Crop evolution

- When and how did the earth become populated with land plants? Order of evolution and plant classes.

- Where is the recognized source of origin and rough time of first cultivation of the field crops in Table 1?

- Why did mankind change from being hunter gatherers to become farmers?

- Did mankind domesticate crop plants before animals or animals before crop plants?

- What is the process of crop evolution? **A combination of natural and conscious human selection to change weedy plant species into domesticated crops.**

- How does natural selection differ from human selection? **Natural is survival of the fittest, Human is survival of the ones chosen by the grower/breeder.**

- What plant characteristics have been altered by human selection, natural selection or human and natural selection?
  - Natural = more shininess, more seed shatter, more toxins, more dormancy, smaller seeds.
  - Human = less shininess, less seed shatter, less toxins, less dormancy, fewer larger seeds and fruits.
  - Both = higher yield, more disease resistance, better drought and stress tolerant.
• What is the difference between a diploid and a polyploid? Diploids have only one set of chromosomes, whereas polyploids either have chromosomes from different diploid ancestors together (allopolyploids) of multiple pairs of chromosomes (autopolyploid).

• What is the difference between an allopolyploid and an autopolyploid? See above.

• List 2 diploid crop species, 2 allopolyploids crop species, and 2 autopolyploid crop species.
  o Diploid: Barley, Pea, Rice, Corn
  o Allopolyploids: Wheat, Canola, Sugar cane, Cotton
  o Autopolyploids: Potato, Peanut, Alfalfa, Cotton

• What impact has agriculture had on the world, ancient and recent?
  o Environmental effects.
    o Soil, Air, Water – pollution.
  o Remove unwanted plants and animals from a farm area.
  o Plants and animals evolved into a symbiotic relationship.
  o Social organization.
    o Structure.
    o Affluence.
  o Population growth.
    o More children mean more workers and care of elderly.

**World Agricultural Production**

• Has world food production kept pace with population growth?

• Has food production been affected by (a) increased land use for farming or (b) increased productivity, or both? Which has had greatest effect over the past 50 years?

• What proportion of the world agricultural land is dedicated to (1) field crops; (2) pasture crops, and (3) permanent crops?

• What are the difference between, field crops, pasture crops and permanent crops?

• Where regions of the world are the major arable farm lands found? North America, Europe and parts of Asia and South America.

• What are the major factors responsible for the dramatic increase in world food?
  o New better adapted and higher yielding cultivars.
- Better management of crops and pastures.
- Farm mechanism.
- Inorganic fertilizers.
- Pesticides.

- Why are the highest crop yields ($/ha) produced in Italy, France and Germany, rather than China, USA and Brazil? **Because the former grow high value crops (like wine grapes) compared to the latter.**

- List 4 of the top 6 crop land countries in the world: **USA, China, India, Russia, Brazil, Argentina**

- List the three major cereal crop worldwide: **Corn, rice, wheat, followed by barley, sorghum and millet.**

- List the three major oilseed crops worldwide: **Soybean, Oil palm, Coconut oil or Canola.**

- List one of the top three root crops, vegetable crops and fruit crops worldwide: **Potato (Cassava), Tomato (cabbage or onion), Orange (apple, grape or banana)**

- What is the 'Green Revolution' and how has it impacted world food supply? **The 'Green Revolution' is the term used when there were large increases in world food production mainly because of the introduction of inorganic fertilizers, herbicides and pesticides.**

- List three of the top six worldwide producers (based on harvested hectarage) of the following:
  - **Corn production:** USA, China, Brazil, France, India, Indonesia.
  - **Wheat production:** China, India, USA, Russia, France, Canada.
  - **Rice production:** China, India, Indonesia, Brazil, USA, Russia.
  - **Soybean production:** USA, Brazil, Argentina, China, India, Canada.
  - **Potato production:** China, Russia, India, Ukraine, USA, Germany.

- List 2 of the world top 4 users of inorganic fertilizer: **China, USA, India, Brazil, France.**

- What are the four types of agriculture discussed in class? **(See map)**
What is the difference between (a) Industrial agriculture, Traditional intensive agriculture, and (c) Shifting agriculture?

- **Industrial**: Relies on large heavy machinery and chemicals; Uses fossil fuels and converts them to food and other crops; Although often considered to highly sophisticated, many operations require large amounts of (low-paid) labor.

- **Traditional**: Produces the highest crops yields/area; Uses lots of hand labor; Cycles soil nutrients through livestock manures and returning other organic matter to the soil; China has maintained good soil fertility for 1000’s of years of farming.

- **Shifting**: Farmers ‘hack’ small plots of farmland from forests; Continue to farm that portion of land until nutrients are depleted; Often utilizes intercropping, legumes and grains; Land is later re-fertilized by natural process.

**USA Crop Production**

- USA population has risen to over 300,000,000 recently, is the ratio of farmer to non-farmers remained constant over the past 100 years? Explain the reasons in your answer.

- What has influence in farm size (in area) as you move from the east to west coast of the USA.

- List four of the major field crops in the USA: **Corn**, **Soybean**, **Wheat**, **Alfalfa**, **Cotton**, **Sorghum**, **Potato**.
• List three of the top six USA state in regard to production of the following field crops:
  o Corn: Iowa, Illinois, Nebraska, Minnesota, Indiana, Ohio
  o Soybean: Iowa, Illinois, Nebraska, Minnesota, Indiana, Ohio
  o Wheat: Kansas, North Dakota, Montana, Oklahoma, Washington, Texas
  o Barley: North Dakota, Montana, Idaho, Washington, Minnesota, Colorado
  o Alfalfa: California, North Dakota, Wisconsin, Minnesota, Idaho, Nebraska

• Should USA agriculture produce more crops for fuel (i.e. ethanol from corn and biodiesel from soy oil) with fewer crops for food? It’s up to you!

Idaho Crop Production

• Briefly outline the history of the state of Idaho and how this relates to agriculture.
  o Inhabited by native Indians for thousands of years. Explored by Lewis & Clark 1805-1806, at that time owned jointly by USA and UK, but the UK was kicked out by Oregon Treaty of 1846.
  o First permanent USA settlement was established by the Mormons at Franklin in 1860. These settlers were Idaho’s first farmers and were instrumental in setting the foundation for irrigated agriculture in the south.
  o In the 1870’s, growing numbers of eastern settlers occupying Indian lands led to a series of battles between US and the Nez Perce, Bannock, and Sheepeater tribes.
  o After gold was discovered at Orofino Creek in 1860. This caused gold prospectors to swarm into the state. This mass increase in population was short lived and most had left soon after leaving ghost town. Mining remains important today where Idaho ranks amongst US states in silver, lead, cobalt and garnet.
  o Timber also added to the state wealth but again ghost towns remained after logging ended.
  o For most of the last century Agriculture has been the leading state export. Recently superseded by the electronics industry. However, agriculture to many is the mainstay of Idaho and its community.
  o Today, tourism is the largest state income. Idaho remains one of the last pristine environments in the nation. Visitors enjoy the scenery, raft, hike and hunt.
• Is there a higher or lower percentage of crop land in Idaho compared to Ohio? Explain why this might be. **Lower percentage in Idaho, ‘cause we’ve loads of mountains.**

• List three of the top six agricultural crops grown in Idaho (based on $ value): **Potato, Alfalfa, Wheat, Barley, Grain corn, Dry beans.**

• Apart from potato, what crops does Idaho rank as 1st, 2nd or 3rd in the USA in total production.
  - Number 1 in the USA in:
    - Potato, Austrian winter pea, Wrinkled pea, Small white/red bean, and Pink bean production.
  - Number 2 in the USA in:
    - Lentils, Edible pea, and Garbanzo Bean production.
  - Number 3 in the USA in:
    - Barley, Sugar beet, Mint, Hops, Onion production.

• Rank the following 4 Idaho regions (1 = highest production, 4 = lowest production) for the following crops.

<table>
<thead>
<tr>
<th>Crop</th>
<th>District 10</th>
<th>District 70</th>
<th>District 80</th>
<th>District 90</th>
</tr>
</thead>
<tbody>
<tr>
<td>Wheat</td>
<td>2</td>
<td>4</td>
<td>3</td>
<td>1</td>
</tr>
<tr>
<td>Grain Corn</td>
<td>4</td>
<td>1</td>
<td>2</td>
<td>3</td>
</tr>
<tr>
<td>Barley</td>
<td>3</td>
<td>4</td>
<td>2</td>
<td>1</td>
</tr>
<tr>
<td>Potato</td>
<td>4</td>
<td>3</td>
<td>2</td>
<td>1</td>
</tr>
<tr>
<td>Sugar beet</td>
<td>4</td>
<td>3</td>
<td>1</td>
<td>2</td>
</tr>
<tr>
<td>Alfalfa</td>
<td>4</td>
<td>3</td>
<td>2</td>
<td>1</td>
</tr>
<tr>
<td>Corn silage</td>
<td>4</td>
<td>2</td>
<td>1</td>
<td>3</td>
</tr>
</tbody>
</table>

**Plant Breeding**

• Describe the three phases of cultivar development.
  - Create/identify genetic variability by: (1) finding genetic diversity, (2) creating variability through artificial cross pollination between chosen parents, (3) introduce genetic variability from related weed species, (4) induced mutagenesis, and (5) recombinant DNA techniques (i.e. GMO’s)
  - Select desirable recombinants, either phenotypically, genetically, or molecularly.
  - Increase seed stocks/planting material of desired new cultivars and make commercially available to farmers.
• Why do private companies fund genetic research and cultivar development? **To make money on intellectual property or seed sales.**

• How can private companies protect their intellectual property? **They apply for (and are awarded) Patents, Plant Variety Rights and Plant Rights.**

• Is it a good or bad idea that a few large biotechnology/breeding companies are responsible for over 50% of the world seed sales? **Explain your answer. (It's up to you!)**

• Briefly outline the stages necessary to insert a GMO into a new crop cultivar.
  - Find a desirable gene
  - Develop a suitable construct
  - Develop a mechanism to transfer the gene into the target plant
  - Select cells that have been transformed
  - Regenerate whole plants from single transformed cells
  - Check functionality of transformed plants

• What are the advantages of genetically modified crops (GMO's)? **Genetic engineering allows plant breeders to transfer genes from different species that could not be possible with traditional breeding techniques.** For example, a cold tolerance gene can be clones from a flounder (fish) and inserted to canola to offer the plant greater cold hardiness. Transgenic crops could offer greater yield potential and increased pest resistance hence allowing lower production costs. GMO crops also offer the possibility of developing Pharm-ing, whereby crops are grown to produce pharmaceutical drugs (i.e. edible vaccines).

• What are some of the concerns that the general public may have with genetically modified crops (GMO's)? **Concerns arise because of lack of trust in western governments.** Some people are concerned about Franken-foods that they are 'not natural', that plant breeders are 'playing God' by creating such foods. There are other concerns relating to allergies, in that some people have life-threatening allergic reactions to some foods and that eating GMO food may cause allergic reactions.

• What are the environmental concerns about genetically modified crops (GMO's)? **There is concern that the engineered genes will escape into the ecosystem either as volunteer plants or by cross pollination with related weedy species.** If these transgenes were to escape into the ecosystem they be become super-weeds. There have also been concerns on the impact on other plants and animals (i.e. Monarch butterflies and B.t. pollen from corn).

• Could there be any affect on reduced genetic variability due to the use of genetically modified crops? **Yes, much of the plant transformation technology is linked to proprietary ownership be a few large chemical and Biotechnology companies.** There is a general trend to have mono-genotypic crops where a single cultivar is grown over wide areas (and countries), replacing many different cultivars of past.
<table>
<thead>
<tr>
<th>Crop</th>
<th>Time of Domestication --Years --</th>
<th>Possible Region of Origin</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Cereals</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Maize, <em>Zea Mays</em></td>
<td>7000</td>
<td>Mexico, Central America</td>
</tr>
<tr>
<td>Rice, <em>Oryza sativa</em></td>
<td>4500</td>
<td>Thailand, Southern China</td>
</tr>
<tr>
<td>Wheat, <em>Triticum</em> spp.</td>
<td>8500</td>
<td>Syria, Jordan, Israel, Iraq</td>
</tr>
<tr>
<td>Barley, <em>Hordeum</em> vulgare</td>
<td>9000</td>
<td>Syria, Jordan, Israel, Iraq</td>
</tr>
<tr>
<td>Sorghum, <em>Sorgum</em> bicolour</td>
<td>8000</td>
<td>Equatorial Africa</td>
</tr>
<tr>
<td><strong>Oilseeds</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Soybean, <em>Glycine</em> max</td>
<td>2000</td>
<td>Northern China</td>
</tr>
<tr>
<td>Oil Palm, <em>Elaeis</em> guineensis</td>
<td>9000</td>
<td>Central Africa</td>
</tr>
<tr>
<td>Rapeseed, <em>Brassica</em> napus</td>
<td>500</td>
<td>Mediterranean Europe</td>
</tr>
<tr>
<td>Sunflower, <em>Helianthus</em></td>
<td>3000</td>
<td>Western United States</td>
</tr>
<tr>
<td><strong>Pulses</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Beans, <em>Phaseolus</em> spp.</td>
<td>7680</td>
<td>Central America, Mexico</td>
</tr>
<tr>
<td>Lentil, <em>Lens</em> culinaris</td>
<td>7000</td>
<td>Syria, Jordan, Israel, Iraq</td>
</tr>
<tr>
<td>Peas, <em>Pisum</em> sativum</td>
<td>9000</td>
<td>Syria, Jordan, Israel, Iraq</td>
</tr>
<tr>
<td><strong>Root crops</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Potato, <em>Solanum</em> tuberosum</td>
<td>7000</td>
<td>Peru</td>
</tr>
<tr>
<td>Cassava, <em>Manihot</em> esculenta</td>
<td>5000</td>
<td>Brazil, Mexico</td>
</tr>
<tr>
<td>Sweet Potato, <em>Ipimica</em> batatas</td>
<td>6000</td>
<td>South Central America</td>
</tr>
<tr>
<td>Sugar Beet, <em>Beta</em> vulgaris</td>
<td>3000</td>
<td>Mediterranean Europe</td>
</tr>
<tr>
<td><strong>Vegetables</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Tomato, <em>Lycopersico</em> esculentum</td>
<td>3000</td>
<td>Western South America</td>
</tr>
<tr>
<td>Cabbage, <em>Brassica</em> oleracea</td>
<td>3000</td>
<td>Mediterranean Europe</td>
</tr>
<tr>
<td>Onion, <em>Allium</em></td>
<td>4500</td>
<td>Iran, Afghanistan, Pakistan</td>
</tr>
<tr>
<td><strong>Fruit</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Orange, <em>Citrus</em> sinesis</td>
<td>9000</td>
<td>South-eastern Asia</td>
</tr>
<tr>
<td>Apple, <em>Malus</em> spp.</td>
<td>3000</td>
<td>Asia Minor, Central Asia</td>
</tr>
<tr>
<td>Grape, <em>Vitaceae</em> spp.</td>
<td>7000</td>
<td>Eastern Asia</td>
</tr>
<tr>
<td>Banana, <em>Musa</em> aceminata, <em>M. balbisiana</em></td>
<td>4500</td>
<td>South-east Asia</td>
</tr>
<tr>
<td><strong>Others</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Cotton, <em>Gossypium</em></td>
<td>4500</td>
<td>Central America, Brazil</td>
</tr>
<tr>
<td>Alfalfa, <em>Medicago</em> sativa</td>
<td>4000</td>
<td>Iran, Northern Pakistan</td>
</tr>
</tbody>
</table>