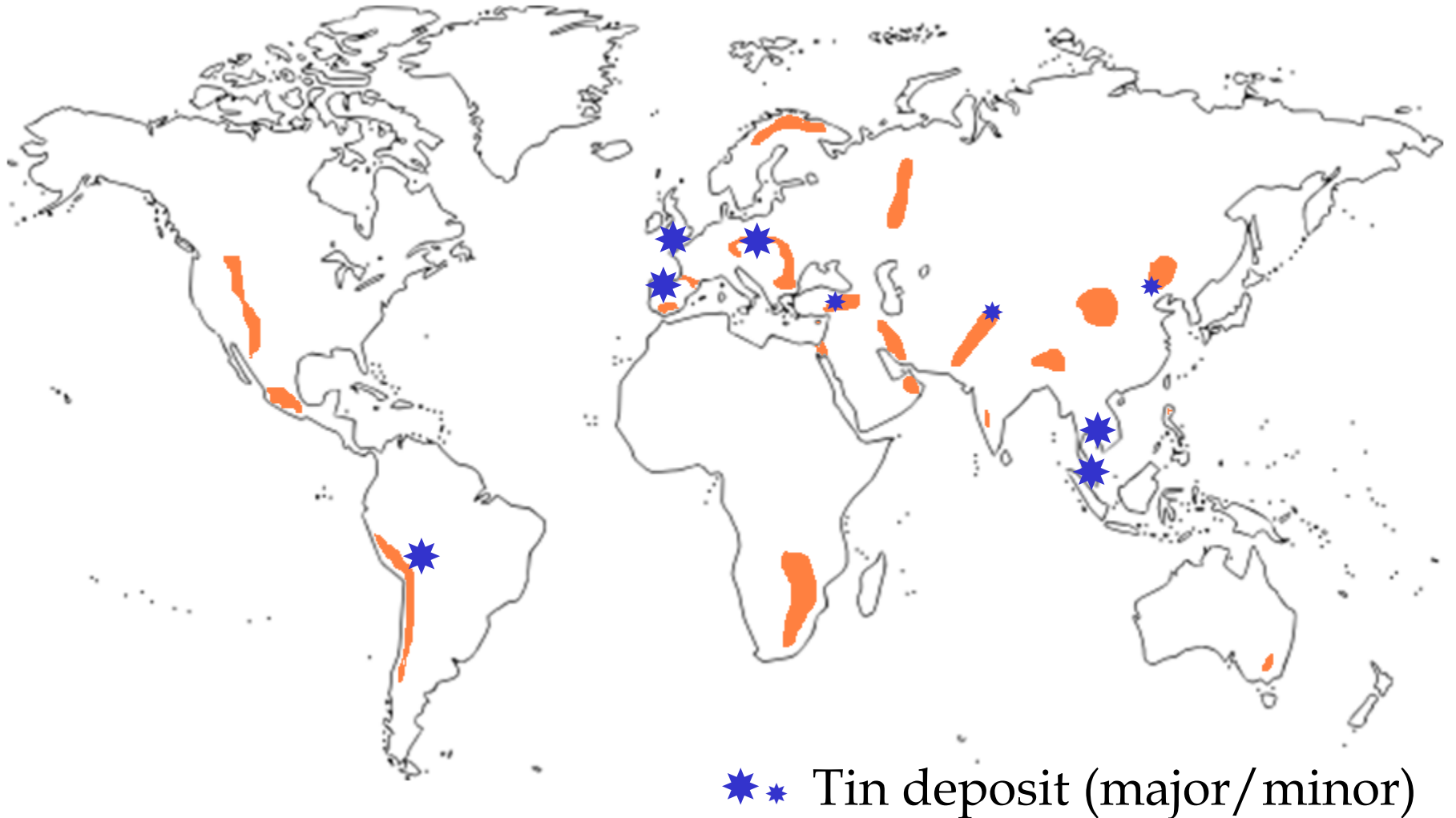
Describe the native resources of the continental United States.

A. Rich in resources; even in the beginning, a Land of Opportunity.

B. Only a few domesticate-able animals but well endowed besides that.

C. Better bring your own.

Describe the native resources of Central America.

A. Rich in resources; even in the beginning, a Land of Opportunity.

B. Only a few domesticate-able animals but well endowed besides that.

C. Better bring your own.

Neolithic (continued)

Given these distributions, it's no wonder why civilization became established first in the places it did.

❑ **The Fertile Crescent**: good grain resources, great animal resources, room to spread out successfully from the native habitat of the plants. Stone and metals a long walk away.

❑ The Nile and Indus valleys: lacked only the grains at first, better stone and mineral resources than the F.C.

- Adjacent to the F.C., so it didn't take them long to get wheat and barley.

❑ The Yellow River plain: not the best of grains or animals but enough of each to get started. Adopted rice rather late from their southern "proto-Austro-Thai" neighbors.

Neolithic (continued)

And why it lagged in places:

- ❑ Africa: lots of large mammals but none of them easy to domesticate; N-S axis, long way to the metals.
- ❑ Europe, north Asia: no native carbs.
- ❑ The Americas: Mostly too little time, but having only one large domesticatable mammal and a N-S axis didn't help.

Success at mammal husbandry

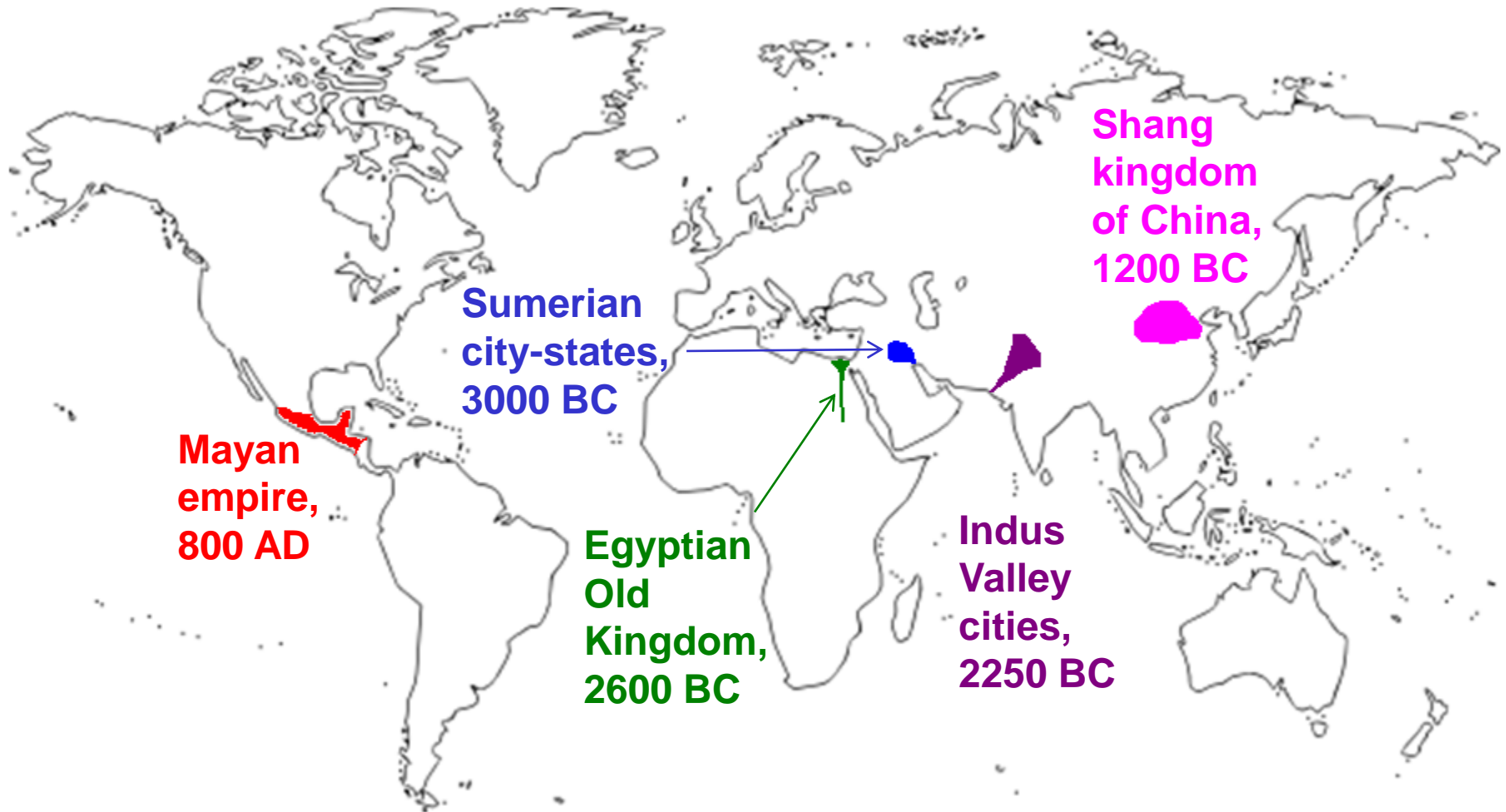| Continent	Candidates	Domesti-cated
Eurasia	72	13
Sub-saharan Africa	51	0
Americas	24	1
Australia	1	0

Candidate: herbivorous or omnivorous mammal, > 100 lb. After Jared Diamond (1997), *Guns, germs and steel.*

The winners: independent emergences of civilization

❑ **Sumer**: agriculture and animal husbandry by 8000 ya, literate by 5500 ya. All other Eurasian civilizations *may* have learned the main skills of civilization from Sumer.

❑ **Egypt**: agriculture by 7000 ya, literate by 5000 ya.

❑ **India** (Indus valley, e.g. Harappa and Mohenjo-Daro): agriculture by 6500 ya, literate by 4700 ya. Linked by many busy trade routes with Sumer.

❑ **China** (Yellow River plain): agriculture by 7000 ya, literate by 4500 ya.

❑ **Mesoamerica**: agriculture by 3200 ya. Never quite got literate but invented pictographs 2000 ya and had complex calendarical inscriptions 1200 ya. Only civilization guaranteed to be independent of Sumer.
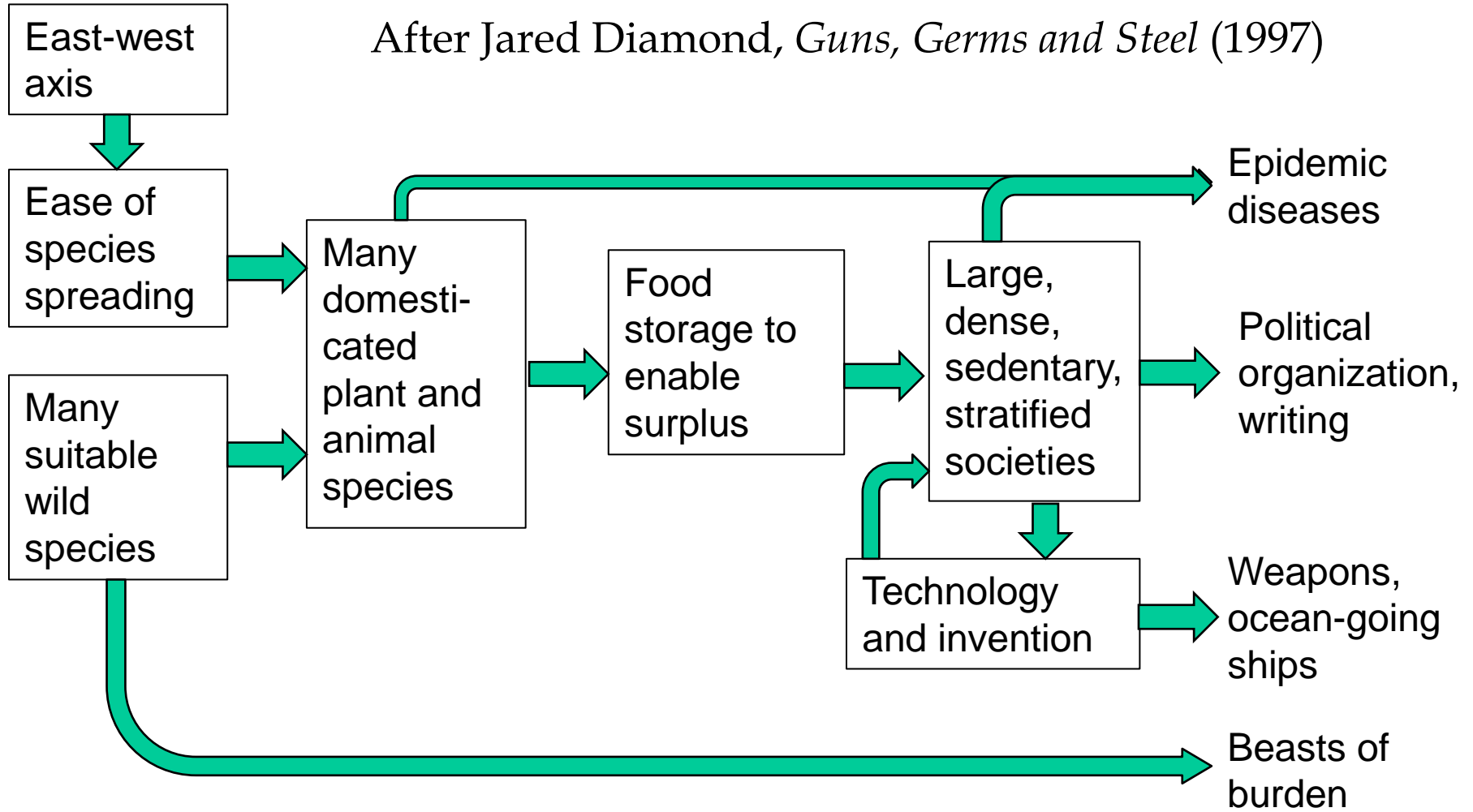
The winners (continued)

Shang kingdom of China, 1200 BC

Sumerian city-states, 3000 BC

Mayan empire, 800 AD

Egyptian Old Kingdom, 2600 BC

Indus Valley cities, 2250 BC

Some Sumerian inventions

- Urban specialization of occupations; thus, leisure.
- Writing, both pictographs and script (cuneiform).
- The wheel, both for potters and carts.
- Irrigation.
- Copper tools.
- Bronze: first arsenic bronzes, then tin bronzes after trade commenced.
- Arithmetic and accounting.
- Astronomically-derived calendar.

- Tanned leather.
- Kiln-dried brick masonry.
- Hand tools: hammer, chisel, brace, bit, nails.
- Waterproof and sail-powered boats.
- Glue.
- Swords and armor.
- Sandals and boots.
- Beer (long credited to the Egyptians).
- Trade (probably).

Factors in the development of civilization

After Jared Diamond, *Guns, Germs and Steel* (1997)

East-west axis

Ease of species spreading

Many suitable wild species

Many domesti-cated plant and animal species

Food storage to enable surplus

Large, dense, sedentary, stratified societies

Technology and invention

Epidemic diseases

Political organization, writing

Weapons, ocean-going ships

Beasts of burden

Intelligence and f_i

Several species one might call intelligent evolved on Earth during the last 200 Myr: humans, dolphins, apes,…

❑ Intelligence developed within 400 Myr of the development of complex organisms.

[Wikimedia Commons](#)

Biodiversity during of the Phanerozoic

❑ There was good luck involved. Diversity developed slowly 'til the continents joined up.

❑ Thus there's a big payoff for connecting the largest number of species in the smallest number of gene pools.

❑ Might have taken a **lot** longer otherwise – many billions of years – and planets might not stay habitable that long.
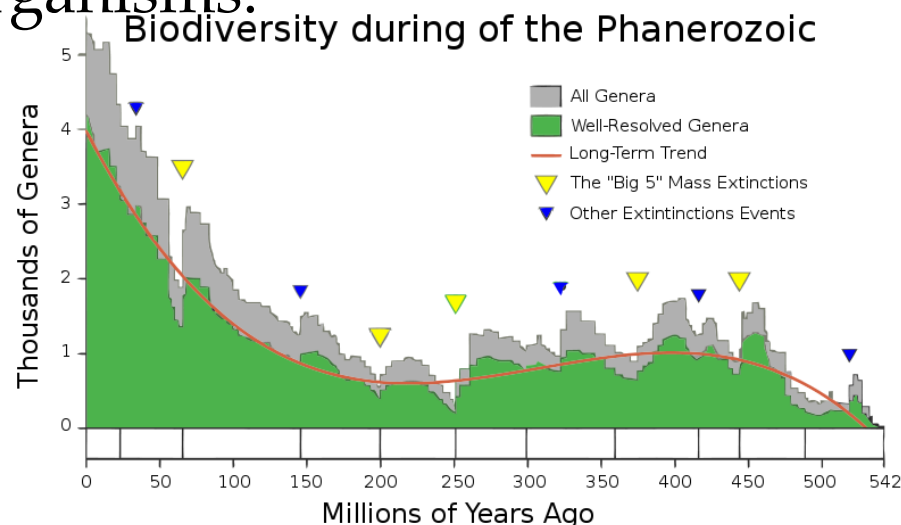
Intelligence and f_i (continued)

❑ Other things equal, this would significantly favor planets with active plate tectonics for the development of land-based intelligence. Less significantly, for ocean species.

❑ So part of the answer is: what fraction of planets offers the maximum concentration of the gene pool for both land and ocean, for at least several hundred Myr at a time?

- Probably not a large fraction of them. Planets much smaller than Earth don't have tectonic activity for very long. (Venus doesn't any more; Mars never did.)

- But it certainly can't be *terribly* rare. The rocky cores of the giant planets are > 10 times Earth's mass, so there used to be more rocks larger than Earth than ones of Earth's size.

Intelligence and f_i (continued)

So we are left with particularly fuzzy constraints:

❑ f_i seems unlikely to be a hefty fraction of 1.

❑ Similarly it seems unlikely to be extremely small, like the 10^{-9} suggested by Evans as the lower bound.

❑ But any value far from these can be defended.

❑ Thus, though we have learned a lot about the evolution of intelligence during the past 50 years, we still haven't improved upon Drake's original guess: f_i **= 0.01**.

❑ It could be ten times larger; it could be 100-1000 times smaller; neither should surprise us.

❑ It would help to know how frequently tectonic activity can be expected; the *Kepler* mission may help us here.

Having heard all this, what do *you* think is the value of f_i?

A. 0.1   B. 0.01   C. 0.001   D. 0.0001   E. 0.00001

How many intelligent species have emerged on Earth? How many of them evolved independently?