

The Importance of Plants

Via the process of photosynthesis, plants provide oxygen and are also the ultimate source of food and metabolic energy for nearly all animals. Besides foods (e.g. grains, fruits, and

vegetables), plants also provide people with shelter, clothing, medicines, fuels, and the raw materials from which innumerable other products are made.



Plant tissues provide the energy for almost all heterotrophic life. Many plants produce delicious fruits in order to spread their seeds.



Plant tissues can be utilized to provide shelter in the form of framing, cladding, and roofing.



Many plants provide fibers for a range of materials including cotton (above), linen (from flax), and coir (from coconut husks).



Plant extracts, including rubber from rubber trees (above), can be utilized in many ways as an important manufacturing material.



Coal, petroleum, and natural gas are fossil fuels which were formed from the dead remains of plants and other organisms. Together with wood, they provide important sources of fuel.



Plants produce many beneficial and not so beneficial substances (e.g. the cannabis plant above). Over 25% of all modern medicines are derived from plant extracts.

1. Using examples, describe how plant species are used by people for each of the following:

- (a) Food: _____

- (b) Fuel: _____

- (c) Clothing: _____

- (d) Building materials: _____

- (e) Aesthetic value: _____

- (f) "Recreational" drugs: _____

- (g) Therapeutic drugs (medicines): _____

2. Outline three reasons for ensuring the protection of native forests:

- (a) _____
- (b) _____
- (c) _____

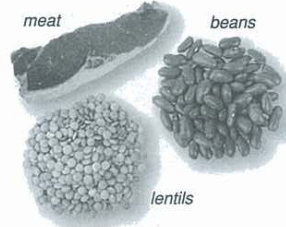
Global Human Nutrition

Globally, 854 million people are undernourished and, despite improvements in agricultural methods and technologies, the number of hungry people in the world continues to rise. The majority of these people live in developing nations, but 9 million live in industrialized countries. Over 6 million people die annually from starvation, while millions of others suffer debilitating diseases as a result of malnutrition. Protein deficiencies (such as kwashiorkor), are common amongst the world's malnourished, because the world's poorest nations consume only a fraction of

the world's protein resources, surviving primarily on cereal crops. Political and environmental factors contribute significantly to the world's hunger problem. In some countries, food production is sufficient to meet needs, but inadequate distribution methods cause food shortages in some regions. Advances in agricultural practices (fertilizer and pesticide application, genetically enhanced stock) improve agricultural productivity and food supply, but can have detrimental effects through loss of biodiversity, soil and water pollution, and increased levels of greenhouse gases.

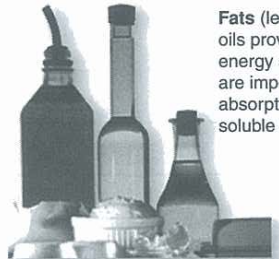
Human Nutritional Requirements

A **balanced diet**, taken from the components below, is essential for human growth, development, metabolism, and good health. In many developing countries, deficiency diseases and starvation are prevalent either because of an absolute scarcity of food or because of inadequate nutrition. In many developed Western nations, an oversupply of cheap, nutritionally poor and highly processed food is contributing to an increase of diet-related diseases such as obesity, diabetes, and heart disease. **Malnutrition** (a lack of specific nutrients), once commonly associated with undernutrition, is now rising in developed nations over consuming on poor quality processed foods.



Proteins (supplied by beans and pulses, and animal products such as meat and fish) are essential to growth and repair of muscle and other tissues. Unlike animal protein, plant protein is incomplete and sources must be chosen to complement one another nutritionally. Deficiencies result in kwashiorkor or marasmus.

Carbohydrates (right) are supplied in breads, starchy vegetables, cereals, and grains. They form the staple of most diets and provide the main energy source for the body.



Fats (left) and oils provide an energy source and are important for absorption of fat soluble vitamins.

Minerals (inorganic elements) and **vitamins** (essential organic compounds) are both required for numerous normal body functions. They are abundant in fruit and vegetables (right)



Agricultural Practices

Essentially, there are two broadly different types of agriculture: industrialized, or high-input, agriculture and traditional or subsistence agricultural systems. These categories exclude the hunter-gatherer societies, such as the Inuit, which collect food directly from the wild using methods of foraging and hunting with little or no domestication of target foodstuffs.



Subsistence agriculture is low technology, low-input farming where only enough food is grown to supply the family unit. It has minimal environmental impact, but can be unsustainable in densely populated areas. Subsistence agriculture occurs mostly in Africa, Asia and South America, and parts of the Pacific (e.g. Niue, left).



Industrialized, intensive agriculture produces high yields per unit of land at cheaper prices to the consumer, but has a large environmental impact because of high inputs of energy, fertilizers, and pesticides. **Wheat production** (left) and animal "factory farming" are examples. Rice production is also an example of intensive agriculture, but remains largely traditional (not mechanized) in many parts of the world.



Plantation agriculture is a form of industrialized agriculture practised mainly in tropical countries solely for the production of a high value cash crop for sale in developed countries. Typical crops include bananas (left), cotton, coffee, sugarcane, tobacco, and cocoa.

1. Discuss the differences between subsistence and industrialized agriculture with respect to relative inputs of land, labor, financial capital, and fossil fuel energy:

2. One of the likely effects of a global fuel crisis would be food shortage. Explain this statement:



Cereal Crop Production

Agricultural ecosystems may be industrialized (high-input) or traditional. Industrialized agriculture uses large amounts of fossil fuel energy, water, fertilizers, and pesticides to increase net production (crop yield). Despite the high diversity of edible plants, the world's population depends on just 30 crops for 95% of its food. Four crops: wheat, rice, maize, and potato, account for a bigger share than all other crops combined. Since 1950, most of the increase in global food production has resulted from increased yields per unit of farmed land. This increase was termed the **green revolution**. More recently, a second green

revolution has been taking place, with the use of fast growing, high yielding varieties of rice, corn, and wheat, specially bred for tropical and subtropical climates. Producing more food from less land increases the per capita food production while at the same time protecting large areas of potentially valuable agricultural land from development. Although food production has nearly tripled since the 1950s, the rate of this increase has started to slow, and soil loss and degradation are taking a toll on formerly productive land. Sustainable farming practices provide one way in which to reduce this loss of productivity.

Wheat (*Triticum* spp.)

Wheat is the most important world cereal crop and is extensively grown in temperate regions. Bread (common) wheat is a soft wheat with a high gluten (protein) content. It is cultivated for the grain, which is used both whole or ground. Durum wheat is a hard (low gluten) wheat used primarily for the manufacture of pasta. Key areas for wheat production are the prairies of Canada and the USA, Europe, and Russia (the former Soviet wheat belt). The economic stability of many nations is affected by the trade in wheat and related commodities. **New developments:** Wheat cultivars are selected for particular nutritional qualities or high yield in local conditions. Research focuses on breeding hardy, disease resistant, and high yielding varieties.

Maize (corn, *Zea mays*)

Maize is a widely cultivated tropical and subtropical C₄ cereal crop, second only to wheat in international importance as a food grain. The USA corn belt produces nearly half the world's maize. Some is exported, but now 85% is used within the USA as animal feed (as grain and silage). Maize is also a major cereal crop in Africa but is second to rice in importance in Asian countries. Nutritionally, maize is poor in the essential amino acids tryptophan and lysine. Recent breeding efforts have been aimed at addressing these deficiencies. **New developments:** Plant breeding has produced high lysine hybrid varieties with better disease resistance and higher yields. Most countries have cultivars suited to local conditions.

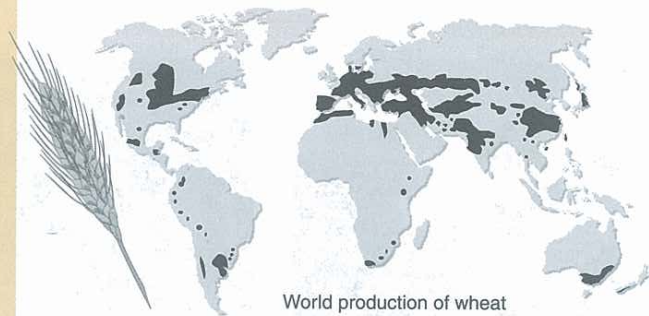
Rice (*Oryza sativa*)

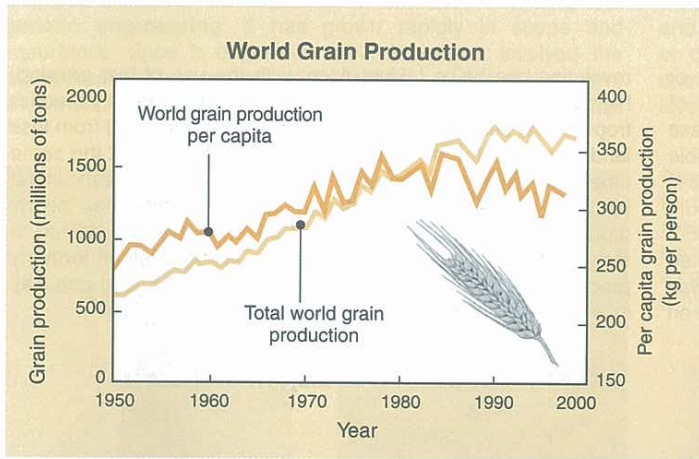
Rice is the basic food crop of monsoon Asia. It is highly nutritious and requires relatively little post-harvest processing. The most common paddy (*japonica*) varieties are aquatic and are often grown under irrigation. Its cultivation is labor intensive. Upland (*indica*) varieties have similar requirements to other cereal crops. Most rice is grown in China, mainly for internal consumption. Other major producers include India, Pakistan, Japan, Thailand and Vietnam. **New developments:** Much effort has gone into producing fast growing, disease resistant, high yielding cultivars which will crop up to 3 times a season. Genetic engineering to increase tolerance to high salinity is extending the range for cultivation in the upland varieties of rice.

Sorghum (*Sorghum bicolor*)

Sorghum is a frost-sensitive, tropical C₄ plant, well adapted to arid conditions. It has low soil nutrition and water requirements, reflecting its origin in the sub-Saharan Sudan region of Africa. Sorghum is now widely cultivated in Africa, the middle East to India and Burma, and parts of Australia, the Americas and Southern Europe. It is nutritious and is used as a human foodstuff in Asia and Africa. In other regions, it is used mainly as animal feed and as an industrial raw material (for oil, starch, and fiber). **New developments:** New hybrids are high yielding, low-growing, and ripen uniformly. Further breeding aims to improve grain quality, and combine high yield properties with the disease resistance of the African wild stocks.

World Production of Major Food Crops



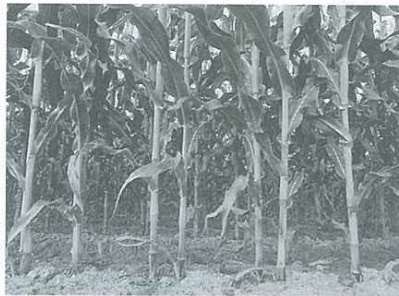


| Cropping properties of major world crop plants | | |
|--|---|--|
| Crop plant | Yield (kg grain ha ⁻¹) | Specific requirements for growth |
| Maize | 1000 - 4000 | Warm, frost free climate, fertile soil, drought intolerant |
| Wheat | 1000 - 14 500 | Adapted to a wide range of temperate climates and soils |
| Rice | 4500 (paddy) 1500 (indica) | Tropical, paddy varieties are aquatic, drought intolerant |
| Sorghum | 300 - 2000. As high as 6500 for irrigated hybrids | Wide range of soils. Drought tolerant. Grown in regions too dry for maize. |



Sorghum is able to grow well in the very hot, dry regions of tropical Africa and central India. Adaptations include:

- A **dense root system** that is very efficient at extracting water from the soil.
- A thick **waxy cuticle** that prevents evaporative water loss through the leaf surface.
- The presence of special cells (called **motor cells**) on the underside of the leaf that cause the leaf to roll inwards in dry conditions. This traps moist air in the rolled leaf and reduces water loss.
- Reduced number of sunken stomata on leaves.



Maize grows well where temperature and light intensity are high. Adaptations include:

- Maize has an additional photosynthetic pathway (the **C₄ pathway**), which is absent in most cooler climate plants. The C₄ pathway allows maize to fix CO₂ at low levels as a four-carbon molecule. This molecule is used to boost CO₂ in the regular C₃ pathway. In tropical conditions, the C₄ pathway allows photosynthesis to continue at high rates (primarily by inhibiting photorespiration).
- The roots are shallow, so maize often has small **aerial roots** at the base of the stem to increase their ability to withstand buffeting by wind.



Most of the **rice** in southeast Asia is grown partly submerged in paddy fields. Adaptations include:

- The stem of a rice plant has **large air spaces** (hollow aerenchyma) running the length of the stem. This allows oxygen to penetrate through to the roots which are submerged in water.
- The roots are also very shallow, allowing access to oxygen that diffuses into the surface layer of the waterlogged soil.
- When oxygen levels fall too low, the root cells respire anaerobically, producing ethanol. Ethanol is normally toxic to cells, but the root cells of rice have an unusually high tolerance to it.

1. Explain how crop yields were increased in:
 - (a) The first green revolution: _____
 - (b) The second green revolution (in the last 30 years): _____
2. Suggest a reason for the decline in per capita production of grain in the last decade: _____

3. Comment on the importance of wheat as a world food crop: _____

4. (a) Suggest when sorghum is a preferable crop to maize: _____

 - (b) Suggest why rice is less important as an export crop than wheat or maize: _____

5. Briefly describe two adaptive features of each of the cereal crops below:
 - (a) Rice: _____

 - (b) Maize: _____
