Origin of Agriculture

from earliest times human distributions have been correlated with the distribution of plants

the history and development of agriculture is intimately related to the development of civilization

for last 30-40,000 yrs (advent of cromagnon) very little physical evolution is evident in fossil record but tremendous cultural evolution

the advent of stationary human societies and consequent development of civilization were possible only after the establishment of agriculture humans did not “put down roots” and remain in one place until they learned to cultivate the land and collect and store agricultural crops

the origin of agriculture provided “release time” for the development of art, writing, culture, technology, etc

Hunter Gatherers

the earliest humans lived in small bands of several families (up to 50 or so)

most ancestors of domesticated crops come from temperate regions of the world probably 10-12,000 years ago

agriculture originated at least 4 separate times in 4 different places

mideast ➔ fertile crescent

China ➔ Yellow River

Egypt ➔ Aswan

Central America ➔ Tehuacan valley

possible scenario:

1. nomadic tribes migrated annually in the fall and spring from the foothills of surrounding mountains to nearby valleys

   probably followed natural migrations of animal herds

   also, valleys provided plants needed for food and fiber and fuel during the winter that were not available at higher elevations

   in spring the animals moved back to the foothills and spent summer in cooler locations

   cycle was repeated each year

2. probably used same routes and same camps each season

for over 1 M years (paleolithic or old stone age) humans obtained food by hunting wild animals and gathering plants depended almost completely on the local environment such hunter gathering societies existed extensively until 10,000 yrs ago

→ a few isolated groups continue to this day

Paleolithic cultures were nomadic by necessity wandered as small family groups in search of game and edible plants

meat was their primary source of protein

sugars & many vitamins were provided by fruits & berries

starches from roots and seed

oils and vitamins from nuts

as seasons changed, nomadic peoples moved on followed game, gathering plants available

Origin & History of Agriculture

agriculture seems to have arisen in temperate regions before it showed up in the tropics

→ no shortage of food in tropics

3. each camp had a designated trash heap or compost pile; seeds fruits wastes were thrown there

4. plants sprouted in these rich compost beds

   as people returned year after year must have noticed and took advantage of fruits and vegetables growing in these beds

   realization of choice plants growing near camp could have led to experimental “farming” with more and more successes could have cultivated more and more plants

4. became increasingly dependent on such activities

5. staying in one place also meant fewer hazards, more leisure time, greater population size

   → more sedentary lifestyle

6. sedentary lifestyle would have allowed other changes:

   accumulation of material goods

   division of labor

   → not everyone needed to be farmers
→ potters, weavers, tanners, artisans, scholars

7. advanced civilizations rapidly evolved

Earliest Agriculture

the first plants to be cultivated were probably the ones that had been gathered by peoples
crops were more likely to be cultivated if
→ If easily cultivated
→ If they were locally abundant
→ If they had many uses

Earliest Domestications:

Near East
barley may have been the 1st crop domesticated there
also wheat, barley, peas, lentils, vetch
with dogs, goats and sheep

China
rice, millet, rape, hemp
cattle, pigs, dogs, poultry

Tehuacan Valley
corn probably first
later squash, avocado, gourds, beans, chili peppers
dog and later turkey were domesticated

Examples of Early Cereals & Grains

we do know that every important civilization depended on cereal crops (rice, corn, wheat, grains) as mainstay of their agricultural base
eg. millets (Setaria, Echinochloa, Panicum) were among the earliest grains to be cultivated
eg. in China & SE Asia, rice (Oryza) was widely cultivated
eg. in Middle East, wheat (Triticum) was cultivated in hilly regions
eg. barley (Hordeum) was grown in southern Egypt
eg. Maize (Zea) was the main cereal crop in the Americas

the use of wild grass grains and development of more productive strains were central to further development of settled villages and great civilizations

as food plants they have several beneficial traits:
a. high yield: a large amount of grain/acre under cultivation
each grain is rich in carbohydrates, minerals, fats, vitamins & proteins
b. compact and dry
→ allowed long term storage
c. could be ground into flour
→ versatile food & also stores well
d. stems and leaves (straw) can be woven or thatched into baskets, bedding and housing
e. cereal plants produce lateral shoots when cut increasing yield even more

Examples of early Root and Stem Crops:
easily cultivated and harvested
high starch levels
deliberate replanting of leftover pieces of root or stem produced continuing crops

a. cassava (Manihot ultissima)
thick root
tapioca made from this plant

b. Irish potato (Solanum tuberosum)
modern tuber crop
easily propagated by “eyes” (buds) on tuber

c. Asia: taro (Colocasia sp.) & West Indies:
tanna (Xanthosma sp.) are both known to be early root crops
both have starch rich corms (swollen underground stems)
easily propagated by buds on corm

Later Developments

Aztecs developed sophisticated irrigation system (=Chinampas) to expand areas of cultivation and yield (1100’s-1300’s)

Romans were using crop rotation, manure, grafting, and experimenting with plant varieties by 200 CE
increased population growth allowed the development of large cities, even in ancient times
and the exchange of crop plants worldwide
continued agricultural advances resulted from selecting more productive strains of crop plants
industrialization lead to large scale agriculture
→ greatly increased areas under cultivation
→ greatly increased productivity/acre
today, in industrialized countries, all the food is produced by only 5% of the population
at least 90% of all human caloric intake is provided by commercially grown plants
of the more than 250,000 known species of plants, only a few species are exploited to any degree:
also, the food plants 1st domesticated remain our primary staple crops today
6 crops: wheat, rice, corn, potatoes, yams, & cassava provide ~80% of the total caloric intake for the world’s population
tomatoes and coffee are the only two major commercial plant crops that have been developed in the past 2000 years

World Hunger & Malnutrition
UN: hunger is a chronic, debilitating and deadly condition
today hunger is very much a part of our world
→ 1.1 B are undernourished and underweight
→ hunger and malnutrition kill ~6 M children/yr (2005)
On the average, a person dies every second as a result of hunger
→ 4000 every hour
→ 100 000 each day
→ 36 million each year
58 % of all deaths (2001-2004 estimates).
today most of the world’s hungry are in India and SubSaharan Africa
e.g. India: 53% of all children are undernourished
e.g. Bangladesh 56%
e.g. Pakistan 38%
what do we need out of food:
calories → energy foods (carbs, fats)
proteins → tissue building foods
vitamins and trace elements → hard to get nutrients

Diseases of Malnutrition
most malnourished don’t starve to death
→ they die from infections and disease
1. Marasmus ("to waste away")
occurs when diet is low in both calories & proteins
symptoms:
bloated belly
shriveled skin
wide eyes, diarrhea, dehydration, anemia
2. Kwashiorkor ("displaced child")
diet high in calories low in proteins
occurs mostly in infants and children
esp when weaned and placed on starchy diet: cereals etc
symptoms:
liquids collect under skin causing entire body to be bloated
rash
hair decoloration
brain damage, anemia loss of appetite, apathy
3. Iron Deficiency Anemia
affects 5-15% adult men, 1/3 adult women,
50% of children in less developed countries
saps energy, increased chance of infection
women more likely to die in childbirth
4. Vitamin A deficiency
leading cause of partial or total blindness in poor children
e.g. India: 20,000 to 250,000 children/yr go blind
5. other causes & complications of malnutrition
a. in addition to physical diseases associated with malnutrition, the stress of hunger and famine can lead to some destructive behaviors as well:
hoarding, stealing, selling children, murder,
suicide, cannibalism, eating clay, bones, rancid food, etc
b. one specific cause of increasing malnutrition & infection of infants in developing countries is due to decrease in breast feeding
1949: 95% of Chilean mothers breast fed for at least 1 yr
1969: 6% did so
major causes of decrease in breast feeding:
another pregnancy

promotion of formula by manufacturers

→ “modern women” don’t breastfeed

breast milk: balanced nutrition, free, antibodies

deficient in vital nutrients, often dilute

often too much, promotes population growth

c. Overnutrition. while most people in the world are underfed

→ affluent peoples are overfed

diets high in calories, fats, salt, sugar

low in fruits, veggies

industrialized countries tend to associate meat consumption with a higher standard of living

produces its own maladies

diabetes

stroke

hypertension

heart disease

Future Prospects for eliminating hunger

There are two general approaches that could possibly help alleviate the problem:

1. education

2. expand world food production

from the beginning of agriculture to 1950’s this was the primary way crops were increased

today 40% of ice free land is under cultivation

since 1950’s all prime cropland was being used

the amount of prime cropland per capita is actually decreasing

eg. most of world’s cropland is used to produce grain; wheat, rice, corn

grain supplies ~1/2 of human caloric intake directly and more indirectly via meat production

grainland area/person has shrunk from 0.23 ha/person in 1950 to 0.12 ha/person in 1997

est 0.08 ha/person in 2030

most (72%) of the hungry poor live in countryside

→ semiarid, fringe, agricultural areas

→ or steeply sloping erodable land

part of the solution depends on stabilizing these fragile ecosystems

in reality we continue to lose cropland rather than gain it:

1. education

a. ~75% of worlds hungry & poor live in rural areas in poor countries

1.1 B are undernourished and underweight

1.3 B are living in poverty (<$1/day)

→ eliminating poverty will eliminate hunger

many studies have shown that education is key to reducing world poverty

b. education is also directly correlated with a reduction in birth rate

there are 80 Million new mouths to feed each year

→ requires 26 M tons of additional grain/yr

2. expand world food production

food production can be increased by:

a. expanding cultivated areas

b. raising crop productivity

a. expanding cultivated areas

Some Causes of Cropland Loss

1. urbanization

1990 – 43% of population lives in urban areas

2025 est 61% will better land near cities

paving is permanent loss

2. industrialization

factories, warehouses, roads, malls

tend to get the best farmland

3. converted to other crops

oilseed, fruits, veggies

eg. 1950 → 95 soybeans 17M → 123 M for cooking oil, livestock supplements

eg. today convert corn crop to biofuels

4. global warming

displace 67 M people in China

7 M people in India

570,000 ha lost

5. land degradation

38%-48% of land is degraded to some degree

15% extremely degraded due to:

overgrazing

deforestation

agricultural mismanagement

over harvest of fuel wood

6. erosion
often masked by fertilizer application

7. salinization
20% of world's irrigated area

8. water scarcity
agriculture requires 2/3's of all freshwater used
16% of world agriculture are irrigated
→ produce 40% of world's crops

total world cropland will not change much in the near future

some will gain, others will lose
eg. India and China will lose cropland
the only remaining land not used now is highly erodable land that has been converted to grassland or forests

b. raising crop productivity

after 1950's yields increased while amount of cropland remained about the same

from 1950 to 1990 productivity increased ~2.1%/yr
between 1990-1995 ~ 1%/yr
→ decades of increased productivity kept pace with increasing demand
but only with heavy inputs of water, fertilizer, energy, cash

cropland yields continue to increase but at a much slower rate than before

can productivity be raised?

feeding the 80—90 M new people each yr depends almost entirely on raising productivity

increases in productivity (=yields) come from:
1. environmental factors
2. genetic advances
3. agronomic improvements

1. environmental factors
rainfall & soil moisture
care
latitude
day length

2. genetic improvements
larger seeds, less plant increase densities
drooping leaves → less self shading
cant improve photosynthesis itself

3. agronomic improvements
more fertilizers
→10 fold rise in use 1950 to 1990
now use is decreasing, reached limit
more irrigation
better disease control
weed control

1. Biotechnology

after 20 yrs biotech has not yet produced a single high-yielding variety of wheat, corn or rice

genetic improvements have been significant in wheat rice and corn but probably maxed out

→ genetic potential is fully exploited

2. fertilizer/water requirements

still limited by physiology and ecology of plant
farming could be improved in marginal areas by irrigation
but aquifer depletion is becoming more common
competition from industry and cities for water:
the economics of water use do not favor the farmer
eg. China(01): 1000 tons of water
→ $200 of wheat or
→ $14,000 industrial output

wherever economic growths and new jobs are central concerns, water will be diverted to industry

more key to making water more available and used
efficiently is pricing water at its market value

→ will increase efficiency of irrigation
→ improve efficiency of industrial processes

also helps disrupt the pest cycles, reduces soil erosion
US could significantly improve crop production this way
→ but no market yet, few incentives

4. Using existing crops more efficiently

US wastes 40-50% of its food
one of the best ways to make more food available is to "eat lower on the food chain"
more efficient use of our grain crop is tied closely to meat consumption
one of the most predictable trends in the global economy is world meat consumption

44 M tons (1950) → 217 M tons (1999) (5x increase)

meat intake per person per yr

17 kg 1950 → 36kg 1999

growth in meat consumption is ~2x's rate of population growth

2/3ths of growth of grain demand is for feeding livestock and poultry

3. increasing crop diversity where climate and soil allow

eg. double cropping
winter wheat and corn
summer soybeans