Index with approximate page numbers for Agriculture

# Agriculture

## 2008/9 Schools Wikipedia Selection. Related subjects: Agriculture

**Agriculture** refers to the production of agricultural goods through the growing of plants and the raising of domesticated animals. The study of agriculture is known as agricultural science. The related practice of gardening is studied in horticulture.

Agriculture encompasses a wide variety of specialties. Cultivation of crops on arable land and the pastoral herding of livestock on rangeland remain at the foundation of agriculture. In the past century a distinction has been made between sustainable agriculture and intensive farming. Modern agronomy, plant breeding, pesticides and fertilizers, and technological improvements have sharply increased yields from cultivation. Selective breeding and modern practices in animal husbandry such as intensive pig farming (similar practices applied to the chicken) have similarly increased the output of meat. The more exotic varieties of agriculture include aquaculture and tree farming.

The major agricultural products can be broadly grouped into foods, fibers, fuels, raw materials, legal and illegal drugs, and an assortment of ornamental or otherwise exotic products. In recent years plants have been used to grow biofuels, biopharmaceuticals, and bioplastic. as well as pharmaceuticals. Specific foods include cereals, (vegetables, fruits, and meat. Fibers include (cotton, wool, hemp, silk and flax). Raw materials include lumber and bamboo. Drugs include tobacco, marijuana, opium, cocaine), and other useful materials such as resins. Biofuels include methane from biomass, ethanol, and biodiesel. Cut flowers, nursery plants, tropical fish and birds for the pet trade are some of the ornamental products.

The history of agriculture has played a major role in human history, as agricultural progress has been a crucial factor in worldwide socio-economic change. Wealth-building and militaristic specializations rarely seen in hunter-gatherer cultures are commonplace in societies which practice agriculture. So, too, are arts such as epic literature and monumental architecture, as well as codified legal systems. When farmers became capable of producing food beyond the needs of their own families, others in their society were freed to devote themselves to projects other than food acquisition. Historians and anthropologists have long argued that the development of agriculture made civilization possible.

In 2007, an estimated 35 percent of the world's workers were employed in agriculture (from 42% in 1996). However, the relative significance of farming has dropped steadily since the beginning of industrialization, and in 2003 – for the first time in history – the services sector overtook agriculture as the economic sector employing the most people

**Agriculture**

**General**
Agribusiness · **Agriculture**

Agricultural science · Agronomy
Animal husbandry
Extensive farming
Factory farming · Free range
Industrial agriculture
Intensive farming
Organic farming · Permaculture
Sustainable agriculture
Urban agriculture

**History**
History of agriculture

Neolithic Revolution
Muslim Agricultural Revolution
British Agricultural Revolution
Green Revolution

**Particular**
Aquaculture · Christmas trees · Dairy farming

Grazing · Hydroponics · IMTA
Intensive pig farming · Lumber

worldwide. Despite the fact that agriculture employs over one-third of the world's population, agricultural production accounts for less than five percent of the gross world product (an aggregate of all gross domestic products).

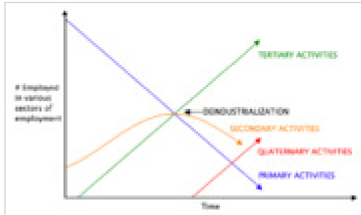
Maize · Orchard
Poultry farming · Ranching · Rice
Sheep husbandry · Soybean
System of Rice Intensification
Wheat

**Categories**
Agriculture by country

Agriculture companies
Agriculture companies, U.S.
Biotechnology
Farming history
Livestock
Meat processing
Poultry farming

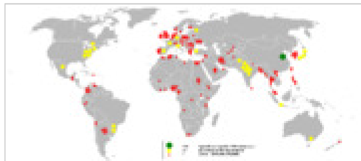
## Overview

Agriculture has played a key role in the development of human civilization—it is widely believed that the domestication of plants and animals allowed humans to settle and give up their previous hunter-gatherer lifestyle during the Neolithic Revolution. Until the Industrial Revolution, the vast majority of the human population labored in agriculture. Development of agricultural techniques has steadily increased agricultural productivity, and the widespread diffusion of these techniques during a time period is often called an agricultural revolution. A remarkable shift in agricultural practices has occurred over the past century in response to new technologies. In particular, the Haber-Bosch method for synthesizing ammonium nitrate made the traditional practice of recycling nutrients with crop rotation and animal manure less necessary. Synthetic nitrogen, along with mined rock phosphate, pesticides and mechanization, have greatly increased crop yields in the early 20th century. Increased supply of grains has led to cheaper livestock as well. Further, global yield increases were experienced later in the 20th century when high-yield varieties of common staple grains such as rice, wheat, and corn were introduced as a part of the Green Revolution. The Green Revolution exported the technologies (including pesticides and synthetic nitrogen) of the developed world out to the developing world. Thomas Malthus famously predicted that the Earth would not be able to support its growing population, but technologies such as the Green Revolution have allowed the world to produce a surplus of food.



The amount of workforce dedicated to agriculture tends to decrease

Many governments have subsidized agriculture to ensure an adequate food supply. These agricultural subsidies are often linked to the production of certain commodities such as wheat, corn, rice, soybeans, and milk. These subsidies, especially when done by developed countries have been noted as protectionist, inefficient, and environmentally damaging. In the past century agriculture has been characterized by enhanced productivity, the use of synthetic fertilizers and pesticides, selective breeding, mechanization, water contamination, and farm subsidies. Proponents of organic farming such as Sir Albert Howard argued in the early 1900s that the overuse of pesticides and synthetic fertilizers damages the long-term fertility of the soil. While this feeling lay dormant for decades, as environmental awareness has increased recently there has been a movement towards sustainable agriculture by some farmers, consumers, and policymakers. In recent years there has been a backlash against perceived external environmental effects of mainstream agriculture, particularly regarding water pollution, resulting in the organic movement. One of the major forces behind this movement has been the European Union, which first certified organic food in 1991 and began reform of its Common Agricultural Policy (CAP) in 2005 to phase out commodity-linked farm subsidies, also known as decoupling. The growth of organic farming has renewed research in alternative technologies such as integrated pest management and selective breeding. Recent mainstream technological developments include genetically modified food.


Agricultural output in 2005

As of late 2007, several factors have pushed up the price of grain used to feed poultry and dairy cows and other cattle, causing higher prices of wheat (up 58%), soybean (up 32%), and maize (up 11%) over the year. Food riots have recently taken place in many countries across the world. An epidemic of stem rust on wheat caused by race UG99 is currently spreading across Africa and into Asia and is causing major concern. Approximately 40% of the world's agricultural land is seriously degraded. In Africa, if current trends of soil degradation continue, the continent might be able to feed just 25% of its population by 2025, according to UNU's Ghana-based Institute for Natural Resources in Africa.

## Practices


Farmers work inside a rice field in Andhra Pradesh, India.

Agricultural practices lie on a spectrum dependent upon the intensity and technology of the methods. At the one end lies the subsistence farmer who farms a small area with limited inputs and produces only enough food to meet the needs of his or her family. At the other end lies intensive agriculture which includes traditional labor intensive farming (e.g. South-East Asia rice paddies), and modern agriculture which includes industrial agriculture, organic farming and sustainable farming. Industrial agriculture involves large fields and/or numbers of animals, high resource inputs (pesticides, fertilizers, etc.), and a high level of mechanization. These operations achieve economies of scale and require large amounts of capital in the form of land and machinery.

The twentieth century saw changes in agricultural practice, particularly in agricultural chemistry and in mechanization. Agricultural chemistry includes the application of chemical fertilizer, chemical insecticides (see pest control), and chemical fungicides, analysis of soil makeup and nutritional needs of farm animals.

Mechanization has increased farm efficiency and productivity in most regions of the world, due especially to the tractor and various "gins" (short for "engine") such as the cotton gin, semi-automatic balers and threshers and, above all, the combine (see agricultural machinery). According to the National Academy of Engineering in the United States, agricultural mechanization is one of the 20 greatest engineering achievements of the 20th century. Early in the century, it took one American farmer to produce food for 2.5 people. By 1999, due to advances in agricultural technology, a single farmer could feed over 130 people.

Other recent changes in agriculture include hydroponics, plant breeding, hybridization, gene manipulation, better management of soil nutrients, and improved weed control. Genetic engineering has yielded crops which have capabilities beyond those of naturally occurring plants, such as higher yields and disease resistance. Modified seeds germinate faster, and thus can be grown on an accelerated schedule. Genetic engineering of plants has proven controversial, particularly in the case of herbicide-resistant plants.

It has been suggested that genetic engineers may some day develop transgenic plants which would allow for irrigation, drainage, conservation, sanitary engineering, and maintaining or increasing yields while requiring fewer fossil fuel derived inputs than conventional crops. Such developments would be particularly important in areas which are normally arid and rely upon constant irrigation, and on large scale farms. These possibilities are questioned by ecologists and economists concerned with unsustainable GMO practices such as terminator seeds, and a January 2008 report shows that GMO practices have failed to address sustainability issues. While there has been some research on sustainability using GMO crops, at least one hyped and promonant multi-year attempt by Monsanto has been unsuccessful, though during the same period traditional breeding techniques yielded a more sustainable variety of the same crop. Additionally, a survey by the bio-tech industry of subsistence farmers in Africa to discover what GMO research would most benefit sustainable agriculture only identified non-transgenic issues as areas needing to be addressed.

The processing, packing and marketing of agricultural products are closely related activities also influenced by science. Methods of quick-freezing and dehydration have increased the markets for many farm products (see food preservation and meat packing industry).

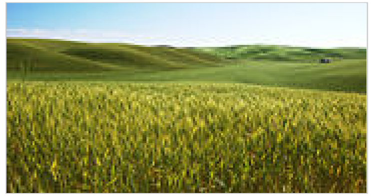
Animals, including horses, mules, oxen, camels, llamas, alpacas, and dogs, are often used to help cultivate fields, harvest crops, wrangle other animals, and transport farm products to buyers. Animal husbandry not only refers to the breeding and raising of animals for meat or to harvest animal products (like milk, eggs, or wool) on a continual basis, but also to the breeding and care of species for work and companionship.

Airplanes, helicopters, trucks, tractors, and combines are used in Western (and, increasingly, Eastern) agriculture for seeding, spraying operations for insect and disease control, harvesting, aerial topdressing and transporting perishable products. Radio and television disseminate vital weather reports and other information such as market reports that concern farmers. Computers have become an essential tool for farm management.

Ploughing rice paddies with water buffalo, in Indonesia.

In recent years, some aspects of intensive industrial agriculture have been the subject of increasing debate. The widening sphere of influence held by large seed and chemical companies, meat packers and food processors has been a source of concern both within the farming community and for the general public. Another issue is the type of feed given to some animals that can cause bovine spongiform encephalopathy in cattle. There has also been concern over the effect of intensive agriculture on the environment.

The patent protection given to companies that develop new types of seed using genetic engineering has allowed seed to be licensed to farmers in much the same way that computer software is licensed to users. This has changed the balance of power in favour of the seed companies, allowing them to dictate terms and conditions previously unheard of. The Indian activist and scientist Vandana Shiva argues that these companies are guilty of biopiracy.



A field of ripening barley

Soil conservation and nutrient management have been important concerns since the 1950s, with the most advanced farmers taking a stewardship role with the land they use. However, increasing contamination of waterways and wetlands by nutrients like nitrogen and phosphorus are concerns that can only be addressed by "enlightenment" of farmers and/or far stricter law enforcement in many countries.

Increasing consumer awareness of agricultural issues has led to the rise of community-supported agriculture, local food movement, " Slow Food", and commercial organic farming.

# Etymology

The word **agriculture** is the English adaptation of Latin *agricultūra*, from *ager*, "a field", and *cultūra*, " cultivation" in the strict sense of " tillage of the soil". Thus, a literal reading of the word yields "tillage of a field / of fields".

# History

Sumerian Harvester's sickle, 3000 BCE. Baked clay. Field Museum.

Agriculture was developed at least 10,000 years ago, and it has undergone significant developments since the time of the earliest cultivation. Evidence points to the Fertile Crescent of the Middle East as the site of the earliest planned sowing and harvesting of plants that had previously been gathered in the wild. Independent development of agriculture occurred in northern and southern China, Africa's Sahel, New Guinea and several regions of the Americas. Agricultural practices such as irrigation, crop rotation, fertilizers, and pesticides were developed long ago but have made great strides in the past century. The Haber-Bosch method for synthesizing ammonium nitrate represented a major breakthrough and allowed crop yields to overcome previous constraints. In the past century agriculture has been characterized by enhanced productivity, the substitution of labor for synthetic fertilizers and pesticides, selective breeding, mechanization, water pollution, and farm subsidies. In recent years there has been a backlash against the external environmental effects of conventional agriculture, resulting in the organic movement.

## Ancient origins

Ancient Egyptian farmer, copied from archaeologically preserved specimen by a modern artist guessing at original colors.
Source: http://www.kingtutone.com

Developed independently by geographically distant populations, systematic agriculture first appeared in Southwest Asia with the bulk of domesticated neolthic crops and livestock now being traced to Turkey via DNA studies. The first grains of domesticated Turkish emmer wheat are found at Abu Hurerya dated to 13,500 BP. The only exceptions to this are barley, domesticated in two sites; in Israel, and East of the Zagros mountains in Iran. The eight so-called founder crops of agriculture appear: first emmer and einkorn wheat, then hulled barley, peas, lentils, bitter vetch, chick peas and flax.Bitter vetch and lentils along with almonds and pistachios appear in Franchthi Cave Greece simultaneously, about 9,000 BC. Neither are native to Greece, and they appear 2,000 years prior to domesticated wheat in the same location. This suggests that the cultivation of legumes and nuts preceded that of grain.

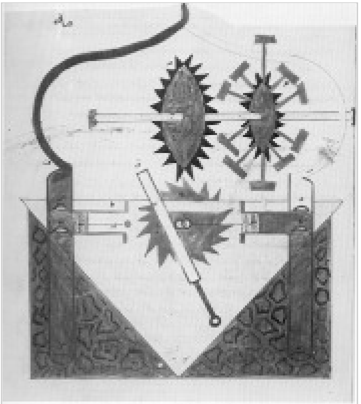
By 7000 BCE, small-scale agriculture reached Egypt. From at least 7000 BCE the Indian subcontinent saw farming of wheat and barley, as attested by archaeological excavation at Mehrgarh in Balochistan. By 6000 BCE, mid-scale farming was entrenched on the banks of the Nile. About this time, agriculture was developed independently in the Far East, with rice, rather than wheat, as the primary crop. Chinese and Indonesian farmers went on to domesticate mung, soy, azuki and taro. To complement these new sources of carbohydrates, highly organized net fishing of rivers, lakes and ocean shores in these areas brought in great volumes of essential protein. Collectively, these new methods of farming and fishing inaugurated a human population boom dwarfing all previous expansions, and is one that continues today.

By 5000 BCE, the Sumerians had developed core agricultural techniques including large scale intensive cultivation of land, mono-cropping, organized irrigation, and use of a specialized labour force, particularly along the waterway now known as the Shatt al-Arab, from its Persian Gulf delta to the confluence of the Tigris and Euphrates. Domestication of wild aurochs and mouflon into cattle and sheep, respectively, ushered in the large-scale use of animals for food/fibre and as beasts of burden. The shepherd joined the farmer as an essential provider for sedentary and semi- nomadic societies.

Maize, manioc, and arrowroot were first domesticated in the Americas as far back as 5200 BCE. The potato, tomato, pepper, squash, several varieties of bean, Canna, tobacco and several other plants were also developed in the New World, as was extensive terracing of steep hillsides in much of Andean South America.

In later years, the Greeks and Romans built on techniques pioneered by the Sumerians but made few fundamentally new advances. Southern Greeks struggled with very poor soils, yet managed to become a dominant society for years. The Romans were noted for an emphasis on the cultivation of crops for trade.

## Middle Ages


A valve-operated reciprocating suction piston pump water-raising machine with a crankshaft- connecting rod mechanism invented by al-Jazari.

During the Middle Ages, Muslim farmers in North Africa and the Near East developed and disseminated agricultural technologies including irrigation systems based on hydraulic and hydrostatic principles, the use of machines such as norias, and the use of water raising machines, dams, and reservoirs. They also wrote location-specific farming manuals, and were instrumental in the wider adoption of crops including sugar cane, rice, citrus fruit, apricots, cotton, artichokes, aubergines, and saffron. Muslims also brought lemons, oranges, cotton, almonds, figs and sub-tropical crops such as bananas to Spain.

The invention of a three field system of crop rotation during the Middle Ages, and the importation of the Chinese-invented moldboard plow, vastly improved agricultural efficiency.

## Modern era


A tractor ploughing an alfalfa field

After 1492, a global exchange of previously local crops and livestock breeds occurred. Key crops involved in this exchange included the tomato, maize, potato, cocoa and tobacco going from the New World to the Old, and several varieties of wheat, spices, coffee, and sugar cane going from the Old World to the New. The most important animal exportations from the Old World to the New were those of the horse and dog (dogs were already present in the pre-Columbian Americas but not in the numbers and breeds suited to farm work). Although not usually food animals, the horse (including donkeys and ponies) and dog quickly filled essential production roles on western hemisphere farms.

By the early 1800s, agricultural techniques, implements, seed stocks and cultivars had so improved that yield per land unit was many times that seen in the Middle Ages. With the rapid rise of mechanization in the late 19th and 20th centuries, particularly in the form of the tractor, farming tasks could be done with a speed and on a scale previously impossible. These advances have led to efficiencies enabling certain modern farms in the United States, Argentina, Israel, Germany, and a few other nations to output volumes of high quality produce per land unit at what may be the practical limit.

In 2005, the agricultural output of China was the largest in the world, accounting for almost one-sixth world share followed by the EU, India and the USA, according to the International Monetary Fund. Economists measure the total factor productivity of agriculture and by this measure agriculture in the United States is roughly 2.6 times more productive than it was in 1948.

# Crops

## Crop statistics

Specific crops are cultivated in distinct growing regions throughout the world. In millions of metric tons, based on FAO estimates.

| Top agricultural products, by crop types (million metric tons) 2004 data | |
|---|---|
| Cereals | 2,263 |
| Vegetables and melons | 866 |
| Roots and Tubers | 715 |
| Milk | 619 |
| Fruit | 503 |
| Meat | 259 |
| Oilcrops | 133 |
| Fish (2001 estimate) | 130 |
| Eggs | 63 |
| Pulses | 60 |
| Vegetable Fibre | 30 |
| *Source: Food and Agriculture Organization (FAO)* | |

| Top agricultural products, by individual crops (million metric tons) 2004 data | |
|---|---|
| Sugar Cane | 1,324 |
| Maize | 721 |
| Wheat | 627 |
| Rice | 605 |
| Potatoes | 328 |
| Sugar Beet | 249 |
| Soybean | 204 |
| Oil Palm Fruit | 162 |
| Barley | 154 |
| Tomato | 120 |
| *Source: Food and Agriculture Organization (FAO)* | |

## Crop alteration

Domestication of plants has, over the centuries increased yield, improved disease resistance and drought tolerance, eased harvest and improved the taste and nutritional value of crop plants. Careful selection and breeding have had enormous effects on the characteristics of crop plants. Plant breeders use greenhouses (known as glasshouses or hothouses in some areas) and other techniques to get as many as three generations of plants per year towards the continued effort of improvement. Plant selection and breeding in the 1920s and 1930s improved pasture (grasses and clover) in New Zealand. Extensive X-ray an ultraviolet induced mutagenesis efforts (i.e. primitive genetic engineering) during the 1950s produced the modern commercial varieties of grains such as wheat, corn and barley.


Tractor and Chaser Bin

For example, average yields of corn (maize) in the USA have increased from around 2.5 tons per hectare (t/ha) (40 bushels per acre) in 1900 to about 9.4 t/ha (150 bushels per acre) in 2001. Similarly, worldwide average wheat yields have increased from less than 1 t/ha in 1900 to more than 2.5 t/ha in 1990. South American average wheat yields are around 2 t/ha, African under 1 t/ha, Egypt and Arabia up to 3.5 to 4 t/ha with irrigation. In contrast, the average wheat yield in countries such as France is over 8 t/ha. Variation in yields are due mainly to variation in climate, genetics, and the level of intensive farming techniques (use of fertilizers, chemical pest control, growth control to avoid lodging).


An agricultural scientist records corn growth

After mechanical tomato-harvesters were developed in the early 1960s, agricultural scientists bred tomatoes that were more resistant to mechanical handling. These varieties have been criticized as being harder and having poor texture. More recently, genetic engineering has begun to be employed in large parts of the world to speed up the selection and breeding process. One widely used modification is a herbicide resistance gene that allows plants to tolerate exposure to glyphosate, a non-systemic (i.e kills all plants) chemical used to control weeds in a crop such as oilseed rape. Normally, expensive systemic herbicides would have to be applied to kill the weeds without harming the crop. Relatively cheap and safe glyphosate may be applied to the modified crops, efficiently killing weeds without harming the resistant crop. Another modification causes the plant to produce a toxin to reduce damage from insects (c.f. Starlink). This, in contrast, requires fewer insecticides to be applied to the crop.


Netting protecting wine grapes from birds

Aquaculture, the farming of fish, shrimp, and algae, is closely associated with agriculture.

Apiculture, the culture of bees, traditionally for honey—increasingly for crop pollination.

*See also* : cultigen, botany,

# Livestock

The farming practices of livestock vary dramatically world-wide and between different types of animals. Livestock are generally kept in an enclosure, are fed by human-provided food and are intentionally bred, but some livestock are not enclosed, or are fed by access to natural foods, or are allowed to breed freely, or all three. Approximately 68% of all agricultural land is used in the production of livestock as permanent pastures.

# Environmental impact

Severe soil erosion in a wheat field near Washington State University, US (c.2005)

Agriculture may often cause environmental problems because it changes natural environments and produces harmful by-products. Some of the negative effects are:

- Loss of biodiversity
- Surplus of nitrogen and phosphorus in rivers and lakes
- Detrimental effects of herbicides, fungicides, insecticides, and other biocides
- Conversion of natural ecosystems of all types into arable land
- Consolidation of diverse biomass into a few species
- Soil erosion
- Deforestation
- Depletion of minerals in the soil
- Particulate matter, including ammonia and ammonium off-gassing from animal waste contributing to air pollution
- Air pollution from farm equipment powered by fossil fuels
- Weed science - feral plants and animals
- Odour from agricultural waste
- Soil salination
- Water crisis

According to the United Nations, the livestock sector (primarily cows, chickens, and pigs) emerges as one of the top two or three most significant contributors to our most serious environmental problems, at every scale from local to global. Livestock production occupies 70% of all land used for agriculture, or 30% of the land surface of the planet.It is one of the largest sources of greenhouse gases—responsible for 18% of the world's greenhouse gas emissions as measured in $CO_2$ equivalents. By comparison, all transportation emits 13.5% of the $CO_2$. It produces 65% of human-related nitrous oxide (which has 296 times the global warming potential of $CO_2$) and 37% of all human-induced methane (which is 23 times as warming as $CO_2$). It also generates 64% of the ammonia, which contributes to acid rain and acidification of ecosystems.

# Biodiversity

Genetic erosion in crops and livestock biodiversity is propelled by several major factors such as variety replacement, land clearing, overexploitation of species, population pressure, environmental degradation, overgrazing, policy and changing agricultural systems.

The main factor, however, is the replacement of local varieties of domestic plants and animals by high yielding or exotic varieties or species. A large number of varieties can also often be dramatically reduced when commercial varieties (including GMOs) are introduced into traditional farming systems. Many researchers believe that the main problem related to agro-ecosystem management is the general tendency towards genetic and ecological uniformity imposed by the development of modern agriculture.

In agriculture and animal husbandry, the green revolution popularized the use of conventional hybridization to increase yield many folds by creating " high-yielding varieties". Often the handful of breeds of plants and animals hybridized originated in developed countries and were further hybridized with local varieties in the rest of the developing world to create high yield strains resistant to local climate and diseases. Hybridization of local breeds to improve performance may lead to the loss of the local breed over time and consequently the loss of specific genetic material due to dilution. When viewed across the world as a whole, the consequent loss in genetic diversity and biodiversity could place agriculture in a situation unable to adapt to sudden changes in the future.

A Genetically Modified Organism (GMO) is an organism whose genetic material has been altered using the genetic engineering techniques generally known as recombinant DNA technology. Genetic engineering has vastly expanded the repertoire of genes available to breeders to create the desired properties in future germlines. However, it is hypothesised that these new strains will replace the wild-type species beyond their original fields, and that these genes may be transferred to other plant species that were not intended.

# Policy

Agricultural policy focuses on the goals and methods of agricultural production. At the policy level, common goals of agriculture include:

- Food safety: Ensuring that the food supply is free of contamination.
- Food security: Ensuring that the food supply meets the population's needs.
- Food quality: Ensuring that the food supply is of a consistent and known quality.
- Poverty Reduction
- Conservation
- Environmental impact
- Economic stability

# Agriculture and petroleum

Since the 1940s, agriculture has dramatically increased its productivity, due largely to the use of petrochemical derived pesticides, fertilizers, and increased mechanization. This has allowed world population to grow more than double over the last 50 years. Every energy unit delivered in food grown using modern techniques requires over ten energy units to produce and deliver. The vast majority of this energy input comes from fossil fuel sources. Because of modern agriculture's current heavy reliance on petrochemicals and mechanization, there are warnings that the ever decreasing supply of oil (the dramatic nature of which is known as peak oil) will inflict major damage on the modern industrial agriculture system, and could cause large food shortages.

Oil shortages are one of several factors making organic agriculture and other sustainable farming methods necessary. This conversion is now occurring, but the reconditioning of soil to restore nutrients lost during the use of monoculture agriculture techniques made possible by petroleum-based technology will take time. Some farmers using modern organic-farming methods have reported yields as high as those available from conventional farming (but without the use of fossil-fuel-intensive artificial fertilizers or pesticides).

Farmers have also begun raising crops such as corn for non-food use in an effort to help mitigate peak oil. This has contributed to a 60% rise in wheat prices recently, and has been indicated as a possible precursor to "serious social unrest in developing countries." Such situations would be exacerbated in the event of future rises in food and fuel costs, factors which have already impacted the ability of charitable donors to send food aid to starving populations.

The state of financial markets following the subprime mortgage crisis increased interest in food commodities from private sectors such as pension funds, as more traditional investment opportunities came to be seen as less favourable. This in turn increased the cost of food worldwide.

# Agriculture safety and health

### United States

Satellite image of circular crop fields characteristic of centre pivot irrigation in Haskell County, Kansas in late June 2001. Healthy, growing crops are green. Corn is growing leafy stalks, but Sorghum, which resembles corn, grows more slowly and is much smaller and therefore paler. Wheat is a brilliant gold as harvest occurs in June. Brown fields have been recently harvested and plowed under or lie fallow for the year.

Agriculture ranks among the most hazardous industries. Farmers are at high risk for fatal and nonfatal injuries, work-related lung diseases, noise-induced hearing loss, skin diseases, and certain cancers associated with chemical use and prolonged sun exposure. Farming is one of the few industries in which the families (who often share the work and live on the premises) are also at risk for injuries, illness, and death.

- In an average year, 516 workers die doing farm work in the U.S. (1992-2005). Of these deaths, 101 are caused by tractor overturns.
- Every day, about 243 agricultural workers suffer lost-work-time injuries, and about 5% of these result in permanent impairment.

### Young Workers

Agriculture is the most dangerous industry for young workers, accounting for 42% of all work-related fatalities of young workers in the U.S. between 1992 and 2000. Unlike other industries, half the young victims in agriculture were under age 15.

For young agricultural workers aged 15–17, the risk of fatal injury is four times the risk for young workers in other workplaces Agricultural work exposes young workers to safety hazards such as machinery, confined spaces, work at elevations, and work around livestock.

- An estimated 1.26 million children and adolescents under 20 years of age resided on farms in 2004, with about 699,000 of these youth performing work on the farms. In addition to the youth who live on farms, an additional 337,000 children and adolescents were hired to work on U.S. farms in 2004.
- On average, 103 children are killed annually on farms (1990-1996). Approximately 40 percent of these deaths were work-related.
- In 2004, an estimated 27,600 children and adolescents were injured on farms; 8,100 of these injuries were due to farm work.

# Additional information

Retrieved from " http://en.wikipedia.org/wiki/Agriculture"

# Arable land

2008/9 Schools Wikipedia Selection. Related subjects: Agriculture

Modern arable agriculture typically uses large fields like this one in Dorset, England.

In geography, **arable land** (from Latin *arare*, to plough) is an agricultural term, meaning land that can be used for growing crops.

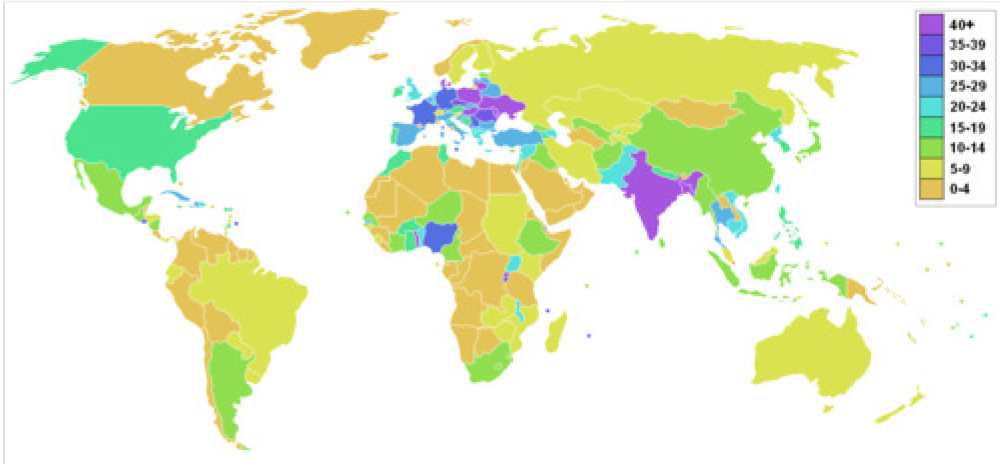
Of the earth's 148,000,000 km² (57 million square miles) of land, approximately 31,000,000 km² (12 million square miles) are arable; however, arable land is currently being lost at the rate of over 100,000 km² (38,610 square miles) per year. A major element of arable land loss comes from deforestation (starting in the Middle Ages in Europe as well as Asia). Such deforestation continues to the present day primarily in tropical countries by commercial over-exploitation of tropical forest. At times, deforestation can be so extreme that it leads to desertification, or the total loss of arable land, as has occurred in portions of the central highland plateau of Madagascar following extensive slash-and-burn activity.

A smaller, but important loss of arable land arises from the lack of renewal of rich flooding sediment due to flood control works. A large part of the arable land on earth is around the largest rivers on earth; for example, the Nile River, the Mississippi River, the Tigris and Euphrates Rivers, the Yellow River, the Amazon River, the Ganges and the Rhine River.

The most productive portion of arable land is that from sediments left by those rivers and the sea in geological times. In modern times, the rivers do not generally flood as much agricultural land, due to the demands of flood control to support intensive agriculture required of a heavily-populated Earth.

The Nile continues to flood regularly, overspilling its banks. When the flood is over, the waters recede, leaving behind rich silt. This silt provides excellent fertilizer for crops. Even if the land is over-farmed and all the nutrients are depleted from the soil, the land renews its fertility when new deposits of silt arrive following the next flood. Flood-control projects in the region, such as levees, may increase human comfort but cause substantial adverse impact to the quantity and quality of arable land.

## Non-arable land



Percentage of arable land by country, from CIA figures

Land which is unsuitable for arable farming usually has at least one of the following deficiencies: no source of fresh water; too hot (desert); too cold (Arctic); too rocky; too mountainous; too salty; too rainy; too snowy; too polluted; or too nutrient poor. Clouds may block the sunlight plants need for photosynthesis (making sunlight into food), reducing productivity. Plants can starve without light. Starvation and nomadism often exists on marginally arable land. Non-arable land is sometimes called *wasteland*, *badlands*, *worthless* or *no man's land*.

However, non-arable land can be converted into arable land. New arable land makes more food, and can reduce starvation. This outcome also makes a country more self-sufficient and politically independent, because food importation is reduced. Making non-arable land arable often involves digging new irrigation canals and new wells, aqueducts, desalination plants, planting trees for shade in the desert, hydroponics, fertilizer, nitrogen fertilizer, pesticides, reverse osmosis water processors, PET film insulation or other insulation against heat and cold, digging ditches and hills for protection against the wind, and greenhouses with internal light and heat for protection against the cold outside and to provide light in cloudy areas. This process is often extremely expensive.

Some examples of infertile **non-arable** land being turned into fertile **arable** land are:

- Aran Islands: This island off the west coast of Ireland, (not to be confused with the Isle of Arran in Scotland's Firth of Clyde), was unsuitable for arable farming because it was too rocky. The people covered the island with a shallow layer of seaweed and sand from the ocean. This made it arable. Today, crops are grown there.
- Israel: Israel's land primarily consisted of desert until the construction of desalination plants along the country's coast. The desalination plants, which remove the salt from ocean water, have created a new source of water for farming, drinking, and washing.
- Slash and burn agriculture uses nutrients in wood ash, but these expire within a few years.

Some examples of fertile **arable** land being turned into infertile land are:

- Droughts like the ' dust bowl' of the Great Depression in the U.S. turned farmland into desert.
- Rainforest Deforestation: The fertile tropical forests turn into infertile desert land. For example, Madagascar's central highland plateau has become virtually totally barren (about ten percent of the country), as a result of slash-and-burn deforestation, an element of shifting cultivation practiced by many natives.
- Romans' destruction of Carthage: At the end of the Punic Wars, legend has it that the victorious Romans sowed the earth with salt, to symbolize total victory. The Roman symbol meant that Carthage would never grow back - their civilization ended. (Whether this actually happened is debatable due to the logistics involved. Salt was very valuable and was used as money at the time, and it would have taken a lot of salt to ruin the whole area. See Carthage

for details.) Most crops do not grow in highly saline soil. Consequently, salt water cannot be used to water crops.

- Each year, arable land is lost to desertification and erosion from human industrial activities. Improper irrigation of farm land can wick the sodium, calcium, and magnesium from the soil and water to the surface. This process steadily concentrates salt in the root zone, decreasing productivity for crops that are not salt-tolerant.
- Urban sprawl: In the United States, 8,900 km² (about 2.2 million acres) of land was added to urban areas between 1992 and 2002.

# Baler

2008/9 Schools Wikipedia Selection. Related subjects: Agriculture

A round baler

A **baler** is a piece of farm machinery that is used to compress a cut and raked crop (such as hay or straw) into bales and bind the bales with twine. There are several different types of balers that are commonly used. Balers are also used in the material recycling facilities, primarily for baling plastic, paper or cardboard for transport to a recycling facility.

## Round baler


Round baler in action


A round bale

The most frequently used type of baler is a round baler. It produces cylindrically shaped "round" or "rolled" bales. The hay is simply rolled up inside the baler using rubberized belts, fixed rollers, or a combination of rollers and belts. When the bale reaches a determined size, the twine or mesh wrap that binds the bale is wrapped around the outside but not knotted. The back of the baler is opened up and the bale is discharged. Straw or fully-dried hay bales are complete at this stage, but if the bale is to be silage, it will also be wrapped in airtight plastic sheeting by another machine. Variable-chamber balers typically produce bales from 48 to 72 inches in diameter (about 120 to 180 cm) and up to 60 inches in width (150 cm). The bales weigh from 1100 lb (500 kg) to 2200 lb (1000 kg), depending upon size, material and dampness.

Early round balers were sold by Allis Chalmers as the Roto Baler. These bales were roughly 16 inches (410 mm) in diameter and 48 inches (1,200 mm) wide. The concept was first pioneered by Ummo Luebbens as early as 1910. Introduced in 1947 and discontinued in 1960, Allis Chalmers was a pioneer in supplying machinery that would form cylindrical bales during a period where rectangular bales were most common.

The modern round baler was designed in 1972 by the Vermeer Company, which as of 2007 continues to produce them.

## Round bale handling and transport

Round bales can weigh a ton or more, and are well-suited for modern large scale farming operations such as a dairy with 200 or more cows. However, due to the ability for a round bale to roll away on a slope, they require special transport and moving equipment.

The most important tool for round bale handling is the bale spear or spike, which is usually mounted on the back of a tractor or the front of a skid-steer. It is inserted into the approximate center of the round bale, then lifted up and the bale is hauled away. Once at the destination, the round bale is set down, and the spear pulled out. Careful placement of the spear in the centre is needed or the round bale can spin around and touch the ground while in transport, causing a loss of control.

Alternatively, a grapple fork may be used to lift and transport round bales. The grapple fork is a hydraulically driven implement attached to the end of a tractor's bucket loader. When the hydraulic cylinder is extended the fork clamps downwards towards the bucket, much like a closing hand. To move a round bale the tractor approaches the bale from the side and places the bucket underneath the bale. The fork is then clamped down across the top of the bale, and the bucket lifted with the bale in tow.

It is difficult to flip a round bale so that the flat surface is facing down and later flip it back up on edge, so transporting many round bales a long distance is a challenge. Flat-bed transport is difficult since the bales could roll off the truck bed going around curves and up hills. To prevent this, the flat-bed trailer is equipped with rounded guard-rails at either end, which prevent bales from rolling either forward or backward. Another solution for this is the saddle wagon, which has closely-spaced rounded saddles or support posts for round bales to sit in. The tall sides of each saddle, or the bale settling down in between posts, prevent the bales from rolling around while on the wagon.

Round bales can be directly used for feeding animals by placing it in a feeding area, tipping it over, removing the bale wrap, and placing a protective ring around the outside so that animals don't walk on hay that has been peeled off the outer perimeter of the bale. The baler's forming and compaction process can assist in unrolling a round bale, as it is often possible to unroll a round bale in a continuous flat strip.

## Silage / Haylage large bales

A recent innovation in hay storage has been the development of the silage or haylage bale, which is a high-moisture wrapped round bale. These are baled much wetter than normal round bales, and are usually smaller than regular round hay bales because the greater moisture content makes them heavier and harder to handle. These bales begin to ferment almost immediately, and the metal bale spear stabbed into the core becomes very warm to the touch from the fermentation process.

They are placed on a special rotating bale spear mounted on a tractor. As the bale spins, a layer of plastic cling film is applied to the exterior of the bale. This roll of plastic is mounted in a sliding shuttle on a steel arm and can move parallel to the bale axis, so that the operator does not need to hold up the heavy roll of plastic themselves. The plastic layer extends over the ends of the bale to form a ring of plastic approximately 12 inches (0.3 meters) wide on the ends with hay exposed in the centre.

In order to stretch the cling-wrap plastic tightly over the bale, the tension is actively adjusted with a knob on the end of the roll which squeezes the ends of the roll in the shuttle. In this example wrapping video, the operator is attempting to use high tension to get a flat, smooth seal on the right end. However the tension increases too much and the plastic tears off. The operator recovers by quickly loosening the tension and allows the plastic to feed out halfway around the bale before reapplying the tension to the sheeting.

These bales are placed in a long continuous row, with each wrapped bale pressed firmly up against all the other bales in the row before being set down onto the ground. The plastic wrap on the ends of each bale sticks together to seal out air and moisture, protecting the hay from the elements. The end-bales are hand-sealed with strips of cling plastic across the hay opening.

The airtight seal between each bale permits the row of round bales to ferment as if they were in a silo bag but are easier to handle than a silo bag since the bale can just be picked up and hauled away as a discrete package, as opposed to a large open bag which is full of loose material that must be scooped up, and which is fragile and easily damaged by the silage loader. However, the plastic usage is high and there is no way to reuse or recycle the hay-contaminated plastic sheeting, other than as a fuel source via incineration. The wrapping cost is approximately US$5 per bale.

An alternative form of the same type of bale is placed on a pair of rollers on a turntable mounted on the three-point linkage of a tractor, and spun about two axes while being wrapped in several layers of cling-wrap plastic film. This covers both the ends and sides of the bale in one operation, and which is thus sealed separately from other bales. The bales are then moved or stacked using a special pincer attachment on the front loader of a tractor which does not damage the film seal. They can also be moved using a standard bale spike, but this punctures the airtight seal. The hole in the film is repaired after moving.

For either type of wrapping, the bale must be unwrapped before being fed to livestock to prevent accidental ingestion of the plastic, and are usually fed to the animals using a *ring feeder*.

## Large rectangular baler

Another type of baler in common use produces large rectangular bales, each bound with a half dozen or so strings of twine which are then knotted. Such bales are highly compacted and generally weigh somewhat more than round bales.

Large rectangular baler

## Rectangular bale handling and transport

Rectangular bales are easier to transport than round bales since there is little risk of the bale rolling off the back of a flatbed trailer. The rectangular shape also saves space and allows a complete solid slab of hay to be stacked up for transport and storage.

They are well-suited for large scale livestock feedlot operations where many tons of feed are rationed every hour.

Due to the huge rectangular shape, large spear forks, or squeeze grips are mounted to heavy lifting machinery, such as: large fork lifts, tractors equipped with front end loaders, telehandlers, hay squeezes or wheel loaders to lift these bales.

## Small square baler


A small square baler

A type of baler which is less common today in some places but which is still prevalent in many countries such as New Zealand and Australia to the exclusion of large bales produces small rectangular (often called "square") bales. Each bale is about 15 in x 18 in x 38 in (38 x 46 x 96 cm). The bales are wrapped with two, three, or sometimes four strands of twine and knotted. The bales are light enough for one person to handle, about 45 lb (20 kg) to 60 lb (25 kg).

To form the bale, the hay in the windrow is lifted by tines in the baler's *pickup*. The hay is then dragged or augered into a chamber that runs the length of one side of the baler. A combination plunger and knife moves back and forth in the front end of this chamber. The knife, positioned just ahead of the plunger, cuts off the hay at the spot where it enters the chamber from the pickup. The plunger rams the hay rearwards, compressing it into the bales. A measuring device measures the amount of hay that is being compressed and, at the appropriate length it triggers the mechanism (the knotter) that wraps the twine around the bale and ties it off. As the next bale is formed the tied one is driven out of the rear of the baling chamber onto the ground or onto a special wagon hooked to the end of the baler. This process continues as long as there is material to be baled.

This form of bale is no longer much used in large-scale commercial agriculture because of the costs involved in handling many small bales. However, it enjoys some popularity in small-scale, low-mechanization agriculture and horse-keeping. Besides using simpler machinery and being easy to handle, these small bales can also be used for insulation and building materials in straw-bale construction. Square bales will also generally weather better than round bales because a more much dense stack can be put up. Convenience is also a major factor in farmers deciding to continue putting up square bales, as they make feeding in confined areas (stables, barns, etc.) much easier.

Many of these older balers are still to be found on farms today, particularly in dry areas where bales can be left outside for long periods.

The automatic-baler for small square bales took on most of its present form in 1940. It was first manufactured by the *New Holland Ag* and it used a small petrol engine to provide operating power. It is based on a 1937 invention for a twine-tie baler with automatic pickup.

## Wire balers

Bales prior to 1937 were manually wire-tied with two baling wires. Even earlier, the baler was a stationary implement, driven by power take-off (PTO) and belt, with the hay being brought to the baler and fed in by hand. The biggest change to this type of baler since 1940 is being powered by the tractor through its PTO, instead of by a built-in internal combustion engine.

In present day production, small square balers can be ordered with twine knotters or wire tie knotters.

## Square/wire bale history

## Pickup and handling methods

In the 1940s most farmers would bale hay in the field with a small tractor with 20 or less horsepower, and the tied bales would be dropped onto the ground as the baler moved through the field. Another team of workers with horses and a flatbed wagon with would come by and use a sharp metal hook to grab the bale and throw it up onto the wagon while an assistant stacks the bale, for transport to the barn.

A later time-saving innovation was to tow the flatbed wagon directly behind the baler, and the bale would be pushed up a ramp to a waiting attendant on the wagon. The attendant hooks the bale off the ramp and stacks it on the wagon, while waiting for the next bale to be produced.

Eventually as tractor horsepower increased, the thrower-baler became possible, which eliminates the need for someone to stand on the wagon and pick up the finished bales. The first thrower mechanism used two fast-moving friction belts to grab finished bales and throws them at an angle up in the air onto the bale wagon. The bale wagon was modified from a flatbed into a 3-sided skeleton frame open at the front, to act as a catcher's net for the thrown bales.

The next innovation of the thrower-baler as tractor horsepower further increased was the hydraulic tossing baler. This employs a flat pan behind the bale knotter. As bales advance out the back of the baler, they are pushed onto the pan one at a time. When the bale has moved fully onto the pan, the pan suddenly pops up, pushed by a large hydraulic cylinder, and tosses the bale up into the wagon like a catapult.

The pan-thrower method puts much less stress on the bales compared to the belt-thrower. The friction belts of the belt-thrower stress the twine and knots as they grip the bale, and would occasionally cause bales to break apart in the thrower or when the bales landed in the wagon.

New Holland has invented a machine named the "Stackcruiser", or a *stacker*. Small "square" bales are dropped by the baler with the strings facing outward, the stacker will drive up to the bales and it will pick it up and set it on a three-bale-wide table (the strings are now facing upwards). once three bales are on the table, the table lifts up and back causing the three bales to face strings to the side again, this happens 3 more times until there are 16 bales on the main table. this table will lift like the smaller one and the bales will be up against a vertical table. The machine will hold 160 bales (ten tiers), usually there will be cross-tiers near the centre to keep the stack from swaying or colasping if any weight is applied to the top of the stack. The full load will be transported to a barn, the whole rear of the stacker will tilt upwards until it is vertical. there will be two pushers that will extend through the machine and hold the bottom of the stack from being pulled out from the stacker while it is driven out of the barn

In Britain (if small square bales are still to be used) they are usually collected as they fall out of the baler in a *bale sledge* dragged behind the baler. This has various channels, controlled by automatic balances, catches and springs, which sort each bale into its place in a square *eight*. When the sledge is full, a catch is tripped automatically, and a door at the rear opens to leave the eight lying neatly together on the ground. These may be picked up individually and loaded by hand, or they may be picked up all eight together by a *bale grab* on a tractor, a special front loader consisting of many hydraulically-powered downward-pointing curved spikes. The square eight will then be stacked, either on a trailer for transport, or in a roughly cubic field stack eight or ten layers high. This cube may then be transported by a large machine attached to the three-point hitch behind a tractor, which clamps the sides of the cube and lifts it bodily.

A simple method of handling large and small round bales can be seen in the article Hay Delivery. This is a simple do-it-yourself modification to the tractor bucket. Two hooks are welded to the outside top of a tractor front loader bucket and a 14-foot (4.3 m) logging chain which allows the user to stay on the tractor, grab bales, transport them, stack them and place them out for animals to eat. The advantage of this simple system is that it uses no fancy expensive equipment which must be swapped back and forth on the tractor. This allows a small farmer to avoid the costs of extra equipment and not have a separate tractor just for that one function. With a little practice one can be as quick as the specialized hydraulic bale grabs. This method developed by Walter Jeffries of Sugar Mountain Farm also has less maintenance involved and is safer than bale spears and clamps.

## Storage methods

Before electrification occurred in rural parts of the United States in the 1940s, some small dairy farms would have tractors but not electric power. Often just one neighbour who could afford a tractor would do all the baling for surrounding farmers still using horses.

To get the bales up into the hayloft, a pulley system ran on a track along the peak of the barn's hayloft. This track also stuck a few feet out the end of the loft, with a large access door under the track. On the bottom of the pulley system was a bale spear, which is pointed on the end and has retractable retention spikes.

A flatbed wagon would pull up next to the barn underneath the end of the track, the spear lowered down to the wagon, and speared into a single bale. The pulley rope would be used to manually lift the bale high up into the air until it could enter the mow through the door, then moved along the track into the barn and finally released for manual stacking in tight rows across the floor of the loft. As the stack filled the loft, the bales would be lifted higher and higher with the pulleys until the hay was stacked all the way up to the peak.

When electricity finally arrived, the bale spear, pulley and track system disappeared, replaced by long motorized bale conveyors known as hay elevators. A typical elevator is an open skeletal frame, with a chain that has dull 3-inch (76 mm) spikes every few feet along the chain to grab bales and drag them along. One elevator replaced the spear track and ran the entire length of the peak of the barn. A second elevator was either installed at a 30-degree slope on the side of the barn to lift bales up to the peak elevator, or used dual front-back chains surrounding the bale to lift bales straight up the side of the barn to the peak elevator.

A bale wagon pulls up next to the lifting elevator, and a farm worker places bales one at a time onto the angled track. Once bales arrive at the peak elevator, there are adjustable tipping gates along the length of the peak elevator. By pulling a cable from the floor of the hayloft, tipping gates can be opened and closed, so that bales will tip off the elevator and drop down to the floor in different areas of the loft. This permits a single elevator to transport hay to one part of a loft and straw to another part.

This complete hay elevator lifting, transport, and dropping system reduced bale storage down to a single person, who simply pulls up with a wagon, turns on the elevators and starts placing bales on it, occasionally checking to make sure that bales are falling in the right locations in the loft.

The neat stacking of bales in the loft is often sacrificed for the speed of just letting them fall and roll down the growing pile in the loft, and changing the elevator gates to fill in open areas around the loose pile. But if desired, the loose bale pile dropped by the elevator could be rearranged into orderly rows between wagon loads.

## Usage once in the barn

The process of retrieving bales from a hayloft has stayed relatively unchanged from the beginning of baling. Typically workers were sent up into the loft, to climb up onto the bale stack, pull bales off the stack, and throw or roll them down the stack to the open floor of the loft. Once the bale is down on the floor, workers climb down the stack, open a cover over a bale chute in the floor of the loft, and push the bales down the chute to the livestock area of the barn.

Most barns were equipped with several chutes along the sides and in the center of the loft floor. This permitted bales to be dropped into the area where they were to be used. Hay bales would be dropped through side chutes, to be broken up and fed to the cattle. Straw bales would be dropped down the centre chute, to be distributed as bedding in the livestock standing/resting areas.

Traditionally multiple bales were dropped down to the livestock floor and the twine removed by hand. After drying and being stored under tons of pressure in the haystack, most bales are tightly compacted and need to be torn apart and fluffed up for use.

One recent method of speeding up all this manual bale handling is the bale shredder, which is a large vertical drum with rotary cutting/ripping teeth at the base of the drum. The shredder is placed under the chute and several bales dropped in. A worker then pushes the shredder along the barn aisle as it rips up a bale and spews it out in a continuous fluffy stream of material.

*Field of straw bales, "curves" in field made by baler*

## Industrial balers

Industrial balers are typically used to compact similar types of waste, such as office paper, cardboard, plastic, foil and cans, for sale to recycling companies. These balers are made of steel with a hydraulic ram to compress the material loaded. Some balers are simple and labor-intensive, but are suitable for smaller volumes. Other balers are very complex and automated, and are used where large quantities of waste are handled.

# Beekeeping

**2008/9 Schools Wikipedia Selection. Related subjects: Agriculture; Recreation**

Beekeeping, tacuinum sanitatis casanatensis (14th century)

**Beekeeping** (or **apiculture**, from Latin *apis*, bee) is the maintenance of honey bee colonies, commonly in hives, by humans. A beekeeper (or apiarist) keeps bees in order to collect honey and beeswax, for the purpose of pollinating crops, or to produce bees for sale to other beekeepers. A location where bees are kept is called an apiary.

Honey seeker depicted on 15000 year old cave painting near Valencia, Spain

# History of beekeeping

## Origins

Globally, there are more than 20,000 species of wild bees, including many which are solitary or which rear their young in burrows and small colonies, like mason bees and bumblebees. Beekeeping, or apiculture, is concerned with the practical management of the social species of honey bees, which live in large colonies of up to 100,000 individuals. In Europe and America the species universally managed by beekeepers is the Western honey bee (*Apis mellifera*), which has several sub-species or regional varieties, such as the Italian bee (*Apis mellifera ligustica* ), European dark bee (*Apis mellifera mellifera*), and the Carniolan honey bee (*Apis mellifera carnica*). In the tropics, other species of social bee are managed for honey production, including *Apis cerana*.

All of the *Apis mellifera* sub-species are capable of inter-breeding and hybridizing. Many bee breeding companies strive to selectively breed and hybridize varieties to produce desirable qualities: disease and parasite resistance, good honey production, swarming behaviour reduction, prolific breeding, and mild disposition. Some of these hybrids are marketed under specific brand names, such as the Buckfast Bee or Midnite Bee. The advantages of the initial F1 hybrids produced by these crosses include: hybrid vigor, increased honey productivity, and greater disease resistance. The disadvantage is that in subsequent generations these advantages may fade away and hybrids tend to be very defensive and aggressive.

Other bee-breeders are trying to resurrect original native varieties such as the British Black, the French Black or the Danish Black bee on the grounds of preserving biodiversity and producing more gentle bees. This native bee movement is notable in the UK (British Isles Bee Breeding Association; BIBBA), in Ireland (Galtee Bee Breeding Group), and in Denmark.

## Wild honey harvesting

Collecting honey from wild bee colonies is one of the most ancient human activities and is still practiced by aboriginal societies in parts of Africa, Asia, Australia, and South America. Some of the earliest evidence of gathering honey from wild colonies is from rock painting, dating to around 13,000 BC. Gathering honey from wild bee colonies is usually done by subduing the bees with smoke and breaking open the tree or rocks where the colony is located, often resulting in the physical destruction of the colony.

## Domestication of wild bees

At some point humans began to domesticate wild bees in artificial hives made from hollow logs, wooden boxes, pottery vessels, and woven straw baskets or "skeps." The domestication of bees was well developed in Egypt and sealed pots of honey were found in the grave goods of Pharaohs such as Tutankhamun. Beekeeping was also documented by the Roman writers Virgil, Gaius Julius Hyginus, Varro, and Columella. Aspects of the lives of bees and beekeeping are discussed at length by Aristotle.

Archaeologist Amihai Mazar of Jerusalem's Hebrew University said that findings in the ruins of the city of Rehov (with 2,000 residents at that time, Israelites and Canaanites) include 30 intact hives, 900 B.C., and evidence that an advanced honey industry existed in the Holy Land at the time of the Bible or 3,000 years ago. The beehives -- made of straw and unbaked clay-- were found in orderly rows, with 100 hives. Ezra Marcus, expert of Haifa University, said the finding was a glimpse of ancient beekeeping seen in texts and ancient art from the Near East. Religious practice was evidenced by an altar decorated with fertility figurines found alongside the hives.

## The study of honey bees

For several thousand years of human beekeeping, human understanding of the biology and ecology of bees was very limited and riddled with superstition and folklore. Ancient observers thought that the queen bee was in fact a male, called "the king bee," and they had no understanding of how bees actually reproduced. It was not until the 18th century that European natural philosophers undertook the scientific study of bee colonies and began to understand the complex and hidden world of bee biology. Preeminent among these scientific pioneers were Swammerdam, René Antoine Ferchault de Réaumur, Charles Bonnet, and the blind Swiss scientist Francois Huber. Swammerdam and Réaumur were among the first to use a microscope and dissection to understand the internal biology of honey bees. Réaumur was among the first to construct a glass walled observation hive to better observe activities within hives. He observed queens laying eggs in open cells, but still had no idea of how a queen was fertilized; nobody had ever witnessed the mating of a queen and drone and many theories held that queens were "self-fertile," while others believed that a vapor or "miasma" emanating from the drones fertilized queens without direct physical contact. Huber was the first to prove by observation and experiment that queens are physically inseminated by drones outside the confines of hives, usually a great distance away.

Following Réaumur's design, Huber built improved glass-walled observation hives and sectional hives which could be opened, like the leaves of a book, to inspect individual wax combs; this greatly improved the direct observation of activity within a hive. Although he became blind before he was twenty, Huber employed a secretary, Francois Burnens, to make daily observations, conduct careful experiments, and to keep accurate notes over a period of more than twenty years. Huber confirmed that a hive consists of one queen who is the mother of all the female workers and male drones in the colony. He was also the first to confirm that mating with drones takes place outside of hives and that queens are inseminated by a number of successive matings with male drones, high in the air at a great distance from their hive. Together, he and Burnens dissected bees under the microscope and were among the first to describe the ovaries and spermatheca, or sperm store, of queens as well as the penis of male drones. Huber is universally regarded as "the father of modern bee-science" and his "Nouvelles Observations sur Les Abeilles (or "New Observations on Bees, ) revealed all the basic scientific truths for the basics of the biology and ecology of honeybees.

## Invention of the moveable comb hive

Early forms of honey collecting entailed the destruction of the entire colony when the honey was harvested. The wild hive was crudely broken into, using smoke to suppress the bees, the honeycombs were torn out and smashed up — along with the eggs, larvae and honey they contained. The liquid honey from the destroyed brood nest was crudely strained through a sieve or basket. This was destructive and unhygienic but for hunter-gatherer societies this did not matter, since the honey was generally consumed immediately and there were always more wild colonies to exploit. However, in settled societies, the destruction of the bee colony meant the loss of a valuable resource; this drawback persisted until the 19th Century, which made beekeeping both inefficient and something of a 'stop and start' activity. There could be no continuity of production and no possibility of selective breeding, since each bee colony was destroyed at harvest time, along with its precious queen. During the medieval period abbeys and monasteries were centers of beekeeping since beeswax was highly prized for candles and fermented honey was used to make alcoholic mead in areas of Europe where vines would not grow.


Lorenzo Langstroth (1810-1895)

The 19th Century saw a revolution in beekeeping practice through the invention and perfection of the movable comb hive by Lorenzo Lorraine Langstroth, an Italian immigrant to the United States. Langstroth was the first person to make practical use of Huber's earlier discovery that there was a specific spatial measurement between the wax combs, later called 'the bee space', which bees would not block with wax, but kept as a free passage. Having determined this 'bee space' (between 5 -8 mm), Langstroth then designed a series of wooden frames within a rectangular hive box, carefully maintaining the correct bee space between successive frames, and found that the bees would build parallel honeycombs in the box without bonding them to each other or to the hive walls. This enables the beekeeper to slide any frame out of the hive for inspection, without harming the bees or the comb, protecting the eggs, larvae and pupae contained within the cells. It also meant that combs containing honey could be gently removed and the honey extracted without destroying the comb. The emptied honey combs could then be returned to the bees intact for refilling. Langstroth's classic book, *The Hive and Honey-bee*, published in 1853, described his rediscovery of the bee space and the development of his patent moveable comb hive.

The invention of the moveable-comb-hive fostered the growth of commercial honey production on a large scale in both Europe and the USA.

## Evolution of hive designs

Langstroth's design for moveable comb hives was seized upon by apiarists and inventors on both sides of the Atlantic and a wide range of moveable comb hives were designed and perfected in England, France, Germany and the United States. Classic designs evolved in each country: Dadant hives and Langstroth hives are still dominant in the USA; in France the De-Layens trough-hive became popular and in the UK a British National Hive became standard as late as the 1930s although in Scotland the smaller Smith hive is still popular. In some Scandinavian countries and in Russia the traditional trough hive persisted until late in the 20th Century and is still kept in some areas. However, the Langstroth and Dadant designs remain ubiquitous in the USA and also in many parts of Europe, though Sweden, Denmark, Germany, France and Italy all have their own national hive designs. Regional variations of hive evolved to reflect the climate, floral productivity and the reproductive characteristics of the various subspecies of native honey bee in each bio-region.

The differences in hive dimensions are insignificant in comparison to the common factors in all these hives: they are all square or rectangular; they all use moveable wooden frames; they all consist of a floor, brood-box, honey-super, crown-board and roof. Hives have traditionally been constructed of cedar, pine, or cypress wood, but in recent years hives made from injection molded dense polystyrene have become increasingly important.

Hives also use queen excluders between the brood-box and honey supers to keep the queen from laying eggs in cells next to those containing honey intended for consumption. Also, with the advent in the 20th century of mite pests, hive floors are often replaced for part of (or the whole) year with a wire mesh and removable tray.

### Pioneers of practical and commercial beekeeping

The 19th Century produced an explosion of innovators and inventors who perfected the design and production of beehives, systems of management and husbandry, stock improvement by selective breeding, honey extraction and marketing. Preeminent among these innovators were:

**L. L. Langstroth**, Revered as the "father of American apiculture", no other individual has influenced modern beekeeping practice more than Lorenzo Lorraine Langstroth. His classic book *The Hive and Honey-bee* was published in 1853.

**Moses Quinby**, often termed 'the father of commercial beekeeping in the United States', author of *Mysteries of Bee-Keeping Explained*.

**Amos Root**, author of the *A B C of Bee Culture* which has been continuously revised and remains in print to this day. Root pioneered the manufacture of hives and the distribution of bee-packages in the United States.

**A.J. Cook**, author of *The Bee-Keepers' Guide; or Manual of the Apiary*, 1876.

**Dr. C.C. Miller** was one of the first entrepreneurs to actually make a living from apiculture. By 1878 he made beekeeping his sole business activity. His book, *Fifty Years Among the Bees*, remains a classic and his influence on bee management persists to this day.

**Major Francesco De Hruschka** was an Italian military officer who made one crucial invention that catalyzed the commercial honey industry. In 1865 he invented a simple machine for extracting honey from the comb by means of centrifugal force. His original idea was simply to support the comb in a metal framework and then spin it around within a container to collect the honey as it was thrown out by centrifugal force. This meant that honeycombs could be returned to the hive undamaged but empty — saving the bees a vast amount of work, time and materials. This single invention greatly improved the efficiency of honey harvesting and catalysed the modern honey industry.

## Traditional beekeeping

### Fixed frame hives

Wooden hives in Stripeikiai in Lithuania

There are considerable regional variations in the type of hive in which bees are kept. A hive is a set of rectangular wooden boxes filled with moveable wood or plastic frames, each of which holds a sheet of wax or plastic foundation. The bees build cells upon the sheets of foundation to create complete honeycombs. Foundation comes in two cell-sizes: worker foundation, which enables the bees to create small, hexagonal worker cells; and drone foundation, which allows the bees to build much larger drone cells, for the production of male bees.

The bottom box, or brood chamber, contains the queen and most of the bees; the upper boxes, or supers, contain just honey. Only the young nurse bees can produce wax flakes which they secrete from between their abdominal plates; they build honeycomb using the artificial wax foundation as a starting point, after which they may raise brood or deposit honey and pollen in the cells of the comb. These frames can be freely manipulated and honey supers with frames full of honey can be taken and extracted for their honey crop.

# Modern beekeeping

## Movable frame hives

In the USA, the Langstroth hive is commonly used. The Langstroth was the first successful top-opened hive with movable frames, and other designs of hive have been based on it. Langstroth hive was however a descendant of Jan Dzierzon's Polish hive designs. In the United Kingdom, the most common type of hive is the British National Hive, but it is not unusual to see some other sorts of hive (Smith, Commercial and WBC, rarely Langstroth). Straw skeps, bee gums, and unframed box hives are now unlawful in most US states, as the comb and brood cannot be inspected for diseases. However, straw skeps are still used for collecting swarms by hobbyists in the UK, before moving them into standard hives.

## Top bar hives

A few hobby beekeepers are adopting various top bar hives of the type commonly found in Africa. These have no frames and the honey filled comb is not returned to the hive after extraction, as it is in the Langstroth hive. Because of this, the production of honey in a top bar hive is only about 20% that of a Langstroth hive, but the initial costs and equipment requirements are far lower. Top-bar hives also offer some advantages in interacting with the bees and the amount of weight that must be lifted is greatly reduced. Top Bar Hives are being widely used in developing countries in Africa and Asia as a result of the 'Bees For Development' program.

## Protective clothing

While knowledge of the bees is the first line of defense, most beekeepers also wear some protective clothing. Novice beekeepers usually wear gloves and a hooded suit or hat and veil. Experienced beekeepers sometimes elect not to use gloves because they inhibit delicate manipulations. The face and neck are the most important areas to protect, so most beekeepers will at least wear a veil.

Beekeepers often wear protective clothing to protect themselves from stings.

Defensive bees are attracted to the breath, and a sting on the face can lead to much more pain and swelling than a sting elsewhere, while a sting on a bare hand can usually be quickly removed by fingernail scrape to reduce the amount of venom injected.

The protective clothing is generally light coloured (but not colourful) and of a smooth material. This provides the maximum differentiation from the colony's natural predators (bears, skunks, etc.) which tend to be dark-colored and furry.

### Smoker

Smoke is the beekeeper's third line of defense. Most beekeepers use a "smoker" — a device designed to generate smoke from the incomplete combustion of various fuels. Smoke calms bees; it initiates a feeding response in anticipation of possible hive abandonment due to fire. Smoke also masks alarm pheromones released by guard bees or when bees are squashed in an inspection. The ensuing confusion creates an opportunity for the beekeeper to open the hive and work without triggering a defensive reaction. In addition, when a bee consumes honey the bee's abdomen distends, supposedly making it difficult to make the necessary flexes to sting, though this has not been tested scientifically.

Bee smoker with heat shield and hook

Smoke is of questionable use with a swarm, because swarms do not have honey stores to feed on in response. Usually smoke is not needed, since swarms tend to be less defensive, as they have no stores to defend, and a fresh swarm will have fed well from the hive.

Many types of fuel can be used in a smoker as long as it is natural and not contaminated with harmful substances. These fuels include hessian, pine needles, corrugated cardboard, and mostly rotten or punky wood. Some beekeeping supply sources also sell commercial fuels like pulped paper and compressed cotton, or even aerosol cans of smoke.

Some bee keepers are using "liquid smoke" as a safer, more convenient, alternative. It is a water-based solution that is sprayed onto the bees from a plastic spray bottle.

## Beekeeping in the United States

### Development of beekeeping in the United States

John Harbison, originally from Pennsylvania, successfully brought bee keeping to the US west coast in the 1860s, in an area now known as Harbison Canyon, California, and greatly expanded the market for honey throughout the country.

Beekeeping was traditionally practiced for the bees' honey harvest, although nowadays crop pollination service can often provide a greater part of a commercial beekeeper's income. Other hive products are pollen, royal jelly, and propolis, which are also used for nutritional and medicinal purposes, and beeswax, which is used in candle making, cosmetics, wood polish, and for modelling. The modern use of hive products has changed little since ancient times.

Western honey bees are not native to the Americas. American, Australian, and New Zealand colonists imported honey bees from Europe, partly for honey and partly for their usefulness as pollinators. The first honey bee species imported were likely European dark bees. Later Italian bees, Carniolan honey bees and Caucasian bees were added.

Western honey bees were also brought to the Primorsky Krai in Russia by Ukrainian settlers around 1850s. These Russian honey bees that are similar to the Carniolan bee were imported into the U.S. in 1990. The Russian honey bee has shown to be more resistant to the bee parasites *Varroa destructor* and *Acarapis woodi*.

Before the 1980s, most U.S. hobby beekeepers were farmers or relatives of a farmer, lived in rural areas, and kept bees with techniques passed down for generations. The arrival of tracheal mites in the 1980s and varroa mites and small hive beetles in the 1990s led to the discontinuation of the practice by most of these beekeepers as their bees could not survive among these new parasites.

In Asia, other species of *Apis* exist which are used by local beekeepers for honey and beeswax. Non-*Apis* species of honey bees, known collectively as melipolines or stingless bees, have also been kept from antiquity in Australia and Central America, although these traditions are dying, and some of the meliponine species used are endangered.

## Types of beekeepers

Beekeepers generally categorize themselves as:

- Commercial beekeeper — Beekeeping is the primary source of income.
- Sideliner — Beekeeping is a secondary source of income.
- Hobbyist — Beekeeping is not a significant source of income.

A beekeeper collecting a bee swarm. If the queen can be swept to the frame and placed into the hive the remaining bees will follow her scent.

Some southern U.S. and southern hemisphere (New Zealand) beekeepers keep bees primarily to raise queens and package bees for sale. In the U.S., northern beekeepers can buy early spring queens and 3- or 4-pound packages of live worker bees from the South to replenish hives that die out during the winter, although this is becoming less practical due to the spread of the Africanized bee.

In cold climates commercial beekeepers have to migrate with the seasons, hauling their hives on trucks to gentler southern climates for better wintering and early spring build-up. Many make "nucs" (small starter or nucleus colonies) for sale or replenishment of their own losses during the early spring. In the U.S. some may pollinate squash or cucumbers in Florida or make early honey from citrus groves in Florida, Texas or California. The largest demand for pollination comes from the almond groves in California. As spring moves northward so do the beekeepers, to supply bees for tree fruits, blueberries, strawberries, cranberries and later vegetables. Some commercial beekeepers alternate between pollination service and honey production but usually cannot do both at the same time.

In the Northern Hemisphere, beekeepers may harvest honey from July until October, according to the honey flows in their area. Good management requires keeping the hive free of pests and disease, and ensuring that the bee colony has room in the hive to expand. Chemical treatments, if used for parasite control, must be done in the off-season to avoid any honey contamination. Success for the hobbyist also depends on locating the apiary so bees have a good nectar source and pollen source throughout the year.

In the Southern Hemisphere, beekeeping is an all-the-year-round enterprise, although in cooler areas (to the south of Australia and New Zealand) the activity may be minimal in the winter (May to August). Consequently, the movement of commercial hives is more localized in these areas.

## Bee rentals and migratory beekeeping

After the winter of 1907, US beekeeper Nephi Miller decided to try moving his hives to different areas of the country to increase their productivity during winter. Since then, "migratory beekeeping" has become widespread in America. It is a crucial element of US agriculture, which could not produce anywhere near its current levels with native pollinators alone. Beekeepers earn much more from renting their bees out for pollination than they do from honey production.

One major US beekeeper reports moving his hives from Idaho to California in January to prepare for almond pollination in February, then to apple orchards in Washington in March, to North Dakota two months later for honey production, and then back to Idaho by November — a journey of several thousands of miles. Others move from Florida to New Hampshire or to Texas. About two thirds of US domestic bees visit California for the almond bloom in February.

Keepers in Europe and Asia are generally far less mobile, with bee populations moving and mingling within a smaller geographic extent (although some keepers do move longer distances, it is much less common). This wider spread and intermingling in the US has resulted in far greater losses from *Varroa* mite infections in recent years.

Moving spring bees from South Carolina to Maine for blueberry pollination

# Bee colonies

## Castes

A colony of bees consists of three castes of bee:

- a queen, which is normally the only breeding female in the colony;
- a large number of female worker bees, typically 30,000–50,000 in number;
- a number of male drones, ranging from thousands in a strong hive in spring to very few during dearth or cold season.

A load of supers

The queen is the only sexually mature female in the hive and all of the female worker bees and male drones are her offspring. The queen may live for up to three years or more and may be capable of laying half a million eggs or more in her lifetime. At the peak of the breeding season, late spring to summer, a good queen may be capable of laying 3,000 eggs in one day, more than her own body weight. This would be exceptional however; a prolific queen might peak at 2,000 eggs a day, but a more average queen might lay just 1500 eggs per day. The queen is raised from a normal worker egg, but is fed a larger amount of royal jelly than a normal worker bee, resulting in a radically different growth and metamorphosis. The queen influences the colony by the production and dissemination of a variety of pheromones or 'queen substances'. One of these chemicals suppresses the development of ovaries in all the female worker bees in the hive and prevents them laying eggs.

### Mating of queens

The queen emerges from her cell after 15 days of development and she remains in the hive for 3-7 days before venturing out on a mating flight. Her first orientation flight may only last a few seconds, just enough to mark the position of the hive. Subsequent mating flights may last from 5 minutes to 30 minutes, and she may mate with a number of male drones on each flight. Over several matings, possibly a dozen or more, the queen will receive and store enough sperm from a succession of drones to fertilize hundreds of thousands of eggs. If she does not manage to leave the hive to mate — possibly due to bad weather or being trapped within part of the hive — she will remain infertile and become a 'drone layer', incapable of producing female worker bees, and the hive is doomed.

Mating takes place at some distance from the hive and often several hundred feet up in the air; it is thought that this separates the strongest drones from the weaker ones - ensuring that only the fastest and strongest drones get to pass on their genes.

#### Fertilized and non-fertilized eggs

Having achieved a successful mating, the queen will begin to lay eggs for the first time a few days later. The vast majority of eggs she lays will be fertilized eggs and will produce female worker bees. If she lays an unfertilized egg it will develop into a male drone. How the colony decides how many workers will be raised versus how many drones will be raised is not fully understood.

### Female worker bees

Almost all the bees in a hive are female worker bees. At the height of summer when activity in the hive is frantic and work goes on non-stop, the life of a worker bee may be as short as 6 weeks; in late autumn, when no brood is being raised and no nectar is being harvested, a young bee may live for 16 weeks, right through the winter. During its life a worker bee performs different work functions in the hive which are largely dictated by the age of the bee.

| Period | Work activity |
|---|---|
| Days 1-3 | Cleaning cells and incubation |
| Day 3-6 | Feeding older larvae |
| Day 6-10 | Feeding younger larvae |
| Day 8-16 | Receiving honey and pollen from field bees |
| Day 12-18 | Wax making and cell building |
| Day 14 onwards | Entrance guards; nectar and pollen foraging |

### Male bees (drones)

Drones are the largest bees in the hive at almost three times the size of a worker bee. They do no work, do not forage for pollen or nectar and are only produced in order to mate with new queens and fertilize them on their mating flights. A bee colony will generally start to raise drones a few weeks before building queen cells in order to supersede a failing queen or in preparation for swarming. When queen raising for the season is over, the bees in colder climates will drive the drones out of the hive to die, biting and tearing at their legs and wings; the drones have become a useless burden on the colony which can no longer be tolerated.

**Differing stages of development**

| Stage of development | Queen | Worker | Drone |
|---|---|---|---|
| Egg | 3 days | 3 days | 3 days |
| Larva | 8 days | 10 days | 13 days |
| Pupa | 4 days | 8 days | 8 days |
| Total | 15 days | 21 days | 24 days |

## Structure of a bee colony

A domesticated bee colony is normally housed in a rectangular hive body, within which ten or twelve parallel frames house the vertical plates of honeycomb which contain the eggs, larvae, pupae and food for the colony. If one were to cut a vertical cross-section through the hive from side to side, the brood nest would appear as a roughly ovoid ball spanning 5-8 frames of comb. The two outside combs at each side of the hive tend to be exclusively used for long-term storage of honey and pollen.

Within the central brood nest, a single frame of comb will typically have a central disk of eggs, larvae and sealed brood cells which may extend almost to the edges of the frame. Immediately above the brood patch an arch of pollen-filled cells extends from side to side, and above that again a broader arch of honey-filled cells extends to the frame tops. The pollen is protein-rich food for developing larvae, while honey is also food but largely energy rich rather than protein rich. The nurse bees which care for the developing brood secrete a special food called 'royal jelly' after feeding themselves on honey and pollen. The amount of royal jelly which is fed to a larva determines whether it will develop into a worker bee or a queen.

Apart from the honey stored within the central brood frames, the bees store surplus honey in combs above the brood nest. In modern hives the beekeeper places separate boxes, called 'supers', above the brood box, in which a series of shallower combs is provided for storage of honey. This enables the beekeeper to remove some of the supers in the late summer, and to extract the surplus honey harvest, without damaging the colony of bees and its brood nest below. If all the honey is 'stolen', including the amount of honey needed to survive winter, the beekeeper must replace these stores by feeding the bees sugar or corn syrup in autumn.

### Annual cycle of a bee colony

The development of a bee colony follows an annual cycle of growth which begins in spring with a rapid expansion of the brood nest, as soon as pollen is available for feeding larvae. Some production of brood may begin as early as January, even in a cold winter, but breeding accelerates towards a peak in May (in the northern hemisphere), producing an abundance of harvesting bees synchronised to the main 'nectar flow' in that region. Each race of bees times this build-up slightly differently, depending on how the flora of its original region blooms. Some regions of Europe have two nectar flows: one in late spring and another in late August. Other regions have only a single nectar flow. The skill of the beekeeper lies in predicting when the nectar flow will occur in his area and in trying to ensure that his colonies achieve a maximum population of harvesters at exactly the right time.

The key factor in this is the prevention, or skillful management of the swarming impulse. If a colony swarms unexpectedly and the beekeeper does not manage to capture the resulting swarm, he is likely to harvest significantly less honey from that hive, since he will have lost half his worker bees at a single stroke. If, however, he can use the swarming impulse to breed a new queen but keep all the bees in the colony together, he will maximize his chances of a good harvest. It takes many years of learning and experience to be able to manage all these aspects successfully, though owing to variable circumstances many beginners will often achieve a good honey harvest.

## Formation of new colonies

### Colony reproduction; swarming and supersedure

All colonies are totally dependent on their queen, who is the only egg-layer. However, even the best queens live only a few years and one or two years longevity is the norm. She can choose whether or not to fertilize an egg as she lays it; if she does so, it develops into a female worker bee; if she lays an unfertilized egg it becomes a male drone. She decides which type of egg to lay depending on the size of the open brood cell which she encounters on the comb; in a small worker cell she lays a fertilized egg; if she finds a much larger drone cell she lays an unfertilized drone egg.


A swarm about to land

All the time that the queen is fertile and laying eggs she produces a variety of pheromones which control the behaviour of the bees in the hive; these are commonly called 'queen substance' but in reality there are various different pheromones with different functions. As the queen ages she begins to run out of stored sperm and her pheromones begin to fail. At some point, inevitably, the queen begins to falter and the bees will decide to replace her by creating a new queen from one of her worker eggs. They may do this because she has been damaged (lost a leg or an antenna), because she has run out of sperm and cannot lay fertilized eggs (has become a 'drone laying queen') or because her pheromones have dwindled to a point where they cannot control all the bees in the hive anymore.

At this juncture the bees will produce one or more queen cells by modifying existing worker cells which contain a normal female egg. However, there are two distinct behaviors which the bees pursue:

1. Supersedure: queen replacement within one hive without swarming
2. Swarm cell production: the division of the hive into two colonies by swarming

Different sub-species of *Apis mellifera* exhibit differing swarming characteristics which reflect their evolution in different ecotopes of the European continent. In general the more northerly black races are said to swarm less and supersede more, whereas the more southerly yellow and grey varieties are said to swarm more frequently. The truth is complicated because of the prevalence of cross-breeding and hybridization of the sub species and opinions differ.

Supersedure is highly valued as a behavioral trait by beekeepers because a hive that supersedes its old queen does not swarm and so no stock is lost; it merely creates a new queen and allows the old one to fade away, or alternatively she is killed when the new queen emerges. When superseding a queen the bees will produce just one or two queen cells, characteristically in the centre of the face of a broodcomb.

In swarming, by contrast, a great many queen cells are created — typically a dozen or more — and these are located around the edges of a broodcomb, most often at the sides and the bottom.

Once either process has begun, the old queen will normally leave the hive with the hatching of the first queen cells. When she leaves the hive the old queen is accompanied by a large number of bees, predominantly young bees (wax-secreters), who will form the basis of the new hive. Scouts are sent out from the swarm to find suitable hollow trees or rock crevices and as soon as one is found the entire swarm moves in, building new wax brood combs within a matter of hours using the honey stores which the young bees have filled themselves with before leaving the old hive. Only young bees can secrete wax from special abdominal segments and this is why there tends to be more young bees than old in swarms. Often a number of virgin queens accompany the first swarm (the 'prime swarm'), and the old queen is replaced as soon as a daughter queen is mated and laying. Otherwise, she will be quickly superseded in their new home.

## Factors that trigger swarming

It is generally accepted that a colony of bees will not swarm until it has completed all its brood combs, i.e. filled all available space with eggs, larvae and brood. This generally occurs in late Spring at a time when the other areas of the hive are rapidly filling with honey stores. So one key trigger of the swarming instinct is when the queen has no more room to lay eggs and the hive population is becoming very congested. Under these conditions a prime swarm may issue with the queen, resulting in a halving of the population within the hive and leaving the old colony with a large amount of hatching bees. The queen who leaves finds herself in a new hive with no eggs, no larvae but lots of energetic young bees who create a new set of brood combs from scratch in a very short time.

Another important factor in swarming is the age of the queen. Those under a year in age are unlikely to swarm unless they are extremely crowded, while older queens are much more predispositioned to swarm.

Beekeepers monitor their colonies carefully in spring and watch for the appearance of queen cells, which are a dramatic signal that the colony is determined to swarm.

When a colony has decided to swarm, queen cells are produced in numbers varying to a dozen or more. When the first of these queen cells is sealed, after 8 days of larval feeding, a virgin queen will pupate and be due to emerge seven days after sealing. Before leaving, the worker bees fill their stomachs with honey in preparation for the creation of new honeycombs in a new home. This cargo of honey also makes swarming bees less inclined to sting and a newly issued swarm is noticeably gentle for up to 24 hours — often capable of being handled without gloves or veil by a beekeeper.

This swarm is looking for shelter. A beekeeper may capture it and introduces it into a new hive helping to meet this need. Otherwise, it will return to a feral state, in which case it will find shelter in a hollow tree, an excavation, an abandoned chimney or even behind shutters.


A swarm attached to a branch

Back at the original hive, the first virgin queen to emerge from her cell will immediately seek out to kill all her rival queens who are still waiting to emerge from their cells. However, usually the bees deliberately prevent her from doing this, in which case, she too will lead a second swarm from the hive. Successive swarms are called 'after-swarms' or 'casts' and can be very small, often with just a thousand or so bees, as opposed to a prime swarm which may contain as many as ten to twenty thousand bees.

Small after-swarms have less chance of survival and may deplete the original hive threatening its survival as well. When a hive has swarmed despite the beekeeper's preventative efforts, a good management practice is to give the depleted hive a couple frames of open brood with eggs. This helps replenish the hive more quickly, and gives a second opportunity to raise a queen, if there is a mating failure.

Each race or sub-species of honeybee has its own swarming characteristics. Italian bees are very prolific and inclined to swarm; Northern European black bees have a strong tendency to supersede their old queen, without swarming. These differences are the result of differing evolutionary pressures in the regions where each sub-species evolved.

## Artificial swarming

When a colony accidentally loses its queen, it is said to be 'queenless'. The workers realize that the queen is absent after as little as an hour, as her pheromones fade in the hive. The colony cannot survive without a fertile queen laying eggs to renew the population. So the workers select cells containing eggs aged less than three days and enlarge these cells dramatically to form 'emergency queen cells'. These appear similar to large peanut-like structure about an inch long, which hangs from the centre or side of the brood combs. The developing larva in a queen cell is fed differently from an ordinary worker-bee, receiving in addition to the normal honey and pollen a great deal of royal jelly, a special food secreted by young 'nurse bees' from the hypopharyngeal gland. This special food dramatically alters the growth and development of the larva so that, after metamorphosis and pupation, it emerges from the cell as a queen bee. The queen is the only bee in a colony which has fully developed ovaries and she secretes a pheromone which suppresses the normal development of ovaries in all her worker-daughters.

Beekeepers use the ability of the bees to produce new queens in order to increase their colonies, a procedure called *splitting a colony*. In order to do this, they remove several brood combs from a healthy hive, taking care that the old queen is left behind. These combs must contain eggs or larvae less than three days old which will be covered by young 'nurse bees' which care for the brood and keep it warm. These brood combs and attendant nurse bees are then placed into a small 'nucleus hive' along with other combs containing honey and pollen. As soon as the nurse bees find themselves in this new hive and realise that they have no queen they set about constructing emergency queen cells using the eggs or larvae which they have in the combs with them.

## World apiculture

**World honey production and consumption in 2005**

| Country | Production (1000 metric tons) | Consumption (1000 metric tons) | Number of beekeepers | Number of bee hives |
|---|---|---|---|---|
| **Europe and Russian Federation** | | | | |
| Turkey | 82.34 | 66 | | |
| Ukraine | 71.46 | 52 | | |
| Russian Federation | 52.13 | 54 | | |
| Spain | 37.00 | 40 | | |
| Germany (*2008) | 21.23 | 89 | 90,000* | 1,000,000* |
| Hungary | 19.71 | 4 | | |
| Romania | 19.20 | 10 | | |
| Greece | 16.27 | 16 | | |
| France | 15.45 | 30 | | |
| Bulgaria | 11.22 | 2 | | |
| Denmark (*1996) | 2.5 | 5 | *4,000 | *150,000 |
| **North America** | | | | |
| United States of America (*2006, **2002) | 70.306* | 158.75* | 12,029** | 2,400,000* |
| Canada | 36.11 | 29 | | |
| **Latin America** | | | | |
| Argentina | 93.42 | 3 | | |
| Mexico | 50.63 | 31 | | |
| Brazil | 33.75 | 2 | | |
| Uruguay | 11.87 | 1 | | |
| **Oceania** | | | | |
| Australia | 18.46 | 16 | | |
| New Zealand | 9.69 | 8 | | |

| | | | | |
|---|---|---|---|---|
| **Asia** | | | | |
| China | 299.33 | 238 | | |
| India | 52.23 | 45 | | |
| South Korea | 23.82 | 27 | | |
| Vietnam | 13.59 | 0 | | |
| Turkmenistan | 10.46 | 10 | | |
| **Africa** | | | | |
| Ethiopia | 41.23 | 40 | | |
| Tanzania | 28.68 | 28 | | |
| Angola | 23.77 | 23 | | |
| Kenya | 22.00 | 21 | | |
| Egypt (*1997) | 16* | | 200,000* | 2,000,000* |
| Central African Republic | 14.23 | 14 | | |
| Morocco (*1997) | 4.5* | | 27,000* | 400,000* |
| *Source: Food and Agriculture Organization of the United Nations ( FAO), August 2007.* | | | | |

Sources:

- Denmark: beekeeping.com (1996)
- Arab countries: beekeeping.com (1997)
- USA: University of Arkansas National Agricultural Law Centre (2002), Agricultural Marketing Resource Centre (2006)

# Images of harvesting honey

# Cattle

2008/9 Schools Wikipedia Selection. Related subjects: Agriculture; Mammals

**Cattle**

A Swiss Braunvieh cow wearing a cowbell

**Conservation status**

Domesticated

**Scientific classification**

| | |
|---|---|
| Kingdom: | Animalia |
| Phylum: | Chordata |
| Class: | Mammalia |
| Order: | Artiodactyla |

**Cattle**, colloquially referred to as **cows** (though technically *cow* refers only to female bovines), are domesticated ungulates, a member of the subfamily Bovinae of the family Bovidae. They are raised as livestock for meat (called beef and veal), dairy products (milk), leather and as draught animals (pulling carts, plows and the like). In some countries, such as India, they are honored in religious ceremonies and revered. It is estimated that there are 1.3 billion cattle in the world today.

## Species of cattle

Cattle were originally identified by Carolus Linnaeus as three separate species. These were *Bos taurus*, the European cattle, including similar types from Africa and Asia; *Bos indicus*, the zebu; and the extinct *Bos primigenius*, the aurochs. The aurochs is ancestral to both zebu and European cattle. More recently these three have increasingly been grouped as one species, with *Bos primigenius taurus*, *Bos primigenius indicus* and *Bos primigenius primigenius* as the subspecies.

Complicating the matter is the ability of cattle to interbreed with other closely related species. Hybrid individuals and even breeds exist, not only between European cattle and zebu but also with yaks (called a dzo), banteng, gaur, and bison (" cattalo"), a cross-genera hybrid. For example, genetic testing of the Dwarf Lulu breed, the only humpless "*Bos taurus*-type" cattle in Nepal, found them to be a mix of European cattle, zebu and yak. Cattle cannot successfully be bred with water buffalo or African buffalo.

The aurochs was originally spread throughout Europe, North Africa, and much of Asia. In historical times, their range was restricted to Europe, and the last animals were killed by poachers in Masovia, Poland, in 1627. Breeders have attempted to recreate cattle of similar appearance to aurochs by careful crossing of domesticated cattle breeds, creating the Heck cattle breed. (See aurochs and zebu articles for more information.)

## Terminology

### Word origin

| | |
|---|---|
| Family: | Bovidae |
| Subfamily: | Bovinae |
| Genus: | *Bos* |
| Species: | ***B. taurus*** |

**Binomial name**

***Bos taurus***
Linnaeus, 1758

*Cattle* did not originate as a name for bovine animals. It derives from the Latin *caput*, head, and originally meant movable property, especially livestock of any kind. The word is closely related to " chattel" (a unit of personal property) and "capital" in the economic sense.

Older English sources like King James Version of the Bible refer to livestock in general as cattle (as opposed to the word deer which then was used for wild animals). Additionally other species of the genus *Bos* are sometimes called wild cattle. Today, the modern meaning of "cattle", without any other qualifier, is usually restricted to domesticated bovines.

## Types of cattle

A Hereford bull

An intact adult male is called a " bull." An adult female who has had more than one or two calves (depending on regional usage) is called a "cow." The adjective applying to cattle in general is usually "bovine." Young cattle are called calves until they are weaned, then *weaners* until they are a year old in some areas, in other areas, particularly with beef cattle, they may be known as *feeder-calves* or simply *feeders*. After that, they are referred to as " yearlings" if between one and two years of age, or by gender: A young female before she has had a calf of her own is called a " heifer" (pronounced /ˈhɛfər/, "heffer"). A young female that has had only one calf is occasionally called a "first-calf heifer." An older (usually over 500 kg) castrated male is called a "bullock" in the British Isles and Australasia, though the term refers to a young bull in North America. The term " steer" is generally used to denote a young castrated male, unless kept for draft purposes, in which case it is called an " ox" (plural "oxen". In North America, draft cattle are called "working steers" until they are 4 years of age, at which time the term "oxen" applies). In the USA, though the term "steer" is used as the generic term for a castrated male, in the extremely uncommon situation where an animal is castrated as an adult, the term "stag" is technically correct, though rarely used. Many other large animal species, including whales, hippopotamuses, camels, elk, and elephants, use the terms "bull", "cow" and "calf" to denote males, females, and young within the species.

## Dilemma about singular terminology

*Cattle* is both a plural and a mass noun, but there is no singular equivalent: it is a plurale tantum. Thus one may refer to "three cattle" or "some cattle", but not "one cattle". There is no universally used singular equivalent in modern English to "cattle", other than the gender and age-specific terms such as cow, bull, steer, heifer, and so on.

Strictly speaking, the singular noun for the domestic bovine was "ox": a bull is a male ox and a cow is a female ox. However, "ox" today is rarely used in this general sense. An ox today generally denotes a draught beast, most commonly a castrated male (but is not to be confused with the unrelated wild musk ox).


A Brahman calf

"Cow" has been in general use as a singular for the collective "cattle" in spite of the objections of those who point out that it is a female-specific term, rendering phrases such as "that cow is a bull" absurd. However, it is easy to use when a singular is needed and the gender is not known, as in "There is a cow in the road". Further, any herd of fully mature cattle in or near a pasture is statistically likely to consist mostly of cows, so the term is probably accurate. Other than the few bulls needed for breeding, the vast majority of male cattle are castrated as calves and slaughtered for meat before the age of three years. Thus, in a pastured herd, any calves or herd bulls usually are clearly distinguishable from the cows due to distinctively different sizes and clear anatomical differences.

Colloquially, more general non- specific terms may denote cattle when a singular form is needed. Australian, New Zealand and British farmers use the term "beast" or "cattle beast". "Bovine" is also used in Britain. The term "critter" is common in the western United States and Canada, particularly when referring to young cattle. In some areas of the American South (particularly the Appalachian region), where both dairy and beef cattle are present, an individual animal was once called a "beef critter", though that term is becoming archaic.

### Other terminology

Obsolete terms for cattle include "neat" (this use survives in " neatsfoot oil", extracted from the feet and legs of cattle), and "beefing" (young animal fit for slaughter).

Cattle raised for human consumption are called " beef cattle". Within the beef cattle industry in parts of the United States, the term "beef" (plural "beeves") is still used in its archaic sense to refer to an animal of either gender. Cows of certain breeds that are kept for the milk they give are called " dairy cows" or "milking cows" (formerly "milch cows" – "milch" was pronounced as "milk"). Most young male offspring of dairy cows are generally sold for veal, and may be referred to as *veal calves.* In some places, a cow kept to provide milk for one family is called a "house cow".

An onomatopoeia imitating one of the commonest sounds made by cattle is "moo", and this sound is also called *lowing*. There are a number of other sounds made by cattle, including calves *bawling* and bulls *bellowing* (a high-pitched yodeling call). The bullroarer makes a sound similar to a territorial call made by bulls.

## Biology

Cattle have one stomach, with four compartments. They are the rumen, reticulum, omasum, and abomasum, the rumen being the largest compartment. Cattle sometimes consume metal objects which are deposited in the reticulum, the smallest compartment, and this is where hardware disease occurs. The reticulum is known as the "Honeycomb." The omasum's main function is to absorb water and nutrients from the digestible feed. The omasum is known as the "Many Plies." The abomasum is most like the human stomach; this is why it is known as the "True Stomach".

Cattle are ruminants, meaning that they have a digestive system that allows them to utilize otherwise indigestible foods by repeatedly regurgitating and rechewing them as "cud." The cud is then reswallowed and further digested by specialized microorganisms that live in the rumen. These microbes are primarily responsible for breaking down cellulose and other carbohydrates into volatile fatty acids (VFAs) that cattle use as their primary metabolic fuel. The microbes that live inside of the rumen are also able to synthesize amino acids from non-protein nitrogenous sources such as urea and ammonia. As these microbes reproduce in the rumen older generations die and their carcasses continue on through the digestive tract. Theses carcasses are then partially digested by the cattle, allowing it to gain a high quality protein source. These features allow cattle to thrive on grasses and other vegetation.

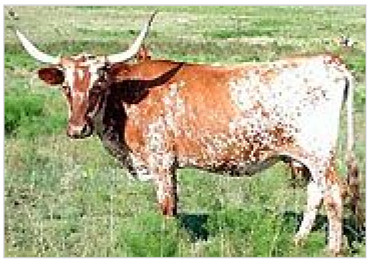

Dairy farming and the milking of cattle - once performed largely by hand, but now usually replaced by machine - exploits the cow's unique ruminant biology.

The gestation period for a cow is nine months. A newborn calf weighs roughly 25 to 45 kg (55 to 100 lb). Very large steers can weigh as much as 1,800 kg (4,000 pounds), although 600 to 900 kg (1,300 to 1,900 lb) is more usual for adults. Cattle usually live up to about 15 years (occasionally as much as 25 years).

A common misconception about cattle (particularly bulls) is that they are enraged by the colour red (something provocative is often said to be "like a red rag to a bull"). This is incorrect, as cattle are red-green colour-blind. The myth arose from the use of red capes in the sport of bullfighting; in fact, two different capes are used. The capote is a large, flowing cape that is magenta and yellow. The more famous muleta is the smaller, red cape, used exclusively for the final, fatal segment of the fight. It is not the colour of the cape that angers the bull, but rather the movement of the fabric that irritates the bull and incites it to charge.

Although cattle cannot distinguish red from green, they do have two kinds of colour receptors in their retinas ( cone cells) and so are theoretically able to distinguish some colours, probably in a similar way to other red-green colour-blind or dichromatic mammals (such as dogs, cats, horses and up to ten percent of male humans).

# Uses of cattle


Texas Longhorns are an iconic U.S. breed

Cattle occupy a unique role in human history, domesticated since at least the early Neolithic. They are raised for meat ( beef cattle), milk ( dairy cattle), and hides. They are also used as draft animals and in certain sports. Some consider cattle the oldest form of wealth, and cattle raiding consequently one of the earliest forms of theft.

In Portugal, Spain, Southern France and some Latin American countries, bulls are used in the sport of bullfighting while a similar sport, Jallikattu, is seen in South India; in many other countries this is illegal. Other sports such as bull riding are seen as part of a rodeo, especially in North America. Bull-leaping, a central ritual in Bronze Age Minoan culture (see Bull (mythology)), still exists in south-western France.

The outbreaks of bovine spongiform encephalopathy ( mad cow disease) have limited some traditional uses of cattle for food, for example the eating of brains or spinal cords.

In modern times, cattle are also entered into agricultural competitions. These competitions can involve live cattle or carcasses.

## Cattle husbandry

A cow being inspected for ticks; cattle are often restrained or confined in Cattle crushes when given medical attention.

Cattle are often raised by allowing herds to graze on the grasses of large tracts of rangeland. Raising cattle in this manner allows the productive use of land that might be unsuitable for growing crops. The most common interactions with cattle involve daily feeding, cleaning and milking. Many routine husbandry practices involve ear tagging, dehorning, loading, medical operations, vaccinations and hoof care, as well as training for agricultural shows and preparations. There are also some cultural differences in working with cattle- the cattle husbandry of Fulani men rests on behavioural techniques, whereas in Europe cattle are controlled primarily by physical means like fences.

Breeders can utilize cattle husbandry to reduce M. bovis infection susceptibility by selective breeding and maintaining herd health to avoid concurrent disease. Cattle are farmed for beef, veal, dairy, leather and they are sometimes used simply to maintain grassland for wildlife- for example, in Epping Forest, England. They are often used in some of the most wild places for livestock. Depending on the breed, cattle can survive on hill grazing, heaths, marshes, moors and semi desert. Modern cows are more commercial than older breeds and, having become more specialized, are less versatile. For this reason many smaller farmers still favour old breeds, like the dairy breed of cattle Jersey.

## Oxen


Draft Zebus in Mumbai, India.

**Oxen** (singular **ox**) are large and heavyset breeds of *Bos taurus* cattle trained as draft animals. Often they are adult, castrated males. Usually an ox is over four years old due to the need for training and to allow it to grow to full size. Oxen are used for plowing, transport, hauling cargo, grain-grinding by trampling or by powering machines, irrigation by powering pumps, and wagon drawing. Oxen were commonly used to skid logs in forests, and sometimes still are, in low-impact select-cut logging. Oxen are most often used in teams of two, paired, for light work such as carting. In the past, teams might have been larger, with some teams exceeding twenty animals when used for logging.

An ox is nothing more than a mature bovine with an "education." The education consists of the animal's learning to respond appropriately to the teamster's (ox driver's) signals. These signals are given by verbal commands or by noise (whip cracks) and many teamsters were known for their voices and language. In North America, the commands are (1) get up, (2) whoa, (3) back up, (4) gee (turn to the right) and (5) haw (turn to the left). Oxen must be painstakingly trained from a young age. Their teamster must make or buy as many as a dozen yokes of different sizes as the animals grow. A wooden yoke is fastened about the neck of each pair so that the force of draft is distributed across their shoulders. From calves, oxen are chosen with horns since the horns hold the yoke in place when the oxen lower their heads, back up, or slow down (particularly with a wheeled vehicle going downhill). Yoked oxen cannot slow a load like harnessed horses can; the load has to be controlled downhill by other means. The gait of the ox is often important to ox trainers, since the speed the animal walks should roughly match the gait of the ox driver who must work with it.

U.S. ox trainers favored larger breeds for their ability to do more work and for their intelligence. Because they are larger animals, the typical ox is the male of a breed, rather than the smaller female. Females are potentially more useful producing calves and milk.

Oxen can pull harder and longer than horses, particularly on obstinate or almost un-movable loads. This is one of the reasons that teams were dragging logs from forests long after horses had taken over most other draught uses in Europe and North America. Though not as fast as horses, they are less prone to injury because they are more sure-footed and do not try to jerk the load.


Riding an ox in Hova, Sweden.

An "ox" is not a unique breed of bovine, nor have any "blue" oxen lived outside the folk tales surrounding Paul Bunyan, the mythical American logger. A possible exception and antecedent to this legend is the Belgian Blue breed which is known primarily for its unusual musculature and at times exhibits unusual White/Blue, Blue Roan, or Blue coloration. The unusual musculature of the breed is believed to be due to a natural mutation of the gene that codes for the protein Myostatin, which is responsible for normal muscle atrophy.

Many oxen are still in use worldwide, especially in developing countries. In the Third World oxen can lead lives of misery, as they are frequently malnourished. Oxen are driven with sticks and goads when they are weak from malnutrition. When there is insufficient food for humans, animal welfare has low priority.

Ox is also used for various cattle products, irrespective of age, sex or training of the beast – for example, ox-blood, ox-liver, ox-kidney, ox-heart, ox-hide etc.

## Cattle in religion, traditions and folklore

Legend of the founding of Durham Cathedral is that monks carrying the body of Saint Cuthbert were led to the location by a milk maid who had lost her dun cow, which was found resting on the spot.

- The Evangelist St. Luke is depicted as an ox in Christian art.
- In Judaism, as described in Numbers 19:2, the ashes of a sacrificed unblemished red heifer that has never been yoked can be used for ritual purification of people who came into contact with a corpse.
- The ox is one of the 12-year cycle of animals which appear in the Chinese zodiac related to the Chinese calendar. See: Ox (Zodiac).
- The constellation Taurus represents a bull.
- An apocryphal story has it that a cow started the Great Chicago Fire by kicking over a kerosene lamp. Michael Ahern, the reporter who created the cow story, admitted in 1893 that he had made it up because he thought it would make colorful copy.
- On February 18, 1930 Elm Farm Ollie became the first cow to fly in an airplane and also the first cow to be milked in an airplane.
- The first known law requiring branding in North America was enacted on February 5, 1644 by Connecticut. It said that all cattle and pigs have to have a registered brand or earmark by May 1, 1644.
- The akabeko (赤べこ, *red cow* ?) is a traditional toy from the Aizu region of Japan that is thought to ward off illness.
- The case of *Sherwood v. Walker* -- involving a supposedly barren heifer that was actually pregnant -- first enunciated the concept of Mutual mistake as a means of destroying the Meeting of the minds in Contract law.
- The Maasai tribe of East Africa traditionally believe that all cows on earth are the God-given property of the Maasai

## Cattle in Hindu tradition

Cows are venerated within the Hindu religion of India. According to Vedic scripture they are to be treated with the same respect 'as one's mother' because of the milk they provide; "The cow is my mother. The bull is my sire." They appear in numerous stories from the Puranas and Vedas, for example the deity Krishna is brought up in a family of cowherders, and given the name Govinda (protector of the cows). Also Shiva is traditionally said to ride on the back of a bull named Nandi. Bulls in particular are seen as a symbolic emblem of selfless duty and religion. In ancient rural India every household had a few cows which provided a constant supply of milk and a few bulls that helped as draft animals. Many Hindus feel that at least it was economically wise to keep cattle for their milk rather than consume their flesh for one single meal.

In Hinduism, the cow is a symbol of wealth, strength, abundance, selfless giving and a full Earthly life.

Gandhi explains his feelings about cow protection as follows:

> "The cow to me means the entire sub-human world, extending man's sympathies beyond his own species. Man through the cow is enjoined to realize his identity with all that lives. Why the ancient rishis selected the cow for apotheosis is obvious to me. The cow in India was the best comparison; she was the giver of plenty. Not only did she give milk, but she also made agriculture possible. The cow is a poem of pity; one reads pity in the gentle animal. She is the second mother to millions of mankind. Protection of the cow means protection of the whole dumb creation of God. The appeal of the lower order of creation is all the more forceful because it is speechless."

## In heraldry

Cattle are represented in heraldry by the **bull**.

## Present status

The world cattle population is estimated to be about 1.3 billion head. India is the nation with the largest number of cattle, about 400 million, followed by Brazil and China, with about 150 million each, and the United States, with about 100 million. Africa has about 200 million head of cattle, many of which are herded in traditional ways and serve largely as tokens of their owners' wealth. Europe has about 130 million head of cattle (CT 2006, SC 2006).

Simmental cattle resting on a Swiss pasture

Cattle today are the basis of a many billion dollar industry worldwide. The international trade in beef for 2000 was over $30 billion and represented only 23 percent of world beef production. (Clay 2004). The production of milk, which is also made into cheese, butter, yogurt, and other dairy products, is comparable in size to beef production and provides an important part of the food supply for much of the world's people. Cattle hides, used for leather to make shoes and clothing, are another important product. In India and other poorer nations, cattle are also important as draft animals as they have been for thousands of years.

# Environmental impact

A 400-page United Nations report from the Food and Agriculture Organization (FAO) states that cattle are "responsible for 18% of greenhouse gases."Cattle are blamed for a host of other environmental crimes, from acid rain to the introduction of alien species, from producing deserts to creating dead zones in the oceans, from poisoning rivers and drinking water to destroying coral reefs.

Cattle - especially when kept on enormous feedlots such as this one - have been named as a contributing factor in the rise in greenhouse gas emissions.

The report, entitled Livestock's Long Shadow, also surveys the damage done by sheep, chickens, pigs and goats. But in almost every case, the world's 1.5 billion cattle are cited as being most to blame. The report concludes that, unless changes are made, the massive damage reckoned to be due to livestock may more than double by 2050, as demand for meat increases. One of the cited changes suggests that intensification of the livestock industry may be necessary, since intensification leads to fewer cattle for a given level of production.

Some of the microbes respire in the gut by an anaerobic process known as methanogenesis (producing the gas methane). Cattle emit a large amount of methane, 95% of it through eructation or burping, not flatulence. As the carbon in the methane comes from the digestion of vegetation produced by photosynthesis, its release into the air by this process would normally be considered harmless, because there is no net increase in carbon in the atmosphere — it's removed as carbon dioxide from the air by photosynthesis and returned to it as methane. But methane is a more potent greenhouse gas than carbon dioxide, having a warming effect 23 times greater, and so the methane gas produced by livestock is a significant contributor to the increase in greenhouse gases. Research is underway on methods of reducing this source of methane, by the use of dietary supplements, or treatments to reduce the proportion of methanogenetic microbes, perhaps by vaccination.

Alternative views on this issue note that the problem may not be cattle *per se*, but rather the concentration of cattle into feedlots, where they are fed a concentrated high-corn diet which produces rapid weight gain, but has side effects which include increased acidity in the digestive system. Manure and other byproducts of concentrated agriculture also have environmental consequences.

# Cereal

### 2008/9 Schools Wikipedia Selection. Related subjects: Agriculture; Plants

**Cereal** crops or **grains** are mostly grasses cultivated for their edible grains or fruitseeds (i.e., botanically a type of fruit called a caryopsis). Cereal grains are grown in greater quantities and provide more energy worldwide than any other type of crop; they are therefore staple crops. They are also a rich source of carbohydrate. In some developing nations, grain in the form of rice or corn constitutes practically the entire diet. In developed nations, cereal consumption is both more moderate and varied but still substantial.


Oats, barley, and some products made from cereal

The word 'cereal' derives from ' Ceres', the name of the pre-Roman goddess of harvest and agriculture. Grains are traditionally called *corn* in the United Kingdom and Ireland, though that word became specified for *maize* in the United States, Canada, New Zealand, and Australia.

## Production

The following table shows annual production of cereal grains, in 1961, 2005 and 2006, ranked by 2006 production. All but buckwheat and quinoa are true grasses (these two are **pseudocereals**).

| Grain | 2006 ( t) | 2005 (t) | 1961 (t) | |
|---|---|---|---|---|
| Maize | 695,287,651 | 712,877,757 | 205,004,683 | A staple food of peoples in North America, South America, and Africa and of livestock worldwide; often called "corn" or "Indian corn" in North America, Australia, and New Zealand. |
| Rice | 634,575,804 | 631,508,532 | 284,654,697 | The primary cereal of tropical regions |
| Wheat | 605,256,883 | 628,697,531 | 222,357,231 | The primary cereal of temperate regions |
| Barley | 138,704,379 | 141,334,270 | 72,411,104 | Grown for malting and livestock on land too poor or too cold for wheat |
| Sorghum | 56,525,765 | 59,214,205 | 40,931,625 | Important staple food in Asia and Africa and popular worldwide for livestock |
| Millets | 31,783,428 | 30,589,322 | 25,703,968 | A group of similar but distinct cereals that form an important staple food in Asia and Africa. |
| Oats | 23,106,021 | 23,552,531 | 49,588,769 | Formerly the staple food of Scotland and popular worldwide for livestock |
| Rye | 13,265,177 | 15,223,162 | 35,109,990 | Important in cold climates |

| | | | | |
|---|---|---|---|---|
| Triticale | 11,338,788 | 13,293,233 | 0 | Hybrid of wheat and rye, grown similarly to rye |
| Buckwheat | 2,365,158 | 2,078,299 | 2,478,596 | Pseudocereal, used in Eurasia. Major uses include various pancakes and groats |
| Fonio | 378,409 | 363,021 | 178,483 | Several varieties of which are grown as food crops in Africa |
| Quinoa | 58,989 | 58,443 | 32,435 | Pseudocereal, grown in the Andes |

Maize, wheat and rice, between them, accounted for 87% of all grain production, worldwide, and 43% of all food calories in 2003. Other grains that are important in some places, but that have little production globally (and are not included in FAO statistics), include:

- Teff, popular in Ethiopia but scarcely known elsewhere. This ancient grain is a staple in Ethiopia. It is high in fibre and protein. Its flour is often used to make injera. It can also be eaten as a warm breakfast cereal similar to farina with a chocolate or nutty flavor. Its flour and whole grain products can usually be found in natural foods stores.
- Wild rice, grown in small amounts in North America
- Amaranth, ancient pseudocereal, formerly a staple crop of the Aztec Empire (besides maize)
- Kañiwa, close relative of quinoa

Several other species of wheat have also been domesticated, some very early in the history of agriculture:

- Spelt, a close relative of common wheat
- Einkorn, a wheat species with a single grain
- Emmer, one of the first crops domesticated in the Fertile Crescent
- Durum, the only tetraploid species of wheat currently cultivated, used to make semolina

# Farming

While each individual species has its own peculiarities, the cultivation of all cereal crops is similar. All are annual plants; consequently one planting yields one harvest. Wheat, rye, triticale, oats, barley, and spelt are the **cool-season** cereals. These are hardy plants that grow well in moderate weather and cease to grow in hot weather (approximately 30 °C but this varies by species and variety). The other **warm-season** cereals are tender and prefer hot weather.


A wheat field in Dorset, England.

Barley and rye are the hardiest cereals, able to overwinter in the subarctic and Siberia. Many cool-season cereals are grown in the tropics. However, some are only grown in cooler highlands, where it may be possible to grow multiple crops in a year.

## Planting

The warm-season cereals are grown in tropical lowlands year-round and in temperate climates during the frost-free season. Rice is commonly grown in flooded fields, though some strains are grown on dry land. Other warm climate cereals, such as sorghum, are adapted to arid conditions.

Cool-season cereals are well-adapted to temperate climates. Most varieties of a particular species are either **winter** or **spring** types. Winter varieties are sown in the autumn, germinate and grow vegetatively, then become dormant during winter. They resume growing in the springtime and mature in late spring or early summer. This cultivation system makes optimal use of water and frees the land for another crop early in the growing season. Winter varieties do not flower until springtime because they require **vernalization** (exposure to low temperature for a genetically determined length of time). Where winters are too warm for vernalization or exceed the hardiness of the crop (which varies by species and variety), farmers grow spring varieties. Spring cereals are planted in early springtime and mature later that same summer, without vernalization. Spring cereals typically require more irrigation and yield less than winter cereals.

## Harvest

Once the cereal plants have grown their seeds, they have completed their life cycle. The plants die and become brown and dry. As soon as the parent plants and their seed kernels are reasonably dry, harvest can begin.

In developed countries, cereal crops are universally machine-harvested, typically using a combine harvester, which cuts, threshes, and winnows the grain during a single pass across the field. In developing countries, a variety of harvesting methods are in use, from combines to hand tools such as the scythe or cradle.

If a crop is harvested during wet weather, the grain may not dry adequately in the field to prevent spoilage during its storage. In this case, the grain is sent to a dehydrating facility, where artificial heat dries it.

In North America, farmers commonly deliver their newly harvested grain to a grain elevator, a large storage facility that consolidates the crops of many farmers. The farmer may sell the grain at the time of delivery or maintain ownership of a share of grain in the pool for later sale. Storage facilities should be protected from small grain pests, rodents and birds.

# Food value


Chickens are often fed grains such as wheat

Cereal grains supply most of their food energy as starch. They are also a significant source of protein, though the amino acid balance, with exceptions as noted below, is not optimal. Whole grains (see below) are good sources of dietary fibre, essential fatty acids, and other important nutrients.

Rice is eaten as cooked entire grains, although rice flour is also produced. Oats are rolled, ground, or cut into bits (steel-cut oats) and cooked into porridge. Most other cereals are ground into flour or meal, which is **milled**. The outer layers of bran and germ are removed (see seed). This lessens the nutritional value but makes the grain more resistant to degradation and makes the grain more appealing to many palates. Health-conscious people tend to prefer whole grains, which are not milled. Overconsumption of milled cereals is sometimes blamed for obesity. Milled grains do keep better because the outer layers of the grains are rich in rancidity-prone fats. The waste from milling is sometimes mixed into a prepared animal feed.

Once (optionally) milled and ground, the resulting flour is made into bread, pasta, desserts, dumplings, and many other products. Besides cereals, flour is sometimes made from potatoes, chestnuts and pulses (especially chickpeas, which is known as besan).

Cereals are the main source of energy providing about 350 kcal per 100 grams. Cereal proteins are typically poor in nutritive quality, being deficient in essential amino acid lysine. The proteins of maize are particularly poor, being deficient in lysine and tryptophan (a precursor of niacin). Rice proteins are richer in lysine than other common cereal proteins and for this reason, rice protein is considered to be of better quality. Rice is a good source of B group vitamins, especially thiamine. It is devoid of vitamins A, D, C and is a poor source of calcium and iron.

Certain grains, including quinoa, buckwheat, and grain amaranth ( Pseudocereal, non-grasses), are exceptionally nutrious. Quinoa was classified as a "supercrop" by the United Nations because of its high protein content (12-18%). Quinoa contains a balanced set of essential amino acids for humans, making it an unusually complete source of protein in plants.

In English, cold breakfast cereals, as opposed to cooked porridges such as oatmeal, are simply called **cereal**.

# Global market

As of late 2007, increased farming for use in biofuels, world oil prices at $130 a barrel as of 2Q 2008, The global grain bubble</ref> global population growth, climate change, loss of agricultural land to residential and industrial development,, growing consumer demand in China and India and feeding 635 million tons per year to livestock as fodder have pushed up the price of grain. Food riots have recently taken place in many countries across the world.

Water deficits, causing decrease in grain production, is one cause of grain independence. It already spurs heavy grain imports in numerous smaller countries, may soon do the same in larger countries, such as China or India. The water tables are falling in scores of countries (including Northern China, the US, and

India) due to widespread overpumping using powerful diesel and electric pumps. Other countries affected include Pakistan, Iran, and Mexico. This will eventually lead to water scarcity and cutbacks in grain harvest. Even with the overpumping of its aquifers, China is developing a grain deficit. When this happens, it will almost certainly drive grain prices upward. Most of the 3 billion people projected to be added worldwide by mid-century will be born in countries already experiencing water shortages. One suggested solution is for population growth to be slowed quickly by investing heavily in female literacy and family planning services. Desalination is also considered a viable and effective solution to the problem of water shortages.

After China and India, there is a second tier of smaller countries with large water deficits — Algeria, Egypt, Iran, Mexico, and Pakistan. Four of these already import a large share of their grain. Only Pakistan remains self-sufficient. But with a population expanding by 4 million a year, it will also likely soon turn to the world market for grain.

# Collective farming

2008/9 Schools Wikipedia Selection. Related subjects: Agriculture; Environment

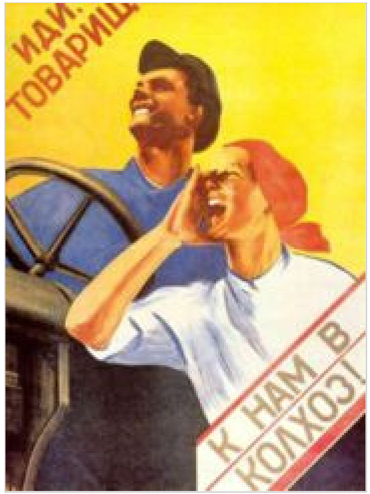
**Collective farming** is an organization of agricultural production in which the holdings of several farmers are run as a joint enterprise. A **collective farm** is essentially an agricultural production cooperative in which members-owners engage jointly in farming activities. Typical examples of collective farms are the kolkhozy that dominated Soviet agriculture between 1930 and 1992 and the Israeli kibbutzim. Both are collective farms based on common ownership of resources and on pooling of labor and income in accordance with the theoretical principles of cooperative organizations. They are radically different, however, in the application of the cooperative principles of freedom of choice and democratic rule. The creation of kolkhozy in the Soviet Union during the country-wide collectivization campaign of 1928-1933 was an example of *forced* collectivization, whereas the kibbutzim in Israel were traditionally created through *voluntary* collectivization and were governed as democratic entities. The element of forced or state-sponsored collectivization that was present in many countries during the 20th century led to the impression that collective farms operate under the supervision of the state, but this is not universally true, as shown by the counter-example of the Israeli kibbutz.

## Communist collectivization

Collective farming was sweepingly introduced in the 12 core republics of the Soviet Union between 1928 and 1933. The Baltic states and the East European countries adopted collective farming after World War II, with the accession of communist regimes to power. In Asia (People's Republic of China, North Korea, North and South Vietnam) the adoption of collective farming was also driven by communist government policies. In all communist countries, the transition to collective farming involved an element of persuasion by force, and the collective farms in these countries, lacking the principle of voluntary membership, can be regarded at best as pseudo-cooperatives.

### Soviet Union

In the Soviet Union, collectivization was introduced by Stalin in the late 1920s as a way, according to the theories of communist leaders, to boost agricultural production through the organization of land and labor into large-scale collective farms ( kolkhozy). At the same time, Soviet leaders argued that collectivization would free poor peasants from economic servitude under the *kulaks*. Stalin believed that the goals of collectivization could be achieved voluntarily, but when the new farms failed to attract the number of peasants hoped, the government blamed the oppression of the *kulaks* and resorted to forceful implementation of the plan, by murder and wholesale deportation of farmers to Siberia. Millions of unfortunates who remained died of starvation, and the centuries-old system of farming was destroyed in one of the most fertile regions in the world for farming, once called " the breadbasket of Europe." The immediate effect of forced collectivization was to reduce grain output and almost halve livestock, thus producing major famines in 1932 and 1933.



Soviet propaganda poster: "Comrade, come join our kolkhoz!"

In 1932-1933, an estimated 3.1–7 million people, mainly in Ukraine, died from famine after Stalin forced the peasants into the collectives (this famine is known in Ukraine as Holodomor). Most modern historians believe that this famine was caused by the sudden disruption of production brought on by collective farming policies that were implemented by the government of the Soviet Union. Some believe that, due to unreasonably high government quotas, farmers often received far less for their labor than they did before collectivization, and some refused to work; others retaliated by destroying their crops. It was not until 1940 that agricultural production finally surpassed its pre-collectivization levels.

## Baltic states

The Baltic states — Estonia, Latvia, and Lithuania — were only occupied by the Soviet Union on the eve of World War II, and had thus missed the first wave of Soviet collectivization. Furthermore, the opposition to kolkhozy was rather high in these countries. Primarily to break this opposition, Stalin ordered the wave of March deportations of 1949. This was successful in motivating peasants and brought great acceleration to collectivization in most regions.

## Hungary

In Hungary, agricultural collectivization was attempted a number of times between 1948 and 1956 (with disastrous results), until it was finally successful in the early 1960s under János Kádár.

The first serious attempt at collectivization based on Stalinist agricultural policy was undertaken in July 1948. Both economic and direct police pressure were used to coerce peasants to join cooperatives, but large numbers opted instead to leave their villages. In the early 1950s, only one-quarter of peasants had agreed to join cooperatives. In the spring of 1955 the drive for collectivization was renewed, again using physical force to encourage membership, but this second wave also ended in dismal failure. After the events of the 1956 Hungarian Revolution, the Hungarian regime opted for a more gradual collectivization drive. The main wave of collectivization occurred between 1959 and 1961, and at the end of this period more than 95% of agricultural land in Hungary had become the property of collective farms. In February 1961, the Central Committee declared that collectivization had been completed. This quick success should not be confused with enthusiastic adoption of collective idealism on the part of the peasants. Still, demoralized after two successive (and harsh) collectivization campaigns and the events of the 1956 Hungarian Revolution, the peasants were less keen to resist. As membership levels increased, those who remained outside likely grew worried about being permanently left out.

## Czechoslovakia (1948-89)

In Czechoslovakia, land reforms after World War I distributed most of the land to peasants and created large groups of relatively well-to-do farmers (though village poor still existed). These groups showed no support for communist ideals. In 1945, immediately after World War II, new land reform started. The first phase involved a confiscation of properties of Germans, Hungarians, and collaborators of the Nazi regime in accordance with the Beneš decree. The second phase, promulgated by so-called Ďuriš's laws (after Communist Minister of Agriculture), in fact meant a complete revision of the pre-war land reform and tried to reduce maximal private property to 150 hectares (ha) of agricultural land and 250 ha of any land (forests, etc...). The third and final phase forbade possession of land above 50 ha for one family. This phase was carried out in April 1948, two months after Communists violently overtook power. Farms started to be collectivized, mostly under threat of sanctions. The most obstinate farmers were persecuted and imprisoned. The most common form of collectivization was *agricultural cooperative* (in Czech *Jednotné zemědělské družstvo*, JZD; in Slovak *Jednotné roľnícke družstvo*, JRD ). The collectivization was implemented in three stages (1949-1952, 1953-1955, 1955-1960) and officially ended with implementation of the constitution establishing the Czechoslovak Socialist Republic, which illegalized private ownership.

Many early cooperatives collapsed and were recreated again. Their productivity was low since they provided tiny salaries and no pensions, and they failed to create a sense of collective ownership; small scale pilfering was common, and food became scarce. Seeing the massive outflow of people from agriculture into cities, the government started to massively subsidize the cooperatives in order to make the standard of living of farmers equal to that of city inhabitants; this was the long-term official policy of the government. Funds, machinery, and fertilizers were provided; young people from villages were forced to study agriculture; and students were regularly sent (mandatorily) to help in cooperatives.

Subsidies and constant pressure destroyed the remaining private farmers; only a handful of them remained after the 1960s. The lifestyle of villagers had eventually reached the level of cities, and village poverty was eliminated. Czechoslovakia was again able to produce enough food for its citizens. The price of this success was a huge waste of resources because the cooperatives had no motivation to improve efficiency. Every piece of land was cultivated regardless of the expense involved, and the soil became heavily polluted with chemicals. Also, the intensive use of heavy machinery damaged topsoil. Furthermore, the cooperatives were infamous for over-employment.

In the late 1980s, the economy of Czechoslovakia stagnated, and the state-owned companies were unable to deal with advent of modern technologies. A few agricultural companies (where the rules were less strict than in state companies) used this situation to start providing high-tech products. For example, the only way to buy a PC compatible computer in the late 1980s was to get it (for an extremely high price) from one agricultural company acting as a reseller.

After the fall of Communism in Czechoslovakia (1989) subsidies to agriculture were stopped with devastating effect. Most of the cooperatives had problems competing with technologically advanced foreign competition and were unable to obtain investment to improve their situation. Quite a large percentage of them collapsed. The others that remained were typically insufficiently funded, lacking competent management, without new machinery and living from day to day. Employment in the agricultural sector dropped significantly (from approx. 3% of the population to approx. 1%).

## People's Republic of China

Collective farming began in the People's Republic of China under Mao Zedong. It was further pursued during the Great Leap Forward, an attempt to rapidly mobilize the country in an effort to transform China into an industrialized communist society. The policy mistakes associated with this collectivization attempt during the Great Leap Forward resulted in mass starvation. According to many other sources, the death toll due to famine was most likely about 20 to 30 million people. The three years between 1959 and 1962 were known as the "Three Bitter Years" and the Three Years of Natural Disasters.

## North Korea

While Hungary arguably provides the best positive example of collective farming in a communist state, North Korea provides its negative counterpart. In the late 1990s, the collective farming system collapsed under the strain of droughts. Estimates of deaths due to starvation ranged into the millions, although the government did not allow outside observers to survey the extent of the famine. Aggravating the severity of the famine, the government was accused of diverting international relief supplies to its armed forces.

## Socialist Republic of Vietnam

Following the Fall of Saigon on 30 April 1975, South Vietnam briefly became the Republic of South Vietnam, a puppet state under military occupation by North Vietnam, before being officially reunified with the North under Communist rule as the Socialist Republic of Vietnam on 2 July 1976. Upon taking control, the Vietnamese communists banned other political parties, arrested suspects believed to have collaborated with the United States and embarked on a mass campaign of collectivization of farms and factories. Reconstruction of the war-ravaged country was slow and serious humanitarian and economic problems confronted the communist regime. In a historic shift in 1986, the Communist Party of Vietnam implemented free-market reforms known as Đổi Mới (*Renovation*). With the authority of the state remaining unchallenged, private ownership of farms and companies, deregulation and foreign investment were encouraged. The economy of Vietnam has achieved rapid growth in agricultural and industrial production, construction and housing, exports and foreign investment. However, the power of the Communist Party of Vietnam over all organs of government remains firm.

## Cuba

Agricultural production cooperatives were experimented with in the first few years following the Cuban Revolution. Between 1977 and 1983, farmers began to collectivize into CPAs — *Cooperativa de Producción Agropecuaria* (agricultural production cooperatives in Spanish). Farmers were encouraged to sell their land to the state for the establishment of a cooperative farm, receiving payments for a period of 20 years while also sharing in the fruits of the CPA. Joining a CPA allowed individuals who were previously dispersed throughout the countryside to move to a centralized location with increased access to electricity, medical care, housing, and schools. Democractic practice tends to be limited to business decisions and is constrained by the centralized economic planning of the Cuban system.

Another type of agricultural production cooperative in Cuba is UBPC — *Unidad Básica de Producción Cooperativa* (basic unit of cooperative production in Spanish). The law authorizing the creation of UBPCs was passed on September 20, 1993. It has been used to transform many state farms into UBPCs, similarly to the transformation of Russian sovkhozes (state farms) into kolkhozes (collective farms) after 1992. The law granted indefinite usufruct to the workers of the UBPC in line with its goal to link the workers to the land, establish material incentives for increased production by tying workers' earnings to the overall production of the UBPC, and increase managerial autonomy and workers' participation in the management of the workplace.

# Israel

Collective farming was also implemented in kibbutzim in Israel, which began to be created in 1909 as a unique combination of Zionism and socialism. The concept has faced occasional criticism as economically inefficient and over-reliant on subsidized credit.

A less known type of collective farm in Israel is moshav shitufi (lit. *collective moshav*), where production and services are managed collectively, as in a kibbutz, whereas consumption decisions are left to individual households. In terms of cooperative organization, moshav shitufi is distinct from the much more common moshav (or *moshav ovdim*), which is essentially a village-level service cooperative, not a collective farm.

In 2006 there were 40 moshavim shitufiim in Israel, compared with 267 kibbutzim.

# Combine harvester

2008/9 Schools Wikipedia Selection. Related subjects: Agriculture

The **combine harvester**, or simply **combine**, also known as a **thresher** is a machine that *combines* the tasks of harvesting, threshing, and cleaning grain crops. The objective is the harvest of the crop; corn (maize), soybeans, flax ( linseed), oats, wheat, or rye among others). The waste straw left behind on the field is the remaining dried stems and leaves of the crop with limited nutrients which is either chopped and spread on the field or baled for feed and bedding for livestock.

## History

The first combine was invented by Hiram Moore in 1838. It took many decades for the combine to become popular. Early combines often took more than 16 horses to drive them. Later combines were pulled by steam engines. George Stockton Berry joined the combine into a single machine using straw to heat the boiler. The header was over forty feet long, cutting over one hundred acres per day.

Early combines, some of them quite large, were drawn by horse or mule teams and used a bull wheel to provide power. In 1902, a combine could harvest enough grain in one hour to make 10 loaves of bread. Tractor-drawn, PTO-powered combines were used for a time. These combines used a shaker to separate the grain from the chaff and straw-walkers (grates with small teeth on an eccentric shaft) to eject the straw while retaining the grain. Tractor drawn combines evolved to have separate gas or diesel engines to power the grain separation. Newer kinds of combines are self-propelled and use diesel engines for power. A significant advance in the design of combines was the rotary design. Straw and grain were separated by use of a powerful fan. "Axial-Flow" rotary combines were introduced by International Harvester "IH" in 1977. In about the 1980's on-board electronics were introduced to measure threshing efficiency. This new instrumentation allowed operators to get better grain yields by optimizing ground speed and other operating parameters.


Old Style Harverster found in the Henty, Australia region.

### Combine Heads

Combines are equipped with removable heads (called headers) that are designed for particular crops. The standard header, sometimes called a grain platform (or platform header), is equipped with a *reciprocating knife cutter bar*, and features a revolving reel with metal or plastic teeth to cause the cut crop to fall into the head. A cross auger then pulls the crop into the throat. The grain header is used for many crops including grains and legumes.


A John Deere 9410 Combine set to harvest Oats.

Wheat headers are similar except that the reel is not equipped with teeth. Some wheat headers, called "draper" headers, use a fabric or rubber apron instead of a cross auger. Draper headers allow faster feeding than cross augers, leading to higher throughputs. In high yielding European crops, such headers have no advantage, as the limiting factor becomes grain separation. On many farms, platform headers are used to cut wheat, instead of separate wheat headers, so as to reduce overall costs.

Dummy heads or pick-up headers feature spring-tined pickups, usually attached to a heavy rubber belt. They are used for crops that have already been cut and placed in windrows or swaths. This is particularly useful in northern climates such as western Canada where swathing kills weeds resulting in a faster dry down.


A John Deere combine harvesting corn

While a grain platform can be used for corn, a specialized corn head is ordinarily used instead. The corn head is equipped with snap rolls that strip the stalk and leaf away from the ear, so that only the ear (and husk) enter the throat. This improves efficiency dramatically since so much less material must go through the cylinder. The corn head can be recognized by the presence of points between each row.

Occasionally rowcrop heads are seen that function like a grain platform, but have points between rows like a corn head. These are used to reduce the amount of weed seed picked up when harvesting small grains.

Self propelled Gleaner combines could be fitted with special tracks instead of tires or tires with tread measuring almost 10in deep to assist in harvesting rice. Some combines, particularly pull type, have tires with a diamond tread which prevents sinking in mud.These tracks can fit other combines by having adapter plates made, they will fit a JD6620 2WD only having to remove one shield.

## Conventional combine

The cut crop is carried up the feeder throat by a *chain and flight elevator*, then fed into the threshing mechanism of the combine, consisting of a rotating *threshing drum*, to which grooved steel bars are bolted. These bars thresh or separate the grains and chaff from the straw through the action of the drum against the *concave*, a shaped "half drum", also fitted with steel bars and a meshed grill, through which grain, chaff and smaller debris may fall, whereas the straw, being too long, is carried through onto the *straw walkers*. The drum speed is variably adjustable, whilst the distance between the drum and concave is finely adjustable fore, aft and together, to achieve optimum separation and output. Manually engaged *disawning plates* are usually fitted to the concave. These provide extra friction to remove the awns from barley crops.

## Sidehill levelling

An interesting technology is in use in the Palouse region of the Pacific Northwest of the United States in which the combine is retrofitted with a hydraulic sidehill levelling system. This allows the combine to harvest the incredibly steep but fertile soil in the region. Hillsides can be as steep as a 50% slope. Gleaner, IH and Case IH, John Deere, and others all have made combines with this sidehill levelling system, and local machine shops have fabricated them as an aftermarket add-on. Linked pictures below show the technology.

The first levelling technology was developed by Holt Co., a California firm, in 1891. Modern levelling came into being with the invention and patent of a level sensitive mercury switch system invented by Raymond Alvah Hanson in 1946. Raymond's son, Raymond, Jr., produced leveling systems exclusively for John Deere combines until 1995 as R. A. Hanson Company, Inc. In 1995, his son, Richard, purchased the company from his father and renamed it RAHCO International, Inc. In April, 2007, the company was renamed The Factory Company International, Inc. Production continues to this day.

Sidehill levelling has several advantages. Primary among them is an increased threshing efficiency on sidehills. Without levelling, grain and chaff slide to one side of separator and come through the machine in a large ball rather than being separated, dumping large amounts of grain on the ground. By keeping the machinery level, the straw-walker is able to operate more efficiently, making for more efficient threshing. IH produced the 453 combine which leveled both side-to-side and front-to-back, enabling efficient threshing whether on a sidehill or climbing a hill head on.

Secondarily, levelling changes a combine's centre of gravity relative to the hill and allows the combine to harvest along the contour of a hill without tipping, a very real danger on the steeper slopes of the region; it is not uncommon for combines to roll on extremely steep hills.

Newer leveling systems do not have as much tilt as the older ones. A John Deere 9600 combine equipped with a Rahco hillside conversion kit will level over to 44%, while the newer STS combines will only go to 35%. These modern combines use the rotary grain separator which makes leveling less critical. Most combines on the Palouse have dual drive wheels on each side to stabilize them.

Sidehill levelling system in Europe was developed by Italian combines' manifacturer Laverda that still today produces those systems as a leader.

## Maintaining threshing speed

Another technology that is sometimes used on combines is a continuously variable transmission. This allows the ground speed of the machine to be varied while maintaining a constant engine and threshing speed. It is desirable to keep the threshing speed since the machine will typically have been adjusted to operate best at a certain speed.

Allis-Chalmers GLEANER L2

Self-propelled combines started with standard manual transmissions that provided one speed based on input rpm. Deficiencies were noted and in the early 1950s combines were equipped with what John Deere called the "Variable Speed Drive". This was simply a variable width sheave controlled by spring and hydraulic pressures. This sheave was attached to the input shaft of the transmission. A standard 4 speed manual transmission was still used in this drive system. The operator would select a gear, typically 3rd. An extra control was provided to the operator to allow him to speed up and slow down the machine within the limits provided by the variable speed drive system. By decreasing the width of the sheave on the input shaft of the transmission, the belt would ride higher in the groove. This slowed the rotating speed on the input shaft of the transmission, thus slowing the ground speed for that gear. A clutch was still provided to allow the operator to stop the machine and change transmission gears.

Later, as hydraulic technology improved, hydrostatic transmissions were introduced by Versatile Mfg for use on swathers but later this technology was applied to combines as well. This drive retained the 4 speed manual transmission as before, but this time used a system of hydraulic pumps and motors to drive the input shaft of the transmission. This system is called a Hydrostatic drive system. The engine turns the hydraulic pump capable of high flow rates at up to 4000 psi. This pressure is then directed to the hydraulic motor that is connected to the input shaft of the transmission. The operator is provided with a lever in the cab that allows for the control of the hydraulic motor's ability to use the energy provided by the pump. By adjusting the swash plate in the motor, the stroke of its pistons are changed. If the swash plate is set to neutral, the pistons do not move in their bores and no rotation is allowed, thus the machine does not move. By moving the lever, the swash plate moves its attached pistons forward, thus allowing them to move within the bore and causing the motor to turn. This provides an infinitely variable speed control from 0 ground speed to what ever the maximum speed is allowed by the gear selection of the transmission. The standard clutch was removed from this drive system as it was no longer needed.

Most if not all modern combines are equipped with hydrostatic drives. These are larger versions of the same system used in consumer and commercial lawn mowers that most are familiar with today. In fact, it was the downsizing of the combine drive system that placed these drive systems into mowers and other machines.

## The threshing process

Despite great advances mechanically and in computer control, the basic operation of the combine harvester has remained unchanged almost since it was invented.

First of all the header, described above, cuts the crop and feeds it into the threshing cylinder. This consists of a series of horizontal *rasp bars* fixed across the path of the crop and in the shape of a quarter cylinder, guiding the crop upwards through a 90 degree turn. Moving rasp bars or rub bars pull the crop through concaved grates that separate the grain and chaff from the straw. The grain heads fall through the fixed concaves onto the *sieves*. The straw exits the top of the concave onto the *straw walkers*.

Since the New Holland TR70 Twin-Rotor Combine came out in 1975, combines have rotors in place of conventional cylinders. A rotor is a long, longitudily mounted rotating cylinder with plates similar to rub bars.

There are usually two sieves, one above the other. Each is a flat metal plate with holes set according to the size of the grain mounted at an angle which shakes. The holes in the top sieve are set larger than the holes in the bottom sieve. While straw is carried to the rear, crop and weed seeds, as well as chaff, fall onto the second sieves, where chaff and crop fall though and are blown out by a fan. The crop is carried to the elevator which carries it into the hopper. Setting the concave clearance, fan speed, and sieve size is critical to ensure that the crop is threshed properly, the grain is clean of debris, and that all of the grain entering the machine reaches the grain tank. ( Observe, for example, that when travelling uphill the fan speed must be reduced to account for the shallower gradient of the sieves.)

Heavy material, e.g., unthreshed heads, fall off the front of the sieves and are returned to the concave for re-threshing.

The straw walkers are located above the sieves, and also have holes in them. Any grain remaining attached to the straw is shaken off and falls onto the top sieve.

When the straw reaches the end of the walkers it falls out the rear of the combine. It can then be baled for cattle bedding or spread by two rotating straw spreaders with rubber arms. Most modern combines are equipped with a straw spreader.

## Rotary vs. Conventional Design

For a considerable time, combine harvesters used the conventional design, which used a rotating cylinder at the front-end which knocked the seeds out of the heads, and then used the rest of the machine to separate the straw from the chaff, and the chaff from the grain.


Case IH Combine set to harvest Soybeans.

In the decades before the widespread adoption of the rotary combine in the late seventies, several inventors had pioneered designs which relied more on centrifugal force for grain separation and less on gravity alone. By the early eighties, most major manufacturers had settled on a "walkerless" design with much larger threshing cylinders to do most of the work. Advantages were faster grain harvesting and gentler treatment of fragile seeds, which were often cracked by the faster rotational speeds of conventional combine threshing cylinders.

It was the disadvantages of the rotary combine (increased power requirements and over-pulverization of the straw by-product) which prompted a resurgence of conventional combines in the late nineties. Perhaps overlooked but nonetheless true, when the large engines that powered the rotary machines were employed in conventional machines, the two types of machines delivered similar production capacities. Also, research was beginning to show that incorporating above-ground crop residue (straw) into the soil is less useful for rebuilding soil fertility than previously believed. This meant that working pulverized straw into the soil became more of a hindrance than a benefit. An increase in feedlot beef production also created a higher demand for straw as fodder. Conventional combines, which use straw walkers, preserve the quality of straw and allow it to be baled and removed from the field.

# Cultivar

2008/9 Schools Wikipedia Selection. Related subjects: Agriculture; Biology

This *Osteospermum* 'Pink Whirls' is a successful cultivar.

A **cultivar** is a cultivated plant that has been selected and given a unique name because it has desirable characteristics (decorative or useful) that distinguish it from otherwise similar plants of the same species. When propagated it retains those characteristics.

The naming of a cultivar should conform to the *International Code of Nomenclature for Cultivated Plants* (the *ICNCP*, commonly known as the "Cultivated Plant Code"). For this, it must be distinct from other cultivars and it must be possible to propagate it reliably, in the manner prescribed for that particular cultivar.

The word *cultivar*, coined by Liberty Hyde Bailey, is generally regarded as a portmanteau of "**culti**vated" and "**var**iety", but could also be derived from "**culti**gen" "**var**iety". The word cultivar is not interchangeable with the botanical rank of variety, nor with the legal term " plant variety".. Cultivars are a sub-set of Bailey's broader grouping the cultigen, defined as "a plant that has been deliberately altered or selected by humans" (see cultigen for Bailey's original definition of the cultivar, his definitions of the cultigen, and discussion of the current definition of cultigen).

## Definition

Article 2.1 of the *International Code of Nomenclature for Cultivated Plants* states that a cultivar is the "primary category of cultivated plants whose nomenclature is governed by this *Code*." and defines a cultivar as "an assemblage of plants that has been selected for a particular attribute or combination of attributes, and that is clearly distinct, uniform and stable in its characteristics and that, when propagated by appropriate means, retains those characteristics" (Art. 2.2).

The status of a cultivar is quite limited, with nomenclatural consequences only; it offers no legal protection.

## Nature of a cultivar

A "Oncidium" cultivar at Singapore Airport

A cultivar is a particular variety of a plant species or hybrid that is being cultivated and/or is recognised as a cultivar under the *ICNCP*. The concept of cultivar is driven by pragmatism, and serves the practical needs of horticulture, agriculture, forestry, etc.

The plant chosen as a cultivar may have been bred deliberately, selected from plants in cultivation, or discovered in the wild. Cultivars can be asexual clones or seed-raised. Clones are genetically identical and will appear so when grown under the same conditions. Seed-raised cultivars can be mixes that show a wide variation in one or more traits such as a mix of flower colors, or highly homogeneous plant strains produced by heavily selecting out undesirable traits thus producing a breeding line that is uniform or they can be F1 hybrids produced by cross breeding. There are a few F2 hybrid seed cultivars too (*Achillea* 'Summer Berries'.)

There is not necessarily a relationship between any cultivar and any particular genome. The *ICNCP* emphasizes that different cultivated plants may be accepted as different cultivars, even if they have the same genome, while cultivated plants with different genomes may be a single cultivar. In some cultivars, the human involvement was limited to making a selection among plants growing in the wild (whether by collecting growing tissue to propagate from or by gathering seed).

Other cultivars are strictly artificial: the plants must be made anew every time, as in the case of an F1 hybrid between two plant lines. It is not required that a cultivar can reproduce itself. The "appropriate means of propagation" vary from cultivar to cultivar. This may range from propagation by seed which was the result of natural pollination to laboratory propagation. Many cultivars are clones and are propagated by cuttings, grafting, etc.

Cultivars include many garden and food crops: ' Granny Smith' and ' Red Delicious' are cultivars of apples propagated by cuttings or grafting, 'Red Sails' and 'Great Lakes' are lettuce cultivars propagated by seeds. Named *Hosta* and *Hemerocallis* plants are cultivars produced by micro propagation or division.

## Cultivar names

Cultivars are identified by uniquely distinguishing names. Names of cultivars are regulated by the *International Code of Nomenclature for Cultivated Plants*, are registered with an International Cultivar Registration Authority (ICRA) and conform to the rules of the ISHS (International Society for Horticultural Science) Commission for Nomenclature and Cultivar Registration. There are separate registration authorities for different plant-groups. In addition, cultivars may get a trademark name, protected by law (see Trade Designations and "Selling Names", below).

A viola cultivar, *Viola* 'Clear Crystals Apricot'

A **cultivar name** consists of a botanical name (of a genus, species, infraspecific taxon, interspecific hybrid or intergeneric hybrid) followed by a cultivar epithet. The cultivar epithet is capitalised and put between single quotes: preferably it should not be italicized. Cultivar epithets published before 1 January 1959 were often given a Latin form and can be readily confused with the specific epithets in botanical names: after that date, newly coined cultivar epithets must be in a modern vernacular language to distinguish them from botanical epithets.

*Cryptomeria japonica* 'Elegans'
*Chamaecyparis lawsoniana* 'Aureomarginata' (pre-1959 name, Latin in form)
*Chamaecyparis lawsoniana* 'Golden Wonder' (post-1959 name, English language)
*Pinus densiflora* 'Akebono' (post-1959 name, Japanese language)

Some **incorrect** examples:

*Cryptomeria japonica* "Elegans" (double quotes are unacceptable)
*Berberis thunbergii* cv. 'Crimson Pygmy' (this once-common usage is now unacceptable, as it is no longer correct to use "cv." in this context; *Berberis thunbergii* 'Crimson Pygmy' is correct)
*Rosa* cv. 'Peace' (this is now incorrect for two reasons: firstly, the use of "cv."; secondly, "Peace" is a trade designation or "selling name" for the cultivar *R.* 'Madame A. Meilland' and should therefore be printed in a different typeface from the rest of the name, without any quote marks, for example: *Rosa* `Peace`.)

Where several very similar cultivars exist, these are termed **Cultivar Groups**; the name is in normal type and capitalised as in a single cultivar, but *not* in single quotes, and followed by "Group" (or its equivalent in other languages)

*Brassica oleracea* Capitata Group (the group of cultivars including all typical cabbages)
*Brassica oleracea* Botrytis Group (the group of cultivars including all typical cauliflowers)
*Hydrangea macrophylla* Groupe Hortensis (in French) = *Hydrangea macrophylla* Hortensia Group (in English)

Where cited with a cultivar name the Cultivar Group should be enclosed in parentheses, as follows:

*Hydrangea macrophylla* (Hortensia Group) 'Ayesha'

Some cultivars and Cultivar Groups are so well "fixed" or established that they "come true from seed", meaning that the plants from a seed sowing (rather than vegetatively propagated) will show very little variation. In the past, such plants were often called by the terms "variety", "selection" or "strain"; these terms (particularly "variety", which has a very different botanical meaning – see below) are best avoided with cultivated plants. Normally, however, plants grown from seed taken from a cultivar can be very variable and such seeds or seedling plants should *never* be labelled with, or sold under, the parent cultivar's name (See an article by Tony Lord of *The RHS Plant Finder*).

## Trade designations and "selling names"

Cultivars that are still being developed and not yet ready for release to retail sale are often coded with letters and/or numbers before being assigned a name. It is common for this code name to be quoted alongside the new cultivar name or **trade designation** when the plant is made available commercially (for example *Rosa* `Fascination` = 'Poulmax') and this may continue, in books or magazines and on plant labels, for several years after the plant was released. Because a name that is attractive in one language may have less appeal in another country, a plant may be given different **selling names** from country to country. Quoting the code allows the correct identification of cultivars around the world and helps to avoid the once-common situation where the same plant might, confusingly, be sold under several different names in one country, having been imported under different aliases.

Another form of what the *Cultivated Plant Code* (*ICNCP*) calls a **trade designation** is the plant "variety", as defined in the UPOV Convention. Not to be confused with the botanical rank of variety.

## Cultivars in the garden and natural world

Some cultivars are "naturalized" in gardening, in other words they are planted out and largely left to their own devices. With pollination and regrowth from seed, true natural processes, the distinct cultivars will disappear over time. The cultivar's genetic material however may become part of the gene pool of a population, where it will be largely but not completely swamped. Cultivars that are propagated by asexual means such as dividing, cuttings or micropropagation generally do not come true from seed. Plants raised from seed saved from these plants should never be called by the cultivar name. Seeds collected from seed raised cultivars may or may not come true from collected seeds that are sown. Cross pollination with other plants in the garden or from the surrounding area could occur that could contaminate the seed line and produce different plants the next generation. Even if a seed raised cultivar is grown in isolation, often the cultivar can change as different combinations of recessive genes are expressed, so good breeders maintain the seed lines by weeding out atypical plants before they can pass on their genes or pathogens to the next generation and affect the cultivar line.

The " Pavlovo lemon", a lemon variety grown throughout Russia as a houseplant, is celebrated by a monument in its hometown

# Legal points

The practice of patent protection (legally protecting) is an important tool to encourage the development of new useful cultivars; "protected cultivars" are the result of deliberate breeding programs and selection activity by nurseries and plant breeders, and are often the result of years of work. "Plant patents" and "plant breeder's rights" (which can be expensive to obtain) are means for the breeder or inventor to obtain financial reward for their work.

With plants produced by genetic engineering becoming more widely used, the companies producing these plants (or plants produced by traditional means) often claim a patent on their product. Plants so controlled retain certain rights that accrue not to the grower, but to the firm or agency that engineered the variety.

Some plants are often labeled "PBR", which stands for " plant breeders' rights", or "PVR", which stands for "plant variety rights." It is illegal in countries that obey international law to harvest seeds from a patented "variety" except for personal use. Other means of legal protection include the use of trade marked names whereby the name the plant is sold under is trademarked, but the plant itself not protected. Trademarking a name is inexpensive and requires less work, while patents can take a few years to be granted and have a greater expense. Some previously named cultivars have been renamed and sold under trademarked names.

In horticulture, plants that are patented or trade marked are often licensed to large wholesalers that multiply and distribute the plants to retail sellers. The wholesalers pay a fee to the patent or trade mark holders for each plant sold, those plants that are patented are labeled with "It's unlawful to propagate this plant" or a similar phrase. Typically the license agreement specifies that a plant must be sold with a tag thus marketed to help ensure that unlawfully produced plants are not sold. The use of plant patents is considered unethical by some people.

# Cymbopogon

## 2008/9 Schools Wikipedia Selection. Related subjects: Agriculture; Plants

***Cymbopogon*** is a genus of about 55 species of grasses, native to warm temperate and tropical regions of the Old World and Oceania. It is a tall perennial grass. Common names include **lemon grass**, **lemongrass**, **barbed wire grass**, **silky heads**, **citronella grass**, **fever grass** or **Hierba Luisa** amongst many others.

***Lemon Grass***

Lemon grass plant

**Scientific classification**

| | |
|---|---|
| Kingdom: | Plantae |
| Division: | Magnoliophyta |
| Class: | Liliopsida |
| Order: | Poales |
| Family: | Poaceae |

## Cultivation and uses

Prepared Lemongrass

Lemon grass is widely used as an herb in Asian (particularly Vietnamese, Hmong, Khmer, Thai, Lao, Malaysian, Indonesian, Philippine, Sri Lankan) and Caribbean cooking. It has a citrus flavour and can be dried and powdered, or used fresh. The stalk itself is too hard to be eaten except for the soft inner part. However, it can be finely sliced and added to recipes. It may also be bruised and added whole as this releases the aromatic oils from the juice sacs in the stalk. The main constituent of lemongrass oil is citral, which makes up around 80% of the total.

Lemon grass is commonly used in teas, soups, and curries. It is also suitable for poultry, fish, and seafood. It is often used as a tea in African and Latino-American countries (e.g. Togo, Mexico, DR Congo).

**East-Indian Lemon Grass** (*Cymbopogon flexuosus*), also called Cochin Grass or Malabar Grass, is native to Cambodia, India, Sri Lanka, Burma,and Thailand while the West-Indian lemon grass (*Cymbopogon citratus*), also known as serai in Malay, is assumed to have its origins in Malaysia. While both can be used interchangeably, *C. citratus* is more suited for cooking. In India *C. citratus* is used both as a medical herb and in perfumes.

Research also shows that lemon grass oil has antifungal properties.


Lemon grass at a market

| Genus: | ***Cymbopogon*** Spreng. |
| --- | --- |
| **Species** | |
| About 55, see text | |

**Citronella Grass** ( *Cymbopogon nardus* and *Cymbopogon winterianus*) is similar to the species above but grows to 2 m and has red base stems. These species are used for the production of citronella oil, which is used in soaps, as a mosquito repellent in insect sprays and candles, and also in aromatherapy, which is famous in Bintan, Indonesia. The principal chemical constituents of citronella, geraniol and citronellol, are antiseptics, hence their use in household disinfectants and soaps. Besides oil production, citronella grass is also used for culinary purposes, in tea and as a flavoring.

**Palmarosa** ( *Cymbopogon martinii*), also called Rosha Grass and Indian Geranium, is another species used in the perfume industry. It is a perennial clumping grass which grows to 150 cm with finer leaves and has a smaller bulbous base than the species above. The leaves and flower tops contain a sweet smelling oil which is used for the production of geraniol. It is also distilled into palmarosa oil and used in aromatherapy for its calming effect to help relieve nervous tension and stress.

Lemongrass in some cases has been used as a mild depressant for the central nervous system. It is also sometimes used as a weed barrier.

One particular alpine grassland variant known as *juzai* is a staple of Kyrgyz, Dungan and Uyghur cooking.

## In the Philippines

Abundant in the Philippines, and 65- to 85-% citral, Cymbopogon citratus contains active ingredients like myrcene, an antibacterial and pain reliever, citronella, citronellol and geranilol. NGO Alternative Indigenous Development Foundation Inc. (Adfi) established in Mambugsay, South of Negros and Escalante, Negros Occidental lemon grass essential oil production, via distillery plants which extract the oil. Hydro steam distillation, condensation and cooling were used to separate the oil from the water. Hydrosol or Hydrolat, as a by-product of the distillation process, is a pure natural water or plant water essence used for the production of skin care products such as lotions, creams and facial cleansing toner in its pure form. The main products are - organic unadulterated lemon grass oil (for industrial users), and “Negros Oil” (mixture of lemon grass oil with virgin coconut oil) used in aromatherapy.

## Partial species list

- *Cymbopogon ambiguus* Australian lemon-scented grass (native of Australia)
- *Cymbopogon bombycinus* Silky Oilgrass (native of Australia)
- *Cymbopogon citratus* Lemon Grass
- *Cymbopogon citriodora* West Indian lemon grass
- *Cymbopogon flexuosus* East Indian lemon grass
- *Cymbopogon martinii* Palmarosa
- *Cymbopogon nardus* Citronella Grass
- *Cymbopogon obtectus* Silky-heads (native of Australia)
- *Cymbopogon procerus* (native of Australia)
- *Cymbopogon proximus* found in Egypt
- *Cymbopogon refractus* Barbed wire grass (native of Australia)
- *Cymbopogon winterianus* Citronella Grass

# Dairy farming

### 2008/9 Schools Wikipedia Selection. Related subjects: Agriculture

**Dairy farming** is a class of agricultural, or an animal husbandry enterprise, for long-term production of milk, which may be either processed on-site or transported to a dairy factory for processing and eventual retail sale. Most dairy farms sell the male calves born by their cows, usually for veal production, or breeding depending on quality of the Bull calf, rather than raising non-milk-producing stock. Many dairy farms also grow their own feed, typically including corn, alfalfa, and hay. This is fed directly to the cows, or is stored as silage for use during the winter season. Additional dietary supplements are added to the feed to increase quality milk production.

## About dairy farming

Dairy farming has been part of agriculture for thousands of years, but historically, it was usually done on a small scale on mixed farms. Specialist scale dairy farming is only viable where either a large amount of milk is required for production of more durable dairy products such as cheese, or there is a substantial market of people with cash to buy milk, but no cows of their own.

Centralized dairy farming as we understand it primarily developed around villages and cities, where residents were unable to have cows of their own due to a lack of grazing land. Near the town, farmers could make some extra money on the side by having additional animals and selling the milk in town. The dairy farmers would fill barrels with milk in the morning and bring it to market on a wagon.

Before mechanization most cows were still milked by hand. At milking time they brought the vacuum pump, and the automatic milking machine.

The first milking machines were an extension of the traditional milk pail. The early milker device fit on top of a regular milk pail and sat on the floor under the cow. Following each cow being milked, the bucket would be dumped into a holding tank.

This developed into the Surge hanging milker. Prior to milking a cow, a large wide leather strap called a surcingle was put around the cow, across the cow's lower back. The milker device and collection tank hung underneath the cow from the strap. This innovation allowed the cow to move around naturally during the milking process rather than having to stand perfectly still over a bucket on the floor.

Surge later developed a vacuum milk-return system known as the Step-Saver, to save the farmer the trouble of carrying the heavy steel buckets of milk all the way back to the storage tank in the milkhouse. The system used a very long vacuum hose coiled around a receiver cart, and connected to a vacuum-breaker device in the milkhouse. Following milking each cow, the hanging milk bucket would be dumped into the receiver cart, which filtered debris from the milk and allowed it to be slowly sucked through the long hose to the milkhouse. As the farmer milked the cows in series, the cart would be rolled further down the centre aisle, the long milk hose unwrapped from the cart, and hung on hooks along the ceiling of the aisle.

The next innovation in automatic milking was the milk pipeline. This uses a permanent milk-return pipe and a second vacuum pipe that encircles the barn or milking parlor above the rows of cows, with quick-seal entry ports above each cow. By eliminating the need for the milk container, the milking device shrank in size and weight to the point where it could hang under the cow, held up only by the sucking force of the milker nipples on the cow's udder. The milk is pulled up into the milk-return pipe by the vacuum system, and then flows by gravity to the milkhouse vacuum-breaker that puts the milk in the storage tank. The pipeline system greatly reduced the physical labor of milking since the farmer no longer needed to carry around huge heavy buckets of milk from each cow.

Innovation in milking focussed on mechanising the milking parlour to maximise throughput of cows per operator Thiel, C; Dodd [1983]. *Machine Milking* (in Eng). UK: NIRD. ISBN 0 7084 0116 3., which streamlined the milking process to permit cows to be milked as if on an assembly line, and to reduce physical stresses on the farmer by putting the cows on a platform slightly above the person milking the cows to eliminate having to constantly bend over. Many older and smaller farms still have tie-stall or stanchion barns, but worldwide a majority of commercial farms have parlours. Newer innovations include automatic take-off systems, which remove the milker from the cow when the milk flow reaches a preset level, computer to measure the production of each animal while it is milking, and computer chips that identify cows individually when they walk into a parlour so their feed intake and milk output can be monitored. These last three are becoming more common because of their value on large farms where it is hard to monitor each cow individually.

In the 1980s and 1990s robotic milking systems were developed and introduced (principally in the EU) [2000] in Hoegeveen: *Robotic Milking, proceedings of the international symposium, Lelystad, 17-19 th August 2000*, Meijering (in Eng), Wageningen Pers. ISBN 9074134874.. Thousands of these systems are now in routine operation. In these systems the cow has a high degree of autonomy to choose her time of milking within pre-defined windows. These systems are generally limited to intensively managed systems although research continues to match them to the requirements of grazing cattle and to develop sensors to detect animal health and fertility automatically (www.ecow.co.uk).

# History of milk preservation methods

Keeping milk cool helps preserve it. When windmills and well pumps were invented, one of its first uses on the farm besides providing water for animals was for cooling milk, to extend the storage life before being transported to the town market. The naturally cold underground water would be continuously pumped into a tub or other containers of milk set in the tub to cool after milking. This method of milk cooling was extremely popular before the arrival of electricity and refrigeration.

When refrigeration first arrived, the equipment was fairly small and did not have the ability to rapidly cool the large volume of milk that was entering the storage tank in a short period of time. This problem was resolved through the development of the ice bank. This is a double-walled tank design where water and cooling coils fill the space underneath and around the milk tank above.

All day long, the small compressor and cooling system slowly draws heat out of the water, while a second pump continuously circulates the water around the coils. Ice eventually builds up around the coils, until it reaches a thickness of about three inches surrounding each pipe, and the cooling system shuts off. When the milking operation starts only the milk agitator and the water circulation pump blowing water across the ice and the steel walls of the tank are needed to rapidly reduce the incoming milk to a temperature below 40 degrees. But because the ice is not permitted to build up until it touches the milk storage tank, the milk does not get cold enough to also freeze.

This cooling method worked well for smaller dairies up to about 40 cows, but for large numbers of animals a better system was needed to rapidly cool the incoming warm milk. This is usually done using a device known as a plate chiller, which is a heat exchanger. Alternating stainless steel plates cause the milk to flow in a thin sheet across the plates, while cold water is circulated in a thin sheet on the other side of the plates. Flattening out the milk flow permits quick. even cooling for all the milk, compared to a round tube where the centre core does not cool as rapidly as the walls.

The plate chiller has high cooling demands, and for many farms this involves a step back into the past, back to the days of windmills and milk-can cooling, except now a large volume of naturally cold underground water is continuously streamed through the plate chiller to quickly bring down the milk down to the temperature of the underground water at about 50 degrees F. The water is usually not just dumped back into the ground again, but reused for washing and other purposes.

But the milk still is not as cold as it needs to be, so the milk storage tank is still used to do further cooling, to bring the milk down to 40 degrees. But with the development of high-power 3-phase electrical service, ice-bank chillers are typically no longer used. Instead the milk storage tank is a direct-cooling system with cooling coils embedded in the walls of the tank, that quickly pull the heat out and dump it across a large array of possibly several different high-horsepower compressors and condensing units. Once the milk has achieved 40 degrees F after milking is finished, only one or two cooling units need to run occasionally to maintain the correct temperature.

# The milking operation

## Original hand milking processes

Until the late 1800s, the milking of the cow was done by hand. In the United States, several large dairy operations existed in some northeastern states and in the west, that involved as many as several hundred cows, but an individual milker could not be expected to milk more than a dozen cows a day. Smaller operations predominated.

Milking took place indoors in a barn with the cattle tied by the neck with ropes or held in place by stanchions. Feeding could occur simultaneously with milking in the barn, although most dairy cattle were pastured during the day between milkings. Such examples of this method of dairy farming are difficult to locate, but some are preserved as a historic site for a glimpse into the days gone by. One such instance that is open for public tours is at Point Reyes National Seashore.

With the availability of electric power and suction milking machines, the production levels that were possible in stanchion barns increased but the scale of the operations continued to be limited by the labor intensive nature of the milking process. Attaching and removing milking machines involved repeated heavy lifting of the machinery and its contents several times per cow and the pouring of the milk into milk cans. As a result, it was rare to find single-farmer operations of more than 50 head of cattle.

## Modern milking parlor operations

Farmers use any number of styles of milking parlors to milk dairy cattle. Many older farms have stanchion or tie-stall facilities, where the milkers are brought to the cows and the milker bends down to apply the milking machine to the cow. More modern farms use recessed parlors, where the milker stands in a recess such that his arms are at the level of the cow's udder. Recessed parlors can be herringbone, where the cows stand in two angled rows either side of the recess and the milker accesses the udder from the side, parallel, where the cows stand side-by-side and the milker accesses the udder from the rear or, more recently, rotary (or carousel), where the cows are on a raised circular platform, facing the centre of the circle, and the platform rotates while the milker stands in one place and accesses the udder from the rear. There are many other styles of milking parlors which are less common.

In herringbone and parallel parlors, the milker generally milks one row at a time. The milker will move a row of cows from the holding yard into the milking parlor, and milk each cow in that row. Once all or most of the milking machines have been removed from the milked row, the milker releases the cows to their feed. A new group of cows is then loaded into the now vacant side and the process repeats until all cows are milked. Depending on the size of the milking parlor, which normally is the bottleneck, these rows of cows can range from four to sixty at a time.

In rotary parlors, The cows are loaded one at a time onto the platform as it slowly rotates. The milker stands near the entry to the parlor and puts the cups on the cows as they move past. By the time the platform has completed almost a full rotation, another milker or a machine removes the cups and the cow steps backwards off the platform and then walks to her feed.

Milking machines are held in place automatically by a vacuum system that draws the ambient air pressure down to 15 to 21 pounds of vacuum. The vacuum is also used to lift milk vertically through small diameter hoses, into the receiving can. A milk lift pump draws the milk from the receiving can through large diameter stainless steel piping, through the plate cooler, then into a refrigerated bulk tank.

Milk is extracted from the cow's udder by flexible rubber sheaths known as liners or inflations that are surrounded by a rigid air chamber. A pulsating flow of ambient air and vacuum is applied to the inflation's air chamber during the milking process. When ambient air is allowed to enter the chamber, the vacuum inside the inflation causes the inflation to collapse around the cow's teat, squeezing the milk out of teat in a similar fashion as a baby calf's mouth massaging the teat. When the vacuum is reapplied in the chamber the flexible rubber inflation relaxes and opens up, preparing for the next squeezing cycle.

It takes the average cow three to five minutes to give her milk. Some cows are faster or slower. Slow-milking cows may take up to fifteen minutes to let down all their milk. Milking speed is only minorly related to the quantity of milk the cow produces - milking speed is a separate factor from milk quantity; milk quantity is not determinative of milking speed. Because most milkers milk cattle in groups, the milker can only process a group of cows at the speed of the slowest-milking cow. For this reason, many farmers will cull slow-milking cows.

The extracted milk passes through a strainer and plate heat exchangers before entering the tank, where it can be stored safely for a few days at approximately 3°C or around 42°F. At pre-arranged times, a milk truck arrives and pumps the milk from the tank for transport to a dairy factory where it will be pasteurized and processed into many products.

## Animal waste from large dairies

As measured in phosphorus, the waste output of 5,000 cows roughly equals a municipality of 70,000 people. In the U.S., dairy operations with more than 1,000 cows meet the EPA definition of a CAFO (Concentrated Animal Feeding Operation), and are subject to EPA regulations. For example, in the San Joaquin Valley of California a number of dairies have been established on a very large scale. Each dairy consists of several modern milking parlor set-ups operated as a single enterprise. Each milking parlor is surrounded by a set of 3 or 4 loafing barns housing 1,500 or 2,000 cattle. Some of the larger dairies have planned 10 or more series of loafing barns and milking parlors in this arrangement, so that the total operation may include as many as 15,000 or 20,000 cows. The milking process for these dairies is similar to a smaller dairy with a single milking parlor but repeated several times. The size and concentration of cattle creates major environmental issues associated with manure handling and disposal, which requires substantial areas of cropland (a ratio of 5 or 6 cows to the acre, or several thousand acres for dairies of this size) for manure spreading and dispersion, or several-acre methane digesters. Air pollution from methane gas associated with manure management also is a major concern. As a result, proposals to develop dairies of this size can be controversial and provoke substantial opposition from environmentalists including the Sierra Club and local activists.


Dairy CAFO - EPA

The potential impact of large dairies was demonstrated when a massive manure spill occurred on a 5,000-cow dairy in Upstate New York, contaminating a 20-mile stretch of the Black River, and killing 375,000 fish. On Aug. 10, 2005, a manure storage lagoon collapsed releasing several million gallons of manure into the Black River. Subsequently the New York Department of Environmental Conservation mandated a settlement package of $2.2 million against the dairy.

## Use of hormones

Approximately 22% of dairy cows in the US are injected with recombinant growth hormones known as recombinant BST or rBGH to maintain slightly higher milk production. The use of rBST is regarded as controversial due to its effects on animal and possibly human health. While the European Union, Japan, Australia and Canada have banned rBST due to such concerns, the U.S. Food and Drug Administration maintains that no "significant difference" has been found between milk from treated and non-treated cows.

## Management of the dairy herd

Modern dairy farmers use milking machines and sophisticated plumbing systems to harvest and store the milk from the cows, which are usually milked twice or thrice daily. During the warm months, in the northern hemisphere, cows may be allowed to graze in their pastures, both day and night, and are brought into the barn only to be milked. Many barns also incorporate tunnel ventilation into the architecture of the barn structure. This ventilation system is highly efficient and involves opening both ends of the structure allowing cool air to blow through the building. Farmers with this type of structure keep cows inside during the summer months to prevent sunburn and damage to udders. During the winter months, especially in northern climates, the cows may spend the majority of their time inside the barn, which is warmed by their collective body heat. Even in winter, the heat produced by the cattle requires the barns to be ventilated for cooling purposes. Many modern facilities, and particularly those in tropical areas, keep all animals inside at all times to facilitate herd management. Housing the cow can be either loose housed or stalls (called cow cubicles in UK).

In the southern hemisphere milking animals are more likely to spend most of their lives outside on pasture.


Holstein cows on a dairy, Comboyne, NSW

There is little research available on dimensions required for cow stalls, and much housing can be out of date, however increasingly companies are making farmers aware of the benefits, in terms of animal welfare, health and milk production.

The production of milk requires that the cow be in lactation, which is a result of the cow having given birth to a calf. The cycle of insemination, pregnancy, parturition, and lactation, followed by a "dry" period before insemination can recur, requires a period of 12 to 16 months for each cow. Dairy operations therefore included both the production of milk and the production of calves. Bull calves are either castrated and raised as steers for beef production or raised for veal. As the size of herds has increased, the conditions in which large numbers of veal calves are raised, fed and marketed on larger dairies also have provoked controversy among animal rights activists.

# Dairy farming in the world

In the United States, the top four dairy states are, in order by total milk production, California, Wisconsin, New York, and Idaho. Dairy farming is also an important industry in Florida, Minnesota, Ohio and Vermont.

In Pennsylvania, the dairy industry is the number one industry in the state. Pennsylvania is home to 8,500 farms and 555,000 dairy cows. Milk produced in Pennsylvania yields about US$1.5 million in farm income every year, and is sold to various states up and down the east coast.

The world's largest exporter of dairy products is New Zealand. Japan is the world's largest importer of dairy products.

There follows two lists of countries by milk production (MT = million tonnes).

Table 1: World production not including countries in the European Union.

| Rank | Country | Production (MT/yr) |
|---|---|---|
| 1 | India | 96.1 |
| 2 | United States | 67.2 |
| 3 | Russia | 32.8 |
| 4 | Brazil | 23.3 |

| | | |
|---|---|---|
| 5 | China | 16.8 |
| 6 | New Zealand | 14.6 |
| 7 | Australia | 10.6 |
| 8 | Mexico | 9.8 |
| 9 | Turkey | 9.5 |
| 10 | Japan | 8.4 |
| 11 | Canada | 8.0 |
| 12 | Argentina | 8.0 |
| 13 | Switzerland | 3.9 |
| 14 | South Africa | 2.6 |
| 15 | South Korea | 2.4 |
| 16 | Norway | 1.6 |

**Notes:**

[a] Source, unless otherwise noted: *2005 OECD Agricultural Outlook Tables, 1970-2014*, OECD, 2003, < http://www.oecd.org/searchResult /0,3400,en_2825_293564_1_1_1_1_1,00.html>. Retrieved on 29 October 2007

The EU is the largest milk producer in the world, with 143.7 million tonnes in 2003. This data, encompassing the present 25 member countries, can be further broken down into the production of the original 15 member countries, with 122 million tonnes, and the new 10 mainly former Eastern European countries with 21.7 million tonnes.

Table 1: Milk production data for EU countries.

| Rank | Country | Production (MT/yr) |
|---|---|---|
| 1 | Germany | 28.5 |
| 2 | France | 24.6 |

| | | |
|---|---|---|
| 3 | United Kingdom | 15.0 |
| 4 | Poland | 11.9 |
| 5 | Netherlands | 11.0 |
| 6 | Italy | 10.8 |
| 7 | Spain | 6.6 |
| 8 | Ireland | 5.4 |
| 9 | Denmark | 4.7 |
| 10 | Sweden | 3.2 |
| 11 | Austria | 3.2 |
| 12 | Belgium | 3.1 |
| 13 | Czech Republic | 2.7 |
| 14 | Finland | 2.5 |
| 15 | Hungary | 1.9 |
| 16 | Portugal | 1.9 |
| 17 | Lithuania | 1.8 |

**Notes:**

[a] Source, unless otherwise noted: *Production of cow's milk and milk deliveries to dairies, European union by country*, MDC Datum, 2003, < http://www.mdcdatum.org.uk/MilkSupply/euproduction.html>. Retrieved on 29 October 2007

# Dairy competition

Most milk-consuming countries have a local dairy farming industry, and most producing countries maintain significant subsidies and trade barriers to protect domestic producers from foreign competition. In large countries, dairy farming tends to be geographically clustered in regions with abundant natural water supplies (both for feed crops and for cattle) and relatively inexpensive land (even under the most generous subsidy regimes, dairy farms have poor return on capital). New Zealand, the fourth largest dairy producing country, does not apply any subsidies to dairy production.

The milking of cows was traditionally a labor-intensive operation and still is in less developed countries. Small farms need several people to milk and care for only a few dozen cows, though for many farms these employees have traditionally been the children of the farm family, giving rise to the term " family farm".

Advances in technology have mostly led to the radical redefinition of "family farms" in industrialized countries such as the United States. With farms of hundreds of cows producing large volumes of milk, the larger and more efficient dairy farms are more able to weather severe changes in milk price and operate profitably, while "traditional" very small farms generally do not have the equity or cashflow to do so. The common public perception of large corporate farms supplanting smaller ones is generally a misconception, as many small family farms expand to take advantage of economies of scale, and incorporate the business to limit the legal liabilities of the owners and simplify such things as tax management.

Before large scale mechanization arrived in the 1950s, keeping a dozen milk cows for the sale of milk was profitable. Now most dairies must have more than one hundred cows being milked at a time in order to be profitable, with other cows and heifers waiting to be "freshened" to join the milking herd. In New Zealand the average herd size, depending on the region, is about 350 cows .

Herd size in the US varies between 1,200 on the West Coast and Southwest, where large farms are commonplace, to roughly 50 in the Northeast, where land-base is a significant limiting factor to herd size. The average herd size in the U.S. is about one hundred cows per farm.

# Farm

## 2008/9 Schools Wikipedia Selection. Related subjects: Agriculture

A **farm** is an area of land, including various structures, devoted primarily to the practice of **farming**, the production and management of food, either produce or livestock (see also ranching). It is the basic production facility in food production. Farms may be owned and operated by a single individual, family, or community, or by a corporation or company. A farm can be a holding of any size from a fraction of a hectare to several thousand hectares.

A business producing tree fruits or nuts is called an *orchard*; a *vineyard* produces raisins, wine or table grapes. The *stable* is used for operations principally involved in the production of horses and other animals and livestock. A farm that is primarily used for the production of milk and dairy is a *dairy farm*. A *market garden* or *truck farm* is a farm that raises vegetables, but little or no grain. Additional specialty farms include fish farms, which raise fish in captivity as a food source, and tree farms, which grow trees for sale for transplant, lumbering, or decorative use. A plantation is usually a large farm or estate, on which cotton, tobacco, coffee, or sugar cane, are cultivated, usually by resident laborers.

The development of farming and farms was an important component in establishing towns. Once people have moved from hunting and/or gathering and from simple horticulture to active farming, social arrangements of roads, distribution, collection, and marketing can evolve. With the exception of plantations and colonial farms, farm sizes tend to be small in newly-settled lands and to extend as transportation and markets become sophisticated. Farming rights have been the central tenet of a number of revolutions, wars of liberation, and post-colonial economics.

# Etymology

The word came via French *ferme* from Late Latin *firma* = "fixed payment" from Latin *firmus* = "firm, solid", and originally referred to a big landowner farming out his land among other men to run it, rather than running it all himself. As times have changed fewer people are needed to assist in running the farm because of the increase of mechanization.

# Farming

The term **farming** covers a wide spectrum of agricultural production work. At one end of this spectrum is the subsistence farmer, who farms a small area with limited resource inputs, and produces only enough food to meet the needs of his/her family. At the other end is commercial intensive agriculture, including industrial agriculture. Such farming involves large fields and/or numbers of animals, large resource inputs (pesticides, fertilizers, etc.), and a high level of mechanization. These operations generally attempt to maximize financial income from grain, produce, or livestock.

Traditionally, the goal of farming was to create a profit, and to produce an amount of cultivated material (i.e. corn, wheat, etc) so that the resulting harvest has more worth than the cost of planting such a harvest. The costs could include the acquisition of seeds as well as the time and energy required to tend to such a venture. The resulting product is often used to sustain those who farm as both a food to eat and a commodity to sell.

### Types of farming

- Collective farming
- Factory farming
- Intensive farming
- Organic farming
- Vertical farming
- Fell farming

## Specialized farms

### Dairy farms


A milking machine in action.

Dairy farming is a class of agriculture, where female cattle, goats, or other mammals are raised for their milk, which may be either processed on-site or transported to a dairy for processing and eventual retail sale.

In most Western countries, a centralized dairy facility processes milk and dairy products, such as cream, butter, and cheese. In the United States, these dairies are usually local companies, while in the southern hemisphere facilities may be run by very large nationwide or trans-national corporations (such as Fonterra).

Dairy farms generally sell the male calves borne by their mothers for veal meat, as dairy breeds are not normally satisfactory for commercial beef production. Many dairy farms also grow their own feed, typically including corn, alfalfa, and hay. This is fed directly to the cows, or stored as silage for use during the winter season. Additional dietary supplements are added to the feed to improve milk production.

### Poultry farms

Poultry farms are devoted to raising chickens, turkeys, ducks, and other fowl, generally for meat or eggs.

## Ownership

Farm control and ownership has traditionally been a key indicator of status and power, especially in agrarian societies. The distribution of farm ownership has historically been closely linked to form of government. Medieval feudalism was essentially a system that centralized control of farmland, control of farm labor and political power, while the early American democracy, in which land ownership was a prerequisite for voting rights, was built on relatively easy paths to individual farm ownership. However, the gradual modernization and mechanization of farming, which greatly increases both the efficiency and capital requirements of farming, has led to increasingly large farms owned by individuals or corporations. This has usually been accompanied by the decoupling of political power from farm ownership.

### Forms of ownership

In some societies (especially socialist and communist), collective farming is the norm, with either government ownership of the land or common ownership by a local group. Especially in societies without widespread industrialized farming, tenant farming and sharecropping are common; farmers either pay landowners for the right to use farmland or give up a portion of the crops.

## History

The practice of agriculture first began around 8000 BC in the Fertile Crescent of Mesopotamia (part of present day Iraq, Turkey, Syria and Jordan which was then greener).

## Farms around the world

### British Isles and Europe

Many farms have fallen into disrepair, such as the ruins of *Higher Hempshaw's* in Anglezarke, England

In the UK, *farm* as an agricultural unit, always denotes the area of pasture and other fields together with its farmhouse and farmyard, barns, cowsheds, stables, etc. In England there is a vague point when a large farm ceases to be referred to as a farm and becomes an estate; although this term can refer to a collection of farms in the same ownership.

### North America

Farming near Klingerstown, Pennsylvania.

The land and buildings of a farm are called the "farmstead." Enterprises where livestock are raised on rangeland are called *ranches*. Where livestock are raised in confinement on feed produced elsewhere, the term *feedlot* is usually used

In 1910 there were 6,406,000 farms and 10,174,000 family workers; In 2000 there were only 2,172,000 farms and 2,062,300 family workers.

Michelsen Farmstead Provincial Historic Site of Alberta, Stirling Agricultural Village

In the United States, eighty-one percent of all farmworkers are migrant workers, and seventy-one percent are foreign-born. Eighty percent of farmworkers are men, with the average age being 31. Additionally, farmworkers earn less than $75,000 per year, making an average hourly rate of less than $27.00. On average, farmworker families earn $10,000 per year, which is significantly below the 2005 U.S. poverty level of $19,874 for a family of four.

In 2007, corn acres are expected to increase by 15% because of the high demand for ethanol, both in and outside of the U.S. Producers are expecting to plant 90.5 million acres (366,000 km²) of corn, making it the largest corn crop since 1944.

## Australia

Farming is a significant economic sector in Australia. A farm is an area of land used for primary production which will include buildings.

Where most of the income is from some other employment, and the farm is really an expanded residence, the term *hobby farm* is common. This will allow sufficient size for recreational use but be very unlikely to produce sufficient income to be self-sustaining. Hobby farms are commonly around 5 acres (20,000 m²) but may be much larger depending upon land prices (which vary regionally).

Often very small farms used for intensive primary production are referred to by the specialization they are being used for, such as a dairy rather than a dairy farm, a piggery, a market garden, etc. This also applies to feedlots, which are specifically developed to a single purpose and are often not able to be used for more general purpose (mixed) farming practices.

In remote areas farms can become quite large. As with *estates* in England, there is no defined size or method of operation at which a large farm becomes a station.

Regardless of size, the term *station* is only used for farms where the main activity is grazing. Some cotton farms in north-western New South Wales or south-western Queensland have been formed by combining previous sheep stations once sufficient water has become available to allow cotton to be grown .

## Farm buildings

A pastoral farm scene with a classic red barn.

Farms require buildings to facilitate the action of farming the material at hand. Such buildings can include a farm house (for the farmers), a grain silo (for storing grain), and a barn (for the storing of certain animals.)

## Farm equipment

- Baler
- Combine harvester
- Farm tractor
- Mower
- Pickup truck
- Plough

# Fertilizer

## 2008/9 Schools Wikipedia Selection. Related subjects: Agriculture


Spreading manure, an organic fertilizer

**Fertilizers** ( also spelled fertiliser) are chemical compounds given to plants to promote growth; they are usually applied either through the soil, for uptake by plant roots, or by foliar feeding, for uptake through leaves. Fertilizers can be organic (composed of organic matter), or inorganic (made of simple, inorganic chemicals or minerals). They can be naturally occurring compounds such as peat or mineral deposits, or manufactured through natural processes (such as composting) or chemical processes (such as the Haber process). These chemical compounds leave lawns, gardens, and soils looking beautiful as they are given different essential nutrients that encourage plant growth.

They typically provide, in varying proportions, the three major plant nutrients (nitrogen, phosphorus, potassium: N-P-K), the secondary plant nutrients (calcium, sulfur, magnesium) and sometimes trace elements (or micronutrients) with a role in plant or animal nutrition: boron, chlorine, manganese, iron, zinc, copper, molybdenum and (in some countries) selenium.

Both organic and inorganic fertilizers were called "manures" derived from the French expression for manual tillage, but this term is now mostly restricted to organic manure.

Though nitrogen is plentiful in the earth's atmosphere, relatively few plants engage in nitrogen fixation (conversion of atmospheric nitrogen to a biologically useful form). Most plants thus require nitrogen compounds to be present in the soil in which they grow.

# History

While manure, cinder and ironmaking slag have been used to improve crops for centuries, the use of fertilizers is arguably one of the great innovations of the Agricultural Revolution of the 19th Century.

## Key people

In the 1730s, Viscount Charles Townshend (1674–1738) first studied the improving effects of the four crop rotation system that he had observed in use in Flanders. For this he gained the nickname of *Turnip Townshend*.

Chemist Justus von Liebig (1803–1883) contributed greatly to the advancement in the understanding of plant nutrition. His influential works first denounced the vitalist theory of humus, arguing first the importance of ammonia, and later the importance of inorganic minerals. Primarily his work succeeded in setting out questions for agricultural science to address over the next 50 years. In England he attempted to implement his theories commercially through a fertilizer created by treating phosphate of lime in bone meal with sulfuric acid. Although it was much less expensive than the guano that was used at the time, it failed because it was not able to be properly absorbed by crops.

At that time in England, Sir John Bennet Lawes (1814–1900) was experimenting with crops and manures at his farm at Harpenden and was able to produce a practical superphosphate in 1842 from the phosphates in rock and coprolites. Encouraged, he employed Sir Joseph Henry Gilbert, who had studied under Liebig at the University of Giessen, as director of research. To this day, the Rothamsted research station that they founded still investigates the impact of inorganic and organic fertilizers on crop yields.

In France, Jean Baptiste Boussingault (1802–1887) pointed out that the amount of nitrogen in various kinds of fertilizers is important.

Metallurgists Percy Gilchrist (1851–1935) and Sidney Gilchrist Thomas (1850–1885) invented the Thomas-Gilchrist converter, which enabled the use of high phosphorus acidic Continental ores for steelmaking. The dolomite lime lining of the converter turned in time into calcium phosphate, which could be used as fertilizer known as Thomas-phosphate.

In the early decades of the 20th Century, the Nobel prize-winning chemists Carl Bosch of IG Farben and Fritz Haber developed the process that enabled nitrogen to be cheaply synthesised into ammonia, for subsequent oxidisation into nitrates and nitrites.

In 1927 Erling Johnson developed an industrial method for producing nitrophosphate, also known as the Odda process after his Odda Smelteverk of Norway. The process involved acidifying phosphate rock (from Nauru and Banaba Islands in the southern Pacific Ocean) with nitric acid to produce phosphoric acid and calcium nitrate which, once neutralized, could be used as a nitrogen fertilizer.

## Industry

The Englishmen James Fison, Edward Packard, Thomas Hadfield and the Prentice brothers each founded companies in the early 19th century to create fertilizers from bonemeal. The developing sciences of chemistry and Paleontology, combined with the discovery of coprolites in commercial quantities in East Anglia, led Fisons and Packard to develop sulfuric acid and fertilizer plants at Bramford, and Snape, Suffolk in the 1850s to create superphosphates, which were shipped around the world from the port at Ipswich. By 1870 there were about 80 factories making superphosphate. After World War I these businesses came under financial pressure through new competition from guano, primarily found on the Pacific islands, as their extraction and distribution had become economically attractive.

The interwar period saw innovative competition from Imperial Chemical Industries who developed synthetic ammonium sulfate in 1923, Nitro-chalk in 1927, and a more concentrated and economical fertilizer called CCF based on ammonium phosphate in 1931. Competition was limited as ICI ensured it controlled most of the world's ammonium sulfate supplies. Other European and North American fertilizer companies developed their market share, forcing the English pioneer companies to merge, becoming Fisons, Packard, and Prentice Ltd. in 1929. Together they were producing 85,000 tonnes of superphosphate per annum by 1934 from their new factory and deep-water docks in Ipswich. By World War II they had acquired about 40 companies, including Hadfields in 1935, and two years later the large Anglo-Continental Guano Works, founded in 1917.

The post-war environment was characterized by much higher production levels as a result of the " Green Revolution" and new types of seed with increased nitrogen-absorbing potential, notably the high-response varieties of maize, wheat, and rice. This has accompanied the development of strong national competition, accusations of cartels and supply monopolies, and ultimately another wave of mergers and acquisitions. The original names no longer exist other than as holding companies or brand names: Fisons and ICI agrochemicals are part of today's Yara International and AstraZeneca companies.

# Inorganic fertilizers (mineral fertilizer)

Naturally occurring inorganic fertilizers include Chilean sodium nitrate, mined rock phosphate, and limestone (a calcium source).

## Macronutrients and micronutrients

Fertilizers can be divided into macronutrients or micronutrients based on their concentrations in plant dry matter. There are six macronutrients: nitrogen, phosphorus, and potassium, often termed "primary macronutrients" because their availability is usually managed with NPK fertilizers, and the "secondary macronutrients" — calcium, magnesium, and sulfur — which are required in roughly similar quantities but whose availability is often managed as part of liming and manuring practices rather than fertilizers. The macronutrients are consumed in larger quantities and normally present as a whole number or tenths of percentages in plant tissues (on a dry matter weight basis). There are many micronutrients, required in concentrations ranging from 5 to 100 parts per million (ppm) by mass. Plant micronutrients include iron (Fe), manganese (Mn), boron (B), copper (Cu), molybdenum (Mo), nickel (Ni), chlorine (Cl), and zinc (Zn).

## Macronutrient fertilizers

Tennessee Valley Authority: "Results of Fertilizer" demonstration 1942.

Synthesized materials are also called **artificial**, and may be described as **straight,** where the product predominantly contains the three primary ingredients of nitrogen (N), phosphorus (P), and potassium (K), which are known as **N-P-K fertilizers** or **compound fertilizers** when elements are mixed intentionally. They are named or labeled according to the content of these three elements, which are macronutrients. The mass fraction (percent) nitrogen is reported directly. However, phosphorus is reported as phosphorus pentoxide ($P_2O_5$), the anhydride of phosphoric acid, and potassium is reported as potassium oxide ($K_2O$), which is the anhydride of potassium hydroxide. Fertilizer composition is expressed in this fashion for historical reasons in the way it was analyzed (conversion to ash for P and K); this practice dates back to Justus von Liebig (see more below). Consequently, an 18-51-20 fertilizer would have 18% nitrogen as N, 51% phosphorus as $P_2O_5$, and 20% potassium as $K_2O$, The other 11% is known as **ballast** and may or may not be valuable to the plants, depending on what is used as ballast. Although analyses are no longer carried out by ashing first, the naming convention remains. If nitrogen is the main element, they are often described as **nitrogen fertilizers.**

In general, the mass fraction (percentage) of elemental phosphorus, $[P] = 0.436 \times [P_2O_5]$

and the mass fraction (percentage) of elemental potassium, $[K] = 0.83 \times [K_2O]$

(These conversion factors are mandatory under the UK fertilizer-labelling regulations if elemental values are declared in addition to the N-P-K declaration.)

An 18−51−20 fertilizer therefore contains, by weight, 18% elemental nitrogen (N), 22% elemental phosphorus (P) and 16% elemental potassium (K).

B5A fertilizer is a macronutritient fertilizer.

## Agricultural versus horticultural

In general, agricultural fertilizers contain only 1 or 2 macronutrients. Agricultural fertilizers are intended to be applied infrequently and normally prior to or alongside seeding. Examples of agricultural fertilizers are granular triple superphosphate, potassium chloride, urea, and anhydrous ammonia. The commodity nature of fertilizer, combined with the high cost of shipping, leads to use of locally available materials or those from the closest/cheapest source, which may vary with factors affecting transportation by rail, ship, or truck. In other words, a particular nitrogen source may be very popular in one part of the country while another is very popular in another geographic region only due to factors unrelated to agronomic concerns.

Horticultural or specialty fertilizers, on the other hand, are formulated from many of the same compounds and some others to produce well-balanced fertilizers that also contain micronutrients. Some materials, such as ammonium nitrate, are used minimally in large scale production farming. The 18-51-20 example above is a horticultural fertilizer formulated with high phosphorus to promote bloom development in ornamental flowers. Horticultural fertilizers may be water-soluble (instant release) or relatively insoluble (controlled release). Controlled release fertilizers are also referred to as sustained release or timed release. Many controlled release fertilizers are intended to be applied approximately every 3-6 months, depending on watering, growth rates, and other conditions, whereas water-soluble fertilizers must be applied at least every 1-2 weeks and can be applied as often as every watering if sufficiently dilute. Unlike agricultural fertilizers, horticultural fertilizers are marketed directly to consumers and become part of retail product distribution lines.

## Nitrogen fertilizer

Nitrogen fertilizer is often synthesized using the Haber-Bosch process, which produces ammonia. This ammonia is applied directly to the soil or used to produce other compounds, notably ammonium nitrate and urea, both dry, concentrated products that may be used as fertilizer materials or mixed with water to form a concentrated liquid nitrogen fertilizer, UAN. Ammonia can also be used in the Odda Process in combination with rock phosphate and potassium fertilizer to produce compound fertilizers such as 10-10-10 or 15-15-15.

**Major users of nitrogen-based fertilizer**

| Country | Total N consumption (Mt pa) | of which used for feed & pasture |
|---|---|---|
| USA | 9.1 | 4.7 |
| China | 18.7 | 3.0 |
| France | 2.5 | 1.3 |
| Germany | 2.0 | 1.2 |
| Canada | 1.6 | 0.9 |
| UK | 1.3 | 0.9 |
| Brazil | 1.7 | 0.7 |
| Spain | 1.2 | 0.5 |
| Mexico | 1.3 | 0.3 |
| Turkey | 1.5 | 0.3 |
| Argentina | 0.4 | 0.1 |

The production of ammonia currently consumes about 5% of global natural gas consumption, which is somewhat under 2% of world energy production. Natural gas is overwhelmingly used for the production of ammonia, but other energy sources, together with a hydrogen source, can be used for the production of nitrogen compounds suitable for fertilizers. The cost of natural gas makes up about 90% of the cost of producing ammonia. The price increases in natural gas in the past decade, among other factors such as increasing demand, have contributed to an increase in fertilizer price.

Nitrogen-based fertilizers are most commonly used to treat fields used for growing maize, followed by barley, sorghum, rapeseed, soyabean and sunflower.

## Health and sustainability issues

Inorganic fertilizers sometimes do not replace trace mineral elements in the soil which become gradually depleted by crops grown there. This has been linked to studies which have shown a marked fall (up to 75%) in the quantities of such minerals present in fruit and vegetables. One exception to this is in Western Australia where deficiencies of zinc, copper, manganese, iron and molybdenum were identified as limiting the growth of crops and pastures in the 1940s and 1950s. Soils in Western Australia are very old, highly weathered and deficient in many of the major nutrients and trace elements. Since this time these trace elements are routinely added to inorganic fertilizers used in agriculture in this state.

In many countries there is the public perception that inorganic fertilizers "poison the soil" and result in "low quality" produce. However, there is very little (if any) scientific evidence to support these views. When used appropriately, inorganic fertilizers enhance plant growth, the accumulation of organic matter and the biological activity of the soil, preventing overgrazing and soil erosion. The nutritional value of plants for human and animal consumption is typically improved when inorganic fertilizers are used appropriately.

There are concerns though about arsenic, cadmium and uranium accumulating in fields treated with phosphate fertilizers. The phosphate minerals contain trace amounts of these elements and if no cleaning step is applied after mining the continuous use of phosphate fertilizers leads towards an accumulation of these elements in the soil. Eventually these can build up to unacceptable levels and get into the produce. (See cadmium poisoning.)

Another problem with inorganic fertilizers is that they are presently produced in ways which cannot be continued indefinitely. Potassium and phosphorus come from mines (or from saline lakes such as the Dead Sea in the case of potassium fertilizers) and resources are limited. Nitrogen is unlimited, but nitrogen fertilizers are presently made using fossil fuels such as natural gas. Theoretically fertilizers could be made from sea water or atmospheric nitrogen using renewable energy, but doing so would require huge investment and is not competitive with today's unsustainable methods. Innovative thermal depolymerization biofuel schemes are trialling the production of byproducts with 9% nitrogen fertilizer sourced from organic waste

## Organic fertilizers

Naturally occurring organic fertilizers include manure, slurry, worm castings, peat, seaweed, sewage , and guano. Green manure crops are also grown to add nutrients to the soil. Naturally occurring minerals such as mine rock phosphate, sulfate of potash and limestone are also considered Organic Fertilizers.


A compost bin

Manufactured organic fertilizers include compost, bloodmeal, bone meal and seaweed extracts. Other examples are natural enzyme digested proteins, fish meal, and feather meal.

The decomposing crop residue from prior years is another source of fertility. Though not strictly considered "fertilizer", the distinction seems more a matter of words than reality.

Biomineral soil management, a total mineral and biological concept evolved by the South Australian Geomite company, utilizes the interaction of an 'insoluble' minerals base with specific micro-organisms to provide nutrition, structure and enhanced biology in soils. It proposes that plants feed by releasing root exudates of precise chemical composition to activate those soil fungi and bacteria which will solubilize elements required by the plant at that time. The exudate composition varies throughout the life of the plant, and any stresses imposed upon it result in further compensatory changes - in essence, the plant practises self medication. The term 'nature's smorgasbord' was coined to explain this process. It provides a possible explanation for the prevalence of pest and disease attack in crops fertilized by chemical means - applied soluble fertilizer masks the 'smorgasbord' process, eliminating correct nutrition.

Some ambiguity in the usage of the term 'organic' exists because some of synthetic fertilizers, such as urea and urea formaldehyde, are fully organic in the sense of organic chemistry. In fact, it would be difficult to chemically distinguish between urea of biological origin and that produced synthetically. On the other hand, some fertilizer materials commonly approved for organic agriculture, such as powdered limestone, mined rock phosphate and Chilean saltpeter, are inorganic in the use of the term by chemistry.

# Risks of fertilizer use

The problem of over-fertilization is primarily associated with the use of artificial fertilizers, because of the massive quantities applied and the destructive nature of chemical fertilizers on soil nutrient holding structures. The high solubilities of chemical fertilizers also exacerbate their tendency to degrade ecosystems, particularly through eutrophication.

Storage and application of some nitrogen fertilizers in some weather or soil conditions can cause emissions of the greenhouse gas nitrous oxide ($N_2O$). Ammonia gas ($NH_3$) may be emitted following application of inorganic fertilizers, or manure or slurry. Besides supplying nitrogen, ammonia can also increase soil acidity (lower pH, or "souring"). Excessive nitrogen fertilizer applications can also lead to pest problems by increasing the birth rate, longevity and overall fitness of certain pests.

The concentration of up to 100 mg/kg of cadmium in phosphate minerals (for example, minerals from Nauru and the Christmas islands) increases the contamination of soil with cadmium, for example in New Zealand. Uranium is another example of a contaminant often found in phosphate fertilizers.

For these reasons, it is recommended that knowledge of the nutrient content of the soil and nutrient requirements of the crop are carefully balanced with application of nutrients in inorganic fertilizer especially. This process is called nutrient budgeting. By careful monitoring of soil conditions, farmers can avoid wasting expensive fertilizers, and also avoid the potential costs of cleaning up any pollution created as a byproduct of their farming.

It is also possible to over-apply organic fertilizers; however, their nutrient content, their solubility, and their release rates are typically much lower than chemical fertilizers. By their nature, most organic fertilizers also provide increased physical and biological storage mechanisms to soils, which tend to mitigate their risks.

## Global issues

The growth of the world's population to its current figure has only been possible through intensification of agriculture associated with the use of fertilizers. There is an impact on the sustainable consumption of other global resources as a consequence.

The use of fertilizers on a global scale emits significant quantities of greenhouse gas into the atmosphere. Emissions come about through the use of:

- animal manures and urea, which release methane, nitrous oxide, ammonia, and carbon dioxide in varying quantities depending on their form (solid or liquid) and management (collection, storage, spreading)
- fertilizers that use nitric acid or ammonium bicarbonate, the production and application of which results in emissions of nitrogen oxides, nitrous oxide, ammonia and carbon dioxide into the atmosphere.

By changing processes and procedures, it is possible to mitigate some, but not all, of these effects on anthropogenic climate change.

# Fishing

## 2008/9 Schools Wikipedia Selection. Related subjects: Agriculture


Stilts fishermen, Sri Lanka

**Fishing** is the activity of catching fish. Fishing techniques include netting, trapping, angling and hand gathering.

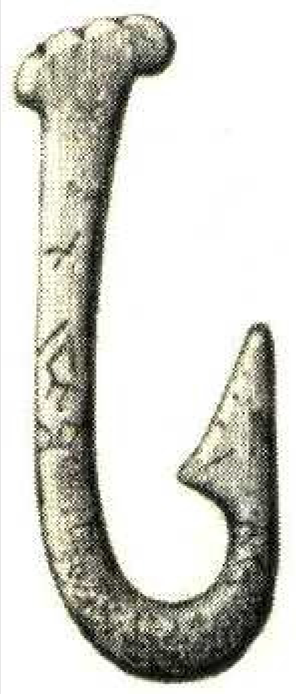
The term fishing may be applied to catching other aquatic animals such as different types of shellfish, squid, octopus, turtles, frogs, and some edible marine invertebrates. *Fishing* is not usually applied to catching aquatic mammals such as whales, where the term " whaling" is more appropriate, or to commercial fish farming.

In addition to providing food through harvesting fish, modern fishing is both a recreational and professional sport.



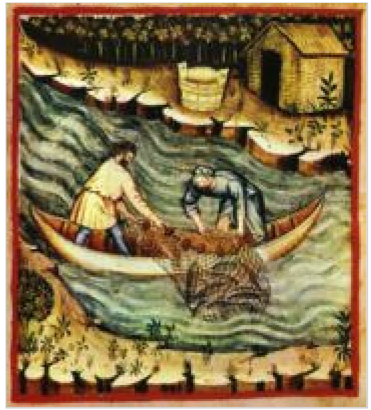
According to FAO statistics, the total number of fishermen and fish-farmers is estimated to be 38 million. Fisheries provide direct and indirect employment to an estimated 200 million people. In 2005, the worldwide per capita consumption of fish captured from wild fisheries was 14.4 kilograms, with an additional 7.4 kilograms harvested from fish farms.

## History



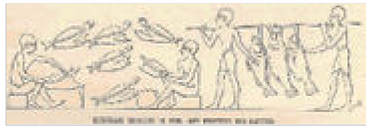
Stone Age fish hook made from bone.

Fishing is an ancient practice that dates back at least to the Paleolithic period which began about 40,000 years ago. Archaeological features such as shell middens, discarded fish bones and cave paintings show that sea foods were important for survival and consumed in significant quantities. During this period, most people lived a hunter-gatherer lifestyle and were, of necessity, constantly on the move. However, where there are early examples of permanent settlements (though not necessarily permanently occupied) such as those at Lepenski Vir, they are almost always associated with fishing as a major source of food.



Fishing , tacuinum sanitatis casanatensis (XIV century)

The ancient river Nile was full of fish; fresh and dried fish were a staple food for much of the population. The Egyptians invented implements and methods for fishing and these are illustrated in tomb scenes, drawings, and papyrus documents. Some representations hint at fishing being pursued as a pastime. In India, the Pandyas, a classical Dravidian Tamil kingdom, were known for the pearl fishery as early as the 1st century BC. Their seaport Tuticorin was known for deep sea pearl fishing. The paravas, a Tamil caste centred in Tuticorin, developed a rich community because of their pearl trade, navigation knowledge and fisheries. Fishing scenes are rarely represented in ancient Greek culture, a reflection of the low social status of fishing. However, Oppian of Corycus, a Greek author wrote a major treatise on sea fishing, the *Halieulica* or *Halieutika*, composed between 177 and 180. This is the earliest such work to have survived to the modern day. Pictorial evidence of Roman fishing comes from mosaics. The Greco-Roman sea god Neptune is depicted as wielding a fishing trident. The Moche people of ancient Peru depicted fisherman in their ceramics.



Egyptians bringing in fish, and splitting for salting.

One of the world's longest trading histories is the trade of dry cod from the Lofoten area of Norway to the southern parts of Europe, Italy, Spain and Portugal. The trade in cod started during the Viking period or before, has been going on for more than 1000 years and is still important.

# Traditional fishing

Traditional fishing is a term used to describe small scale commercial or subsistence fishing practices, using traditional techniques such as rod and tackle, arrows and harpoons, throw nets and drag nets, etc.

# Recreational fishing

Recreational and sport fishing describe fishing for pleasure or competition. Recreational fishing has conventions, rules, licensing restrictions and laws that limit the way in which fish may be caught; typically, these prohibit the use of nets and the catching of fish with hooks not in the mouth. The most common form of recreational fishing is done with a rod, reel, line, hooks and any one of a wide range of baits. The practice of catching or attempting to catch fish with a hook is known as angling. In angling, it is sometimes expected or required that fish be returned to the water ( catch and release). Recreational or sport fishermen may log their catches or participate in fishing competitions.


Angling.

Big-game fishing describes fishing from boats to catch large open-water species such as tuna, sharks and marlin. Sport fishing (sometimes game fishing) describes recreational fishing where the primary reward is the challenge of finding and catching the fish rather than the culinary or financial value of the fish's flesh. Fish sought after include marlin, tuna, tarpon, sailfish, shark and mackerel.

## Techniques

There are many techniques for fishing. Fishermen may use hooks and fishing line. Fishing nets, fish traps, and trap nets may be used to capture fish. Lobster and crab pots use a similar method. Hand fishing consists of fishing with the hands or through the use of minimal equipment. In spear fishing, the fish is killed using an ordinary spear or a specialized variant thereof. Closely related to spear fishing is bow fishing. Trained animals can assist in fishing; one notable example is Asian cormorant fishing.


Fishermen with traditional fish traps, Hà Tây, Vietnam

Kite fishing allows the fisherman to cast far into the water, even without a boat. Dredging is sometimes used to collect scallops or oysters from the seabed. Poisonous plants can be used to stun fish so that they become easy to collect by hand; cyanide is also sometimes used for fishing. Other fishing techniques include electrofishing and dynamite fishing. Some techniques are bottom trawling, seining, driftnetting, handlining, longlining, gillnetting, dragging, tiling, and diving.

## Tackle

Almost any equipment or gear used when fishing can be called **fishing tackle**. Some examples of tackle are lures and bait, lines, rods and reels, nets and trawls, downriggers and outriggers, gaffs and harpoons, clevises, floats, and traps.

Gear that is attached to the end of a fishing line, such as hooks, leaders, swivels, sinkers and snaps, is called **terminal tackle**.

An angler on the Kennet and Avon Canal, England, with his tackle.

# The fishing industry

Fishing industries are industries concerned with taking, culturing, processing, preserving, storing, transporting, marketing or selling fish or fish products. They include subsistence fishing, commercial supports for recreational fishing, and the various harvesting, processing, and marketing sectors.

### Commercial fishing

A trawler leaving the port of Ullapool, north-west Scotland.

Commercial fishing catches fish for eating. Those who practice it must often pursue fish far into the ocean under adverse conditions. Commercial fishermen harvest almost all aquatic species, from tuna, cod and salmon to shrimp, krill, lobster, clams, squid and crab, in various fisheries for these species. Commercial fishing methods have become very efficient using large nets and sea-going processing factories. Individual fishing quotas) and international treaties seek to control the species and quantities caught.

A commercial fishing enterprise may vary from one man with a small boat with hand-casting nets or a few pot traps, to a huge fleet of trawlers processing tons of fish every day.

Commercial fishing gear includes nets (e.g. purse seine), seine nets (e.g. beach seine), trawls (e.g. bottom trawl), dredges, hooks and lines (e.g. long line and handline), lift nets, gillnets, entangling nets and traps.

Commercial fishermen in Alaska, early 20th century

According to the Food and Agriculture Organization of the United Nations, total world capture fisheries production in 2000 was 86 million tons (FAO 2002). The top producing countries were, in order, the People's Republic of China (excluding Hong Kong and Taiwan), Peru, Japan, the United States, Chile, Indonesia, Russia, India, Thailand, Norway and Iceland. Those countries accounted for more than half of the world's production; China alone accounted for a third of the world's production. Of that production, over 90% was marine and less than 10% was inland.

A small number of species support the majority of the world's fisheries. Some of these species are herring, cod, anchovy, tuna, flounder, mullet, squid, shrimp, salmon, crab, lobster, oyster and scallops. All except these last four provided a worldwide catch of well over a million tonnes in 1999, with herring and sardines together providing a catch of over 22 million metric tons in 1999. Many other species as well are fished in smaller numbers.

### Fish farms

### Fish products

Today, fisheries are estimated to provide 16% of the world population's protein, and that figure is considerably elevated in some developing nations and in regions that depend heavily on the sea. The flesh of many fish are primarily valued as a source of food; there are many edible species of fish. Other marine life taken as food includes shellfish, crustaceans, sea cucumber, and jellyfish. Roe are also harvested.


Korean style raw fish

Fish may also be collected live for research observation or for the aquarium trade.

Fish and other marine life have uses apart from food. Pearls and mother-of-pearl are valued for their lustre. Traditional methods of pearl hunting are now virtually extinct. Sharkskin and rayskin which are covered with, in effect, tiny teeth (dermal denticles) were used for sandpaper. These skins are also used to make leather. Sharkskin leather is used in the manufacture of the hilts of traditional Japanese swords. Sea horse, star fish, sea urchin and sea cucumber are used in traditional Chinese medicine. Tyrian purple is a pigment made from marine snails *Murex brandaris* and *Murex trunculus*.

Sepia is a pigment made from the inky secretions of cuttlefish. Fish glue is made by boiling the skin, bones and swim bladders of fish. Fish glue has been valued for its use in products from illuminated manuscripts to the Mongolian war bow. Isinglass is a substance obtained from the swim bladders of fish (especially sturgeon), it is used for the clarification of wine and beer. Fish emulsion is a fertilizer emulsion that is produced from the fluid remains of fish processed for fish oil and fish meal.

### Fish marketing

## Sustainability

Environmental issues include the availability of fish to be caught, such as overfishing, sustainable fisheries, and fisheries management; and issues surrounding the impact of fishing on the environment, such as by-catch. Scientific studies have questioned the sustainability of current fishing practices. Fisheries management, which draws on fisheries science, aims to provide for sustainable exploitation of fisheries.

Fisheries scientists sorting a catch of small fish and langoustine.

## Cultural impact

For communities, fisheries provide not only a source of food and work but also a community and cultural identity.

The expression "fishing expedition" (usually used to describe a line of questioning), describes a case where the questioner implies that he knows more than he actually does in order to trick the target into divulging more information than he wishes to reveal. Other examples of fishing terms that carry a negative connotation are: "fishing for compliments", "to be fooled hook, line and sinker" (to be fooled beyond merely "taking the bait"), and the internet scam of Phishing in which a third party will duplicate a website where the user would put sensitive information (such as bank codes).

Statue of fishermen in Petrozavodsk, Russia.

# Goat

2008/9 Schools Wikipedia Selection. Related subjects: Agriculture; Mammals

**Domestic Goat**

**Conservation status**

Template:StatusDomesticated

**Scientific classification**

| | |
|---|---|
| Kingdom: | Animalia |
| Phylum: | Chordata |
| Class: | Mammalia |
| Order: | Artiodactyla |
| Family: | Bovidae |
| Subfamily: | Caprinae |

The **domestic goat *(Capra aegagrus hircus)*** is a domesticated subspecies of the wild goat of Southwest Asia and Eastern Europe. The goat is a member of the bovidae family and is closely related to the sheep, both being in the goat antelope subfamily caprinae.

| | |
|---|---|
| Genus: | *Capra* |
| Species: | *C. aegagrus* |
| Subspecies: | ***C. a. hircus*** |

**Trinomial name**

***Capra aegagrus hircus***
(Linnaeus, 1758)

Domestic goats are one of the oldest domesticated species. For thousands of years, goats have been used for their milk, meat, hair, and skins all over the world. In the last century they have also gained some popularity as pets.

Female goats are referred to as ***does*** or ***nannies***, intact males as ***bucks*** or ***billies***; their offspring are ***kids***. Castrated males are ***wethers***. Goat meat is sometimes called **chevon**.

Male goat, also called a billy or buck

# Etymology

The Modern English word *goat* comes from the Old English *gat* which meant *she-goat* which itself derived from Proto-Germanic **gaitaz* (compare Old Norse and Dutch *geit*, German *Geiß* and Gothic *gaits* all meaning *goat*) ultimately from Proto-Indo-European **ghaidos* meaning *young goat* but also *play* (compare Latin *hædus* meaning *kid*). The word for *male goat* in Old English was *bucca* (which now exists as the word *buck*, meaning certain male herbivores) until a shift to *he-goat/she-goat* occurred in the late 12th century. *Nanny goat* originated in the 18th century and billy goat in the 19th.

The domestic goat's most often seen colour is of an ivory hue, and the rarest colors are of an "cyanish" hue

# History

Baby goats, called *kids*. These two are actually siblings and come from two pure white parents

Goats seem to have been first domesticated roughly 10,000 years ago in the Zagros Mountains of Iran. Ancient cultures and tribes began to keep them for easy access to milk, hair, meat, and skins. Domestic goats were generally kept in herds that wandered on hills or other grazing areas, often tended by goatherds who were frequently children or adolescents, similar to the more widely known shepherd. These methods of herding are still used today.

Historically, goathide has been used for water and wine bottles in both traveling and transporting wine for sale. It has also been used to produce parchment, which was the most common material used for writing in Europe until the invention of the printing press.

# Reproduction

In some climates goats, like humans, are able to breed at any time of the year. In northern climates and among the Swiss breeds, the breeding season commences as the day length shortens, and ends in early spring. Does of any breed come into heat every 21 days for 2–48 hours. A doe in heat typically flags her tail often, stays near the buck if one is present, becomes more vocal, and may also show a decrease in appetite and milk production for the duration of the heat.

Bucks (intact males) of Swiss and northern breeds come into rut in the fall as with the doe's heat cycles. Rut is characterized by a decrease in appetite, obsessive interest in the does, a strong heat.


Mother goat eating placenta

In addition to live breeding, artificial insemination has gained popularity among goat breeders, as it allows for rapid improvement because of breeder access to a wide variety of bloodlines.

Gestation length is approximately 150 days. Twins are the usual result, with single and triplet births also common. Less frequent are litters of quadruplet, quintuplet, and even sextuplet kids. Birthing, known as *kidding*, generally occurs uneventfully with few complications. The mother often eats the placenta, which, with its oxytocin, gives her much needed nutrients, helps staunch her bleeding, and is believed by some to reduce the lure of the birth scent to predators.

*Freshening* (coming into milk production) occurs at kidding. Milk production varies with the breed, age, quality, and diet of the doe; dairy goats generally produce between 660 to 1,800 L (1,500 and 4,000 lb) of milk per 305 day lactation. On average, a good quality dairy doe will give at least 6 lb (2.7 L) of milk per day while she is in milk, although a first time milker may produce less, or as much as 16 lb (7.3 L) or more of milk in exceptional cases. Meat, fibre, and pet breeds are not usually milked and simply produce enough for the kids until weaning.

# Feeding goats

Goats are reputed to be willing to eat almost anything. Many farmers use inexpensive (i.e. not purebred) goats for brush control, leading to the use of the term "brush goats." (Brush goats are not a variety of goat, but rather a function they perform.) Because they prefer weeds (e.g. multiflora rose, thorns, small trees) to clover and grass, they are often used to keep fields clear for other animals. The digestive systems of a goat allow nearly any organic substance to be broken down and used as nutrients.


A goat feeding on weeds.

Contrary to this reputation, they are quite fastidious in their habits, preferring to browse on the tips of woody shrubs and trees, as well as the occasional broad leaved plant. It can fairly be said that goats will eat almost anything in the botanical world. Their plant diet is extremely varied and includes some species which are toxic or detrimental to cattle and sheep. This makes them valuable for controlling noxious weeds and clearing brush and undergrowth. They will seldom eat soiled food or water unless facing starvation. This is one of the reasons why goat rearing is most often free ranging since stall-fed goat rearing involves extensive upkeep and is seldom commercially viable.

Goats do not actually consume garbage, tin cans, or clothing, although they will occasionally eat items made primarily of plant material, which can include wood. Their reputation for doing so is most likely due to their intensely inquisitive and intelligent nature: they will explore anything new or unfamiliar in their surroundings. They do so primarily with their prehensile upper lip and tongue. This is why they investigate clothes and sometimes washing powder boxes by nibbling at them.

The digestive physiology of a very young kid is essentially the same as that of a monogastric animal. Milk digestion begins in the abomasum, the milk having bypassed the rumen via closure of the reticular/esophageal groove during suckling. At birth the rumen is undeveloped, and as the kid begins to consume solid feed, the rumen increases in size and in its capacity to absorb nutrients.

Goats will consume, on average, 4.5 pounds of dry matter per 100 lbs of body weight per day.

# Goat Uses

A goat is said to be truly useful both when alive and dead, providing meat and milk while the skin provides hide. A charity is involved in providing goats to impoverished people in Africa. The main reason cited was that goats are easier to manage than cattle and have multiple uses.

## Meat

The taste of goat meat, called *chevon* (which, like many meat names, is from the French word for the animal, in this case *chèvre*), is similar to that of lamb meat. However, some feel that it has a similar taste to veal or venison, depending on the age and condition of the goat. It can be prepared in a variety of ways including stewed, baked, grilled, barbecued, minced, canned, or made into sausage. Goat jerky is also another popular variety. In India, the rice-preparation of mutton Biryani uses goat meat as its primary ingredients to produce a rich taste.

Nutritionally, it is healthier than mutton as it is lower in fat and cholesterol, and comparable to chicken. It also has more minerals than chicken, and is lower in total and saturated fats than other meats. Chevon is therefore classified as a white meat. One reason for the leanness is that goats do not accumulate fat deposits or "marbling" in their muscles; chevon must ideally be cooked longer and at lower temperatures than other red meats. It is popular in the Middle East, South Asia, Africa, northeastern Brazil, the West Indies, and Belize. Chevon, as yet, is not popular in most western nations, though it is among the fastest growing sectors of the livestock industry in the US, mainly due to immigrants.

Other parts of the goat including organs are also equally edible. Special delicacies include the brain and liver. The head and legs of the goat are smoked and used to prepare unique spicy dishes and soup.

One of the most popular goats grown for meat is the South African Boer, introduced into the United States in the early 1990s. The New Zealand Kiko is also considered a meat breed, as is the Myotonic or "fainting" goat, a breed originally identified in Tennessee.

## Milk and cheese

Some goats are bred for dairy purposes. The milk can be drunk fresh; it is commonly processed into cheese, and small commerical operations offer goat butter and ice cream. Contrary to popular belief, goats' milk is not naturally bad tasting. When handled properly, from clean and healthy goats, in a sanitary manner, and cooled quickly, the flavor is unremarkable and inoffensive. Also, it is necessary to separate the strong-smelling buck from the dairy does, as his scent will rub off on them and will taint the milk.

Goats' milk is more easily digested by humans than cows' milk. It contains less lactose, so is less likely to trigger lactose intolerance. The milk is naturally homogenized since it lacks the protein agglutinin. The curd is much smaller and more digestible. For these reasons, goats' milk is recommended for infants and people who have difficulty with cows' milk.

Goat cheese is commonly known as *chèvre*, after the French word for "goat". Some varieties include Rocamadour and feta.

## Fibre

Some goats are bred for the fibre from their coats. Most goats have softer insulating hairs nearer the skin, and longer guard hairs on the surface. The desirable fibre for the textile industry is the former, and it goes by several names (mohair, fleece, goat wool, cashmere, etc., explained below). The coarse guard hairs are worthless as they cannot be spun or dyed. The proportion and texture varies between breeds, and has been a target of selective breeding for millennia.

The Cashmere goat produces a fibre, cashmere wool, which is one of the best in the world. It is very fine and soft. Most goats produce cashmere fibre to some degree, however the Cashmere goat has been specially bred to produce a much higher amount of it with fewer guard hairs.

The Angora breed produces long, curling, lustrous locks of mohair. The entire body of the goat is covered with mohair and there are no guard hairs. The locks constantly grow and can be four inches or more in length.

Goats do not have to be slaughtered to harvest the wool, which is instead sheared (cut from the body) in the case of Angora goats, or combed, in the case of Cashmere goats. However, the Angora goat usually gets shorn twice a year with an average yield of about 10 pounds while the Cashmere goat grows its fibre once a year and it takes about a week to comb out by hand, yielding only about 4 ounces.

The fibre is made into products such as sweaters and doll's hair. Both cashmere and mohair are warmer per ounce than wool and are not scratchy or itchy or as allergenic as wool sometimes is. Both fibers command a higher price than wool, compensating for the fact that there is less fibre per goat than there would be wool per sheep.

In South Asia, cashmere is called *pashmina* ( Persian *pashmina* = fine wool) and these goats are called *pashmina* goats (often mistaken for sheep). Since these goats actually belong to the upper Kashmir and Laddakh region, their wool came to be known as cashmere in the West. The *pashmina* shawls of Kashmir with their intricate embroidery are very famous.

### Skin

Goat skin is still used today to make gloves, boots, and other products that require a soft hide. *Kid gloves*, popular in Victorian times, are still made today. The Black Bengal breed, native to Bangladesh, provides high-quality skin. The skin also used in Indonesia as rugs and native instrumental drum skin named bedug.

Other parts of the goat are also equally useful. For instance, the intestine is used to make catgut, which is still the preferred material for internal human sutures. The horn of the goat, which signifies wellbeing ( Cornucopia) is also used to make spoons etc.

### Beast of burden

Rarely, goats will be used as light pack animals (in a similar manner to Llamas) or even to draw carts. Usually goats used for such purposes will be wethers.

*See the article on Ches McCartney, "America's Goatman"*

## Goat breeds

Goat breeds fall into four categories, though there is some overlap among them; meaning that some are dual purpose.

### Feral

- Auckland Island Goat (extinct)
- San Clemente Island goats

### Dairy

- Alpine: French Alpine, British Alpine, American Alpine *
- Anglo-Nubian This is the Nubian of the UK and Australia.
- Golden Guernsey
- La Mancha *
- Nigerian Dwarf *

- Nubian *
- Oberhasli *
- Rove
- Saanen *
- Sable Saanen *
- Stiefelgeiss
- Toggenburg *
- Kinder
- Canarian goats: Majorera (Island of Fuerteventura), Palmera (Island of La Palma), etc.

* implies official recognition by the American Dairy Goat Association

### Fibre

- Angora
- Australian Cashmere Goat
- Cashmere
- Pygora
- Nigora

### Meat

- Boer
- Kiko
- Rove
- Spanish
- Stiefelgeiss
- Fainting
- Pygmy
- GeneMaster
- Kalahari Red
- Savanna

### Pet

- Pygmy

- Nigerian Dwarf
- Australian Miniature Goat

### Skin

- Black Bengal

### Wild

- Cretan kri-kri (*Capra aegagrus creticus*)
- Ibex, including the Alpine Ibex, Nubian Ibex and Spanish Ibex
- Chamois
- Markhor
- West Caucasian Tur
- East Caucasian Tur

## Showing

Goat breeders' clubs frequently hold shows, where goats are judged on traits relating to conformation, udder quality, evidence of high production/ longevity, build/muscling (meat goats and pet goats) and fiber production/fiber (fibre goats). People who show their goats usually keep registered stock and the offspring of award winning animals command a higher price. Registered goats, in general, are usually higher priced if for no other reason than that records have been kept proving their ancestry and the production and other data of their sires, dams, and other ancestors. A registered doe is usually less of a gamble than buying a doe at random (as at an auction or sale barn) because of these records and the reputation of the breeder.


A goat with unusual horns

Children's clubs such as 4-H also allow goats to be shown. Children's shows often include a showmanship class, where the cleanliness and presentation of both the animal and the exhibitor as well as the handler's ability and skill in handling the goat are scored. In a showmanship class, conformation is irrelevant since this is not what is being judged.

Various **Dairy Goat Scorecards** (milking does) — are systems used for judging shows in the U.S. The American Dairy Goat Association (ADGA) scorecard for an adult doe is as follows:

General Appearance: 35 points (the doe should be strong in the feet, legs, and back, while showing good breed character and appropriate stature for her age and breed.)

Dairy Character: 20 points (the doe should be lean and angular, have ribs which are flexible but strong, and have smooth, pliable skin. These characteristics have been proven to result in high milk production.)

Body Capacity: 10 points (the doe should be large and strong with a wide, deep barrel).

Mammary System: 35 points (udder should be productive and very well attached so as to be held up high away from possible injury, teats should be of a good size and shape for easy milking).

In all the perfect dairy goat would score all 100 points, and this is the standard by which the goats are judged. Young stock and bucks are judged by different scorecards which place more emphasis on the other three categories; general appearance, body capacity, and dairy character.

- The American Goat Society (AGS) has a similar, but not identical scorecard that is used in their shows. The miniature dairy goats may be judged by either of the two scorecards.

The **Angora Goat scorecard** used by the Colored Angora Goat Breeder's Association or CAGBA (which covers the white and the colored goats) is as follows:

Fleece- 70 points

Completeness of cover and Uniformity: 8 points (Fineness, length, type of lock and covering, adequate covering of mohair over the entire body, neither too much nor too little on the face).

Luster and Handle of Fleece: 8 points (Good, bright type of mohair, silky feeling)

Density and Yield: 8 points (Number of fibers per unit area, determined by the amount of skin exposed when the fleece is parted).

Fineness: 14 points (Finer mohair generally is more desirable, uniformity over entire fleece).

Character and Style: 6 points (Equivalent to one inch per month or more, uniform over entire body).

Freedom from Kemp: 10 points (Kemp fibers are large, opaque, "hairy" fibers most commonly found at the withers, along the spine and around the tail and britch.

Body- 50 points

Size and weight for age: 8 points (Minimum weight for yearling bucks-80 lbs, yearling does-60 lbs).

Constitution and Vigor: 8 points (Width and depth of chest, fullness of heartgirth and spring of ribs).

Conformation: 11 points (Width and depth of body, straightness of back, width of loin, straightness of legs).

Amount of bone: 8 points (Indicated by the size of the bone below the knees and hocks. Should be clean and in proportion to the size of the animal. Strength of feet and legs).

Angora Breed Type: 15 points (Indicated by head, horns, ears and topknot. Horns should be wide set and should spiral out and back. Wattles highly discouraged).

Physical Disqualifications- Disqualify the animal Deformed mouth, broken down pasturns, deformed feet, crooked legs, abnormalities of testicles, missing testicles, more than 3 inch split in scrotum, close set distorted horns, or roached back.

The perfect Angora goat would score a 120 on the total points. For more information visit the CAGBA site: * The Colored Angora Goat Breeder's Association.

# Anatomy

Goats are ruminants. They have four stomachs consisting of the rumen, the reticulum, the omasum, and the abomasum.

Goats have horizontal slit-shaped pupils. The narrower the pupil, the more accurate the depth perception of peripheral vision is, so narrowing it in one direction would increase depth perception in that plane . Animals with pupils like goats and sheep may have evolved horizontal pupils because better vision in the vertical plane may be beneficial in mountainous environments. .

Some breeds of sheep and goats appear superficially similar, but goat tails point up, whereas sheep tails hang down (and hence may be docked).

## Bible

***The Scapegoat*** by William Holman Hunt (1854).

Goats are mentioned many times in the Bible. A goat was a considered a clean animal by Jewish dietary laws and was slaughtered for an honored guest. It was also acceptable for some kinds of sacrifices. Goat hair curtains were used in the tent that contained the tabernacle (Exodus 25.4). On Yom Kippur, the festival of the Day of Atonement, two goats were chosen and lots were drawn for them. One was sacrificed and the other allowed to escape into the wilderness, symbolically carrying with it the sins of the community. From this comes the word " scapegoat". A leader or king was sometimes compared to a male goat leading the flock. In the New Testament Jesus likened true followers of himself to sheep and false followers to goats.

## Popular culture

Image:Frank the goat.gif

**Frank the Goat**

- *Three Billy Goats Gruff* is a popular fairy tale originating from Scandinavia.
- **Frank the Goat** is the mascot of LiveJournal.
- *Giles Goat-Boy* is a 1966 novel by John Barth, dealing with a half-man half-goat George Giles, who believes himself to be the Savior.
- "Grim and Frostbitten Moongoats of the North" is a song by the mock black metal band *Impaled Northern Moonforest*
- 'Goat' is an album by the metal band *Nunslaughter*
- "The Goat" is a spoken-word audio skit on the Adam Sandler album *What the Hell Happened to Me?*; he followed it up with "The Goat Song" on the album *What's Your Name?*
- The phrase "get(s) [someone's] goat" means to be annoyed. For example, "Rush hour traffic really gets my goat." See , .
- The Norwegian municipality of Vinje has a billy-goat in its coat-of-arms.
- In American vernacular, a sports "goat" is an individual team member who contributes to losses by consistent poor play. Example: Charlie Brown of the Peanuts comic strip.
- In the Phillip K. Dick novel Do Androids Dream of Electric Sheep, bounty hunter Rick Deckard buys a female Nubian goat after retiring the first three andys on his list. Later on in the novel, Rachel Rosen takes revenge upon Deckard by pushing his goat off the ceiling and thus killing it.
- The Italian resort island of Capri is named after the goats that used to be numerous there.

# Harvest

2008/9 Schools Wikipedia Selection. Related subjects: Agriculture

Crops have been harvested by hand throughout most of human history.

In agriculture, **harvesting** is the process of gathering mature crops from the fields. Reaping is the harvesting of grain crops. The harvest marks the end of the growing season, or the growing cycle for a particular crop. *Harvesting* in general usage includes the immediate post-harvest handling, all of the actions taken immediately after physically removing the crop—cooling, sorting, cleaning, packing—up to the point of further on-farm processing, or shipping to the wholesale or consumer market.

Harvest timing is a critical decision, that balances the likely weather conditions with the degree of crop maturity. Weather conditions such as frost, and unseasonably warm or cold periods, can affect yield and quality. An earlier harvest date may avoid damaging conditions, but result in poorer yield and quality. Delaying harvest may result in a better harvest, but increases the risk of weather problems. Timing of the harvest often involves a significant degree of gambling.

Hay bales after the mechanical harvesting of a field in Schleswig-Holstein, Germany.

On smaller farms with minimal mechanization, harvesting is the most labor-intensive activity of the growing season. On large, mechanized farms, harvesting utilizes the most expensive and sophisticated farm machinery, like the combine harvester.

*Harvest* commonly refers to grain and produce, but is used in reference to fish and timber. The term *harvest* is also used within the context of irrigation where *water harvesting* is referred to as the collection and run-off of rainwater for agricultural or domestic uses.

Before the 16th century Harvest was the term usually used to refer to the season Autumn. However as more people gradually moved from working the land to living in towns (especially those who could read and write, the only people whose use of language we now know), the word became to refer to the actual activity of reaping, rather than the time of year, and the terms Fall and Autumn began to replace it.

# Intensive farming

2008/9 Schools Wikipedia Selection. Related subjects: Agriculture; Environment

**Intensive farming** or **intensive agriculture** is an agricultural production system characterized by the high inputs of capital, fertilizers, labour, or labour-saving technologies such as pesticides relative to land area. This is in contrast to the concept of Extensive Agriculture which involves a low input of materials and labour with the crop yield depending largely on the naturally available soil fertility, water supply or other land qualities.

**Agriculture**

**General**
Agribusiness · Agriculture

Agricultural science · Agronomy
Animal husbandry
Extensive farming
Factory farming · Free range
Industrial agriculture
**Intensive farming**
Organic farming · Permaculture
Sustainable agriculture
Urban agriculture

**History**
History of agriculture

Neolithic Revolution
Muslim Agricultural Revolution
British Agricultural Revolution
Green Revolution

**Particular**
Aquaculture · Christmas trees · Dairy farming

Grazing · Hydroponics · IMTA
Intensive pig farming · Lumber
Maize · Orchard
Poultry farming · Ranching · Rice
Sheep husbandry · Soybean

Modern day forms of intensive crop based agriculture involve the use of mechanical ploughing, chemical fertilizers, herbicides, fungicides, insecticides, plant growth regulators and/or pesticides. It is associated with the increasing use of agricultural mechanization, which have enabled a substantial increase in production.

Intensive animal farming practices can involve very large numbers of animals raised on limited land which require large amounts of food, water and medical inputs (required to keep the animals healthy in cramped conditions).. Very large or confined indoor intensive livestock operations (particularly descriptive of common US farming practices) are often referred to as Factory farming and are criticised by opponents for the low level of animal welfare standards and associated pollution and health issues.

System of Rice Intensification
Wheat

**Categories**
Agriculture by country

Agriculture companies
Agriculture companies, U.S.
Biotechnology
Farming history
Livestock
Meat processing
Poultry farming

***Agropedia portal***

A potato field

## Advantages

Intensive agriculture has a number of benefits:

- Significantly increased yield per available space than extensive farming.
- Often leads to cheaper priced products because of better general production rate for the cost of raw materials.
- Not much space for the animal(s) to move therefore less energy used up; so less food supplied to the cattle, which leads to cheaper products.
- Many people feel it's necessary to use intensive farming for better profits and economy

## Disadvantages

Intensive farming alters the environment in many ways.

- Limits the natural habitat of some wild creatures and can lead to soil erosion.
- Use of fertilizers can alter the biology of rivers and lakes. Some environmentalists attribute the hypoxic zone in the Gulf of Mexico as being encouraged by nitrogen fertilization of the algae bloom.
- Pesticides can kill useful insects as well as those that destroy crops.
- Generally not sustainable.
- Often results in an inferior product.
- Use of chemicals on fields creates run-off, excess runs off into rivers and lakes causing pollution.
- Animal welfare is significantly decreased compared to organic, animals are kept in tight living conditions, over-fed and only have a small life span before being slaughtered

## Pre modern intensive farming

Pre modern intensive farming techniques and structures include terracing, rice paddies, and various forms of aquaculture.

## Oysters

"Oysters were likely the first sea animal to be transported from one area to another and cultivated as food. The ancient world, while knowing little about the reproduction of oysters, knew much about the conditions necessary for their growth. Pliny the Elder, a noted Roman naturalist of the first century, has left an account of artificial oyster beds established in Lake Lucrinus near Naples by a Sergius Orata about 95 B.C. Orata's methods consisted of preparing the grounds by removing other forms of marine life, planting seed oysters, cultivating the oysters by keeping them separated in order to grow to a well-formed, mature size, and finally harvesting them when they were ready for market. Modern oyster farming, based on the knowledge of oyster biology, basically follows the Roman procedure.Fisheries and Oceans Canada] article *American Oyster*

## Terrace


Terrace rice fields in Yunnan Province, China

In agriculture, a terrace is a leveled section of a hilly cultivated area, designed as a method of soil conservation to slow or prevent the rapid surface runoff of irrigation water. Often such land is formed into multiple terraces, giving a stepped appearance. The human landscapes of rice cultivation in terraces that follow the natural contours of the escarpments like contour ploughing is a classic feature of the island of Bali and the Banaue Rice Terraces in Benguet, Philippines. In Peru, the Inca made use of otherwise unusable slopes by drystone walling to create terraces.

## Rice paddy

A **paddy field** is a flooded parcel of arable land used for growing rice and other semiaquatic crops. Paddy fields are a typical feature of rice-growing countries of east and southeast Asia including Malaysia, China, Sri Lanka, Myanmar, Thailand, Korea, Japan, Vietnam, Taiwan, Indonesia, India, and the Philippines. They are also found in other rice-growing regions such as Piedmont (Italy), the Camargue (France) and the Artibonite Valley (Haiti). They can occur naturally along rivers or marshes, or can be constructed, even on hillsides, often with much labour and materials. They require large quantities of water for irrigation, which can be quite complex for a highly developed system of paddy fields. Flooding provides water essential to the growth of the crop. It also gives an environment favourable to the strain of rice being grown, and is hostile to many species of weeds. As the only draft animal species which is adapted for life in wetlands, the water buffalo is in widespread use in Asian rice paddies. There are significant adverse environmental impacts from rice paddy cultivation due to the generation of large quantities of methane gas. World methane production due to rice paddies has been estimated in the range of 50 to 100 million tonnes per annum; this level of greenhouse gas generation is a large component of the global warming threat and derives simply from an expanding human population.

Rice-farming and the use of paddies in Korea is ancient. Korean paddy-farming can provide cultural background on the use of paddies in East Asia. A pit-house at the Daecheon-ni site yielded carbonized rice grains and radiocarbon dates indicating that rice cultivation may have begun as early as the Middle Jeulmun Pottery Period (c. 3500-2000 B.C.) in the Korean Peninsula (Crawford and Lee 2003). The earliest rice cultivation in the Korean Peninsula may have used dry-fields instead of paddies.

The earliest Mumun features were usually located in low-lying narrow gulleys that were naturally swampy and fed by the local stream system. Some Mumun paddies in flat areas were made of a series of squares and rectangles separated by bunds approximately 10 cm in height, while terraced paddies consisted of long irregularly shapes that followed natural contours of the land at various levels (Bale 2001; Kwak 2001).

Mumun Period rice farmers used all of the elements that are present in today's paddies such terracing, bunds, canals, and small reservoirs. We can grasp some paddy-farming techniques of the Middle Mumun (c. 850-550 B.C.) from the well-preserved wooden tools excavated from archaeological rice paddies at the Majeon-ni Site. However, iron tools for paddy-farming were not introduced until sometime after 200 B.C. The spatial scale of individual paddies, and thus entire paddy-fields, increased with the regular use of iron tools in the Three Kingdoms of Korea Period (c. A.D. 300/400-668).

### French Intensive Horticulture

## Modern intensive farming types

Modern intensive farming refers to the industrialized production of animals (livestock, poultry and fish) and crops. The methods deployed are designed to produce the highest output at the lowest cost; usually using economies of scale, modern machinery, modern medicine, and global trade for financing, purchases and sales. The practice is widespread in developed nations, and most of the meat, dairy, eggs, and crops available in supermarkets are produced in this manner.

### Sustainable intensive farming

Biointensive agriculture focuses on maximizing efficiency: yield per unit area, yield per energy input, yield per water input, etc. Agroforestry combines agriculture and orchard/forestry technologies to create more integrated, diverse, productive, profitable, healthy and sustainable land-use systems. Intercropping can also increase total yields per unit of area or reduce inputs to achieve the same, and thus represents (potentially sustainable) agricultural intensification. Unfortunately, yields of any specific crop often diminish and the change can present new challenges to farmers relying on modern farming equipment which is best suited to monoculture.

### Intensive aquaculture

Aquaculture is the cultivation of the natural produce of water (fish, shellfish, algae, seaweed and other aquatic organisms). Intensive Aquaculture can often involve tanks or other highly controlled systems which are designed to boost production for the available volume or area of water resource.

### Intensive livestock farming

The modern examples of intensive farming are broadly referred to as Concentrated Animal Feeding Operations (CAFOs) or often termed Factory farming. These include:

- Intensive pig farming or Intensive piggery farming
- Large scale chicken farms
- Cattle feed lots

### Managed intensive grazing

This sustainable intensive livestock management system is increasingly used to optimize production within a sustainability framework and is generally not considered Factory farming.

## Individual industrial agriculture farm

Major challenges and issues faced by individual industrial agriculture farms include:

- integrated farming systems
- crop sequencing
- water use efficiency
- nutrient audits
- herbicide resistance
- financial instruments (such as futures and options)
- collect and understand own farm information;
- knowing your products
- knowing your markets
- knowing your customers
- satisfying customer needs
- securing an acceptable profit margin
- cost of servicing debt;
- ability to earn and access off-farm income;
- management of machinery and stewardship investments.

#### Integrated farming systems

An integrated farming system is a progressive biologically integrated sustainable agriculture system such as Integrated Multi-Trophic Aquaculture or Zero waste agriculture whose implementation requires exacting knowledge of the interactions of numerous species and whose benefits include sustainability and increased profitability.

Elements of this integration can include:

- intentionally introducing flowering plants into agricultural ecosystems to increase pollen-and nectar-resources required by natural enemies of insect pests
- using crop rotation and cover crops to suppress nematodes in potatoes

### Crop sequencing

Crop rotation or crop sequencing is the practice of growing a series of dissimilar types of crops in the same space in sequential seasons for various benefits such as to avoid the build up of pathogens and pests that often occurs when one species is continuously cropped. Crop rotation also seeks to balance the fertility demands of various crops to avoid excessive depletion of soil nutrients. A traditional component of crop rotation is the replenishment of nitrogen through the use of green manure in sequence with cereals and other crops. It is one component of polyculture. Crop rotation can also improve soil structure and fertility by alternating deep-rooted and shallow-rooted plants.

Satellite image of circular crop fields in Haskell County, Kansas in late June 2001. Healthy, growing crops are green. Corn would be growing into leafy stalks by then. Sorghum, which resembles corn, grows more slowly and would be much smaller and therefore, (possibly) paler. Wheat is a brilliant gold as harvest occurs in June. Fields of brown have been recently harvested and plowed under or lie fallow for the year.

### Water use efficiency

Crop irrigation accounts for 70% of the world's fresh water use. The agricultural sector of most countries is important both economically and politically, and water subsidies are common. Conservation advocates have urged removal of all subsidies to force farmers to grow more water-efficient crops and adopt less wasteful irrigation techniques.


Overhead irrigation, centre pivot design

For crop irrigation and plant irrigation, optimal water efficiency means minimizing losses due to evaporation or runoff. An evaporation pan can be used to determine how much water is required to irrigate the land. Flood irrigation, the oldest and most common type, is often very uneven in distribution, as parts of a field may receive excess water in order to deliver sufficient quantities to other parts. Overhead irrigation, using centre-pivot or lateral-moving sprinklers, gives a much more equal and controlled distribution pattern, but in extremely dry conditions much of the water may evaporate before it reaches the ground. Drip irrigation is the most expensive and least-used type, but offers the best results in delivering water to plant roots with minimal losses.

As changing irrigation systems can be a costly undertaking, conservation efforts often concentrate on maximizing the efficiency of the existing system. This may include chiseling compacted soils, creating furrow dikes to prevent runoff, and using soil moisture and rainfall sensors to optimize irrigation schedules.

Water catchment management measures include recharge pits, which capture rainwater and runoff and use it to recharge ground water supplies. This helps in the formation of ground water wells etc. and eventually reduces soil erosion caused due to running water.

## Nutrient audits

Better nutrient audits allow farmers to spend less money on nutrients and to create less pollution since less nutrient is added to the soil and thus there is less to run off and pollute. Methodologies for assessing soil nutrient balances have been studied and used for farms and entire countries for decades. But at present "there is no standard methodology for calculating nutrient budgets and there are no accepted 'benchmarks' figures against which to assess farm nutrient use efficiency. [A standard methodology] for calculating nutrient budgets on farms [is hoped to help reduce] diffuse water and air pollution from agriculture [through] best management practices in the use of fertilisers and organic manures, as part of the continued development of economically and environmentally sustainable farming systems."

## Herbicide resistance

In agriculture large scale and systematic weeding is usually required, often performed by machines such as cultivators or liquid herbicide sprayers. Selective herbicides kill specific targets while leaving the desired crop relatively unharmed. Some of these act by interfering with the growth of the weed and are often based on plant hormones. Weed control through herbicide is made more difficult when the weeds become resistant to the herbicide. Solutions include:

- using cover crops (especially those with allelopathic properties) that out-compete weeds and/or inhibit their regeneration.
- using a different herbicide
- using a different crop (e.g. genetically altered to be herbicide resistant; which ironically can create herbicide resistant weeds through horizontal gene

transfer)
- using a different variety (e.g. locally-adapted variety that resists, tolerates, or even out-competes weeds)
- ploughing
- ground cover such as mulch or plastic
- manual removal

# Organic farming

2008/9 Schools Wikipedia Selection. Related subjects: Agriculture; Environment

**Organic farming** is a form of agriculture that relies on crop rotation, green manure, compost, biological pest control, and mechanical cultivation to maintain soil productivity and control pests, excluding or strictly limiting the use of synthetic fertilizers and synthetic pesticides, plant growth regulators, livestock feed additives, and genetically modified organisms. Since 1990 the market for organic products has grown at a rapid pace, averaging 20-25 percent per year to reach $33 billion in 2005. This demand has driven a similar increase in organically managed farmland. Approximately 306,000 square kilometres (30.6 million hectares) worldwide are now farmed organically, representing approximately 2% of total world farmland. In addition, as of 2005 organic wild products are farmed on approximately 62 million hectares (IFOAM 2007:10).

Organic agricultural methods are internationally regulated and legally enforced by many nations, based in large part on the standards set by the International Federation of Organic Agriculture Movements, an international umbrella organization for organic organizations established in 1972. The overarching goal of organic farming is defined as follows:

> "The role of organic agriculture, whether in farming, processing, distribution, or consumption, is to sustain and enhance the health of ecosystems and organisms from the smallest in the soil to human beings."
>
> — International Federation of Organic Agriculture Movement (IFOAM) - The Principles of Organic Agriculture - Principle of health

**Agriculture**

**General**
Agribusiness · Agriculture

Agricultural science · Agronomy
Animal husbandry
Extensive farming
Factory farming · Free range
Industrial agriculture
Intensive farming
**Organic farming** · Permaculture
Sustainable agriculture
Urban agriculture

**History**
History of agriculture

Neolithic Revolution
Muslim Agricultural Revolution
British Agricultural Revolution
Green Revolution

**Particular**
Aquaculture · Christmas trees · Dairy farming

Grazing · Hydroponics · IMTA
Intensive pig farming · Lumber
Maize · Orchard
Poultry farming · Ranching · Rice

# Geography

## Distribution

The markets for organic products are strongest in North America and Europe, which as of 2001 are estimated to have $6 and $8 billion respectively of the $20 billion market (2003:6). However, as of 2007 organic farmland is distributed across the globe. Australasia has 39% of the total organic farmland with Australia's 11.8 million hectares, but 97 percent of this land is sprawling rangeland (2007:35), which results in total sales of approximately 5% of US sales (2003:7). Europe has 23 percent of total organic farmland (6.9 million hectares), followed by Latin America with 19 percent (5.8 million hectares). Asia has 9.5 percent while North America has 7.2 percent. Africa has a mere 3 percent.

Besides Australia, the countries with the most organic area are Argentina (3.1 million hectares), China (2.3 million hectares), and the United States (1.6 million hectares). Much of Argentina's organic farmland is pasture, like that of Australia (2007:42). Italy, Spain, Germany, Brazil, Uruguay, and the UK follow the United States by the amount of land managed organically (2007:26).

Sheep husbandry · Soybean
System of Rice Intensification
Wheat

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Agriculture by country

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Livestock
Meat processing
Poultry farming

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## Growth

As of 2001, the estimated total market value of certified organic products was estimated to be $20 billion. By 2002 this was $23 billion and by 2005 $33 billion, with Organic Monitor projecting sales of $40 billion in 2006 (IFOAM 2007:11). The change from 2001 to 2005 represents a compound growth of 10.6 percent.

In recent years both Europe and North America have experienced strong growth in organic farmland. Each added half a million hectares from 2004 to 2007 -- for the US this is a 29 percent change (IFOAM 2007:11,27). However, this growth has occurred under different conditions. While the European Union has shifted agricultural subsidies to organic farmers in recognition of its environmental benefits, the United States has taken a free market approach. As a result, as of 2001 3 percent of European farmland was organically managed compared to just .3 percent of United States farmland (Lotter 2003:7). By 2005 Europe's organic land was 3.9 percent while the United States' had risen to 0.6 percent (IFOAM 2007:14-15).

IFOAM's **The World of Organic Agriculture: Statistics and Emerging Trends 2007** lists the countries which added the most hectares and had the highest percentage growth in 2007 (IFOAM 2007:27-28). Among these, China is listed third in adding the most hectares behind the United States and Argentina. China jumped from approximately 300,000 hectares of organic land in 2005 to approximately 3.5 million hectares in 2006 -- an increase of over a thousand percent. This rise can be attributed to the certification of China's Organic Food Development Centre in 2002 by IFOAM. The end of 2005 marks the end of the three-year transition period begun in 2002..

# History

The organic movement began in the 1930s and 1940s as a reaction to agriculture's growing reliance on synthetic fertilizers. Artificial fertilizers had been created during the 18th century, initially with superphosphates and then ammonia derived fertilizers mass-produced using the Haber-Bosch process developed during World War I. These early fertilizers were cheap, powerful, and easy to transport in bulk. The 1940s has been referred to as the 'pesticide era'. Sir Albert Howard is widely considered to be the father of organic farming. Rudolf Steiner , an Austrian philosopher, made important strides in the earliest organic theory with his biodynamic agriculture. More work was done by J.I. Rodale in the United States, Lady Eve Balfour in the United Kingdom, and many others across the world.

As a percentage of total agricultural output, organic farming has remained tiny since its beginning. As environmental awareness and concern increased, the originally supply-driven movement became demand-driven. Standardized certification brought premium prices, and in some cases government subsidies attracted many farmers into converting. In the developing world, many farmers farm according to traditional methods but are not certified. In other cases, farmers in the developing world have converted out of necessity. As a proportion of total global agricultural output, organic output remains small, but it has been growing rapidly in many countries, notably in Europe.

## Methods


Organic cultivation of mixed vegetables in Capay, California. Note the hedgerow in the background.

"An organic farm, properly speaking, is not one that uses certain methods and substances and avoids others; it is a farm whose structure is formed in imitation of the structure of a natural system that has the integrity, the independence and the benign dependence of an organism"

— Wendell Berry, "The Gift of Good Land"

The term holistic is often used to describe organic farming , Enhancing soil health is the cornerstone of organic farming . A variety of methods are employed, including crop rotation, green manure, cover cropping, application of compost, and mulching. Organic farmers also use certain processed fertilizers such as seed meal, and various mineral powders such as rock phosphate and greensand, a naturally occurring form of potash. These methods help to control erosion, promote biodiversity, and enhance the health of the soil.

Pest control targets animal pests (including insects), fungi, weeds and disease. Organic pest control involves the cumulative effect of many techniques, including, allowing for an acceptable level of pest damage, encouraging or even introducing beneficial organisms, careful crop selection and crop rotation, and mechanical controls such as row covers and traps. These techniques generally provide benefits in addition to pest control—soil protection and improvement, fertilization, pollination, water conservation, season extension, etc.—and these benefits are both complementary and cumulative in overall effect on farm health . Effective organic pest control requires a thorough understanding of pest life cycles and interactions.

Weeds are controlled mechanically, thermically and through the use of covercrops and mulches.

## Standards

Organic farming is distinguished by formal standards regulating production methods, and in some cases, final output. Standards may be voluntary or legislated. As early as the 1970s, private associations created standards, against which organic producers could voluntarily have themselves certified. In the 1980s, governments began to produce organic production guidelines. Beginning in the 1990s, a trend toward legislation of standards began, most notably the EU-Eco-regulation developed in the European Union. As of 2007 over 60 countries have regulations on organic farming (IFOAM 2007:11).

Organic Agriculture also is the only government enforced humane laws, such as limited to de-beaking on chickens, guarantee to pasture time to cows, and more humane ways to deal with bees.

In 1991, the European Commission formulated the first government system to regulate organic labeling, setting the rules for 12 countries. Organic certification became mandatory and was also required for organic imports. The mandatory certification solidified consumer trust in organic products.

The international framework for organic farming is provided by IFOAM. For IFOAM members, organic agriculture is based upon the Principles of Organic Agriculture and the IFOAM Norms. The IFOAM Norms consist of the IFOAM Basic Standards and IFOAM Accreditation Criteria.

The IFOAM Basic Standards are a set of "standards for standards." They are established through a democratic and international process and reflect the current state of the art for organic production and processing. They are best seen as a work in progress to lead the continued development of organic practices worldwide. They provide a framework for national and regional standard-setting and certification bodies to develop detailed certification standards that are responsive to local conditions.

Legislated standards are established at the national level, and vary from country to country. In recent years, many countries have legislated organic production, including the EU nations (1990s), Japan (2001), and the US (2002). Non-governmental national and international associations also have their own production standards. In countries where production is regulated, these agencies must be accredited by the government.

Since 1993 when EU Council Regulation 2092/91 became effective, organic food production has been strictly regulated in the UK.

In India, standards for organic agriculture were announced in May 2001, and the National Programme on Organic Production (NPOP) is administered under the Ministry of Commerce.

In 2002, the United States Department of Agriculture (USDA) established production standards, under the National Organic Program (NOP), which regulate the commercial use of the term *organic*. Farmers and food processors must comply with the NOP in order to use the word.

The materials used are tested independently by the Organic Materials Review Institute.

### Composting

Under USDA organic standards, manure must be composted and allowed to reach a sterilizing temperature. If raw animal manure is used, 120 days must pass before the crop is harvested.

## Economics

The economics of organic farming, a subfield of agricultural economics, encompasses the entire process and effects of organic farming in terms of human society, including social costs, opportunity costs, unintended consequences, information asymmetries, and economies of scale. Although the scope of economics is broad, agricultural economics tends to focus on maximizing yields and efficiency at the farm level. Mainstream economics takes an anthropocentric approach to the value of the natural world: biodiversity, for example, is considered beneficial only to the extent that it is valued by people and increases profits. Some governments such as the European Union subsidize organic farming, in large part because these countries believe in the external benefits of reduced water use, reduced water contamination by pesticides and nutrients of organic farming, reduced soil erosion, reduced carbon emissions, increased biodiversity, and assorted other benefits.

Organic farming is labor and knowledge-intensive whereas conventional farming is capital-intensive, requiring more energy and manufactured inputs. Organic farmers in California have cited marketing as their greatest obstacle.

## Productivity and Profitability

A 2006 study suggests that converted organic farms have lower pre-harvest yields than their conventional counterparts in developed countries (92%) and that organic farms have higher pre-harvest yields than their low-intensity counterparts in developing countries (132%). The researcher attributes this to a relative lack of expensive fertilizers and pesticides in the developing world compared to the intensive, subsidy-driven farming of the developed world. Nonetheless, the researcher purposely avoids making the claim that organic methods routinely outperform green-revolution (conventional) methods. This study incorporated a 1990 review of 205 crop comparisons which found that organic crops had 91% of conventional yields. A major US survey published in 2001, analyzed results from 150 growing seasons for various crops and concluded that organic yields were 95-100% of conventional yields.

Lotter (2003:10) reports that repeated studies have found that organic farms withstand severe weather conditions better than conventional farms, sometimes yielding 70-90% more than conventional farms during droughts. A 22-year farm trial study by Cornell University published in 2005 concluded that organic farming produces the same corn and soybean yields as conventional methods over the long-term averages, but consumed less energy and used zero pesticides. The results were attributed to lower yields in general but higher yields during drought years. A study of 1,804 organic farms in Central American hit by Hurricane Mitch in 1998 found that the organic farms sustained the damage much better, retaining 20 to 40% more topsoil and smaller economic losses at highly significant levels than their neighbors.

On the other hand, a prominent 21-year Swiss study found an average of 20% lower organic yields over conventional, along with 50% lower expenditure on fertilizer and energy, and 97% less pesticides. A long-term study by U.S Department of Agriculture Agricultural Research Service (ARS) scientists concluded that, contrary to widespread belief, organic farming can build up soil organic matter better than conventional no-till farming, which suggests long-term yield benefits from organic farming. An 18-year study of organic methods on nutrient-depleted soil concluded that conventional methods were superior for soil fertility and yield in a cold-temperate climate, arguing that much of the benefits from organic farming are derived from imported materials which could not be regarded as "self-sustaining".

While organic farms have lower yields, organic methods require no synthetic fertilizer and pesticides. The decreased cost on those inputs, along with the premiums which consumers pay for organic produce, create higher profits for organic farmers. Organic farms have been consistently found to be as or more profitable than conventional farms with premiums included, but without premiums profitability is mixed (Lotter 2003:11). Welsh (1999) reports that organic farmers are more profitable in the drier states of the United States, likely due to their superior drought performance.

## Macroeconomic Impact

Organic methods often require more labor, providing rural jobs but increasing costs to urban consumers.

## Externalities

Agriculture in general imposes external costs upon society through pesticides, nutrient runoff, excessive water usage, and assorted other problems. As organic methods minimize some of these factors, organic farming is believed to impose fewer external costs upon society.

### Pesticides

Due to the increased concern for the risk to human health, as well as the recent and ongoing development of pesticide resistance, need to reduce use of pesticides is well recognised but implementation for reduction and elimination of pesticide is technologically very difficult. Most organic farm products use reduced pesticide claim but very few manage to eliminate the use of pesticide entirely.

While organic farming can, with extra cost, easily substitute chemical fertilizer with organic one, finding an alternative method for eliminating weeds as well as insects which feast on crops is difficult. Pest resistant GM crops are an alternative to pesticide use, but one which is unacceptable to many in the organic farming movement.

One natural method to control pests is to introduce a natural predator in place of the pesticide, though this approach has various control issues. Another method is crop rotation, which restricts expansion of the insect population. For weed elimination, the traditional method is to remove weeds by hand, which is still practiced in developing countries by small scale farmers. However, this has proven too costly in developed countries where labor is more expensive. One recent innovation in rice farming is to introduce ducks and fish to wet paddy fields, which eat both weeds and insects.

#### Health Risks

Organic farms use few pesticides, although they are allowed to use some natural ones. The main three are Bt, pyrethrum and rotenone. However, surveys have found that fewer than 10% of organic farmers use these pesticides regularly; one survey found that only 5.3% of vegetable growers in California use rotenone while 1.7% use pyrethrum (Lotter 2003:26). Nevertheless, rotenone has been linked to Parkinson's in rats and can be considered toxic to humans (Lotter 2003:26).

On the other hand, conventional farming uses large quantities of pesticides through techniques such as crop dusting. Studies have shown that people who work with pesticides have an increased risk of developing Parkinson's disease. The pesticides examined in these two long-term studies, paraquat and dieldrin, are not allowed on organic farms. The herbicide paraquat and fungicide maneb together, but not alone, have been shown to cause brain damage in mice.

Around 31,000 tonnes of pesticides are used in the UK every year, and 40% of fruit, vegetables, and bread sampled in the UK were found to have pesticide residues in 2004.

#### Children's health

Some parents are concerned about the potential neurological health risks posed to children by trace pesticide residues in food. A 2001 study demonstrated that children fed organic diets experienced significantly lower organophosphorus pesticide exposure than children fed conventional diets. A similar study in 2006 measured the levels of organophosphorus pesticide exposure in 23 preschool children before and after replacing their diet with organic food: levels of organophosphorus pesticide exposure dropped dramatically and immediately when the children switched to an organic diet. Although the researchers did not collect health *outcome* data in this study, they concluded "it is intuitive to assume that children whose diets consist of organic food items would have a lower probability of neurologic health risks."

#### Runoff

Pesticide runoff is one of the most significant effects of pesticide use. The USDA Natural Resources Conservation Service tracks the environmental risk posed by pesticide water contamination from farms, and its conclusion has been that "the Nation's pesticide policies during the last twenty six years have succeeded in reducing overall environmental risk, in spite of slight increases in area planted and weight of pesticides applied. Nevertheless, there are still areas of the country where there is no evidence of progress, and areas where risk levels for protection of drinking water, fish, algae and crustaceans remain high".

### Genetically modified organisms

A key characteristic of organic farming is rejection of genetically engineered products, including plants and animals. On 19 October 1998, participants at IFOAM's 12th Scientific Conference of IFOAM) issued the Mar del Plata Declaration, where more than 600 delegates from over 60 countries voted unanimously to exclude the use of genetically modified organisms in food production and agriculture. From this point, it became widely recognized that GMOs are categorically excluded from organic farming.

Despite this vehement opposition to use of any transgenic technologies in organic farming, agricultural researchers such as Luis Herrera-Estrella & Ariel Alvarez-Morales continue to advocate integration of transgenic technologies into organic farming as the optimal means to sustainable agriculture, particularly in the developing world. Similarly, some organic farmers question the rationale behind the ban on the use of genetically engineered seed because they see it a biological technology consistent with organic principles

Although GMOs are excluded from use in organic farming, there is concern that the pollen from genetically modified crops is increasingly contaminating organic and heirloom genetics making it difficult, if not impossible, to keep these genetics from entering the organic food supply. International trade restrictions limit the availability GMOs to certain countries.

The actual dangers that genetic modification could pose to the environment or, supposedly, individual health, are hotly contended. See GM food controversy.

### Food quality

*Healthy soils equals healthy food equals healthy people* is a basic tenet of many organic farming systems.

There is extensive scientific research being carried out in Switzerland at over 200 farms to determine differences in the quality of organic food products compared to conventional in addition to other tests. The FiBL Institute states that "organic products stand out as having higher levels of secondary plant compounds and vitamin C. In the case of milk and meat, the fatty acid profile is often better from a nutritional point of view. As far as carbohydrates and minerals, organic products are no different from conventional products. However, in regard to undesirables such as nitrate and pesticide residues, organic products have a clear advantage. A £12m EU-funded investigation into the difference between organic and ordinary farming has shown that organic foods have far more nutritional value. A recent study found that organically grown produce has double the flavonoids, an important antioxidant.. A 2007 study found that organically grown kiwi fruits had more antioxidants than conventional kiwi.

A 2007 study found that consumption of organic milk is associated with a decrease in risk for eczema, although no comparable benefit was found for organic fruits, vegetables, or meat.

### Soil conservation

In *Dirt: The Erosion of Civilizations*, geomorphologist David Montgomery outlines a coming crisis from soil erosion. Agriculture relies on roughly one meter of topsoil, and that is being depleted ten times faster than it is being replaced. No-till farming, which some claim depends upon pesticides, is regarded as one way to minimize erosion. However, a recent study by the USDA's Agricultural Research Service has found that organic farming is even better at building up the soil than no-till.

### Soil carbon and Climate Change

Agricultural production in most parts of the world will face less predictable weather conditions to those which were experienced during the intensification of agriculture over the last century. Intensive agriculture was, and remains, a short-sighted option. Organic agriculture is fast emerging as the only sustainable long-term approach to food production. Its emphasis on recycling techniques, biodiversity, low external input and high level output strategies make it an ideal replacement for the petroleum intensive agricultural methods that are currently contributing to global warming. In *The Organic Answer to Climate Change*, Anthony Meleca explains that organic agriculture - with its emphasis on closed nutrient cycles, biodiversity, and effective soil management - has the capacity to mitigate and even reverse the effects of climate change.

### Nutrient Leaching

Excess nutrients in lakes, rivers, and groundwater can cause algal blooms, eutrophication, and subsequent dead zones. In addition, nitrates are harmful to aquatic organisms by themselves. The main contributor to this pollution is nitrate fertilizers whose use is expected to "double or almost triple by 2050". Researchers at the United States National Academy of Sciences found that that organically fertilizing fields "significantly [reduces] harmful nitrate leaching" over conventionally fertilized fields: "annual nitrate leaching was 4.4-5.6 times higher in conventional plots than organic plots".

Scientists believe that the large dead zone in the Gulf of Mexico is caused in large part by agricultural pollution: a combination of fertilizer runoff and livestock manure runoff. A study by the United States Geological Survey (USGS) found that over half of the nitrogen released into the Gulf comes from agriculture. The economic cost of this for fishermen may be large, as they must travel far from the coast to find fish.

At the 2000 IFOAM Conference, researchers presented a study of nitrogen leaching into the Danube River. They found that nitrogen runoff was substantially lower among organic farms and suggested that the external cost could be internalized by charging 1 euro per kg of nitrogen released.

A 2005 study published in *Nature* found a strong link between agricultural runoff and algae blooms in California.

# Sales and Marketing

Organic farmers report that marketing and distribution are difficult obstacles. Most of organic sales are concentrated in developed nations. These products are what economists call credence goods in that they rely on uncertain certification. As food prices rise, organic products may experience falling demand. A 2008 survey by WSL Strategic Retail found that interest in organic products had dropped since 2006, and that 42% of Americans polled don't trust organic produce. and The Hartman Group reports that 69% of Americans claim to occasionally buy organic products, down from 73% in 2005. The Hartman Group says that people may be substituting local produce for organic produce.

## Distributors

In the United States, 75% of organic farms are smaller than 2.5 hectares and in California 2% of the farms account for over half of the sales (Lotter 2003:4). Groups of small farms join together in cooperatives such as Organic Valley, Inc. to market their goods more effectively.

Over the past twenty years, however, most of these cooperative distributors have merged or been bought out. Rural sociologist Philip H. Howard has researched the structure and transformation of the organic industry in the United States. He claims that in 1982 there were 28 consumer cooperative distributors but as of 2007 there are only 3, and he has created a graphic displaying the consolidation. His research shows that most of these small cooperatives have been absorbed into large multinational corporations such as General Mills, Heinz, ConAgra, Kellog, and assorted other brands. This consolidation has raised concerns among consumers and journalists of potential fraud and degradation in standards. Most of these large corporations sell their organic products through subsidiaries, allowing them to keep their names off the labels.

## Farmers' Markets

Price premiums are important for the profitability of small organic farmers, and so many sell directly to consumers in farmers' markets. In the United States the number of farmers' markets has grown from 1,755 in 1994 to 4,385 in 2006.

# Capacity building

Organic agriculture can contribute to meaningful socio-economic and ecologically sustainable development, especially in poorer countries . On one hand, this is due to the application of organic principles, which means efficient management of local resources (e.g. local seed varieties, manure, etc.) and therefore cost-effectiveness. On the other hand, the market for organic products – at local and international level – has tremendous growth prospects and offers creative producers and exporters in the South excellent opportunities to improve their income and living conditions.

Organic Agriculture is a very knowledge intensive production system . Therefore capacity building efforts play a central role in this regard. There are many efforts all around the world regarding the development of training material and the organization of training courses related to Organic Agriculture. Big parts of existing knowledge is still scattered and not easy accessible. Especially in Developing Countries this situation remains an important constraint for the growth of the organic sector.

For that reason, the International Federation of Organic Agriculture Movements created an Internet Training Platform whose objective is to become the global reference point for Organic Agriculture training through free access to high quality training materials and training programs on Organic Agriculture. In November 2007, the Training Platform hosted more than 170 free manuals and 75 training opportunities.

# Organic farming and associated biodiversity

## Benefits to biodiversity

Nearly all non-crop, naturally-occurring species observed in comparative farm land practice studies show a preference in organic farming both by population and richness. Spanning all associated species, there is an average of 30% more on organic farms versus conventional farming methods. Birds, butterflies, soil microbes, beetles, earthworms, spiders, vegetation, and mammals are particularly affected. Organic crops use little or no herbicides and pesticides and thus biodiversity fitness and population density benefit. Many weed species attract beneficial insects that improve soil qualities and forage on weed pests. Soil-bound organisms often benefit because of increased bacteria populations due to natural fertilizer spread such as manure, while experiencing reduced intake of herbicides and pesticides commonly associated with conventional farming methods. Increased biodiversity, especially from soil microbes such as mycorhizzae, have been proposed as an explanation for the high yields experienced by some organic plots, especially in light of the differences seen in a 21-year comparison of organic and control fields.

### Impact of increased biodiversity

The level of biodiversity that can be yielded from organic farming provides a natural capital to humans. Species found in most organic farms provides a means of agricultural sustainability by reducing amount of human input (e.g. fertilizers, pesticides) . Farmers that produce with organic methods reduce risk of poor yields by promoting biodiversity. Common game birds such as the ring-necked pheasant and the northern bobwhite often reside in agriculture landscapes, and are a natural capital yielded from high demands of recreational hunting. Because bird species richness and population are typically higher on organic farm systems, promoting biodiversity can be seen as logical and economical.

**Farmers' Benefits from Increased Biodiversity**

Biological research on soil and soil organisms has proven beneficial to the system of organic farming. Varieties of bacteria and fungi break down chemicals, plant matter and animal waste into productive soil nutrients. In turn, the producer benefits by healthier yields and more arable soil for future crops. Furthermore, a 21-year study was conducted testing the effects of organic soil matter and its relationship to soil quality and yield. Controls included actively managed soil with varying levels of manure, compared to a plot with no manure input. After the study commenced, there was significantly lower yields on the on the control plot when compared to the fields with manure. The concluded reason was an increased soil microbe community in the manure fields, providing a healthier, more arable soil system.

# Controversy

There are contentions that organic farming is unsustainable. One study from the Danish Environmental Protection Agency found that, area-for-area, organic farms of potatoes, sugar beet and seed grass produce as little as half the output of conventional farming. Findings like these, and the dependence of organic food on manure from low-yield cattle, has prompted criticism that organic farming is environmentally unsound and incapable of feeding the world population. Among these critics are Norman Borlaug, father of the "green revolution," and winner of the Nobel Peace Prize, who asserts that organic farming practices can at most feed 4 billion people, after expanding cropland dramatically and destroying ecosystems in the process. Yet, organic agriculture can reduce the level of negative externalities from (conventional) agriculture. Whether this is seen as private or public benefits depends upon the initial specification of property rights.

One study published in *Renewable Agriculture and Food Systems* argues that organic farming could produce enough food *per capita* to sustain the current human population; the difference in yields between organic and non-organic methods were small, with non-organic methods resulting in slightly higher yields in developed areas and organic methods resulting in slightly higher yields in developing areas.

Urs Niggli, director of the FiBL Institute contents that the wave of newpaper articles like 'Organic food exposed' or 'The hypocrisy of organic farmers' are a part of a global campaign against organic farming that take their arguments mostly from the book 'The truth about organic farming', by Alex Avery of the Hudson Institute.

In 1998, Dennis Avery of the Hudson Institute claimed the risk of E. coli infection was eight times higher when eating organic food rather than non-organic food, using the Centre for Disease Control (CDC) as a source. When the CDC was contacted, it stated that there was no evidence for the claim. The *New York Times* commented on Avery's attacks: "The attack on organic food by a well-financed research organization suggests that, though organic food accounts for only 1 percent of food sales in the United States, the conventional food industry is worried."

In the UK, some of the debate has been summarized in an exchange between Prof A. Trewavas and Lord P. Melchett, and published by a major supermarket, concerned about examining the issues. Trewavas contests the notion that organic agricultural systems are more friendly to the environment and more sustainable than high-yielding farming systems.

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# Pedology (soil study)

## 2008/9 Schools Wikipedia Selection. Related subjects: Agriculture; Geology and geophysics

**Pedology** (from Greek: πέδον, *pedon*, "soil"; and λόγος, *logos*, "knowledge") is the study of soils in its natural environment. It is one of two main branches of soil science, the other being edaphology. Pedology deals with pedogenesis, soil morphology, soil classification.

# Overview

Soil is not only a support for vegetation, but it is also the zone (the pedosphere) of numerous interactions between climate (water, air, temperature), soil life (micro-organisms, plants, animals) and its residues, the mineral material of the original and added rock, and its position in the landscape. During its formation and genesis, the soil profile slowly deepens and develops characteristic layers, called 'horizons', while a steady state balance is approached.

Soil users (such as agronomists) showed initially little concern in the dynamics of soil. They saw it as medium whose chemical, physical and biological properties were useful for the services of agronomic productivity . On the other hand, pedologists and geologists did not initially focus on the agronomic applications of the soil characteristics (edaphic properties) but upon its relation to the nature and history of landscapes. Today, there's an integration of the two disciplinary approaches as part of landscape and environmental sciences.

Pedologists are now also interested in the practical applications of a good understanding of pedogenesis processes (the evolution and functioning of soils), like interpreting its environmental history and predicting consequences of changes in land use, while agronomists understand that the cultivated soil is a complex medium, often resulting from several thousands of years of evolution. They understand that the current balance is fragile and that only a thorough knowledge of its history makes it possible to ensure its sustainable use.

# Concepts

- Complexity in soil genesis is more common than simplicity.
- Soils lie at the interface of Earth's atmosphere, biosphere, hydrosphere and lithosphere. Therefore, a thorough understanding of soils requires some knowledge of meteorology, climatology, ecology, biology, hydrology, geomorphology, geology and many other earth sciences and natural sciences.
- Contemporary soils carry imprints of pedogenic processes that were active in the past, although in many cases these imprints are difficult to observe or quantify. Thus, knowledge of paleoecology, palaeogeography, glacial geology and paleoclimatology is important for the recognition and understanding of soil genesis and constitute a basis for predicting the future soil changes.
- Five major, external factors of soil formation (climate, organisms, relief, parent material and time), and several smaller, less identifiable ones, drive pedogenic processes and create soil patterns.

- Characteristics of soils and soil landscapes, e.g., the number, sizes, shapes and arrangements of soil bodies, each of which is characterized on the basis of soil horizons, degree of internal homogeneity, slope, aspect, landscape position, age and other properties and relationships, can be observed and measured.
- Distinctive bioclimatic regimes or combinations of pedogenic processes produce distinctive soils. Thus, distinctive, observable morphological features, e.g., illuvial clay accumulation in B horizons, are produced by certain combinations of pedogenic processes operative over varying periods of time.
- Pedogenic (soil-forming) processes act to both create and destroy order ( anisotropy) within soils; these processes can proceed simultaneously. The resulting soil profile reflects the balance of these processes, present and past.
- The geological Principle of Uniformitarianism applies to soils, i.e., pedogenic processes active in soils today have been operating for long periods of time, back to the time of appearance of organisms on the land surface. These processes do, however, have varying degrees of expression and intensity over space and time.
- A succession of different soils may have developed, eroded and/or regressed at any particular site, as soil genetic factors and site factors, e.g., vegetation, sedimentation, geomorphology, change.
- There are very few old soils (in a geological sense) because they can be destroyed or buried by geological events, or modified by shifts in climate by virtue of their vulnerable position at the surface of the earth. Little of the soil continuum dates back beyond the Tertiary period and most soils and land surfaces are no older than the Pleistocene Epoch. However, preserved/lithified soils (paleosols) are an almost ubiqutious feature in terrestrial (land-based) environments throughout most of geologic time. Since they record evidence of ancient climate change, they present immense utility in understanding climate evolution throughout geologic history.
- Knowledge and understanding of the genesis of a soil is important in its classification and mapping.
- Soil classification systems cannot be based entirely on perceptions of genesis, however, because genetic processes are seldom observed and because pedogenic processes change over time.
- Knowledge of soil genesis is imperative and basic to soil use and management. Human influence on, or adjustment to, the factors and processes of soil formation can be best controlled and planned using knowledge about soil genesis.
- Soils are natural clay factories (clay includes both clay mineral structures and particles less than 2 µm in diameter). Shales worldwide are, to a considerable extent, simply soil clays that have been formed in the pedosphere and eroded and deposited in the ocean basins, to become lithified at a later date.

## Famous pedologists

- Olivier de Serres
- Bernard Palissy
- Vasily V. Dokuchaev
- Eugene W. Hilgard
- Hans Jenny
- Charles E. Kellogg
- Curtis F. Marbut

# Pig

2008/9 Schools Wikipedia Selection. Related subjects: Agriculture; Mammals

**Pig and piglet**

A sow and her piglet.

**Scientific classification**

| | |
|---|---|
| Kingdom: | Animalia |
| Phylum: | Chordata |
| Class: | Mammalia |
| Order: | Artiodactyla |
| Family: | Suidae |
| Genus: | ***Sus*** Linnaeus, 1758 |

**Species**

*Sus barbatus*
*Sus bucculentus†*
*Sus cebifrons*
*Sus celebensis*
*Sus domestica*
*Sus falconeri†*
*Sus heureni*
*Sus hysudricus†*

**Pigs**, also called **hogs** or **swine**, are ungulates native to Eurasia collectively grouped under the genus ***Sus*** within the Suidae family. The nearest living relatives of the swine family are the peccaries and hippopotamuses.

## Description and behaviour

A pig has a snout for a nose, small eyes, and a small tail, which may be curly, kinked, or straight. It has a thick body and short legs. There are four toes on each foot, with the two large middle toes used for walking.

Pigs are omnivores, which means that they consume both plants and small animals. Pigs will scavenge and have been known to eat any kind of food, including dead insects, worms, tree bark, rotting carcasses, excreta (including their own), garbage, and other pigs. In the wild, they are foraging animals, primarily eating leaves and grasses, roots, fruits and flowers. Occasionally, in captivity, pigs may eat their own young, often if they become severely stressed.

A typical pig has a large head with a long snout which is strengthened by a special bone called the prenasal bone and by a disk of cartilage in the tip. The snout is used to dig into the soil to find food and is a very sensitive sense organ. Pigs have a full set of 44 teeth. The canine teeth, called tusks, grow continually and are sharpened by the lowers and uppers rubbing against each other.

Pigs that are allowed to forage may be watched by swineherds. Because of their foraging abilities and excellent sense of smell, they are used to find truffles in many European countries. Domesticated pigs are commonly raised as livestock by farmers for meat (called pork), as well as for leather. Their bristly hairs are also used for brushes. Some breeds of pigs, such as the Asian pot-bellied pig, are kept as pets.

A female pig can become pregnant at around 8-18 months of age. She will then go into heat every 21 days. Male pigs become sexually active at 8-10 months of age. A litter of piglets typically contains between 6 and 12 piglets.

Pigs do not have functional sweat glands, so pigs cool themselves using water or mud during hot weather. They also use mud as a form of sunscreen to protect their skin from sunburn. Mud also provides protection against flies and parasites.

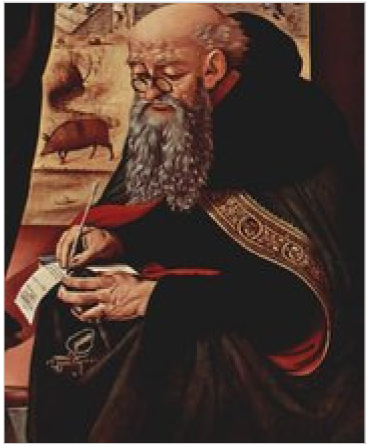
## Species

- Sus barbatus
- Sus bucculentus † (extinct).
- Sus cebifrons
- Sus celebensis
- Sus falconeri † (extinct).
- Sus heureni
- Sus hysudricus † (extinct).
- Sus philippensis
- Sus salvanius
- Sus scrofa
- Sus strozzi † (extinct).
- Sus timoriensis
- Sus verrucosus

*Sus philippensis*
*Sus salvanius*
*Sus scrofa*
*Sus strozzi†*
*Sus timoriensis*
*Sus verrucosus*

## Pigs in religion

- In ancient Egypt pigs were associated with Set, the rival to the sun god Horus. When Set fell into disfavor with the Egyptians swineherds were forbidden to enter temples.
- In Hinduism the god Vishnu took the form of a boar in order to save the earth from a demon who had dragged it to the bottom of the sea.
- In ancient Greece, a sow was an appropriate sacrifice to Demeter and had been her favorite animal since she had been the Great Goddess of archaic times. Initiates at the Eleusinian Mysteries began by sacrificing a pig.
- The pig is one of the 12-year cycle of animals which appear in the Chinese zodiac related to the Chinese calendar. Believers in Chinese astrology associate each animal with certain personality traits. See: Pig (Zodiac).
- The dietary laws of Judaism ( Kashrut, adj. Kosher) and Islam ( Halal) forbid the eating of flesh of swine or pork in any form, considering the pig to be an unclean animal (see taboo food and drink). Seventh-day Adventists and some other fundamental Christian denominations also consider pork unclean as food.
- In Catholicism, Eastern Orthodoxy and other older Christian groups, pigs are associated with Saint Anthony, the patron saint of swineherds.



Painting of Saint Anthony with pig in background by Piero di Cosimo c. 1480

## Environmental impacts

Feral pigs in Florida, United States

Domestic pigs which escaped from farms or were allowed to forage in the wild, and in some cases wild boars which were introduced as prey for hunting, have given rise to large populations of feral pigs in North and South America, Australia, New Zealand, Hawaii and other areas where pigs are not native. Accidental or deliberate releases of pigs into countries or environments where they are an alien species have caused extensive environmental change. Their omnivorous diet, aggressive behaviour and their feeding method of rooting in the ground all combine to severely alter ecosystems unused to pigs. Pigs will even eat small animals and destroy nests of ground nesting birds. The Invasive Species Specialist Group lists feral pigs as number 90 on the list of the world's 100 worst invasive species and says about them:

> “ Feral pigs like other introduced mammals are major drivers of extinction and ecosystem change. They have been introduced into many parts of the world, and will damage crops and home gardens as well as potentially spreading disease. They uproot large areas of land, eliminating native vegetation and spreading weeds. This results in habitat alteration, a change in plant succession and composition and a decrease in native fauna dependent on the original habitat. ”

# Health issues

Unlike most other "domestic" animals used as food for humans (cows, sheep, goats, chickens, etc...), pigs harbour a range of parasites and diseases that can be easily transmitted to humans. These include trichinosis, cysticercosis, and brucellosis. Very commonly, pigs are also known to host large concentrations of parasitic ascarid worms in their digestive tract. The presence of these diseases and parasites is one of the main reasons why pork meat should always be well cooked or cured before eating. Religious groups who consider pork unclean may refer to these issues as support for their views.

Pigs are extremely susceptible to pneumonia, usually caused by weather. Pigs have small lungs; for this reason, bronchitis or pneumonia can kill a pig quickly.

Pigs can be aggressive and pig-induced injuries are relatively common in areas where pigs are reared or where they form part of the wild or feral fauna.

Domestic pigs are often inbred, leading to the expression of recessive traits. Congenital malformations are common. One such malformation is the duplication of a pig's head.

# Plough

2008/9 Schools Wikipedia Selection. Related subjects: Agriculture

The traditional way: a German farmer works the land with horses and plough

The **plough** (American spelling: **plow**; both pronounced /plaʊ/) is a tool used in farming for initial cultivation of soil in preparation for sowing seed or planting. It has been a basic instrument for most of recorded history, and represents one of the major advances in agriculture. The primary purpose of ploughing is to turn over the upper layer of the soil, bringing fresh nutrients to the surface, while burying weeds and the remains of previous crops, allowing them to break down. It also aerates the soil, and allows it to hold moisture better. In modern use, a ploughed field is typically left to dry out, and is then harrowed before planting.

Ploughs were initially pulled by oxen, and later in many areas by horses. In industrialised countries, the first mechanical means of pulling a plough used steam-power ( ploughing engines or steam tractors), but these were gradually superseded by internal-combustion-powered tractors. In the past two decades plough use has reduced in some areas (where soil damage and erosion are problems), in favour of shallower ploughing and other less invasive tillage techniques.

Ploughs are even used under the sea, for the laying of cables, as well as preparing the earth for side-scan sonar in a process used in oil exploration.

A plough in action in South Africa. Notice the soil being turned over

## Etymology

In English, as in other Germanic languages, the plough was traditionally known by other names, e.g. Old English *sulh*, Old High German *medela* or *huohili*, and Old Norse *arðr*.

The current word *plough* also comes from Germanic, but it appears relatively late (it is absent from Gothic), and is thought to be a loanword from one of the north Italic languages. In these it had different meanings: in Raetic *plaumorati* (Pliny), and in Latin *plaustrum* "wagon, cart", *plóstrum, plóstellum* "cart", and *plóxenum, plóximum* "cart box".

The word first appears in Germanic as Lombardic *plóvum*. This term was borrowed into Slavic languages, such as Old Church Slavonic *plugŭ*, and Baltic languages, such as Lithuanian *plúgas*. Ultimately, the word is thought to derive from an ancestral PIE **blōkó*, related to Armenian *pelem* "to dig" and Welsh *bwlch* "gap, notch".

# History of the plough

## Hoeing

When agriculture was first developed, simple hand-held digging sticks or hoes would have been used in highly fertile areas, such as the banks of the Nile where the annual flood rejuvenates the soil, to create furrows wherein seeds could be sown. In order to regularly grow crops in less fertile areas, the soil must be turned to bring nutrients to the surface.

## Scratch plough

The domestication of oxen in Mesopotamia and by its contemporary Indus valley civilization, perhaps as early as the 6th millennium BC, provided mankind with the pulling power necessary to develop the plough. The very earliest plough was the simple *scratch-plough*, or *ard*, which consists of a frame holding a vertical wooden stick that was dragged through the topsoil (still used in many parts of the world). It breaks up a strip of land directly along the ploughed path, which can then be planted. Because this form of plough leaves a strip of undisturbed earth between the rows, fields are often cross-ploughed at right angles, and this tends to lead to squarish fields In the archeology of northern Europe, such squarish fields are referred to as " Celtic fields".

## Crooked ploughs

The Greeks apparently introduced the next major advance in plough design; the crooked plough, which angled the cutting surface forward, leading to the name. The cutting surface was often faced with bronze or (later) iron. Metal was expensive, so in times of war it was melted down or forged to make weapons – or the reverse in more peaceful times. This is presumably the origin of the term "beat your swords to ploughshares".

## Mouldboard plough


Ploughing with oxen. A miniature from an early-sixteenth-century manuscript of the Middle English poem *God Spede ye Plough*, held at the British Museum


Chinese iron plough with curved mouldboard, 1637.

A major advance in plough design was the *mouldboard plough* (American spelling: *moldboard plow*), which aided the cutting blade. The *coulter*, *knife* or *skeith* cuts vertically into the ground just ahead of the *share* (or *frog*) a wedge-shaped surface to the front and bottom of the *mouldboard* with the landside of the frame supporting the below-ground components. The upper parts of the frame carries (from the front) the coupling for the motive power (horses), the coulter and the landside frame. Depending on the size of the implement, and the number of furrows it is designed to plough at one time, there is a wheel or wheels positioned to support the frame. In the case of a single-furrow plough there is only one wheel at the front and handles at the rear for the ploughman to steer and manoeuvre it.


Horse-drawn, two-furrow plough.

When dragged through a field the coulter cuts down into the soil and the share cuts horizontally from the previous furrow to the vertical cut. This releases a rectangular strip of sod that is then lifted by the share and carried by the mouldboard up and over, so that the strip of sod (slice of the topsoil) that is being cut lifts and rolls over as the plough moves forward, dropping back to the ground upside down into the furrow and onto the turned soil from the previous run down the field. Each gap in the ground where the soil has been lifted and moved across (usually to the right) is called a *furrow*. The sod that has been lifted from it rests at about a 45 degree angle in the next-door furrow and lies up the back of the sod from the previous run.

In this way, a series of ploughing runs down a field (paddock) leaves a row of sods that lie partly in the furrows and partly on the ground lifted earlier. Visually, across the rows, there is the land (unploughed part) on the left, a furrow (half the width of the removed strip of soil) and the removed strip almost upside-down lying on about half of the previous strip of inverted soil, and so on across the field. Each layer of soil and the gutter it came from forms the classic furrow.

The mouldboard plough greatly reduced the amount of time needed to prepare a field, and as a consequence, allowed a farmer to work a larger area of land. In addition, the resulting pattern of low (under the mouldboard) and high (beside it) ridges in the soil forms water channels, allowing the soil to drain. In areas where snow buildup is an issue, this allows the soil to be planted earlier as the snow runoff is drained away more quickly.

Parts of a mouldboard plough: There are 5 major parts of a mouldboard plough

1. Mouldboard
2. Share
3. Landside
4. Frog
5. Tailpiece

A *runner* extending from behind the share to the rear of the plough controls the direction of the plough, because it is held against the bottom land-side corner of the new furrow being formed. The holding force is the weight of the sod, as it is raised and rotated, on the curved surface of the mouldboard. Because of this runner, the mouldboard plough is harder to turn around than the scratch plough, and its introduction brought about a change in the shape of fields—from mostly square fields into longer rectangular "strips" (hence the introduction of the furlong).

An advance on the basic design was the *ploughshare*, a replaceable horizontal cutting surface mounted on the tip of the mouldboard. Introduced by the Celts in

Britain around 4000 BC (without the replaceable feature), early mouldboards were basically wedges that sat inside the cut formed by the coulter, turning over the soil to the side. The ploughshare spread the cut horizontally below the surface, so when the mouldboard lifted it, a wider area of soil was turned over.

## Heavy ploughs

In the basic mouldboard plough the depth of the cut is adjusted by lifting against the runner in the furrow, which limited the weight of the plough to what the ploughman could easily lift. This limited the construction to a small amount of wood (although metal edges were possible). These ploughs were fairly fragile, and were unsuitable for breaking up the heavier soils of northern Europe. The introduction of wheels to replace the runner allowed the weight of the plough to increase, and in turn allowed the use of a much larger mouldboard faced in metal. These *heavy ploughs* led to greater food production and eventually a significant population increase around 600 AD.

Heavy Iron ploughs were invented in Han Dynasty China around 100 BC. Despite a number of innovations, the Romans never achieved the heavy wheeled mouldboard plough. The first indisputable appearance after the Roman period is from 643, in a northern Italian document. Old words in connected with the heavy plough and its use appear in Slavic, suggesting possible early use in this region. The general adoption of the mouldboard plough in Europe appears to have accompanied the adoption of the three-field system in the later eighth and early ninth centuries, leading to an improvement of the agricultural productivity per unit of land in northern Europe.

Research by the French historian Marc Bloch in medieval French agricultural history showed the existence of names for two different ploughs, "the *araire* was wheel-less and had to be dragged across the fields, while the *charrue* was mounted on wheels".

## Improved designs

The basic plough with coulter, ploughshare and mouldboard remained in use for a millennium. Major changes in design did not become common until the Age of Enlightenment, when there was rapid progress in design. The Dutch are credited with the introduction of newer shapes for the mouldboard in the 1600s, although these shapes were known earlier in China and may have been discovered by the Dutch while there.

Joseph Foljambe in Rotherham, England, in 1730 used these new shapes as the basis for the Rotherham plough, which also covered the mouldboard with iron. Unlike the heavy plough, the Rotherham (or Rotherham swing) plough consisted entirely of the coulter, mouldboard and handles. It was much lighter than conventional designs and became very popular in England. It may have been the first plough to be widely built in factories.

A pair of metal wheels from a plough on a farm near Dordrecht, Eastern Cape.

James Small further improved the design. Using mathematical methods he experimented with various designs until he arrived at a shape cast from a single piece of iron, the *Scots plough*. This was again improved on by Jethro Wood, a blacksmith of Scipio, New York, who made a three-part Scots Plough that allowed a broken piece to be replaced. In 1837 John Deere introduced the first steel plough; it was much stronger than iron designs that it was able to work the soil in areas of the US that had earlier been considered unsuitable for farming. Improvements on this followed developments in metallurgy; steel coulters and shares with softer iron mouldboards to prevent breakage, the *chilled plough* which is an early example of surface-hardened steel, and eventually the face of the mouldboard grew strong enough to dispense with the coulter.

## Single-sided ploughing

Yaks are used to plough fields in parts of Asia.

The first mouldboard ploughs could only turn the soil over in one direction ( conventionally always to the right), as dictated by the shape of the mouldboard, and so the field had to be ploughed in long strips, or *lands*. The plough was usually worked clockwise around each land, ploughing the long sides and being dragged across the short sides without ploughing. The length of the strip was limited by the distance oxen (or later horses) could comfortably work without a rest, and their width by the distance the plough could conveniently be dragged. These distances determined the traditional size of the strips: a furlong, (or "furrow's length", 220 yards (200 m)) by a chain (22 yards (20 m)) – an area of one acre (about 0.4 hectares); this is the origin of the acre. The one-sided action gradually moved soil from the sides to the centre line of the strip. If the strip was in the same place each year, the soil built up into a ridge, creating the ridge and furrow topography still seen in some ancient fields.

## Turnwrest plough

The turnwrest plough allows ploughing to be done to either side. The mouldboard is removable, turning to the right for one furrow, then being moved to the other side of the plough to turn to the left (the coulter and ploughshare are fixed). In this way adjacent furrows can be ploughed in opposite directions, allowing ploughing to proceed continuously along the field and thus avoiding the ridge and furrow topography.

## Reversible plough

The reversible plough has two mouldboard ploughs mounted back-to-back, one turning to the right, the other to the left. While one is working the land, the other is carried upside-down in the air. At the end of each row, the paired ploughs are turned over, so the other can be used. This returns along the next furrow, again working the field in a consistent direction.

Horse-drawn, reversible plough.

## Riding and multiple-furrow ploughs

Early steel ploughs, like those for thousands of years prior, were *walking ploughs*, directed by the ploughman holding onto handles on either side of the plough. The steel ploughs were so much easier to draw through the soil that the constant adjustments of the blade to react to roots or clods was no longer necessary, as the plough could easily cut through them. Consequently it was not long after that the first *riding ploughs* appeared. On these, wheels kept the plough at an adjustable level above the ground, while the ploughman sat on a seat where he would have earlier walked. Direction was now controlled mostly through the draught team, with levers allowing fine adjustments. This led very quickly to riding ploughs with multiple mouldboards, dramatically increasing ploughing performance.

A single draught horse can normally pull a single-furrow plough in clean light soil, but in heavier soils two horses are needed, one walking on the land and one in the furrow. For ploughs with two or more furrows more than two horses are needed and, usually, one or more horses have to walk on the loose ploughed sod—and that makes hard going for them, and the horse treads the newly ploughed land down. It is usual to rest such horses every half hour for about ten minutes.

Heavy volcanic loam soils, such as are found in New Zealand, require the use of four heavy draught horses to pull a double-furrow plough. Where paddocks are more square than long-rectangular it is more economical to have horses four wide in harness than two-by-two ahead, thus one horse is always on the ploughed land (the sod). The limits of strength and endurance of horses made greater than two-furrow ploughs uneconomic to use on one farm.

Amish farmers tend to use a team of about seven horses or mules when spring ploughing and as Amish farmers often help each other plough, teams are sometimes changed at noon. Using this method about 10 acres can be ploughed per day in light soils and about 2 acres (8,100 $m^2$) in heavy soils.

## Steam ploughing

The advent of the mobile steam engine allowed steam power to be applied to ploughing from about 1850. In Europe, soil conditions were too soft to support the weight of the heavy traction engines. Instead, counterbalanced, wheeled ploughs, known as *balance ploughs*, were drawn by cables across the fields by pairs of ploughing engines which worked along opposite field edges. The balance plough had two sets of ploughs facing each other, arranged so when one was in the ground, the other set was lifted into the air. When pulled in one direction the trailing ploughs were lowered onto the ground by the tension on the cable. When the plough reached the edge of the field, the opposite cable was pulled by the other engine, and the plough tilted (balanced), the other set of shares were put into the ground, and the plough worked back across the field.

A German "balance plough"

One set of ploughs was right-handed, and the other left-handed, allowing continuous ploughing along the field, as with the turnwrest and reversible ploughs. The man credited with the invention of the ploughing engine and the associated balance plough, in the mid nineteenth century, was John Fowler, an English agricultural engineer and inventor.

Ploughing engine *Heumar*, made by the Ottomayer company (Germany), used in pairs with a balance plough. Built 1929, 220 PS, 21 tons.

In America the firm soil of the Plains allowed direct pulling with steam tractors, such as the big Case, Reeves or Sawyer Massey breaking engines. Gang ploughs of up to fourteen bottoms were used. Often these big ploughs were used in regiments of engines, so that in a single field there might be ten steam tractors each drawing a plough. In this way hundreds of acres could be turned over in a day. Only steam engines had the power to draw the big units. When internal combustion engines appeared, they had neither the strength nor the ruggedness compared to the big steam tractors. Only by reducing the number of shares could the work be completed.

## Stump-jump plough

The Stump-jump plough was an Australian invention of the 1870s, designed to cope with the breaking up of new farming land, that contains many tree stumps and rocks that would be very expensive to remove. The plough uses a moveable weight to hold the ploughshare in position. When a tree stump or other obstruction such as a rock is encountered, the ploughshare is thrown upwards, clear of the obstacle, to avoid breaking the plough's harness or linkage; ploughing can be continued when the weight is returned to the earth after the obstacle is passed.

A simpler system, developed later, uses a concave disc (or a pair of them) set at a large angle to the direction of progress, that uses the concave shape to hold the disc into the soil – unless something hard strikes the circumference of the disk, causing it to roll up and over the obstruction. As the arrangement is dragged forward, the sharp edge of the disc cuts the soil, and the concave surface of the rotating disc lifts and throws the soil to the side. It doesn't make as good a job as the mouldboard plough (but this is not considered a disadvantage, because it helps fight the wind erosion), but it does lift and break up the soil.

## Modern ploughs

Modern ploughs are usually multiple reversible ploughs, mounted on a tractor via a three-point linkage. These commonly have between two and as many as seven mouldboards – and *semi-mounted* ploughs (the lifting of which is supplemented by a wheel about half-way along their length) can have as many as eighteen mouldboards. The hydraulic system of the tractor is used to lift and reverse the implement, as well as to adjust furrow width and depth. The ploughman still has to set the draughting linkage from the tractor so that the plough is carried at the proper angle in the soil. This angle and depth can be controlled automatically by modern tractors.

# Specialist ploughs

## Chisel plough

The *chisel plough* is a common tool to get deep tillage with limited soil disruption. The main function of this plough is to loosen and aerate the soils while leaving crop residue at the top of the soil. This plough can be used to reduce the effects of compaction and to help break up ploughpan and hardpan. Unlike many other ploughs the chisel will not invert or turn the soil. This characteristic has made it a useful addition to no-till and limited-tillage farming practices which attempt to maximise the erosion-prevention benefits of keeping organic matter and farming residues present on the soil surface through the year. Because of these attributes, the use of a chisel plough is considered by some to be more sustainable than other types of plough, such as the mouldboard plough.

The chisel plough is typically set to run up to a depth of eight to twelve inches (200 to 300 mm). However some models may run much deeper. Each of the individual ploughs, or shanks, are typically set from nine inches (229 mm) to twelve inches (305 mm) apart. Such a plough can encounter significant soil drag, consequently a tractor of sufficient power and good traction is required. When planning to plough with a chisel plough it is important to bear in mind that 10 to 15 horsepower (7 to 11 kW) per shank will be required.

A modern John Deere 8110 Farm Tractor using a chisel plough.

## Ridging plough

A ridging plough is used for crops, such as potatoes, which are grown buried in ridges of soil. A ridging plough has two mouldboards facing away from each other, cutting a deep furrow on each pass, with high ridges either side. The same plough may be used to split the ridges to harvest the crop.

## Mole plough

The *mole plough* or *subsoiler* allows underdrainage to be installed without trenches, or it breaks up deep impermeable soil layers which impede drainage. It is a very deep plough, with a torpedo-shaped or wedge-shaped tip, and a narrow blade connecting this to the body. When dragged through the ground, it leaves a channel deep under the ground, and this acts as a drain. Modern mole ploughs may also bury a flexible perforated plastic drain pipe as they go, making a more permanent drain – or they may be used to lay pipes for water supply or other purposes.

# Use of the mouldboard plough

In modern use, the mouldboard plough was used for three reasons:-

- Foremost was the control of weeds. In this function, mouldboard ploughing is very successful, a farmer can control weed growth with far fewer herbicides by using this technique than is otherwise possible with any other method, aside from hand weeding, which is labour-intensive and not practical for large operations.
- To break up the soil for planting.
- To warm the soil for planting.

Only the first reason for mouldboard ploughing really paid off. Most plants require little soil agitation to germinate, so breaking up soil is unnecessary beyond what a planting implement accomplishes on its own. Soil warming is also unnecessary beyond two or three inches (76 mm) below the surface, therefore bringing black fresh soil which heats more quickly and more deeply after the final frost of the year is unneeded.

## Problems with mouldboard ploughing

Mouldboard ploughing has become increasingly recognised as a highly destructive farming practice with the possibility of rapidly depleting soil resources. In the short term, however, it can be successful, hence the reason it was practised for such a long time. A field that is mouldboarded once will generally have an extraordinary one time yield as the larvae of pests and seed from weeds are buried too deeply to survive. After the first harvest, however, continued mouldboarding will diminish yields greatly.

The diminishing returns of mouldboard ploughing can be attributed to a number of side effects of the practice:-

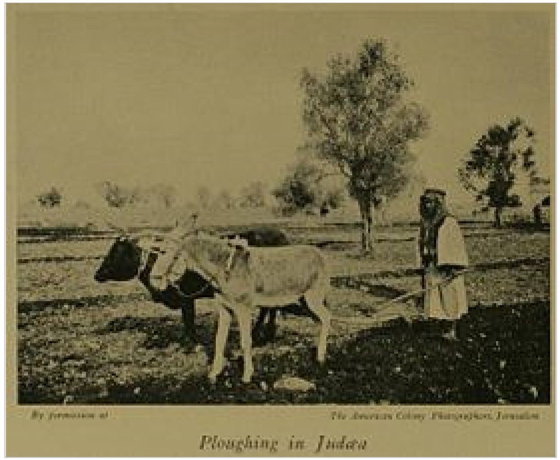
- Foremost is the formation of hardpan, or the calcification of the sub layer of soil. In some areas, hardpan could once be found so thick it could not be broken up with a pickaxe. The only effective means of removing hardpan is using a "ripper", or chisel plough, which is pulled through the hardpan by an extremely powerful and costly tractor. Obviously, this layer eventually becomes impenetrable to the roots of plants and restricts growth and yields. This layer also becomes impenetrable to water, leading to flooding and the drowning of crops.
- Deep (> 15-20 cm) mouldboard ploughing rapidly depletes the organic matter content of soil and promotes erosion; these two problems go hand in hand. As soil is brought to the surface, the root structure of the previous harvest is broken up, and the natural adhesion of soil particles is also lost; though loose soil appears good for plant germination (and it is), this loose soil without cohesion is highly susceptible to erosion, multiplying the rate of erosion by several factors compared to a non-mouldboarded plot. This increased rate of erosion will not only outpace the rate of soil genesis but also the replacement rate for organics in the soil, thus depleting the soil more rapidly than normal.
- Deep (> 15-20 cm) mouldboard ploughing leads to increased soil compaction and loss of pore space within the soil. Soil is a bit like a bucket full of balls filled with sand. Each ball represents a cohesive particle of soil, and when stacked the balls leave a great deal of air space, required for healthy root growth and proper drainage. Mouldboarding so disturbs the soil that it breaks these balls and releases their contents. When this happens, the much smaller particles that are within the larger particles are released and pore space diminishes, leading to hard compacted soil that floods easily and restricts root growth.

## Soil erosion

One negative effect of ploughing is to dramatically increase the rate of soil erosion, both by wind and water, where soil is moved elsewhere on land or deposited in bodies of water, such as the oceans. Ploughing is thought to be a contributing factor to the Dust Bowl in the US in the 1930s. Alternatives to ploughing, such as the no till method, have the potential to limit damage while still allowing farming.

## Plough parts

- Frame
- Frog
- Share (also called a *plowshare* or *ploughshare*)
- Mouldboard (or moldboard)
- Runner
- Landside
- Shin
- Trashboard
- Handles
- Hitch
- Knife, skeith or coulter


A farmer ploughs his fields in Judea, 1913.

On modern ploughs and some older ploughs, the mouldboard is separate from the share and runner, allowing these parts to be replaced without replacing the mouldboard. Abrasion eventually destroys all parts of a plough that contact the soil.

# Sesame

## 2008/9 Schools Wikipedia Selection. Related subjects: Agriculture; Plants

**Sesame** (*Sesamum indicum*) is a flowering plant in the genus *Sesamum*. The precise natural origin of the species is unknown, although numerous wild relatives occur in Africa and a smaller number in India. It is widely naturalized in tropical regions around the world and is cultivated for its edible seeds.

It is an annual plant growing to 50 to 100 cm (2-3 feet) tall, with opposite leaves 4 to 14 cm (5.5 in) long with an entire margin; they are broad lanceolate, to 5 cm (2 in) broad, at the base of the plant, narrowing to just 1 cm (half an inch) broad on the flowering stem. The flowers are white to purple, tubular, 3 to 5 cm (1 to 2 in) long, with a four-lobed mouth.

**Sesame**

Sesame plants

**Scientific classification**

| | |
|---|---|
| Kingdom: | Plantae |
| Division: | Magnoliophyta |
| Class: | Magnoliopsida |

# Origins

Despite the fact that the majority of the wild species of the genus *Sesamum* are native to sub-saharan Africa, Zohary and Hopf argue that sesame was first domesticated in India. They cite morphological and cytogenetic affinities between domesticated sesame and the south Indian native *S. mulayanum* Nair., as well as archeological evidence that it was cultivated at Harappa in the Indus Valley between 2250 and 1750 BC, and a more recent find of charred sesame seeds in Miri Qalat and Shahi Tump in the Makran region of Pakistan. They regard the identification of sesame seeds in the finds from the tomb of Tutankhamen from ancient Egypt "might be true, but are in need of further verification."

## Etymology

The word *sesame* is from Latin *sesamum*, borrowed from Greek *sēsámon* "seed or fruit of the sesame plant", borrowed from Semitic (cf. Aramaic *shūmshĕmā*, Arabic *simsim*), from Late Babylonian **shawash-shammu*, itself from Assyrian *shamash-shammū*, from *shaman shammī* "plant oil".

In India, where sesame has been cultivated since the Harappan period, there are two independent names for it: Sanskrit tila [तिल] (Hindi/Urdu til [तिल, تل]) is the source of all names in North India - ex. Gujrati and Bengali it is til ( তিল). In contrast, most of the Dravidian languages in South India feature an independent name for sesame exemplified by Tamil, Malayalam and Kannada ellu [எள்ளு, എള്ള്, ಎಳ್ಳು] and Telugu "Nuvvulu"(నువ్వులు).

| | |
|---|---|
| Order: | Lamiales |
| Family: | Pedaliaceae |
| Genus: | *Sesamum* |
| Species: | ***S. indicum*** |

**Binomial name**

***Sesamum indicum***
L.

From all the 3 roots above, words with the generalized meaning “oil; liquid fat” are derived, e.g., Sanskrit taila [तैल]. Similar semantic shifts from the name of an oil crop to a general word “fat, oil” are also known for other languages, e.g., “olive” has given rise to English “oil”.

In some languages of the Middle East, sesame is named differently and evolved from Middle Persian kunjid. This has been imported into a few western languages - ex. Russian kunzhut [кунжут], Estonian kunžuut and Yiddish kunzhut [קונזשוט].

Portuguese (Brazil only) gergelim and Spanish ajonjolí (sesame seeds) and Hindi gingli [गिंगली] derive from an Arabic noun jaljala [جلجلة] “sound, echo”, referring to the rattling sound of ripe seeds within the capsule.

In southern US and the Caribbean, where the sesame seed was introduced by Slaves imported from Africa, it is also known by an African name, benne.

### Mythological background

According to Assyrian legend, when the gods met to create the world, they drank wine made from sesame seeds. In early Hindu legends, tales are told in which sesame seeds represent a symbol of immortality. " Open sesame," the famous phrase from the Arabian Nights, reflects the distinguishing feature of the sesame seed pod, which bursts open when it reaches maturity..

It is also used in Urdu literature as proverbs "*til dharnay ki jagah na hona*"; meaning by, a place so crowded that there is no room for a single seed of sesame and "*in tilon mein teil nahee*" (ان تلوں میں تیل نہیں); referred for a person who is very mean, meaning by there is no oil left in this sesame.

In recent times the seeds have become an ingredient in wiccan practices. Cunningham's Encyclopedia of Wicca in the Kitchen suggests their use to aid conception, to draw money, or for protection.

## Uses in food and cuisines


Magnified image of white sesame seeds

Sesame is grown primarily for its oil-rich seeds, which come in a variety of colors, from cream-white to charcoal-black. In general, the paler varieties of sesame seem to be more valued in the West and Middle East, while the black varieties are prized in the Far East. The small sesame seed is used whole in cooking for its rich nutty flavour (although such heating damages their healthful poly-unsaturated fats), and also yields sesame oil.

Sesame seeds are sometimes added to breads, including bagels and the tops of hamburger buns. Sesame seeds may be baked into crackers, often in the form of sticks. Sesame seeds are also sprinkled onto some sushi style foods. Whole seeds are found in many salads and baked snacks as well in Japan. Tan and black sesame seed varieties are roasted and used for making the flavoring gomashio. In Greece seeds are used in cakes, while in Togo, seeds are a main soup ingredient. The seeds are also eaten on bread in Sicily and France (called "*ficelle sésame*", sesame thread). About one-third of the sesame crop imported by the United States from Mexico is purchased by McDonald's for their sesame seed buns (The Nut Factory 1999). In Punjab province of Pakistan and Tamil Nadu state of India, a sweet ball called "*Pinni*" (پنی) in Urdu and 'Ell urundai' in Tamil, is made of its seeds mixed with sugar. Also in Tamil Nadu, 'Milakai Podi', a ground powder made of sesame and dry chili is used to enhance flavor and consumed along with other traditional foods such as idli. Sesame (benne) seed cookies and wafers, both sweet and savory, are still consumed today in places like Charleston, South Carolina - and the seeds are believed to have been brought into 17th century colonial America by West African slaves.

Ground and processed, the seeds can also be used in sweet confections. Sesame seeds can be made into a paste called tahini (used in various ways, including in hummus) and a Middle Eastern confection called halvah. In India, sections of the Middle East, and East Asia, popular treats are made from sesame mixed with honey or syrup and roasted (called *pasteli* in Greece). In Japanese cuisine *goma-dofu* (胡麻豆腐) is made from sesame paste and starch.

East Asian cuisines, like Chinese cuisine use sesame seeds and oil in some dishes, such as dim sum, sesame seed balls ( traditional Chinese: 麻 糰; pinyin: mátuăn or 煎堆; Cantonese: jin deui), and the Vietnamese *bánh rán*. Sesame flavour (through oil and roasted or raw seeds) is also very popular in Korean cuisine, used to marinate meat and vegetables. Chefs in tempura restaurants blend sesame and cottonseed oil for deep-frying. Sesame oil was the preferred cooking oil in India until the advent of groundnut (peanut) oil.

Although sesame leaves are edible as a potherb , recipes for Korean cuisine calling for "sesame leaves" are often a mistranslation, and really mean perilla .

# Nutrition and health treatments

The seeds are rich in manganese, copper, and calcium (90 mg per tablespoon for unhulled seeds, 10 mg for hulled), and contain vitamin B1 (thiamine) and vitamin E (tocopherol). They contain lignans, including unique content of sesamin, which are phytoestrogens with antioxidant and anti-cancer properties. Among edible oils from six plants, sesame oil had the highest antioxidant content. Sesame seeds also contain phytosterols associated with reduced levels of blood cholesterol, but do not contain caffeine. The nutrients of sesame seeds are better absorbed if they are ground or pulverized before consumption.

Women of ancient Babylon would eat halva, a mixture of honey and sesame seeds to prolong youth and beauty, while Roman soldiers ate the mixture for strength and energy .

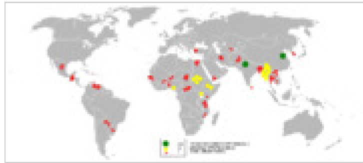
While sesame seeds are generally considered nutritious, they produce one of the uncommon food allergies, 5-13 per 100,000 .

There have been erroneous claims that sesame seeds also contain THC which may be detectable on random screening. This error stems from a misunderstanding of the commercial drug Dronabinol, a synthetic form of THC. The normal delivery mechanism for synthetic Dronabinol is via infusion into sesame oil and encapsulation into soft gelatin capsules. As a result some people are under the mistaken assumption that sesame oil naturally contains THC. In fact, THC, CBD, CBN and the other cannibinoids are unique to the *Cannabis* genus.

**Sesame oil** is used for massage and health treatments of the body in the ancient Indian ayurvedic system with the types of massage called abhyanga and shirodhara. Ayurveda views sesame oil as the most viscous of the plant oils and believes it may pacify the health problems associated with Vata aggravation.

# Cultivation

Sesame is grown in many parts of the world on over 5 million acres (20,000 $km^2$). The largest producer of the crop in 2007 was India, followed by China, Myanmar, Sudan, Ethiopia, Uganda and Nigeria. Seventy percent of the world's sesame crop is grown in Asia, with Africa growing 26%.


Sesame output in 2005

Beginning in the 1950s, U.S. production of the crop has been largely centered in Texas, with acerage fluctuating between 10,000 to 20,000 acres (40 to 80 $km^2$) in recent years. The country's crop does not make up a significant global source; indeed imports have now outstripped domestic production.

## Pests

Sesame is used as a food plant by the larvae of some Lepidoptera species, including the Turnip Moth.

# Shrimp farm

## 2008/9 Schools Wikipedia Selection. Related subjects: Agriculture


Shrimp growout pond on a farm in South Korea.

A **shrimp farm** is an aquaculture business for the cultivation of marine shrimp or prawns for human consumption. Commercial shrimp farming began in the 1970s, and production grew steeply, particularly to match the market demands of the U.S., Japan and Western Europe. The total global production of farmed shrimp reached more than 1.6 million tonnes in 2003, representing a value of nearly 9,000 million U.S. dollars. About 75% of farmed shrimp is produced in Asia, in particular in China and Thailand. The other 25% is produced mainly in Latin America, where Brazil is the largest producer. The largest exporting nation is Thailand.

Shrimp farming has changed from traditional, small-scale businesses in Southeast Asia into a global industry. Technological advances have led to growing shrimp at ever higher densities, and broodstock is shipped world-wide. Virtually all farmed shrimp are penaeids (i.e., shrimp of the family *Penaeidae*), and just two species of shrimp—the *Penaeus vannamei* (Pacific white shrimp) and the *Penaeus monodon* (giant tiger prawn)—account for roughly 80% of all farmed shrimp. These industrial monocultures are very susceptible to diseases, which have caused several regional wipe-outs of farm shrimp populations. Increasing ecological problems, repeated disease outbreaks, and pressure and criticism from both NGOs and consumer countries led to changes in the industry in the late 1990s and generally stronger regulation by governments. In 1999, a program aimed at developing and promoting more sustainable farming practices was initiated, including governmental bodies, industry representatives, and environmental organizations.

**fisheries**

**fish farming**
broodstock
fish stock
hatchery
stocking
salmon
catfish
tilapia
prawn
**shrimp**
oysters
tailwater
hirudiculture
US hatcheries

sea louse
necrosis
taura
white spot
yellowhead

## History and geography

Shrimp have been farmed for centuries in Asia, using traditional low-density methods. Indonesian brackish water ponds called *tambaks* can be traced back as far as the 15th century. Shrimp were farmed on a small scale in ponds, in monocultures or together with other species such as milkfish, or in rotation with rice, using the rice paddies for shrimp cultures during the dry season, when no rice could be grown. Such traditional cultures often were small operations in coastal areas or on river banks. Mangrove areas were favoured because of their naturally abundant supply of shrimp. Wild juvenile shrimp were trapped in ponds and reared on naturally occurring organisms in the water until they had the desired size and then were harvested.

The origins of industrial shrimp farming can be traced back to the 1930s, when Kuruma shrimp (*Penaeus japonicus*) was spawned and cultivated for the first time in Japan. By the 1960s, a small shrimp farming industry had appeared in Japan. Commercial shrimp farming began in the late 1960s and early 1970s. Technological advances led to ever more intensive forms of shrimp farming, and the growing market demand led to a proliferation of shrimp farms throughout the world, concentrated in tropical and sub-tropical regions. The growing consumer demand coincided in the early 1980s with faltering wild shrimp catches, creating a veritable boom in shrimp aquaculture. Taiwan was amongst the early adopters and a major producer in the 1980s; its production collapsed beginning in 1988 due to poor management practices and disease. In Thailand, large-scale intensive shrimp farming expanded rapidly from 1985. In South America, shrimp farming was pioneered by Ecuador, where it expanded dramatically from 1978. Brazil had been active in shrimp farming since 1974, but the trade really boomed there only in the 1990s, making the country a major producer within a few years. Today, there are marine shrimp farms in over fifty countries.

aquaculture

INDEX

# Farming methods

When shrimp farming emerged in the 1970s as an economically viable alternative to satisfy growing market demands that had surpassed the capacity of the wild shrimp fishery, the subsistence farming methods of old were rapidly replaced by the more intensive practices of an export-oriented business. Industrial shrimp farming at first followed these traditional methods with so-called extensive shrimp farms, but compensated for the low yield per area with increased pond sizes: instead of ponds of just a few hectares, ponds of sizes up to 100 ha (one km²) were used in some places. The initially largely unregulated business boomed, and in many regions whole coastlines were transformed and huge areas of mangroves cleared. Further technological advances made more intensive farming practices possible that could achieve higher yields per area while using less land. Semi-intensive and intensive farms appeared, where the shrimp were reared on artificial feeds and ponds were actively managed. Although there are still many extensive farms, new farms typically are of the (semi-)intensive kind.

Until the mid-1980s, most shrimp farms were stocked with young wild shrimp, called *postlarvae*, typically caught by local fishermen. Postlarvae fishing became an important economic sector in many countries. To counteract the beginning depletion of fishing grounds and to ensure a steady supply of young shrimp to farms, the industry started raising shrimp from the egg and maintaining adult shrimp for reproductive purposes in specialized installations called hatcheries.

## Life cycle of shrimp

Shrimp mature and breed only in a marine habitat. The females lay 50,000 to 1 million eggs, which hatch after some 24 hours into tiny nauplii. These nauplii feed on yolk reserves within their body and then undergo a metamorphosis into zoeae. This second larval stage feeds in the wild on algae and after a few days metamorphoses again into the third stage to become myses. The myses already look akin to tiny shrimp and feed on algae and zooplankton. After another three to four days they metamorphose a final time into postlarvae: young shrimp having all the characteristics of adults. The whole process takes about 12 days from hatching. In the wild, the postlarvae then migrate into estuaries, which are rich in nutrients and low in salinity. There they grow and eventually migrate back into open waters when they mature. Adult shrimp are benthic animals living primarily on the sea bottom.

A nauplius of a shrimp.

## Technologies

In shrimp farming, this lifecycle occurs under controlled conditions. The reasons to do so include more intensive farming, improved size control resulting in more uniformly sized shrimp, and better predator control, but also the ability to speed up the cycle by controlling the climate (especially in farms in the temperate zones, using greenhouses). There are three different stages:

- *Hatcheries* breed shrimp and produce nauplii or even postlarvae, which they sell to farms. Large shrimp farms maintain their own hatcheries and sell nauplii or postlarvae to smaller farms in the region.
- *Nurseries* are those parts of a shrimp farm where postlarvae are grown and accustomed to the marine conditions in the growout ponds.
- In the *growout* ponds the shrimp are grown from juveniles to marketable size, which takes between three to six months.

Most farms produce one to two harvests a year; in tropical climates, a farm may even produce three. Because of the need for salt water, shrimp farms are located on or near a coast. Inland shrimp farms have also been tried in some regions, but the need to ship salt water and competition for land with agricultural users led to problems. Thailand banned inland shrimp farms in 1999.

## Hatcheries

Small-scale hatcheries are very common throughout Southeast Asia. Often run as family businesses and using a low-technology approach, they use small tanks (less than ten tons) and often low animal densities. They are susceptible to disease, but due to their small size, they can typically restart production quickly after disinfection. The survival rate is anywhere between zero and 90%, depending on a wide range of factors, including disease, the weather, and the experience of the operator.


Tanks in a shrimp hatchery.

*Greenwater* hatcheries are medium-sized hatcheries using large tanks with low animal densities. To feed the shrimp larvae, an algal bloom is induced in the tanks. The survival rate is about 40%.

*Galveston* hatcheries (named after Galveston, Texas, where they were developed) are large-scale, industrial hatcheries using a closed and tightly controlled environment. They breed the shrimp at high densities in large (15 to 30 ton) tanks. Survival rates vary between zero and 80%, but typically achieve 50%.

In hatcheries, the developing shrimp are fed on a diet of algae and later also brine shrimp nauplii, sometimes (especially in industrial hatcheries) augmented by artificial diets. The diet of later stages also includes fresh or freeze-dried animal protein, for example krill. Nutrition and medication (such as antibiotics) fed to the brine shrimp nauplii are passed on to the shrimp that eat them.

## Nurseries

Many farms have nurseries where the postlarval shrimp are grown into juveniles for another three weeks in separate ponds, tanks, or so-called raceways. A raceway is a rectangular, long, shallow tank through which water flows continuously.

Farmers transferring postlarvae from the tanks on the truck to a growout pond.

In a typical nursery, there are 150 to 200 animals per square metre. They are fed on a high-protein diet for at most about three weeks before they are moved to the growout ponds. At that time, they weigh between one and two grams. The water salinity is adjusted gradually to that of the growout ponds.

Farmers refer to postlarvae as "PLs", with the number of days suffixed (i.e., PL-1, PL-2, etc.). They are ready to be transferred to the growout ponds after their gills have branched, which occurs around PL-13 to PL-17 (about 25 days after hatching). Nursing is not absolutely necessary, but is favored by many farms because it makes for better food utilization, improves the size uniformity, helps utilize the infrastructure better, and can be done in a controlled environment to increase the harvest. The main disadvantage of nurseries is that some of the postlarval shrimp die upon the transfer to the growout pond.

Some farms do not use a nursery but stock the postlarvae directly in the growout ponds after having acclimated them to the appropriate temperature and salinity levels in an acclimation tank. Over the course of a few days, the water in these tanks is changed gradually to match that of the growout ponds. The animal density should not exceed 500/liter for young postlarvae and 50/liter for larger ones, such as PL-15.

## Growout

In the growout phase, the shrimp are grown to maturity. The postlarvae are transferred to ponds where they are fed until they reach marketable size, which takes about another three to six months. Harvesting the shrimp is done by fishing them from the ponds using nets or by draining the ponds. Pond sizes and the level of technical infrastructure vary.

Shrimp pond with paddlewheel aerators in Indonesia. The pond is in an early stage of cultivation; plankton has been seeded and grown (whence the greenish colour of the water); shrimp fry is to be released next.

Extensive shrimp farms using traditional low-density methods are invariably located on a coast and often in mangrove areas. The ponds range from just a few to more than 100 hectares; shrimp are stocked at low densities (2–3 animals per square metre, or 25,000/ha). The tides provide for some water exchange, and the shrimp feed on naturally occurring organisms. In some areas, farmers even grow wild shrimp by just opening the gates and impounding wild larvae. Prevalent in poorer or less developed countries where land prices are low, extensive farms produce annual yields from 50 to 500 kg/ha of shrimp (head-on weight). They have low production costs (US$1–3/kg live shrimp), are not very labor intensive, and do not require advanced technical skills.

Semi-intensive farms do not rely on tides for water exchange but use pumps and a planned pond layout. They can therefore be built above the high tide line. Pond sizes range from 2 to 30 ha; the stocking densities range from 10 to 30/m² (100,000–300,000/ha). At such densities, artificial feeding using industrially prepared shrimp feeds and fertilizing the pond to stimulate the growth of naturally occurring organisms become a necessity. Annual yields range from 500 to 5,000 kg/ha, while production costs are in the range of US$2–6/kg live shrimp. With densities above 15 animals per square metre, aeration is often required to prevent oxygen depletion. Productivity varies depending upon water temperature, thus it is common to have larger sized shrimp in some seasons than in others.

A one- horsepower paddlewheel aerator. The splashing may increase the evaporation rate of the water and thus increase the salinity of the pond.

Intensive farms use even smaller ponds (0.1–1.5 ha) and even higher stocking densities. The ponds are actively managed: they are aerated, there is a high water exchange to remove waste products and maintain water quality, and the shrimp are fed on specially designed diets, typically in the form of formulated pellets. Such farms produce annual yields between 5,000 and 20,000 kg/ha; a few super-intensive farms can produce as much as 100,000 kg/ha. They require an advanced technical infrastructure and highly trained professionals for constant monitoring of water quality and other pond conditions; their production costs are in the range of US$4–8/kg live shrimp.

Estimates on the production characteristics of shrimp farms vary. Most studies agree that about 55–60% of all shrimp farms worldwide are extensive farms, another 25–30% are semi-intensive, the rest being intensive farms. Regional variation is high, though, and [Tacon (2002)] reports wide discrepancies in the percentages claimed for individual countries by different studies.

The intake of a two-horsepower "Turbo aerator", which paddles one metre below the water surface. To avoid stirring up pond sediments, the water depth should be at least 1.5 m.

### Feeding the shrimps

While extensive farms mainly rely on the natural productivity of the ponds, more intensively managed farms rely on artificial shrimp feeds, either exclusively or as a supplement to the organisms that naturally occur in a pond. A food chain is established in the ponds, based on the growth of phytoplankton. Fertilizers and mineral conditioners are used to boost the growth of the phytoplankton to accelerate the growth of the shrimps. Waste from the artificial food pellets and excrements of the shrimps can lead to the eutrophication of the ponds.

Artificial feeds come in the form of specially formulated, granulated pellets that disintegrate quickly. Up to 70% of such pellets are wasted, as they decay before the shrimps have eaten them. The shrimps are fed two to five times daily; the feeding can be done manually either from ashore or from boats, or using mechanized feeders distributed all over a pond. The feed conversion rate (FCR), i.e. the amount of food needed to produce a unit (e.g. one kilogram) of shrimp, is claimed by the industry to be around 1.2–2 in modern farms, but this is an optimum value that is not always attained in practice. For a farm to be profitable, a feed conversion rate below 2.5 is necessary; in older farms or under suboptimal pond conditions, the ratio may easily rise to 4:1. Lower FCRs result in a higher profit for the farm.

## Farmed species

Although there are many species of shrimp and prawn, only a few of the larger ones are actually cultivated, all of which belong to the family of penaeids ( family Penaeidae), and within it to the genus *Penaeus*. Many species are unsuitable for farming: they are too small to be profitable, or simply stop growing when crowded together, or are too susceptible to diseases. The two species dominating the market are:

- Pacific white shrimp (*Litopenaeus vannamei*, also called "whiteleg shrimp") is the main species cultivated in western countries. Native to the Pacific coast from Mexico to Peru, it grows to a size of 23 cm. *P. vannamei* accounts for 95% of the production in Latin America. It is easy to breed in captivity, but succumbs to the Taura disease.
- Giant tiger prawn (*P. monodon*, also known as "black tiger shrimp") occurs in the wild in the Indian Ocean and in the Pacific Ocean from Japan to Australia. The largest of all the cultivated shrimp, it can grow to a length of 36 cm and is farmed in Asia. Because of its susceptibility to whitespot disease and the difficulty of breeding it in captivity, it is gradually being replaced by *L. vannamei* since 2001.

Together, these two species account for about 80% of the whole farmed shrimp production. Other species being bred are:

- Western blue shrimp (*P. stylirostris*) was a popular choice for shrimp farming in the western hemisphere, until the IHHN virus wiped out nearly the whole population in the late 1980s. A few stocks survived and became resistant against this virus. When it was discovered that some of these were also resistant against the Taura virus, some farms again bred *P. stylirostris* from 1997 on.
- Chinese white shrimp (*P. chinensis*, also known as the *fleshy prawn*) occurs along the coast of China and the western coast of Korea and is being farmed in China. It grows to a maximum length of only 18 cm, but tolerates colder water (min. 16 ° C). Once a major factor on the world market, it is today used almost exclusively for the Chinese domestic market after a disease wiped out nearly all the stocks in 1993.
- Kuruma shrimp (*P. japonicus*) is farmed primarily in Japan and Taiwan, but also in Australia; the only market is in Japan, where live Kuruma shrimp reach prices of the order of US$100 per pound ($220/kg).
- Indian white shrimp (*P. indicus*) is a native of the coasts of the Indian Ocean and is widely bred in India, Iran and the Middle East and along the African shores.
- Banana shrimp (*P. merguiensis*) is another cultured species from the coastal waters of the Indian Ocean, from Oman to Indonesia and Australia. It can be grown at high densities.


Kuruma shrimp in an aquaculture observation tank in Taiwan.

Several other species of *Penaeus* play only a very minor role in shrimp farming. Some other kinds of shrimp also can be farmed, e.g. the "Akiami paste shrimp" or *Metapenaeus spp.* Their total production from aquaculture is of the order of only about 25,000 tonnes per year, small in comparison to that of the penaeids.

# Diseases

There are a variety of lethal viral diseases that affect shrimp. In the densely populated, monocultural farms such virus infections spread rapidly and may wipe out whole shrimp populations. A major transfer vector of many of these viruses is the water itself; and thus any virus outbreak also carries the danger of decimating shrimp living in the wild.

Yellowhead disease, called *Hua leung* in Thai, affects *P. monodon* throughout Southeast Asia. It had been reported first in Thailand in 1990. The disease is highly contagious and leads to mass mortality within 2 to 4 days. The cephalothorax of an infected shrimp turns yellow after a period of unusually high feeding activity ending abruptly, and the then moribund shrimp congregate near the surface of their pond before dying.

Whitespot syndrome is a disease caused by a family of related viruses. First reported in 1993 from Japanese *P. japonicus* cultures, it spread throughout Asia and then to the Americas. It has a wide host range and is highly lethal, leading to mortality rates of 100% within days. Symptoms include white spots on the carapace and a red hepatopancreas. Infected shrimp become lethargic before they die.

Taura syndrome was first reported from shrimp farms on the Taura river in Ecuador in 1992. The host of the virus causing the disease is *P. vannamei*, one of the two most commonly farmed shrimp. The disease spread rapidly, mainly through the shipping of infected animals and broodstock. Originally confined to farms in the Americas, it has also been propagated to Asian shrimp farms with the introduction of *P. vannamei* there. Birds are thought to be a route of infection between farms within one region.

Infectious Hypodermal and Hematopoietic Necrosis (IHHN) is a disease that causes mass mortality among *P. stylirostris* (as high as 90%) and severe deformations in *P. vannamei*. It occurs in Pacific farmed and wild shrimp, but not in wild shrimp on the Atlantic coast of the Americas.

There are also a number of bacterial infections that are lethal to shrimp. The most common is vibriosis, caused by the bacterium *Vibrio spp.* The shrimp become weak and disoriented and may have dark wounds on the cuticle. The mortality rate can exceed 70%. Another bacterial disease is Necrotising hepatopancreatitis (NHP); symptoms include a soft exoskeleton and fouling. Most such bacterial infections are strongly correlated to stressful conditions such as overcrowded ponds, high temperatures, and poor water quality: factors that positively influence the growth of bacteria. Treatment is done using antibiotics. Importing countries have repeatedly placed import bans on shrimp containing various antibiotics. One such antibiotic is chloramphenicol, which has been banned in the European Union since 1994, but continues to pose problems.

With their high mortality rates, diseases represent a very real danger to shrimp farmers, who may lose their income for the whole year if their ponds are infected. Since most diseases cannot yet be treated effectively, the industry's efforts are focused on preventing diseases to break out in the first place. Active water quality management helps avoid poor pond conditions favourable to the spread of diseases, and instead of using larvae from wild catches, specific pathogen free broodstocks raised in captivity in isolated environments and certified not to carry diseases are used increasingly. To avoid introducing diseases into such disease-free populations on a farm, there is also a trend to create more controlled environments in the ponds of (semi-)intensive farms, such as by lining them with plastic to avoid soil contact, and by minimizing water exchange in the ponds.

# Economy

The total global production of farmed shrimp reached more than 1.6 million tonnes in 2003, representing a farm-gate value of nearly 9 billion U.S. dollars. This accounts for 25% of the total shrimp production that year (farming and wild catches combined). The largest market for shrimp is the United States, importing more than 500,000 tonnes of shrimp in 2003. About 250,000 tonnes went to Japan, while the four major European shrimp importing countries (France, Spain, the UK, and Italy) imported together about another 500,000 tonnes.

The import prices for shrimp fluctuate wildly. In 2003 the import price per kilogram shrimp in the United States was US$ 8.80, slightly higher than in Japan at US$8.–. The average import price in the EU was only about US$5.–/kg; this much lower value is explained by the fact that the EU imports more coldwater shrimp (from catches) that are much smaller than the farmed warm water species and thus attain lower prices. In addition, Mediterranean Europe prefers head-on shrimp which weigh approximately 30% more but have a lower unit price.

About 75% of the world production of farmed shrimp comes from Asian countries; the two leading nations being China and Thailand, closely followed by Vietnam, Indonesia, and India. The other 25% are produced in the western hemisphere, where the South-American countries (Brazil, Ecuador, Mexico) dominate. In terms of export, Thailand is by far the leading nation with a market share of more than 30%, followed by China, Indonesia, and India, accounting each for about 10%. Other major export nations are Vietnam, Bangladesh, and Ecuador. Thailand exports nearly all of its production, while China uses most of its shrimp in the domestic market. The only other major export nation that has a strong domestic market for farmed shrimp is Mexico.

| Region | Country | Production in 1,000 tonnes per year, rounded | | | | | | | | | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | 1985 | 86 | 87 | 88 | 89 | 1990 | 91 | 92 | 93 | 94 | 95 | 96 | 97 | 98 | 99 | 2000 | 01 | 02 | 03 | 04 | 05 | 06 |
| **Asia** | *China* | *40* | *83* | *153* | *199* | *186* | *185* | *220* | *207* | ***88*** | *64* | *78* | *89* | *103* | *143* | *170* | *218* | *304* | *384* | 789 | 935 | 1'025 | 1'242 |
| | Thailand | 10 | 12 | 19 | 50 | 90 | 115 | 161 | 185 | 223 | 264 | 259 | **238** | 225 | 250 | 274 | 309 | 279 | 264 | 330 | 360 | 401 | 501 |
| | Vietnam | *8* | *13* | *19* | 27 | 28 | 32 | 36 | 37 | 39 | 45 | 55 | 46 | 45 | 52 | 55 | 90 | 150 | *181* | *232* | *276* | *327* | *349* |
| | Indonesia | 25 | 29 | 42 | 62 | 82 | 84 | 116 | 120 | 117 | 107 | 121 | 125 | 127 | 97 | 121 | 118 | 129 | 137 | 168 | 218 | 266 | 326 |
| | India | *13* | *14* | *15* | *20* | *28* | *35* | *40* | *47* | *62* | *83* | *70* | *70* | 67 | 83 | 79 | 97 | 103 | 115 | 113 | 118 | 131 | 132 |
| | Bangladesh | 11 | 15 | 15 | 17 | 18 | 19 | 20 | 21 | 28 | 29 | 32 | 42 | 48 | 56 | 58 | 59 | 55 | 56 | 56 | 58 | 63 | 65 |
| | Philippines | 29 | 30 | 35 | 44 | 47 | 48 | 47 | 77 | 86 | 91 | 89 | 77 | **41** | 38 | 39 | 41 | 42 | 37 | 37 | 37 | 39 | 40 |
| | Myanmar | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 1 | 2 | 2 | 2 | 5 | 5 | 6 | *7* | *19* | *30* | *49* | *60* |
| | Taiwan | 17 | 45 | 80 | **34** | 22 | 15 | 22 | 16 | 10 | 8 | 11 | 13 | 6 | 5 | 5 | 6 | 8 | 10 | 10 | 8 | 8 | 7 |
| **Americas** | Brazil | *<1* | *<1* | *<1* | *<1* | *1* | *2* | *2* | *2* | *2* | *2* | 2 | 3 | 4 | 7 | 16 | 25 | *40* | *60* | 90 | 76 | 63 | *65* |
| | Ecuador | 30 | 44 | 69 | 74 | 70 | 76 | 105 | 113 | **83** | 89 | 106 | 108 | 133 | 144 | 120 | **50** | *45* | *47* | *56* | *56* | *56* | *56* |
| | Mexico | <1 | <1 | <1 | <1 | 3 | 4 | 5 | 8 | 12 | 13 | 16 | 13 | 17 | 24 | 29 | 33 | 48 | 46 | 46 | 62 | 90 | 112 |
| | U.S. | <1 | <1 | 1 | 1 | <1 | <1 | *2* | *2* | *3* | *2* | *1* | *1* | *1* | *2* | 2 | 2 | 3 | 4 | 5 | 5 | 4 | 4 |
| **Middle East** | Saudi Arabia | 0 | 0 | 0 | 0 | <1 | <1 | <1 | <1 | <1 | <1 | <1 | <1 | 1 | 2 | 2 | 2 | 4 | 5 | 9 | 9 | 11 | 12 |
| | Iran | 0 | 0 | 0 | 0 | 0 | 0 | 0 | <1 | <1 | <1 | <1 | <1 | <1 | 1 | 2 | 4 | 8 | 6 | 7 | 9 | 4 | 6 |
| **Oceania** | Australia | 0 | <1 | <1 | <1 | <1 | <1 | <1 | <1 | 1 | 2 | 2 | 2 | 1 | 1 | 2 | 3 | 3 | 4 | 3 | 4 | 3 | 4 |
| Entries in *italics* indicate gross estimates in the FAO databases. Bolded numbers indicate some recognizable disease events. | | | | | | | | | | | | | | | | | | | | | | | |

**Aquaculture shrimp production by the major producer nations.**

From top to bottom: pieces of the carapace of *Litopenaeus vannamei*; a harvested healthy *L. vannamei* of size 66 (17 g); a dead *L. vannamei* infected by the Taura syndrome virus (TSV). The color of healthy shrimp is determined by the color of the plankton, the type of soil at the pond bottom, and the additional nutrients used. The white colour of the shrimp at the bottom is due to the TSV infection.

Disease problems have repeatedly impacted the shrimp production negatively. Besides the near-wipeout of *P. chinensis* in 1993, there were outbreaks of viral diseases that led to marked declines in the per-country production in 1996/97 in Thailand and repeatedly in Ecuador. In Ecuador alone, production suffered heavily in 1989 (IHHN), 1993 (Taura), and 1999 (whitespot). Another reason for sometimes wild changes in shrimp farm output are the import regulations of the destination countries, which do not allow shrimp contaminated by chemicals or antibiotics to be imported.

In the 1980s and through much of the 1990s, shrimp farming promised high profits. The investments required for extensive farms were low, especially in regions with low land prices and wages. For many tropical countries, especially those with poorer economies, shrimp farming was an attractive business, offering jobs and incomes for poor coastal populations and has, due to the high market prices of shrimp, provided many developing countries with non-negligible foreign currency earnings. Many shrimp farms were funded initially by the World Bank or substantially subsidized by local governments.

In the late 1990s, the economic situation changed. Governments and farmers alike were under increasing pressure from NGOs and the consumer countries, who criticized the practices of the trade. International trade conflicts erupted, such as import bans by consumer countries on shrimp containing antibiotics, the United States' shrimp import ban against Thailand in 2004 as a measure against Thai shrimp *fishers* not using Turtle Excluder Devices in their nets, or the "anti- dumping" case initiated by U.S. shrimp fishers in 2002 against shrimp farmers world-wide, which resulted two years later in the U.S. imposing anti-dumping tariffs of the order of about 10% against many producer countries (except China, which received a 112% duty). Diseases caused significant economic losses. In Ecuador, where shrimp farming was a major export sector (the other two are Bananas and Oil), the whitespot outbreak of 1999 caused an estimated 130,000 workers to lose their jobs. Furthermore, shrimp prices dropped sharply in 2000. All of these factors contributed to the slowly growing acceptance by farmers that improved farming practices were needed, and resulted in tighter government regulation of the business, both of which internalized some of the external costs that were ignored during the boom years.

## Socio-economic aspects

Shrimp farming offers significant employment opportunities, which may help alleviate the poverty of the local coastal populations in many areas, if it is properly managed. The published literature on that topic shows large discrepancies, and much of the available data is of anecdotal nature. Estimates of the labor-intensiveness of shrimp farms range from about three times less to three times more than when the same area was used for rice paddies, with much regional variation and depending on the type of farms surveyed. In general, intensive shrimp farming requires more labour per unit area than extensive farming. Extensive farms cover much more land area and are often but not always located in areas where no agricultural land uses are possible. Supporting industries such as feed production or storage, handling, and trade companies should also not be neglected, even if not all of them are exclusive to shrimp farming.

Typically, workers on a shrimp farm can get better wages than with other employments. A global estimate from one study is that a shrimp farm worker can earn 1.5 – 3 times as much as in other jobs; a study from India arrived at a salary increase of about 1.6, and a report from Mexico states that the lowest paid job at shrimp farms was paid in 1996 at 1.22 times the average worker salary in the country.

NGOs have frequently criticized that most of the profits went to large conglomerates instead of to the local population. While this may be true in certain regions such as Ecuador, where most shrimp farms are owned by large companies, it does not apply in all cases. For instance in Thailand, most farms are owned by small local entrepreneurs, although there is a trend to vertically integrate the industries related to shrimp farming from feed producers to food processors and trade companies. A 1994 study reported that a farmer in Thailand could increase his income by a factor of ten by switching from growing rice to farming shrimp. An Indian study from 2003 arrives at similar figures for shrimp farming in the East Godavari district in Andhra Pradesh.

Whether the local population benefits from shrimp farming is also dependent on the availability of sufficiently trained people. Extensive farms tend to offer mainly seasonal jobs during harvest that do not require much training. In Ecuador, many of these positions are known to have been filled by migrant workers. More intensive farms have a need for year-round labour in more sophisticated jobs.

### Marketing

For commercialization, shrimps are graded and marketed in different categories. From complete shrimps (known as "head-on, shell-on" or HOSO) to peeled and deveined (P&D), any presentation is available in stores. The animals are graded by their size uniformity and then also by their count per weight unit, with larger shrimps attaining higher prices.

## Ecological impacts

Mangrove estuaries provide a habitat for many animals and plants.

Shrimp farms of all types, from extensive to super-intensive, can cause severe ecological problems wherever they are located. For extensive farms, huge areas of mangroves were cleared, reducing biodiversity. During the 1980s and 1990s, about 35% of the world's mangrove forests have vanished. Shrimp farming was a major cause of this, accounting for over a third of it according to one study; other studies report between 5% and 10% globally, with enormous regional variability. Other causes of mangrove destruction are population pressure, logging, pollution from other industries, or conversion to other uses such as salt pans. Mangroves, through their roots, help stabilize a coastline and capture sediments; their removal has led to a marked increase of erosion and less protection against floods. Mangrove estuaries are also especially rich and productive ecosystems and provide the spawning grounds for many species of fish, including many commercially important ones. Many countries have protected their mangroves and forbidden the construction of new shrimp farms in tidal or mangrove areas. The enforcement of the respective laws is often problematic, though, and especially in the least developed countries such as Bangladesh, Myanmar, or Vietnam the conversion of mangroves to shrimp farms remains an issue.


Two false-colour images show the widespread conversion of natural mangrove swamps to shrimp farms along Pacific Coast of Honduras between 1987 and 1999. The shrimp farms appear as rows of rectangles. In the older image (bottom), mangrove swamps wander through the estuaries of several rivers as they reach the Pacific coast. At least one major shrimp farm can be seen in this scene in the upper left quadrant, verifying that shrimp farming was already underway at the time. By 1999 (top image), much of the region had been converted to blocks of shrimp ponds.

Intensive farms, while reducing the direct impact on the mangroves, have other problems. Their nutrient-rich effluents (industrial shrimp feeds disintegrate quickly, as little as 30% are actually eaten by the shrimp with a corresponding economic loss to the farmer, the rest is wasted) are typically discharged into the environment, seriously upsetting the ecological balance. These waste waters contain significant amounts of chemical fertilizers, pesticides, and antibiotics that cause pollution of the environment. Furthermore, releasing antibiotics in such ways injects them into the food chain and increases the risks of bacteria becoming resistant against them. However, most aquatic bacteria, unlike bacteria associated with terrestrial animals, are not zoonotic. Only a few disease transfers from animals to humans have been reported.

Prolonged use of a pond can lead to an incremental build-up of a sludge at the pond's bottom from waste products and excrements. The sludge can be removed mechanically or dried and plowed to allow bio-decomposition, at least in areas without acid problems. Flushing a pond never completely removes this sludge, and eventually, the pond is abandoned, leaving behind a wasteland with the soil made unusable for any other purposes due to the high levels of salinity, acidity, and toxic chemicals. A typical pond in an extensive farm can be used only a few years. An Indian study estimated the time to rehabilitate such lands to about 30 years. Thailand has banned inland shrimp farms since 1999 because they caused too much destruction of agricultural lands due to salination. A Thai study estimated that 60% of the shrimp farming area in Thailand was abandoned in the years 1989 – 1996. Much of these problems stem from using mangrove land that has high natural pyrite content ( acid sulfate soil) and poor drainage. The shift to semi-intensive farming requires higher elevations for drain harvesting and low sulfide (pyrite) content to prevent acid formation when the soils shift from anaerobic to aerobic conditions.

A toxic sludge oozing out of the bottom of a shrimp pond of a farm in Indonesia after the harvest. The liquid pictured here contained sulfuric acid resulting from oxidation of pyrite contained in the soil. Such contamination of a pond leads to stunted growth of the shrimp and increased mortality rates; the growth of the plankton is reduced drastically. Liming can be applied to counteract to some extent the acidification of the water in ponds on acid sulfate soil, such as mangrove soils.

The global nature of the shrimp farming business and in particular the shipment of broodstock and hatchery products throughout the world have not only introduced various shrimp species as exotic species, but also distributed the diseases the shrimp may carry world-wide. As a consequence, most broodstock shipment require health certificates and/or to be SPF (specific pathogen free) status. Many organizations lobby actively for consumers to avoid buying farmed shrimp; some also advocate the development of more sustainable farming methods. A joint programme of the World Bank, the Network of Aquaculture Centres in Asia-Pacific (NACA), the WWF, and the FAO was established in August 1999 to study and propose improved practices for shrimp farming. Some existing attempts at sustainable export-oriented shrimp farming marketing the shrimp as "ecologically produced" are criticized by NGOs as being dishonest and trivial window-dressing.

Yet the industry has been slowly changing since about 1999. It has adopted the "best management practices" developed by e.g. the World Bank *et al.* programme and instituted educational programmes to promote them. Due to the mangrove protection laws enacted in many countries, new farms are usually of the (semi-)intensive kind, which are best constructed outside of mangrove areas anyway. There is a trend to create even more tightly controlled environments in these farms with the hope to achieve better disease prevention. Waste water treatment has attracted considerable attention; modern shrimp farms routinely have effluent treatment ponds where sediments are allowed to settle at the bottom and other residuals are filtered. As such improvements are costly, the World Bank *et al.* programme also recommends low-intensity polyculture farming for some areas. Since it has been discovered that mangrove soils are effective in filtering waste waters and tolerate high nitrate levels, the industry has also developed an interest in mangrove reforestation, although its contributions in that area are still minor. The long-term effects of these recommendations and industry trends cannot be evaluated conclusively yet.

## Social changes

Shrimp farming in many cases has far-reaching effects on the local coastal population. Especially in the boom years of the 1980s and 1990s, when the business was largely unregulated in many countries, the very fast expansion of the industry caused significant changes that sometimes were detrimental to the local population. Conflicts can be traced back to two root causes: competition for common resources such as land and water, and changes induced by wealth redistribution.

A significant problem causing much conflict in some regions, for instance in Bangladesh, are the land use rights. With shrimp farming, a new industry expanded into coastal areas and started to make exclusive use of previously public resources. In some areas, the rapid expansion resulted in the local coastal population being denied access to the coast by a continuous strip of shrimp farms with serious impacts on the local fisheries. Such problems were compounded by poor ecological practices that caused a degradation of common resources (such as excessive use of freshwater to control the salinity of the ponds, causing the water table to sink and leading to the salination of freshwater aquifers by an inflow of salt water). With growing experience, countries usually introduced stronger governmental regulations and have taken steps to mitigate such problems, for instance through land zoning legislations. Some late adopters have even managed to avoid some problems through proactive legislation, e.g. Mexico. The situation in Mexico is unique owing to the strongly government-regulated market. Even after the liberalisation in the early 1990s, most shrimp farms are still owned and controlled by locals or local co-ops ( ejidos).

Social tensions have occurred due to changes in the wealth distribution within populations. The effects of this are mixed, though, and the problems are not unique to shrimp farming. Changes in the distribution of wealth tend to induce changes in the power structure within a community. In some cases, there is a widening gap between the general population and local élites who have easier access to credits, subsidies, and permits and thus are more likely to become shrimp farmers and benefit more. In Bangladesh, on the other hand, local élites were opposing shrimp farming, which was controlled largely by an urban élite. Land concentrations in a few hands has been recognized to carry an increased risk of social and economic problems developing, especially if the landowners are non-local.

In general, it has been found that shrimp farming is accepted best and introduced most easily and with the greatest benefits for the local communities if the farms are owned by local people instead of by restricted remote élites or large companies because local owners have a direct interest in maintaining the environment and good relations with their neighbors, and because it avoids the formation of large-scale land property.

# Soil biology

## 2008/9 Schools Wikipedia Selection. Related subjects: Agriculture; Environment

**Soil biology** is the study of microbial and faunal activity and ecology in soil. These organisms include earthworms, nematodes, protozoa, fungi and bacteria. Soil biology plays a vital role in determining many soil characteristics yet, being a relatively new science, much remains unknown about soil biology and about how the nature of soil is affected.

## Overview

The soil is home to a large proportion of the world's genetic diversity. The linkages between soil organisms and soil functions are observed to be incredibly complex. The interconnectedness and complexity of this soil 'food web' means any appraisal of soil function must necessarily take into account interactions with the living communities that exist within the soil. We know that soil organisms break down organic matter, making nutrients available for uptake by plants and other organisms. The nutrients stored in the bodies of soil organisms prevent nutrient loss by leaching. Microbial exudates act to maintain soil structure, and earthworms are important in bioturbation. However, we find that we don't understand critical aspects about how these populations function and interact. The discovery of glomalin in 1995 indicates that we lack the knowledge to correctly answer some of the most basic questions about the biogeochemical cycle in soils. We have much work ahead to gain a better understanding of how soil biological components affect us and the planet they share with us.

## Scope

Soil biology involves work in the following areas:

- Modelling of biological processes and population dynamics.
- Soil biology, physics and chemistry: occurrence of physicochemical parameters and surface properties on biological processes and population behaviour.
- Population biology and molecular ecology: methodological development and contribution to study microbial and faunal populations; diversity and population dynamics; genetic transfers, influence of environmental factors.
- Community ecology and functioning processes: interactions between organisms and mineral or organic compounds; involvement of such interactions in soil pathogenicity; transformation of mineral and organic compounds, cycling of elements; soil structuration

Complementary disciplinary approaches are necessarily utilized which involve molecular biology, genetics, ecophysiology, biogeography, ecology, soil processes, organic matter, nutrient dynamics and landscape ecology.

# Soil classification

## 2008/9 Schools Wikipedia Selection. Related subjects: Agriculture; Geology and geophysics


Soil types

**Soil classification** deals with the systematic categorization of soils based on distinguishing characteristics as well as criteria that dictate choices in use.

## Overview

Soil classification is a dynamic subject, from the structure of the system itself, to the definitions of classes, and finally in the application in the field. Soil classification can be approached from the pespective of soil as a material and soil as a resource.

## Types by discipline

### Engineering

Engineers, typically Geotechnical engineers, classify soils according to their engineering properties as they relate to use for foundation support or building material. Modern engineering classification systems are designed to allow an easy transition from field observations to basic predictions of soil engineering properties and behaviors.

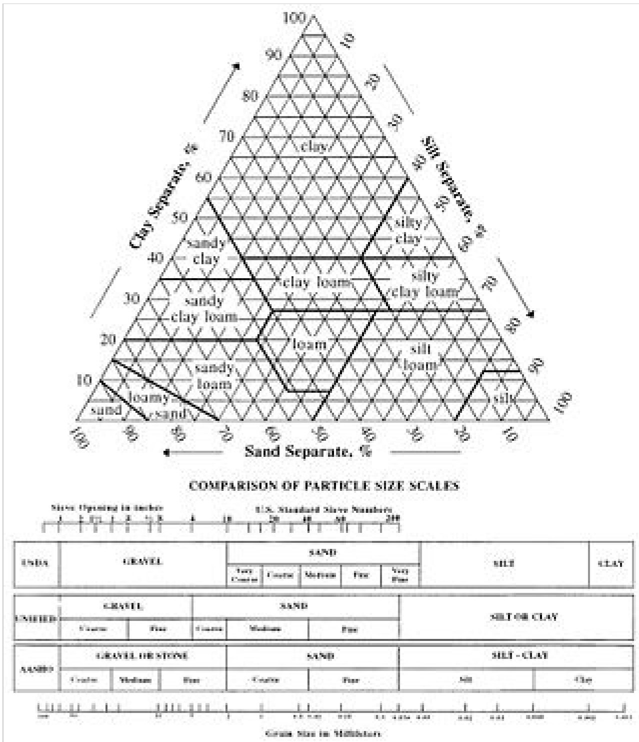
The most common engineering classification system for soils in North America is the Unified Soil Classification System (USCS). The USCS has three major classification groups: (1) coarse-grained soils (e.g. sands and gravels); (2) fine-grained soils (e.g. silts and clays); and (3) highly organic soils (referred to as " peat"). The USCS further subdivides the three major soil classes for clarification.

Other engineering soil classification systems in the States include the AASHTO Soil Classification System and the Modified Burmeister.

A full geotechnical engineering soil description will also include other properties of the soil including colour, in-situ moisture content, in-situ strength, and somewhat more detail about the material properties of the soil than is provided by the USCS code.

### Soil science

For soil resources, experience has shown that a natural system approach to classification, i.e. grouping soils by their intrinsic property ( soil morphology), behaviour, or genesis, results in classes that can be interpreted for many diverse uses. Differing concepts of pedogenesis, and differences in the significance of morphological features to various land uses can affect the classification approach. Despite these differences, in a well-constructed system, classification criteria group similar concepts so that interpretations do not vary widely. This is in contrast to a technical system approach to soil classification, where soils are grouped according to their fitness for a specific use and their edaphic characteristics.



USDA soil classification system based on grain size

Natural system approaches to soil classification, such as the French Soil Reference System (Référentiel pédologique français) are based on presumed soil genesis. Systems have developed, such as USDA soil taxonomy and the World Reference Base for Soil Resources, which use taxonomic criteria involving soil morphology and laboratory tests to inform and refine hierarchical classes.

Another approach is numerical classification, also called ordination, where soil individuals are grouped by multivariate statistical methods such as cluster analysis. This produces natural groupings without requiring any inference about soil genesis.

In soil survey, as practiced in the United States, soil classification usually means criteria based on soil morphology in addition to characteristics developed during soil formation. Criteria are designed to guide choices in land use and soil management. As indicated, this is a hierarchical system that is a hybrid of both *natural* and objective criteria. USDA soil taxonomy provides the core criteria for differentiating soil map units. This is a substantial revision of the 1938 USDA soil taxonomy which was a strictly natural system. Soil taxonomy based soil map units are additionally sorted into classes based on technical classification systems. Land Capability Classes, hydric soil, and prime farmland are some examples.

In addition to scientific soil classification systems, there are also vernacular soil classification systems. Folk taxonomies have been used for millennia, while scientifically based systems are relatively recent developments.

# Sugar beet

2008/9 Schools Wikipedia Selection. Related subjects: Agriculture; Plants

**Sugar beet** (*Beta vulgaris* L.), a member of the *Chenopodiaceae* family, is a plant whose root contains a high concentration of sucrose. It is grown commercially for sugar.

The sugar beet is directly related to the beetroot, chard and fodder beet, all descended by cultivation from the sea beet.

The European Union, the United States, and Russia are the world's three largest sugar beet producers, although only the European Union and Ukraine are significant exporters of sugar from beet. Beet sugar accounts for 30% of the world's sugar production.

In the United States, genetically modified sugar beets resistant to glyphosate, (marketed by Monsanto as Roundup) a herbicide, are slated to be planted for the first time in the spring of 2008. Sugar from the biotechnology-enhanced sugarbeet has been approved for human and animal consumption in the European Union. This action by the EU executive body allows unrestricted imports of food and feed products made from (H7-1) glyphosate-tolerant (Roundup Ready) sugarbeets.

**Sugar beet**

Two sugar beets - the one on the left has been selectively bred to be smoother than the traditional beet, so that it traps less soil.

**Scientific classification**

| | |
|---|---|
| Kingdom: | Plantae |
| Division: | Magnoliophyta |
| Class: | Magnoliopsida |

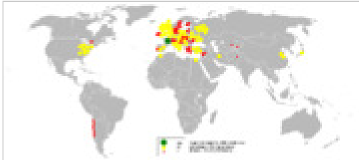
## Culture

Sugar beet is a hardy biennial plant that can be grown commercially in a wide variety of temperate climates. During its first growing season, it produces a large (1–2 kg) storage root whose dry mass is 15–20% sucrose by weight. If not harvested, during its second growing season, the nutrients in this root are consumed to produce the plant's flowers and seeds. In commercial beet production, the root is harvested after the first growing season, when the root is at its maximum size.

| | |
|---|---|
| Order: | Caryophyllales |
| Family: | Amaranthaceae |
| Subfamily: | Chenopodiaceae |
| Genus: | *Beta* |
| Species: | ***B. vulgaris*** |

**Binomial name**

***Beta vulgaris***
L.



Sugar beet output in 2005

In most temperate climates, beets are planted in the spring and harvested in the autumn. At the northern end of its range, growing seasons as short as 100 days can produce commercially viable sugarbeet crops. In warmer climates, such as in California's Imperial Valley, sugarbeets are a winter crop, being planted in the autumn and harvested in the spring. In recent years, Syngenta AG has developed the so-called tropical sugar beet. It allows the plant to grow in tropical and subtropical regions. Beets are planted from a small seed; 1 kg of beet seed comprises 100,000 seeds and will plant over a hectare of ground (1 lb will plant about an acre).

Up until the latter half of the 20th century, sugarbeet production was highly labor-intensive, as weed control was managed by densely planting the crop, which then had to be manually thinned with a hoe two or even three times during the growing season. Harvesting also required many workers. Although the roots could be lifted by a plough-like device which could be pulled by a horse team, the rest of the preparation was by hand. One laborer grabbed the beets by their leaves, knocked them together to shake free loose soil, and then laid them in a row, root to one side, greens to the other. A second worker equipped with a beet hook (a short handled tool something between a billhook and a sickle) followed behind, and would lift the beet and swiftly chop the crown and leaves from the root with a single action. Working this way he would leave a row of beet that could then be forked into the back of a cart.

| Top Ten Sugar Beet Producers - 2005 (million metric ton) | |
|---|---|
| France | 29 |
| Germany | 25 |
| United States | 25 |
| Russia | 22 |
| Ukraine | 16 |
| Turkey | 14 |
| Italy | 12 |
| Poland | 11 |
| United Kingdom | 8 |
| Spain | 7 |
| **World Total** | **242** |

Today, mechanical sowing, herbicide application for weed control and mechanical harvesting has removed this reliance on workers.

A beet harvester

Harvesting is now entirely mechanical. The beet harvester chops the leaf and crown (which is high in non-sugar impurities) from the root, lifts the root, and removes excess soil from the root in a single pass over the field. A modern harvester is typically able to cover six rows at the same time. The beet is left in piles at the side of the field and then conveyed into a trailer for delivery to the factory. The conveyor removes more soil -a farmer would be penalized at the factory for excess soil in his load.

If beet is to be left for later delivery, it is formed into clamps. Straw bales are used to shield the beet from the weather. Provided the clamp is well built with the right amount of ventilation, the beet does not significantly deteriorate. Beet that is frozen and then defrosts, produce complex carbohydrates that cause severe production problems in the factory. In the UK, loads may be hand examined at the factory gate before being accepted.

In the US, the fall harvest begins with the first hard frost, which arrests photosynthesis and the further growth of the root. Depending on the local climate, it may be carried out in few weeks or be prolonged throughout the winter months. The harvest and processing of the beet is referred to as "the campaign", reflecting the organization required to deliver crop at a steady rate to processing factories that run 24 hours a day for the

*Source:*
*UN Food & Agriculture Organisation (FAO)*

duration of the harvest and processing (for the UK the campaign lasts approx 5 months). In the Netherlands this period is known as "*de bietencampagne*", a time to be careful when driving local roads in the area the beets are grown. The reason for this is the naturally high clay content of the soil, causing slippery roads when soil falls from the trailers during transport.

Sebewaing, Michigan is known as the sugar beet capital of the world. Sebewaing lies in the Thumb region of Michigan, both the region and state are major sugar beet producers. Sebewaing is home to one of three other Michigan Sugar Company factories, and is home to the "Michigan Sugar Festival".

# Processing

## Reception

After harvesting, the beets are hauled to the factory. Delivery in the UK is by hauler or, for local farmers, by tractor and trailer. Railways and boats were once used in the UK, but no longer. Some beet was carried by rail in the Republic of Ireland, until the 2006 shutdown of sugar beet production in the country due to the end of subsidies.

A sugar factory located in Shropshire, England.

Each load entering is weighed and sampled before tipping onto the reception area, typically a "flat pad" of concrete, where it is moved into large heaps. The beet sample is checked for

- soil tare - the amount of non beet delivered
- crown tare - the amount of low sugar beet delivered
- sugar content ( "pol") - amount of sucrose in the crop
- nitrogen content - for recommending future fertilizer use to the farmer.

From these the actual sugar content of the load is calculated and the grower's payment determined.

The beet is moved from the heaps into a central channel or gulley where it is washed towards the processing plant.

## Diffusion

After reception at the processing plant the beet roots are washed, mechanically sliced into thin strips called ***cossettes***, and passed to a machine called a diffuser to extract their sugar content into a water solution.

Diffusers are long (many metres) vessels in which the beet slices go in one direction while hot water goes in the opposite direction. The movement may either be by a rotating screw or the whole unit rotates and the water and cossettes move through internal chambers. There are three common designs of diffuser, the horizontal rotating 'RT' (from Raffinerie Tirlemontoise, the manufacturer), inclined screw 'DDS' (*De Danske Sukkerfabrikker*), or vertical screw "Tower". A less common design uses a moving belt of cossettes and water is pumped onto the top of the belt and pours through. In all cases the flow rates of cossettes and water are in the ratio one to two. Typically cossettes take about 90 minutes to pass through the diffuser, the water only 45 minutes. These are all countercurrent exchange methods that extract more sugar from the cossettes using less water than if they merely sat in a hot water tank. The liquid exiting the diffuser is called ***raw juice***. The colour of raw juice varies from black to a dark red depending on the amount of oxidation which is itself dependent on diffuser design.

The used cossettes, or ***pulp***, exits the diffuser at about 95% moisture but low sucrose content. Using screw presses, the wet pulp is then pressed down to 75% moisture. This recovers additional sucrose in the liquid pressed out of the pulp, and reduces the energy needed to dry the pulp. The pressed pulp is dried and sold as animal feed, while the liquid pressed out of the pulp is combined with the raw juice or more often introduced into the diffuser at the appropriate point in the countercurrent process.

During diffusion there is a degree of breakdown of the sucrose into invert sugars and these can undergo further breakdown into acids. These breakdown products are not only losses of sucrose but also have knock-on effects reducing the final output of processed sugar from the factory. To limit (thermophilic) bacterial action the feed water may be dosed with formaldehyde and control of the feed water pH is also practised. There have been attempts at operating diffusion under alkaline conditions but the process has proven problematic - the improved sucrose extraction in the diffuser offset by processing problems in the next stages.

## Carbonatation

The raw juice contains many impurities that must be removed before crystallization. This is accomplished via carbonatation. First, the juice is mixed with hot milk of lime (a suspension of calcium hydroxide in water). This treatment precipitates a number of impurities, including multivalent anions such as sulfate, phosphate, citrate and oxalate, which precipitate as their calcium salts and large organic molecules such as proteins, saponins and pectins, which aggregate in the presence of multivalent cations. In addition, the alkaline conditions convert the simple sugars, glucose and fructose, along with the amino acid glutamine, to chemically stable carboxylic acids. Left untreated, these sugars and amines would eventually frustrate crystallization of the sucrose.

Next, carbon dioxide is bubbled through the alkaline sugar solution, precipitating the lime as calcium carbonate ( chalk). The chalk particles entrap some impurities and absorb others. A recycling process builds up the size of chalk particles and a natural flocculation occurs where the heavy particles settle out in tanks (clarifiers). A final addition of more carbon dioxide precipitates more calcium from solution; this is filtered off, leaving a cleaner golden light brown sugar solution called ***thin juice***.

Before entering the next stage the thin juice may receive soda ash to modify the pH and sulphitation with a sulfur-based compound to reduce colour formation due to decomposition of monosaccharides under heat.

## Evaporation

The thin juice is concentrated via multiple-effect evaporation to make a ***thick juice***, roughly 60% sucrose by weight and similar in appearance to pancake syrup. Thick juice can be stored in tanks for later processing, reducing load on the crystallization plant.

### Crystallization

The thick juice is fed to the crystallizers, recycled sugar is dissolved into it and the resulting syrup is called "mother liquor". This is concentrated further by boiling under vacuum in large vessels and seeded with fine sugar crystals. These crystals grow, as sugar from the mother liquor forms around them. The resulting sugar crystal and syrup mix is called a *massecuite* (from French "cooked mass"). The massecuite is passed to a centrifuge where the liquid is removed from the sugar crystals. Remaining syrup is rinsed off with water and the crystals dried in a granulator using warm air. The remaining syrup is fed to another crystallizer from which a second batch of sugar is produced. This sugar ("raw") is of lower quality with a lot of colour and impurities and is the main source of the sugar that is re-dissolved into the mother liquor. The syrup from the raw is also sent to a crystalliser. From this a very low quality sugar crystal is produced (known in some systems as "AP sugar") that is also redissolved. The syrup separated is molasses; still containing sugar but with too much impurity to be economically processed further.

There are variations on the above system, with different recycling and crystallisation paths.

## Other uses

### Beverages

In a number of countries, most notably the Czech Republic, sugar from sugar beet is used to make a type of " rum" which is now known as *tuzemak*. On the Åland Islands, a similar drink is made under the brand name *Kobba Libre*. In some European countries, especially in the Czech Republic and Germany, sugar beet is also used to make rectified spirit and vodka.

### Sugar beet syrup

An unrefined sugary syrup can be produced directly from sugar beet. This thick, dark syrup is produced by cooking shredded sugar beet for several hours, then pressing the resulting sugar beet mash and concentrating the juice produced until it has the consistency similar to that of honey. No other ingredients are used. In Germany, particularly the Rhineland area, this sugar beet syrup (called *Zuckerrüben-Sirup* in German) is used as a spread for sandwiches, as well as for sweetening sauces, cakes and desserts.

Commercially, if the syrup has a Dextrose Equivalency above 30 DE, the product has to be hydrolyzed and converted to a high-fructose syrup, much like high-fructose corn syrup, or iso-glucose syrup in the EU.

### Betaine

Betaine can be isolated from the by-products of sugar beet processing. Production is chiefly by chromatagraphic separation using techniques such as the "simulated moving bed".

### Uridine

Uridine can be isolated from sugar beet. Uridine in combination with omega 3 fatty acids has been shown to alleviate depression.

### Alternative fuel

There are plans by BP and Associated British Foods to use agricultural surpluses of sugar beet to produce biobutanol in East Anglia in the United Kingdom.

## History


A geneticist evaluates sugar beet plants for resistance to the fungal disease *Rhizoctonia root rot*.

Although beets have been grown as vegetables and for fodder since antiquity (a large root vegetable appearing in 4000-year old Egyptian temple artwork may be a beet), their use as a sugar crop is relatively recent. As early as 1590, the French botanist Olivier de Serres extracted a sweet syrup from beetroot, but the practice did not become common. The Prussian chemist Andreas Sigismund Marggraf used alcohol to extract sugar from beets (and carrots) in 1747, but his methods did not lend themselves to economical industrial-scale production. His former pupil and successor Franz Karl Achard began selectively breeding sugar beet from the *White Silesian* fodder beet in 1784. By the beginning of the 19th century, his beet was approximately 5–6 percent sucrose by weight, compared to around 20 percent in modern varieties. Under the patronage of Frederick William III of Prussia, he opened the world's first beet sugar factory in 1801, at Cunern in Silesia.

The development of the European beet sugar industry was encouraged by the Napoleonic Wars. In 1807 the British began a blockade of France, preventing the import of sugarcane from the Caribbean. Partly in response, in 1812, Frenchman Benjamin Delessert came up with a sugar extraction process suitable for industrial application, and in 1813, Napoleon instituted a retaliatory embargo. By the end of the wars, over 300 sugar beet mills operated in France and central Europe.

The first U.S. sugar beet mill opened in 1838, but the first commercially successful mill was established by E. H. Dyer in 1879.

## Agriculture

Sugar beet is an important part of a rotating crop cycle.

Sugar beet plants are susceptible to rhizomania ("root madness") which turns the bulbous tap root into many small roots making the crop economically unprocessable. Strict controls are enforced in European countries to prevent the spread, but it is already endemic in some areas. Continual research looks for varieties with resistance as well as increased sugar yield. Sugar beet breeding research in the United States is most prominently conducted at various USDA Agricultural Research Stations, including one in Fort Collins, Colorado, headed by Linda Hanson and Leonard Panella, one in Fargo, North Dakota, headed by John Wieland, and one at Michigan State University in East Lansing, Michigan, headed by J. Mitchell McGrath.

Other economically important members of the Chenopodioideae subfamily:

- Beetroot
- Chard
- Mangelwurzel or Fodder Beet

# Sugarcane

## 2008/9 Schools Wikipedia Selection. Related subjects: Agriculture; Plants

**Sugarcane** or **sugar cane** (*Saccharum*) is a genus of 6 to 37 species (depending on taxonomic interpretation) of tall perennial grasses (family Poaceae, tribe Andropogoneae), native to warm temperate to tropical regions of the Old World. They have stout, jointed, fibrous stalks that are rich in sugar and measure 2 to 6 meters tall. All of the sugarcane species interbreed, and the major commercial cultivars are complex hybrids.

**Sugarcane**

Cut sugarcane

**Scientific classification**

| | |
|---|---|
| Kingdom: | Plantae |
| Division: | Magnoliophyta |
| Class: | Liliopsida |
| Order: | Poales |
| Family: | Poaceae |
| Genus: | ***Saccharum*** L. |

**Species**

*Saccharum arundinaceum*
*Saccharum bengalense*
*Saccharum edule*
*Saccharum officinarum*

## Cultivation and uses

About 200 countries grow the crop to produce 1,324.6 million tons (more than six times the amount of sugar beet produced). As of the year 2005, the world's largest producer of sugar cane by far is Brazil followed by India. Uses of sugar cane include the production of sugar, Falernum, molasses, rum, soda, cachaça (the national spirit of Brazil) and ethanol for fuel. The bagasse that remains after sugarcane crushing may be burned to provide both heat - used in the mill, and electricity - typically sold to the consumer electricity grid. It may also, because of its high cellulose content, be used as raw material for paper and cardboard, branded as " environmentally friendly" as it is made from a by-product of sugar production.

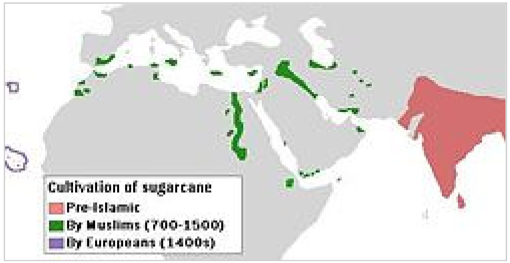
Fibre from Bengal Cane (*Saccharum munja* or *Saccharum bengalense*) is also used to make mats, screens or baskets etc. in West Bengal. This fibre is also used in Upanayanam - a rite-of-passage ritual in India and therefore is also significant religiously.

## History

*Saccharum procerum*
*Saccharum ravennae*
*Saccharum robustum*
*Saccharum sinense*
*Saccharum spontaneum*

Sugarcane was originally from tropical South Asia and Southeast Asia. Different species likely originated in different locations with *S. barberi* originating in India and *S. edule* and *S. officinarum* coming from New Guinea. The thick stalk stores energy as sucrose in the sap. From this juice, sugar is extracted by evaporating the water. Crystallized sugar was reported 5000 years ago in India.

Legend has it that Alexander the Great was surprised to find the sweet substance different from honey during his campaign in North India. Around the eighth century A.D., Arabs introduced sugar to the Mediterranean, Mesopotamia, Egypt, North Africa, and Spain. By the tenth century, sources state, there was no village in Mesopotamia that didn't grow sugar cane. It was among the early crops brought to the Americas by Spaniards. Brazil is currently the biggest sugar cane producing country.



The diffusion of sugarcane in pre-Islamic times (shown in red), in the medieval Muslim world (green) and by Europeans (violet).

The methods of growing sugarcane and processing sugar were technologies transferred to China from India in the 7th century, during the reign of Harsha (r. 606–647) over North India and the reign of Emperor Taizong (r. 626–649) over Tang China. Two sugar makers summoned from leaders of Mahabodhi Temple traveled alongside a delegation of Buddhist monks to China, where they successfully taught the Chinese how to grow sugarcane and produce sugar.

A *boiling house* was used in the 17th through 19th centuries to make **sugarcane** juice into raw sugar. These houses were add-ons to the sugar plantations in the western colonies. This process was often conducted by the African slaves, under very poor conditions. The boiling house was made of cut stone. The furnaces were rectangular boxes of brick or stone with openings near to one side, and at the bottom to stoke the fire and pull out the ashes. At the top of each furnace were up to seven copper kettles or boilers, each one smaller than the previous one and hotter. The cane juice was placed in the first copper kettle which was the largest. The juice was then heated and a little lime added to remove impurities. The juice was then skimmed then channeled to the other copper kettles. The last kettle,which was called the 'teache' was where the cane juice became syrup. It was then put into cooling troughs where the sugar crystals hardened around a sticky core of molasses. The raw sugar was then shoveled from the cooling trough into hogsheads (wooden barrels) where they were put in the curing house.

Sugarcane was, and still is, extensively grown in the Caribbean, where it was first brought by Christopher Columbus during his second voyage to The Americas, initially to the island of Hispaniola (Modern day Haiti And the Dominican Republic) . In colonial times, sugar was a major product of the triangular trade of New World raw materials, European manufactures, and African slaves. France found its sugarcane islands so valuable it effectively traded its portion of Canada, famously dubbed " a few acres of snow," to Britain for their return of Guadeloupe, Martinique and St. Lucia at the end of the Seven Years' War. The Dutch similarly kept Suriname, a sugar colony in South America, instead of seeking the return of the New Netherlands (New Amsterdam). Cuban sugarcane produced sugar that received price supports from and a guaranteed market in the USSR; the dissolution of that country forced the closure of most of Cuba's sugar industry. Sugarcane remains an important part of the economy of Belize, Barbados, Haiti along with the Dominican Republic, Guadeloupe, Jamaica, and other islands. The sugarcane industry is a major export for the Caribbean, but it is expected to collapse with the removal of European preferences by 2009.

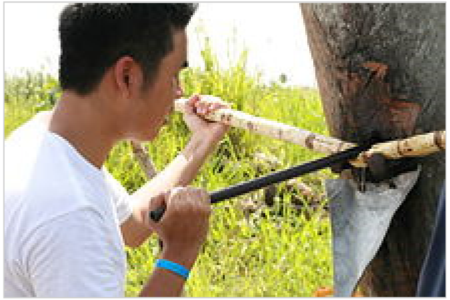

Sugar cane field on Madeira

Sugarcane production greatly influenced many tropical Pacific islands, including Okinawa and most particularly Hawaii and Fiji. In these islands, sugar cane came to dominate the economic and political landscape after the arrival of powerful European and American agricultural business, which promoted immigration from various Asian countries for workers to tend and harvest the crop. Sugar-industry policies eventually established the ethnic makeup of the island populations that now exist, profoundly affecting modern politics and society in the islands.

Brazil is a major grower of sugarcane, which is used to produce sugar and provide the ethanol used in making gasoline-ethanol blends ( gasohol) for transportation fuel. In India, sugarcane is sold as jaggery and also refined into sugar, primarily for consumption in tea and sweets, and for the production of alcoholic beverages.

## Cultivation


Sugarcane flowering, Australia.


Extracting juice from sugarcane

Sugarcane cultivation requires a tropical or subtropical climate, with a minimum of 600 mm (24 in) of annual moisture. It is one of the most efficient photosynthesizers in the plant kingdom, able to convert up to 2 percent of incident solar energy into biomass. In prime growing regions, such as Peru, Brazil, Colombia, Australia, Ecuador, Cuba and Hawaii, sugarcane can produce 20 kg for each square meter exposed to the sun.

Sugarcane is propagated from cuttings, rather than from seeds; although certain types still produce seeds, modern methods of stem cuttings have become the most common method of reproduction. Each cutting must contain at least one bud, and the cuttings are usually planted by hand. Once planted, a stand of cane can be harvested several times; after each harvest, the cane sends up new stalks, called **ratoons.** Usually, each successive harvest gives a smaller yield, and eventually the declining yields justify replanting. Depending on agricultural practice, two to ten harvests may be possible between plantings.

Sugarcane is harvested mostly by hand or sometimes mechanically. Hand harvesting accounts for more than half of the world's production, and is especially dominant in the developing world. When harvested by hand, the field is first set on fire. The fire spreads rapidly, burning away dry dead leaves, and killing any venomous snakes hiding in the crop, but leaving the water-rich stalks and roots unharmed. With cane knives or machetes, harvesters then cut the standing cane just above the ground. A skilled harvester can cut 500 kg of sugarcane in an hour.

Sugarcane mechanical harvest in Jaboticabal, São Paulo state, Brazil.

With mechanical harvesting, a sugarcane combine (or chopper harvester), a harvesting machine originally developed in Australia, is used. The Austoft 7000 series was the original design for the modern harvester and has now been copied by other companies including Cameco and John Deere. The machine cuts the cane at the base of the stalk, separates the cane from its leaves, and deposits the cane into a haulout transporter while blowing the trash back onto the field. Such machines can harvest 100 tonnes of cane each hour, but cane harvested using these machines must be transported to the processing plant rapidly; once cut, sugarcane begins to lose its sugar content, and damage inflicted on the cane during mechanical harvesting accelerates this decay.

Sugarcane field in India.

Sugar cane is cultivated in almost all the world only for some months of the year, in a period called 'safra', the Portuguese word for harvest. The only place in the world where there is no 'safra', and therefore sugar cane is cultivated and produced year round is Colombia in South America.

## Pests

The most important sugarcane pests are the larvae of some butterfly/moth species, including the turnip moth, the sugarcane borer (*Diatraea saccharalis*), the Mexican rice borer (*Eoreuma loftini*), leaf-cutting ants, termites; spittlebugs (especially *Mahanarva fimbriolata* and *Deois flavopicta*), and the beetle *Migdolus fryanus*. The planthopper *Eumetopina flavipes* is an insect which acts as a vector for the phytoplasma which causes the sugarcane disease ramu stunt.

## Diseases

## Processing

Sugar mill in 1950 years, Pernambuco, Brazil

Traditionally, sugarcane has been processed in two stages. Sugarcane mills, located in sugarcane-producing regions, extract sugar from freshly harvested sugarcane, resulting in raw sugar for later refining, and in "mill white" sugar for local consumption. Sugar refineries, often located in heavy sugar-consuming regions, such as North America, Europe, and Japan, then purify raw sugar to produce refined white sugar, a product that is more than 99 percent pure sucrose. These two stages are slowly becoming blurred. Increasing affluence in the sugar-producing tropics has led to an increase in demand for refined sugar products in those areas, where a trend toward combined milling and refining has developed.

Sugarcane trains on 2-foot narrow gauge tracks in front of Proserpine Sugar Mill in Proserpine, Queensland

## Milling

Sugarcane first has to be moved to a mill which is usually located close to the area of cultivation. Small rail networks are a common method of transporting the cane to a mill.

Sugar crystals

In a sugar mill, sugarcane is washed, chopped, and shredded by revolving knives. The shredded cane is repeatedly mixed with water and crushed between rollers; the collected juices (called garapa in Brazil) contain 10–15 percent sucrose, and the remaining fibrous solids, called bagasse, are burned for fuel. Bagasse makes a sugar mill more than self-sufficient in energy; the surplus bagasse can be used for animal feed, in paper manufacture, or burned to generate electricity for the local power grid.

The cane juice is next mixed with lime to adjust its pH to 7. This mixing arrests sucrose's decay into glucose and fructose, and precipitates out some impurities. The mixture then sits, allowing the lime and other suspended solids to settle out, and the clarified juice is concentrated in a multiple-effect evaporator to make a syrup about 60 percent by weight in sucrose. This syrup is further concentrated under vacuum until it becomes supersaturated, and then seeded with crystalline sugar. Upon cooling, sugar crystallizes out of the syrup. A centrifuge is used to separate the sugar from the remaining liquid, or molasses. Additional crystallizations may be performed to extract more sugar from the molasses; the molasses remaining after no more sugar can be extracted from it in a cost-effective fashion is called blackstrap.

Raw sugar has a yellow to brown colour. If a white product is desired, sulfur dioxide may be bubbled through the cane juice before evaporation; this chemical bleaches many colour-forming impurities into colourless ones. Sugar bleached white by this *sulfitation* process is called "mill white," "plantation white," and "crystal sugar." This form of sugar is the form most commonly consumed in sugarcane-producing countries.

## Refining

In sugar refining, raw sugar is further purified. It is first mixed with heavy syrup and then centrifuged clean. This process is called 'affination'; its purpose is to wash away the outer coating of the raw sugar crystals, which is less pure than the crystal interior. The remaining sugar is then dissolved to make a syrup, about 70 percent by weight solids.

The Santa Elisa sugarcane processing plant, one of the largest and oldest in Brazil, is located in Sertãozinho, Brazil. Photo by Renato M.E. Sabbatini

The sugar solution is clarified by the addition of phosphoric acid and calcium hydroxide, which combine to precipitate calcium phosphate. The calcium phosphate particles entrap some impurities and absorb others, and then float to the top of the tank, where they can be skimmed off. An alternative to this "phosphatation" technique is ' carbonatation,' which is similar, but uses carbon dioxide and calcium hydroxide to produce a calcium carbonate precipitate.

After any remaining solids are filtered out, the clarified syrup is decolorized by filtration through a bed of activated carbon; bone char was traditionally used in this role, but its use is no longer common. Some remaining colour-forming impurities adsorb to the carbon bed. The purified syrup is then concentrated to supersaturation and repeatedly crystallized under vacuum, to produce white refined sugar. As in a sugar mill, the sugar crystals are separated from the molasses by centrifuging. Additional sugar is recovered by blending the remaining syrup with the washings from affination and again crystallizing to produce brown sugar. When no more sugar can be economically recovered, the final molasses still contains 20–30 percent sucrose and 15–25 percent glucose and fructose.

To produce granulated sugar, in which the individual sugar grains do not clump together, sugar must be dried. Drying is accomplished first by drying the sugar in a hot rotary dryer, and then by conditioning the sugar by blowing cool air through it for several days.

## Ribbon cane syrup

Ribbon cane is a subtropical type that was once widely grown in southern United States, as far north as coastal North Carolina. The juice was extracted with horse or mule-powered crushers; the juice was boiled, like maple syrup, in a flat pan, and then used in the syrup to form as a sweetener for other foods. It is not a commercial crop nowadays, but a few growers try to keep alive the old traditions and find ready sales for their product. Most sugarcane production in the United States occurs in Florida and Louisiana, and to a lesser extent in Hawaii and Texas.

Evaporator with baffled pan and foam dipper for making ribbon cane syrup. Three Rivers Historical Society Museum at Browntown, South Carolina

## Production

**Top 10 Sugarcane Producers - 2005**

| Country | 1000 tons |
|---|---|
| Brazil | 588,025 (2008) |
| India | 232,300 |
| People's Republic of China | 87,768 |
| Pakistan | 47,244 |
| Mexico | 45,195 |
| Thailand | 43,665 |
| Colombia | 39,849 |
| Australia | 37,822 |
| Indonesia | 29,505 |
| USA | 25,307 |
| **World Total** | **1,011,581** |
| *Source:* *UN Food & Agriculture Organisation (FAO)* | |

In India, the states of Uttar Pradesh (38.57 %), Maharashtra (17.76 %) and Karnataka (12.20 %) lead the nation in sugarcane production.

In the United States, sugar cane is grown commercially in Florida, Hawaii, Louisiana, Texas, and Puerto Rico.

## Cane ethanol / Energy cane

This is generally available as a by-product of sugar mills producing sugar. It can be used as a fuel, mainly as a biofuel alternative to gasoline, and is widely used in cars in Brazil. It is steadily becoming a promising alternative to gasoline throughout much of the world and thus instead of sugar may be produced as a primary product out of sugar canes processing.

A textbook on renewable energy describes the energy transformation:

> At present, 75 tons of raw sugar cane are produced annually per hectare in Brazil. The cane delivered to the processing plant is called burned and cropped (b&c) and represents 77% of the mass of the raw cane. The reason for this reduction is that the stalks are separated from the leaves (which are burned and whose ashes are left in the field as fertilizer) and from the roots that remain in the ground to sprout for the next crop. Average cane production is, therefore, 58 tons of b&c per hectare per year.
>
> Each ton of b&c yields 740 kg of juice (135 kg of sucrose and 605 kg of water) and 260 kg of moist bagasse (130 kg of dry bagasse). Since the higher heating value of sucrose is 16.5 M J/kg, and that of the bagasse is 19.2 M J/kg, the total heating value of a ton of b&c is 4.7 G J/kg of which 2.2 G J come from the sucrose and 2.5 from the bagasse.
>
> Per hectare per year, the biomass produced corresponds to 0.27 T J. This is equivalent to 0.86 W per square meter. Assuming an average insolation of 225 W per square meter, the photosynthetic efficiency of sugar cane is 0.38%.
>
> The 135 kg of sucrose found in 1 ton of b&c are transformed into 70 liters of ethanol with a combustion energy of 1.7 G J. The practical sucrose-ethanol conversion efficiency is, therefore, 76% (compare with the theoretical 97%).
>
> One hectare of sugar cane yields 4000 liters of ethanol per year (without any additional energy input because the bagasse produced exceeds the amount needed to distill the final product). This however does not include the energy used in tilling, transportation, and so on. Thus, the solar energy-to-ethanol conversion efficiency is 0.13%.

## Sugarcane as food

Sugarcane juice vendors in Dhaka, Bangladesh

In most countries where sugarcane is cultivated, there are several foods and popular dishes derived from it, such as:

- Direct consumption of raw sugarcane cylinders or cubes, which are chewed to extract the juice, and the bagasse is spat out
- Freshly extracted juice ( garapa, *guarab, guarapa, guarapo, papelón,* '*aseer asab* or *caldo de cana*) by hand or electrically operated small mills, with a touch of lemon and ice, makes a delicious and popular drink.
- Molasses, used as a sweetener and as a syrup accompanying other foods, such as cheese or cookies
- Rapadura, a candy made of flavored solid brown sugar in Brazil, which can be consumed in small hard blocks, or in pulverized form (flour), as an add-on to other desserts.
- Sugarcane is also used in rum production, especially in the Caribbean.
- Cane sugar syrup was the traditional sweetener in soft drinks for many years, but has been largely supplanted (in the US at least) by high-fructose corn syrup, which is less expensive, but is considered by some to not taste quite like the sugar it replaces.

# Sustainable agriculture

### 2008/9 Schools Wikipedia Selection. Related subjects: Agriculture

**Sustainable agriculture** integrates three main goals: environmental stewardship, farm profitability, and prosperous farming communities. These goals have been defined by a variety of disciplines and may be looked at from the vantage point of the farmer or the consumer.

## Description

Sustainable agriculture refers to the ability of a farm to produce food indefinitely, without causing irreversible damage to ecosystem health. Two key issues are biophysical (the long-term effects of various practices on soil properties and processes essential for crop productivity) and socio-economic (the long-term ability of farmers to obtain inputs and manage resources such as labor).

The physical aspects of sustainability are partly understood (Altieri 1995). Practices that can cause long-term damage to soil include excessive tillage (leading to erosion) and irrigation without adequate drainage (leading to accumulation of salt in the soil). Long-term experiments provide some of the best data on how various practices affect soil properties essential to sustainability.

Although air and sunlight are available everywhere on Earth, crops also depend on soil nutrients and the availability of water. When farmers grow and harvest crops, they remove some of these nutrients from the soil. Without replenishment, the land would suffer from nutrient depletion and be unusable for further farming. Sustainable agriculture depends on replenishing the soil while minimizing the use of non-renewable resources, such as natural gas (used in converting atmospheric nitrogen into synthetic fertilizer), or mineral ores (e.g., phosphate). Possible sources of nitrogen that would, in principle, be available indefinitely, include:

1. recycling crop waste and livestock or human manure
2. growing legume crops and forages such as, peanuts, or alfalfa that form symbioses with nitrogen-fixing bacteria called rhizobia
3. industrial production of nitrogen by the Haber Process uses hydrogen, which is currently derived from natural gas, (but this hydrogen could instead be made by electrolysis of water using electricity (perhaps from solar cells or windmills)) or
4. genetically engineering (non-legume) crops to form nitrogen-fixing symbioses or fix nitrogen without microbial symbionts.

The last option was proposed in the 1970s, but would be well beyond the capability of early 21st century technology, even if various concerns about biotechnology were addressed. Sustainable options for replacing other nutrient inputs (phosphorus, potassium, etc.) are more limited.

In some areas, sufficient rainfall is available for crop growth, but many other areas require irrigation. For irrigation systems to be sustainable they must be managed properly (to avoid salt accumulation) and not use more water from their source than is naturally replenished, otherwise the water source becomes, in effect, a non-renewable resource. Improvements in water well drilling technology and the development of submersible pumps have made it possible for large crops to be regularly grown where reliance on rainfall alone previously made this level of success unpredictable. However, this progress has come at a price, in that in many areas where this has occurred, such as the Ogallala Aquifer, the water is being used at a greater rate than its rate of recharge.

Socioeconomic aspects of sustainability are also partly understood. Regarding less concentrated farming, the best known analysis is Netting's (1993) study on smallholder systems through history.

Sustainable agriculture was also addressed by the 1990 farm bill [Food, Agriculture, Conservation, and Trade Act of 1990 (FACTA), Public Law 101-624, Title XVI, Subtitle A, Section 1603].

It was defined as follows:

Stated by: “the term sustainable agriculture means an integrated system of plant and animal production practices having a site-specific application that will, over the long term:

- satisfy human food and fibre needs
- enhance environmental quality and the natural resource base upon which the agricultural economy depends
- make the most efficient use of nonrenewable resources and on-farm resources and integrate, where appropriate, natural biological cycles and controls
- sustain the economic viability of farm operations
- enhance the quality of life for farmers and society as a whole.”

Green Revolution

**Particular**
Aquaculture · Christmas trees · Dairy farming
Grazing · Hydroponics · IMTA
Intensive pig farming · Lumber
Maize · Orchard
Poultry farming · Ranching · Rice
Sheep husbandry · Soybean
System of Rice Intensification
Wheat

**Categories**
Agriculture by country
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Agriculture companies, U.S.
Biotechnology
Farming history
Livestock
Meat processing
Poultry farming

# Economics

Given the finite supply of natural resources at any specific cost and location, agriculture that is inefficient or damaging to needed resources may eventually exhaust the available resources or the ability to afford and acquire them. It may also generate negative externality, such as pollution as well as financial and production costs.

The way that crops are sold must be accounted for in the sustainability equation. Food sold locally requires little additional energy, aside from that necessary for cultivation, harvest, and transportation (including consumers). Food sold at a remote location, whether at a farmers' market or the supermarket, incurs a different set of energy cost for materials, labour, and transport.

The most important factors for an individual site are sun, air, soil and water. Of the four, water and soil quality and quantity are most amenable to human intervention through time and labour.

What grows and how and where it is grown are a matter of choice. Two of the many possible practices of sustainable agriculture are crop rotation and soil amendment, both designed to ensure that crops being cultivated can obtain the necessary nutrients for healthy growth.

# Methods

Monoculture, a method of growing only one crop at a time in a given field, is a very widespread practice, but there are questions about its sustainability, especially if the same crop is grown every year. Growing a mixture of crops (polyculture) sometimes reduces disease or pest problems Nature 406, 718-722 Genetic diversity and disease control in rice, Environ. Entomol. 12:625) but polyculture has rarely, if ever, been compared to the more widespread practice of growing different crops in successive years crop rotation with the same overall crop diversity. For example, how does growing a corn-bean mixture every year compare with growing corn and bean in alternate years? Cropping systems that include a variety of crops (polyculture and/or rotation) may also replenish nitrogen (if legumes are included) and may also use resources such as sunlight, water, or nutrients more efficiently (Field Crops Res. 34:239).

Replacing a natural ecosystem with a few specifically chosen plant varieties as is done in farming results in an artificial ecosystem that lacks the genetic diversity found in wildlife and is thus more susceptible to widespread disease. The Great Irish Famine (1845-1849) is a well-known example of the dangers of monoculture.

Many scientists, farmers, and businesses have debated how to make agriculture farming sustainable. One of the many practices includes growing a diverse number of perennial crops in a single field, each of which would grow in separate season so as not to compete with each other for natural resources. This system would result in increased resistance to diseases and decreased effects of erosion and loss of nutrients in soil. Nitrogen fixation from legumes, for example, used in conjunction with plants that rely on nitrate from soil for growth, helps to allow the land to be reused annually. Legumes will grow for a season and replenish the soil with ammonium and nitrate, and the next season other plants can be seeded and grown in the field in preparation for harvest.

In practice, there is no single approach to sustainable agriculture, as the precise goals and methods must be adapted to each individual case. There may be some techniques of farming that are inherently in conflict with the concept of sustainability, but there is widespread misunderstanding on impacts of some practices. For example, the slash-and-burn techniques that are the characteristic feature of shifting cultivators are often cited as inherently destructive, yet slash-and-burn cultivation has been practiced in the Amazon for at least 6000 years (Sponsel 1986); serious deforestation did not begin until the 1970s, largely as the result of Brazilian government programs and policies (Hecht and Cockburn 1989).

There are also many ways to practice sustainable animal husbandry. Some of the key tools to grazing management include fencing off the grazing area into smaller areas called paddocks, lowering stock density, and moving the stock between paddocks frequently.

Several attempts have been made to produce an artificial meat, using isolated tissues to produce it in vitro; Jason Matheny's work on this topic, whichin the New Harvest project, is one of the most commented.

# Off-farm impacts

What if a farm is able to "produce perpetually", yet has negative effects on environmental quality elsewhere? Most people concerned with sustainability take a global view, so they try to avoid negative off-farm impacts. For example, over-application of synthetic fertilizer or animal manures can pollute nearby rivers and coastal waters. On the other hand, if crop yields are too low, because of soil exhaustion of nutrients or reduced ability to retain water, farmers would need to access new lands for agriculture, leading to the decimation of the rainforest, draining wetlands, etc.

We must also consider the impact of sustainability on overall production. If the human population is to continue its growth, it will need food and fibre to do so. The United Nations estimates the world will inhabit 9.3 billion people by 2050, which will necessitate a dramatic increase in production capabilities. The increased production will likely come from one of two different ways. First, you can either break out virgin land to grow crops, though concerns over global warming make this option unsavory. Second, you can increase yields on existing land, which will likely require adopting technologies many sustainable advocates are opposed to, principally Genetically modified organism crops.

Many advocates of sustainable agriculture think that organic agriculture is the only system which can be sustained over the long-term. However, organic production methods, especially in transition, yield less than their conventional counterparts. While there is evidence which gives organic an advantage during periods of drought one must be careful not to place too much emphasis on these figures. While drought is a real threat to agriculture production, it is hardly the norm. Even when drought strikes, stockpiles help mitigate food security concerns. Regardless of reduced yields under optimal conditions, it should be noted that during periods of prolonged drought as predicted by global warming scientists, organic production methods should be considered as a way to adapt to a changing climate.

# Urban planning

There has been considerable debate about which form of human residential habitat may be a better social form for sustainable agriculture. Generally, it is thought that village communities can improve sustainability in that such communities tend to provide a cooperative environment that supports farming.

Many environmentalists pushing for increased population density to preserve agricultural land point out that urban sprawl is less sustainable and more damaging to the environment than living in the cities where cars are not needed because food and other necessities are within walking distance. However, others have theorized that sustainable ecocities, or ecovillages which combine habitation and farming with close proximity between producers and consumers, may provide greater sustainability.

The use of available city space (e.g., rooftop gardens and community gardens) for cooperative food production is another way to achieve greater sustainability.

One of the latest ideas in achieving sustainable agricultural involves shifting the production of food plants from major factory farming operations to large, urban, technical facilities called vertical farms. The advantages of vertical farming include year-round production, isolation from pests and diseases, controllable resource recycling, and on-site production that eliminates the need for transportation costs. While a vertical farm has yet to become a reality, the idea is gaining momentum among those who believe that current sustainable farming methods will be insufficient to provide for a growing global population. For vertical farming to become a reality, billions of dollars in tax credits and subsidies will need to be made available to the operation. It may be difficult to justify spending billions of dollars on a vertical farm that will only feed 50,000 people when agriculture land remains abundant.

# Tractor

2008/9 Schools Wikipedia Selection. Related subjects: Agriculture; Road transport

A **tractor** is a vehicle specifically designed to deliver a high tractive effort at slow speeds, for the purposes of hauling a trailer or machinery used in agriculture or construction. Most commonly, the term is used to describe the distinctive farm vehicle: agricultural implements may be towed behind or mounted on the tractor, and the tractor may also provide a source of power if the implement is mechanised. Another common use of the term is for the power unit of a semi-trailer truck.


A modern European farm tractor

The word *tractor* was taken from Latin, being the agent noun of *trahere* "to pull". '. The first recorded use of the word meaning "an engine or vehicle for pulling wagons or ploughs" occurred in 1901, from the earlier term *traction engine* (1859).

The first tractors were steam-powered ploughing engines. They were used in pairs either side of a field to haul a plough back and forth between them using a wire cable.

## National variations


Ebro farm tractor

In Britain, Ireland, Australia, India, Spain, and Germany the word "tractor" usually means "farm tractor", and the use of the word "tractor" to mean other types of vehicles is familiar to the vehicle trade but unfamiliar to much of the general public. In Canada and the US the word is also used to refer to a road tractor.

## History

The first powered farm implements in the early 1800s were portable engines – steam engines on wheels that could be used to drive mechanical farm machinery by way of a flexible belt. Around 1850, the first traction engines were developed from these, and were widely adopted for agricultural use. Where soil conditions permitted, like the US, steam tractors were used to direct-haul ploughs, but in the UK and elsewhere, ploughing engines were used for cable-hauled ploughing instead. Steam-powered agricultural engines remained in use well into the 20th century, until reliable internal combustion engines had been developed.

In 1892, John Froelich built the first practical gasoline-powered tractor in Clayton County, Iowa. Only two were sold, and it was not until 1911, when the Twin City Traction Engine Company developed the design, that it became successful.

In Britain, the first recorded tractor sale was the oil-burning Hornsby-Ackroyd Patent Safety Oil Traction engine, in 1897. However, the first commercially successful design was Dan Albone's three-wheel Ivel tractor of 1902. In 1908, the Saunderson Tractor and Implement Co. of Bedford introduced a four-wheel design, and went on to become the largest tractor manufacturer outside the USA at that time.

While unpopular at first, these gasoline-powered machines began to catch on in the 1910s when they became smaller and more affordable. Henry Ford introduced the Fordson, the first mass-produced tractor in 1917. They were built in the U.S., Ireland, England and Russia and by 1923, Fordson had 77% of the U.S. market. The Fordson dispensed with a frame, using the strength of the engine block to hold the machine together. By the 1920s, tractors with a gasoline-powered internal combustion engine had become the norm.

A 1920 International Harvester tractor, showing features inherited from earlier steam tractor designs.

The classic farm tractor is a simple open vehicle, with two very large driving wheels on an axle below and slightly behind a single seat (the seat and steering wheel consequently are in the centre), and the engine in front of the driver, with two steerable wheels below the engine compartment. This basic design has remained unchanged for a number of years, but enclosed cabs are fitted on almost all modern models, for reasons of operator safety and comfort.

Originally, plows and other equipment were connected via a draw-bar, or a proprietary connecting system; prior to Harry Ferguson patenting the three-point hitch. Recently, Bobcat's patent on its front loader connection has expired; and compact tractors are now being outfitted with quick-connect attachments for their front-end loaders.

There are also lawn tractors. Cub Cadet, Husqvarna, John Deere, Massey Ferguson and Toro are some of the better-known brands.

# Operation

Modern farm tractors usually have five foot-pedals for the operator on the floor of the tractor. The pedal on the left is the clutch. The operator presses on this pedal to disengage the transmission for either shifting gears or stopping the tractor. Two of the pedals on the right are the brakes. The left brake pedal stops the left rear wheel and the right brake pedal does the same with the right side. This independent left and right wheel braking augments the steering of the tractor when only the two rear wheels are driven. This is usually done when it is necessary to make a tight turn. The split brake pedal is also used in mud or soft dirt to control a tire that spins due to loss of traction. The operator presses both pedals together to stop the tractor. For tractors with additional front-wheel drive, this operation often engages the 4-wheel locking differential to help stop the tractor when travelling at road speeds.

A lawn tractor towing a cargo cart

A fifth pedal just in front of the seat operates the rear differential lock (diff lock) which prevents wheelslip. The differential allows the outside wheel to travel faster than the inside one during a turn. However, in traction conditions on a soft surface the same mechanism could allow one wheel to slip, thus preventing traction to the other wheel. The diff lock overrides this, causing both wheels to supply equal traction. Care must be taken to unlock the differential, usually by hitting the pedal a second time, before turning, since the tractor cannot perform a turn with the diff lock engaged.

The pedal furthest to the right is the foot throttle. Unlike in automobiles, it can also be controlled from a hand-operated lever ("hand throttle"). This helps provide a constant speed in field work. It also helps provide continuous power for stationary tractors that are operating an implement by shaft or belt. The foot throttle gives the operator more automobile-like control over the speed of the tractor for road work. This is a feature of more recent tractors; older tractors often did not have this feature. In the UK it is mandatory to use the foot pedal to control engine speed while travelling on the road. Some tractors, especially those designed for row-crop work, have a 'de-accelerator' pedal, which operates in the reverse fashion to an automobile throttle, in that the pedal is pushed down to slow the engine. This is to allow fine control over the speed of the tractor when manoeuvring at the end of crop rows in fields- the operating speed of the engine is set using the hand throttle, and if the operator wishes to slow the tractor to turn, he simply has to press the pedal, turn and release it once the turn is completed, rather than having to alter the setting of the hand throttle twice during the maneuver.

## Power and transmission

Modern farm tractors employ large diesel engines, which range in power output from 18 to 575 horsepower (15 to 480 kW). Tractors can be generally classified as two-wheel drive, two-wheel drive with front wheel assist, four-wheel drive (often with articulated steering), or track tractors (with either two or four powered rubber tracks). Variations of the classic style include the diminutive *lawn tractors* and their more capable and ruggedly constructed cousins, *garden tractors*, that range from about 10 to 25 horsepower (7.5-18.6 kW) and are used for smaller farm tasks and mowing grass and landscaping. Their size—especially with modern tractors—and the slower speeds are reasons motorists are urged to use caution when encountering a tractor on the roads.

A 1958 Series II Field Marshall

A PTO shaft connected to a tractor.

Most tractors have a means to transfer power to another machine such as a baler, slasher or mower. Early tractors used belts wrapped around a flywheel to power stationary equipment. Modern tractors use a power take-off (PTO) shaft to provide rotary power to machinery that may be stationary or pulled. Almost all modern tractors can also provide external hydraulic fluid and electrical power.

Most farm tractors use a manual transmission. They have several sets of gear ratios divided into speeds. In order to change the ratio, it is usually necessary to stop the tractor. Between them they provide a range of speeds from less than one mile per hour suitable for working the land, up to about 25 miles per hour (40 km/h) for road use. Furthermore it is usually not necessary to change gear in order to reverse, one simply selects a lever. Older tractors usually require that the operator depress the clutch in order to shift between gears (a limitation of straight-cut gears in the gearbox), but many modern tractors have eliminated this requirement with the introduction of technologies such as power shifting in the 1960s and more modern continuously variable transmissions. This allows the operator more and easier control over working speed than the throttle alone could provide.

Slow, controllable speeds are necessary for most operations that are performed with a tractor. They help give the farmer a larger degree of control in certain situations, such as field work. However, when travelling on public roads, the slow operating speeds can cause problems, such as long queues or tailbacks, which can delay or aggravate other road users. To alleviate conditions, some countries (for example the Netherlands) employ a road sign on some roads that means "no farm tractors". Some modern tractors, such as the JCB *Fastrac*, are now capable of much more tolerable road speeds of around 50 mph (80 km/h).

## Backhoe loader

The most common variation of the classic farm **tractor** is the **hoe**, also called a **hoe-loader**. As the name implies, it has a loader assembly on the front and a backhoe on the back. Backhoes attach to a 3 point hitch on farm or industrial tractors. Industrial tractors are often heavier in construction particularly with regards to the use of steel grill for protection from rocks and the use of construction tires. When the backhoe is permanently attached, the machine usually has a seat that can swivel to the rear to face the hoe controls. Removable backhoe attachments almost always have a separate seat on the attachment.

A common backhoe-loader. The backhoe is on the left, the bucket/blade on the right.

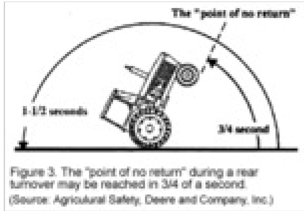
Backhoe-loaders are very common and can be used for a wide variety of tasks: construction, small demolitions, light transportation of building materials, powering building equipment, digging holes,loading trucks, breaking asphalt and paving roads. Some buckets have a retractable bottom, enabling them to empty their load more quickly and efficiently. Buckets with retractable bottoms are also often used for grading and scratching off sand. The front assembly may be a removable attachment or permanently mounted. Often the bucket can be replaced with other devices or tools.

Their relatively small frame and precise control make backhoe-loaders very useful and common in urban engineering projects such as construction and repairs in areas too small for larger equipment. Their versatility and compact size makes them one of the most popular urban construction vehicles.

In the UK, the word " JCB" is sometimes used colloquially as a genericized trademark for any such type of engineering vehicle. The term JCB now appears in the Oxford English Dictionary, although it is still legally a trademark of J. C. Bamford Ltd.

## Safety

Agriculture in the United States is one of the most hazardous industries, only surpassed by mining and construction. No other farm machine is so identified with the hazards of production agriculture as the tractor. Tractor related injuries account for approximately 32% of the fatalities and 6% of the non-fatal injuries in agriculture. Over 50% is attributed to tractor overturns.



Farm tractor rear turnover

The roll over protection structure(ROPS) and seat belt, when worn, are the two most important safety devices to protect operators from death during tractor overturns.

Modern tractors have rollover protection systems (ROPS) to prevent an operator from being crushed if the tractor overturns. It is important to remember that the ROPS does not prevent tractor overturns. Rather, it prevents the operator from being crushed during an overturn. This is especially important in open-air tractors, where the ROPS is a steel beam that extends above the operator's seat. For tractors with operator cabs, the ROPS is part of the frame of the cab. A ROPS with enclosed cab further reduces the likelihood of serious injury because the operator is protected by the sides and windows of the cab.


The classic Row Crop tractor (an Allis-Chalmers WD). Note the absence of any rollover protection system.

ROPS were first required by legislation in Sweden in 1959. Before ROPS were required, some farmers died when their tractors rolled on top of them. Row-crop tractors, before ROPS, were particularly dangerous because of their 'tricycle' design with the two front wheels spaced close together and angled inward toward the ground. Some farmers were killed by rollovers while operating tractors along steep slopes. Others have been killed while attempting to tow or pull an excessive load from above axle height, or when cold weather caused the tires to freeze down, in both cases causing the tractor to pivot around the rear axle.

For the ROPS to work as designed, the operator must stay within the protective frame of the ROPS. This means the operator must wear the seat belt. Not wearing the seat belt may defeat the primary purpose of the ROPS.

# Applications

## For farming

The most common use of the term is for the vehicles used on farms. The farm tractor is used for pulling or pushing agricultural machinery or trailers, for plowing, tilling, disking, harrowing, planting, and similar tasks. Charles City, Iowa is the birthplace of the farm tractor in the early 1900s by the Hart-Parr Company, Later sold to White Tractor.


A modern John Deere 8110 Farm Tractor plowing a field using a chisel plow.

Farm implements can be attached to the rear of the tractor by either a drawbar or a three-point hitch. The three-point hitch was invented by Harry Ferguson and has been standard since the 1960s. Equipment attached to the three-point hitch can be raised or lowered hydraulically with a control lever. The equipment attached to the three-point hitch is usually completely supported by the tractor. Another way to attach an implement is via a Quick Hitch, which is attached to the three-point hitch. This enables a single person to attach an implement quicker and put the person in less danger when attaching the implement.


A fairly recent farmtractor used to de-weed a plot of land

Some farm-type tractors are found elsewhere than on farms: with large universities' gardening departments, in public parks, or for highway workman use with blowtorch cylinders strapped to its sides and a pneumatic drill air compressor permanently fastened over its power take-off. These are often fitted with grass (turf) tyres which are less damaging to soft surfaces than agricultural tires.

Supposedly, I4 (industrial bar tires) are less damaging to lawns and soft surfaces than agricultural tires, but provide similar traction, and have the benefit of being self-cleaning. Often, these can be seen on road construction backhoes.

### Precision agriculture


A farm tractor used to power a pump for irrigating a plot of land

Space technology has been incorporated into agriculture in the form of GPS devices, and robust on-board computers installed as *optional features* on farm tractors. These technologies are used in modern, precision farming techniques. The spin-offs from the space race have actually facilitated automation in plowing and the use of autosteer systems drone on tractors that are manned but only steered at the end of a row, the idea being to neither overlap and use more fuel nor leave streaks when performing jobs such as cultivating.

## Other types of tractors

### Engineering tractors

The durability and engine power of tractors made them very suitable for engineering tasks. Tractors can be fitted with engineering tools such as dozer blade, bucket, hoe, ripper, and so on. The most common attachments for the front of a tractor are dozer blade or a bucket. When attached with engineering tools the tractor is called an engineering vehicle.

A tractor factory in Chelyabinsk in the Soviet Union circa 1930.

A bulldozer is a track-type tractor attached with blade in the front and a rope-winch behind. Bulldozers are very powerful tractors and have excellent ground-hold, as their main tasks are to push or drag things.

Bulldozers have been further modified over time to evolve into new machines which are capable of working in ways that the original bulldozer can not. One example is that loader tractors were created by removing the blade and substituting a large volume bucket and hydraulic arms which can raise and lower the bucket, thus making it useful for scooping up earth, rock and similar loose material to load it into trucks.

A front-loader or loader is a tractor with an engineering tool which consists of two hydraulic powered arms on either side of the front engine compartment and a tilting implement. This is usually a wide open box called a bucket but other common attachments are a pallet fork and a bale grappler.

Other modifications to the original bulldozer include making the machine smaller to let it operate in small work areas where movement is limited. There are also tiny wheeled loaders, officially called Skid-steer loaders but nicknamed " Bobcat" after the original manufacturer, which are particularly suited for small excavation projects in confined areas.

## Compact Utility Tractor

Kubota and New Holland Compact Tractors equipped with Front End Loaders

In the middle is a 24 hp (18 kW) diesel CUT illustrating the size difference between a small farm tractor and a garden tractor

A Compact Utility Tractor, also called a CUT is a smaller version of an agricultural tractor but designed primarily for landscaping and estate management type tasks rather than for planting and harvesting on a commercial scale. Typical CUTs range in from 20 to 50 horsepower (15-37 kW) with available power take off (PTO) horsepower ranging from 15 to 45 hp (11-34 kW). CUTs are often equipped with both a mid-mounted PTO and a standard rear PTO, especially those below 40 horsepower (30 kW). The mid-mount PTO shaft typically rotates at/near 2000 rpms and is typically used to power such implements as mid-mount finish mower, a front mounted snow blower or front mounted rotary broom. The rear PTO is standardized at 540 rpms for the North American markets, but in some parts of the world a dual 540/1000 rpm PTO is standard and implements are available for either standard in those markets.

One of the most common attachment for a Compact Utility Tractor is the front end loader or FEL. Like the larger agricultural tractors, a CUT will have an adjustable three-point hitch that is hydraulically controlled. Typically a CUT will have four wheel drive, or more correctly 4 wheel assist. Modern Compact Utility Tractors often feature a Hydrostatic transmission, but many variants of gear drive transmissions are also offered from low priced simple gear transmissions to synchronized transmissions to advanced glide-shift transmissions. All modern CUTs feature a government mandated roll over protection structure (ROPS) just like agricultural tractors. The most well known brands in North America include Kubota, John Deere Tractor, New Holland Ag, Case-Farmall and Massey-Ferguson. Although less common, compact backhoes are often attached to compact utility tractors.


Howse brand modular Subsoiler mounted to a tractor

Compact Utility Tractors require special smaller implements than full size agricultural tractors. Very common implements include the box blade, the grader blade, the landscape rake, the post hole digger *(or post hole auger)*, the rotary cutter *(also called a slasher or a brush hog)*, a mid or rear mount finish mower, broadcast seeder, subsoiler and the rototiller *(also rotary tiller)*. In northern climates, a rear mounted snow blower is very common, on smaller CUTs some models are available with front mounted snow blowers that are powered by a mid-PTO shaft. There are many more implement brands than there are tractor brands offering CUT owners a wide selection of choice.


JD 71 Flexi Planter for tractors 20 to 35 horsepower


Broadcast seeder mounted to a Kubota Compact Utility Tractor

For small scale farming or large scale gardening, there are some planting and harvesting implements sized for CUTs. One and two row planting units are commonly available as are cultivators, sprayers and different types of seeders *(slit, rotary and drop)*.

## Garden Tractors

Garden Tractors (also called Mini Tractors) are small, light and simple tractors designed for use in domestic gardens. Garden Tractors are usually designed primarily for cutting grass, being fitted with horizontal rotary cutting decks. The distinction between a garden tractor and a ride-on lawnmower is often hard to make- generally Garden Tractors are more sturdily built, with stronger frames, axles and transmissions. Garden Tractors are generally capable of mounting other implements such as harrows, cultivators/rotavators, sweepers, rollers and dozer-blades. Like ride-on mowers, Garden Tractors generally have a horizontally-mounted engine with a belt-drive to a transaxle-type transmission (usually of 4- or 5-speeds, although some my also have two-speed reduction gearboxes or hydraulic gearboxes). However, Wheel Horse (now part of Toro) garden tractors have vertically-mounted engines with belt-drive, whilst Allen/ Gutbrod tractors had an automotive-type clutch and gearbox. The engines are generally 1- or 2-cylinder petrol (gasoline) engine, although diesel engine models are also available, especially in Europe.

In the U.S., the term riding lawn mower today refers to mid or rear engined machines. Front-engined tractor layout machines designed primarily for cutting grass and light towing are called lawn tractors, and heavy duty lawn tractors, often shaft driven, are garden tractors. The primary difference between a lawn tractor and a garden tractor are the frame weight, the rear wheels (garden tractors almost always have multiple mounting bolts, while most lawn tractors have a single bolt or clip on the hub.), and the ability to use ground engaging equipment such as plows or disk-harrows. Craftsman, MTD, Snapper and other major mowing equipment manufacturers use these terms.

As well as dedicated manufacturers, many makers of agricultural tractors have made (or continue to make) ranges of garden tractors, such as Case, Massey-Ferguson, International Harvester and John Deere.

## EPA tractor

A Ford rebuilt to an EPA tractor.

During World War II there was a shortage of tractors in Sweden and this led to the invention of a new type of tractor called the *EPA tractor* (EPA was a chain of discount stores and it was often used to signify something lacking in quality). An EPA tractor was simply an automobile, truck or lorry, with the passenger space cut off behind the front seats, equipped with two gearboxes in a row. When done to an older car with a ladder frame, the result was not dissimilar to a tractor and could be used as one.

After the war it remained popular, now not as a farm vehicle, but as a way for young people without a driver's license to own something similar to a car. Since it was legally seen as a tractor it could be driven from 16 years of age and only required a tractor license. Eventually the legal loophole was closed and no new EPA tractors were allowed to be made, but the remaining were still legal, something that led to inflated prices and many protests from people that preferred EPA tractors to ordinary cars.

A Volvo Duett rebuilt to an EPA tractor. Obviously the intended use is no longer as a farm vehicle.

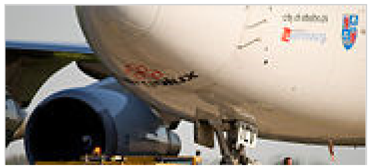
An "A tractor" based on Volvo 760. Notice the slow vehicle triangle and the longer boot.

In 31 March 1975 a similar type of vehicle was introduced, the *A tractor* [from *arbetstraktor* (work tractor)]. The main difference is that an A tractor has a top speed of 30 km/h. This is usually done by fitting two gearboxes in a row and not using one of them. Volvo Duett was for a long time the primary choice for conversion to an EPA or A tractor, but, since supplies have dried up, other cars have been used, in most cases a Volvo.

## Alternative machine types 'called' tractors

The term *tractor* (US & Canada) or *tractor unit* (UK) is also applied to:

- **Road tractors**, **tractor units** or traction heads, familiar as the front end of an articulated lorry / semi-trailer truck. They are heavy-duty vehicles with large engines and several axles.
  - The majority of these tractors are designed to pull long semi-trailers, most often to transport freight of some kind over a significant distance, and is connected to the trailer with a fifth wheel coupling. In England this type of "tractor" is often called an " artic cab".
  - A minority is the ballast tractor, whose load is hauled from a drawbar.
- *Pushback tractors* are used on airports to move aircraft on the ground, most commonly pushing aircraft away from their parking stands.
- Locomotive tractors ( engines) or Rail car movers
  - The amalgamation of machines, electrical generators, controls and devices that comprise the traction component of railway vehicles
- Artillery tractors

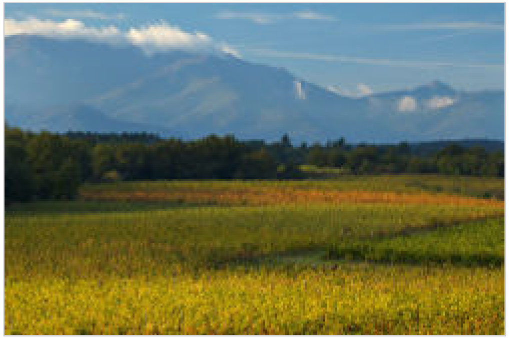


  - Vehicles used to tow artillery pieces of varying weights.
- NASA and other space agencies use very large tractors to ferry launch vehicles such as booster rockets and space shuttles from their hangars to (and, in rare cases, from) the launchpad.

# Vineyard

## 2008/9 Schools Wikipedia Selection. Related subjects: Agriculture

A **vineyard** is a plantation of grape-bearing vines, grown mainly for winemaking, but also raisins, table grapes and non-alcoholic grape juice. The science, practice and study of vineyard production is known as viticulture.



The extensive vineyards of the Languedoc-Roussillon region, southern France

A vineyard is often characterised by its terroir, a French term loosely translating as "a sense of place" that refers to the specific geographical and geological characteristics of grapevine plantations, which may be imparted in the wine. The precise conditions which a vineyard must maintain are often tightly-regulated and in recent years have become the subject of progressive and often radical change.

## History

Common vineyard (ca. 1910)

The earliest evidence of wine production dates from between 6000 and 5000 BC. Wine making technology improved considerably with the ancient Greeks but it wasn't until the end of the Roman Empire that cultivation techniques as we know them were common throughout Europe.

In medieval Europe the Christian Church was a staunch supporter of wine, which was necessary for the celebration of the Catholic Mass. During the lengthy instability of the Middle Ages, the Christian monasteries maintained and developed viticultural practices, having the resources, security, stability and interest in improving the quality of their vines. They owned and tended the best vineyards in Europe and *vinum theologium* was considered superior to all others.

European vineyards were planted with a wide variety of the *Vitis vinifera* grape. However, in the late 19th century, the entire species was nearly destroyed by the plant louse *phylloxera* accidentally introduced to Europe from North America. Native American grapevines include varieties such as *Vitis labrusca*, which is resistant to the bug, but produce wines with a foxy, animal-like taste. *Vitis vinifera* varieties were saved by being grafted onto the rootstock of native American varieties, although there is still no remedy for *phylloxera*, which remains a danger to any vineyard not planted with grafted rootstock.


Modern vineyards on the banks of the Rhine river in Germany.

The oldest productive vineyard in the world is claimed to be located in Maribor, Slovenia, based largely on the celebrated *Stara trta*, a 400-year-old grapevine which grows there and was recognized as the oldest living example by the *Guinness Book of Records* in 2004.

# Modern practices


A vineyard with bird-netting.

The quest for vineyard efficiency has produced a bewildering range of systems and techniques in recent years. Due to the often much more fertile New World growing conditions, attention has focussed heavily on managing the vine's more vigorous growth. Innovation in *palissage* (training of the vine, usually along a trellis, and often referred to as "canopy management") and pruning and thinning methods (which aim to optimize the Leaf Area/Fruit (LA/F) ratio relative to a vineyard's microclimate) have largely replaced more general, traditional concepts like "yield per unit area" in favour of "maximizing yield of desired quality". Many of these new techniques have since been adopted in place of traditional practice in the more progressive of the so-called "Old World" vineyards.

Other recent practices include spraying water on vines to protect them from sub-zero temperatures ( aspersion), new grafting techniques, soil slotting, and mechanical harvesting. Such techniques have made possible the development of wine industries in New World countries such as Canada. Today there is increasing interest in developing organic, ecologically sensitive and sustainable vineyards. Biodynamics has become increasingly popular in viticulture. The use of drip irrigation in recent years has expanded vineyards into areas which were previously unplantable. As a consequence of irrigation, yields are more consistent and vintage years virtually irrelevant.

For well over half a century Cornell University, the University of California at Davis, and California State University at Fresno, among others, have been conducting scientific experiments to improve viticulture and educating practitioners. The research includes developing improved grape varieties and investigating pest control. The International Grape Genome Program is a multi-national effort to discover a genetic means to improving quality, increasing yield and providing a "natural" resistance to pests.

"Old World" vineyard using modern spacing and trellising methods

The implementation of mechanical harvesting is often stimulated by changes in labor laws, labor shortages, and bureaucratic complications. It can be expensive to hire labor for short periods of time, which does not square well with the need to reduce production costs and harvest quickly, often at night. However, very small vineyards, incompatible widths between rows of grape vines and steep terrain hinder the employment of machine harvesting even more than the resistance of traditional views which reject such harvesting.

# Current trends

A vineyard in Alexander Valley, California.

Numbers of New World vineyard plantings have been increasing almost as fast as European vineyards are being uprooted. Between 1990 and 2003, U.S. vineyards increased from 292,000 acres (1,180 $km^2$) to 954,000 acres (3,860 $km^2$), while Australian vineyard numbers more than doubled from 146,000 acres (590 $km^2$) to 356,000 acres (1,440 $km^2$) and Chilean vineyards grew from 161,500 acres (654 $km^2$) to 415,000 acres (1,680 $km^2$). The size of individual vineyards in the New World is significant. Europe's 1.6 million vineyards are an average of 0.2 square kilometres each, while the average Australian vineyard is 0.5 square kilometres, providing considerable economies of scale. Exports to Europe from New World growers increased by 54% in the six years up to 2006.

There are also changes in the kinds of grapes grown. For example, in Chile, large areas of low-quality grapes have been replaced with such grapes as Chardonnay and Cabernet Sauvignon. Grape changes are often in response to changing consumer demand but sometimes result from vine pull schemes designed to promote vineyard change. Alternatively, the development of "T" budding now permits the grafting of a different grape variety onto existing rootstock in the vineyard, making it possible to switch varieties within a two year period.

Local legislation often dictates which varieties are selected, how they are grown, whether vineyards can be irrigated and exactly when grapes can be harvested, all of which in serves to reinforce tradition. Of course, changes in the law can change which grapes are planted. For example, during Prohibition in the U.S. (1920-1933), vineyards in California expanded sevenfold to meet the increasing demand for home-brewing. However, they were largely planted in varieties with tough skins that could be transported across the country to home wine-makers and the resulting wine was of low quality.

Leading wine critic Robert M. Parker, Jr. has had a significant influence on viticulture around the world. His taste preferences have led many growers in Bordeaux, for example, to practice " green harvesting," in which whole grape clusters are removed and discarded during the growing season in order to reduce yields. Also, because of Parker's influence, many growers now strip sections of leaves away from vines to permit more direct sunlight to reach the grapes.

## Terroir

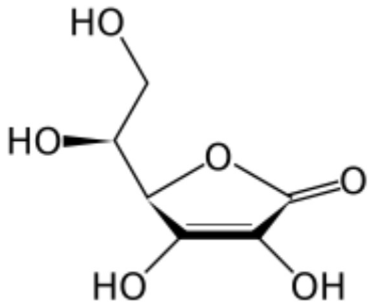
Vines growing in volcanic lapilli in the La Geria region of Lanzarote. The low, curved walls are traditionally used to protect the vines from the constant wind.

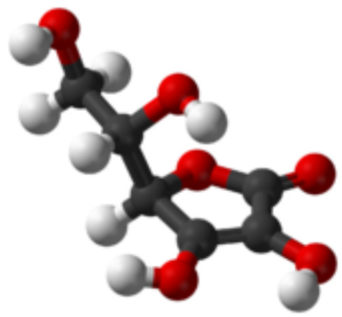
Terroir refers to the combination of natural factors associated with any particular vineyard. These factors include such things as soil, underlying rock, altitude, slope of hill or terrain, orientation toward the sun, and microclimate (typical rain, winds, humidity, temperature variations, etc.) No two vineyards have the exact same terroir, although any difference in the resulting wine may be virtually undetectable.

Vineyards are often on hillsides and on soil of marginal value to other plants. A common saying is that "the worse the soil, the better the wine." Planting on hillsides, especially those facing south, is most often in an attempt to maximize the amount of sunlight that falls on the vineyard. For this reason some of the best wines come from vineyards planted on quite steep hills, conditions which would make most other agricultural products uneconomic. The stereotypical vineyard site for wine grapes (in the Northern hemisphere) is a hillside in a dry climate with a southern exposure, good drainage to reduce unnecessary water uptake, and balanced pruning to force the vine to put more of its energy into the fruit, rather than foliage.

# Vitamin C

**2008/9 Schools Wikipedia Selection. Related subjects: Agriculture; Chemical compounds**



Vitamin C

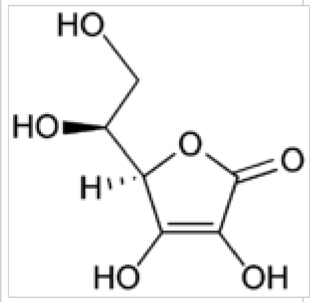
**Systematic (IUPAC) name**

2-oxo-L-threo-hexono-1,4- lactone-2,3-enediol
*or*
(*R*)-3,4-dihydroxy-5-((*S*)- 1,2-dihydroxyethyl)furan-2(5*H*)-one

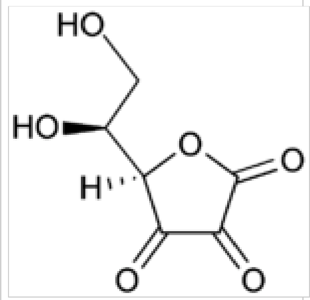
| | |
|---|---|
| **Identifiers** | |
| CAS number | |
| ATC code | A |
| PubChem | |
| **Chemical data** | |
| Formula | $C_6H_8O_6$ |
| Mol. mass | 176.14 grams per mol |
| Synonyms | L-ascorbate |
| **Physical data** | |
| Melt. point | 190–192 °C (374–378 °F) *decomposes* |

| | |
|---|---|
| **Pharmacokinetic data** | |
| Bioavailability | rapid & complete |
| Protein binding | negligible |
| Metabolism | ? |
| Half life | 30 minutes |
| Excretion | renal |
| **Therapeutic considerations** | |
| Pregnancy cat. | A |
| Legal status | general public availability |
| Routes | oral |

**Vitamin C** or **L-ascorbate** is an essential nutrient for a large number of higher primate species, a small number of other mammalian species (notably guinea pigs and bats), a few species of birds, and some fish.




ascorbic acid
( reduced form)




dehydroascorbic acid
( oxidized form)

The presence of ascorbate is required for a range of essential metabolic reactions in all animals and plants. It is made internally by almost all organisms, humans being the most well-known exception. It is widely known as the vitamin whose deficiency causes scurvy in humans. It is also widely used as a food additive.

The pharmacophore of vitamin C is the ascorbate ion. In living organisms, ascorbate is an antioxidant, since it protects the body against oxidative stress, and is a cofactor in several vital enzymatic reactions.

The uses and the daily requirement amounts of vitamin C are matters of on-going debate. People consuming diets rich in ascorbate from natural foods, such as fruits and vegetables, are healthier and have lower mortality from a number of chronic illnesses. However, a recent meta-analysis of 68 reliable antioxidant supplementation experiments involving a total of 232,606 individuals concluded that consuming additional ascorbate from supplements may not be as beneficial as thought.

# Biological significance

Vitamin C is purely the L-enantiomer of ascorbate; the opposite D-enantiomer has no physiological significance. Both forms are mirror images of the same molecular structure. When L-ascorbate, which is a strong reducing agent, carries out its reducing function, it is converted to its oxidized form, L-dehydroascorbate. L-dehydroascorbate can then be reduced back to the active L-ascorbate form in the body by enzymes and glutathione.

L-ascorbate is a weak sugar acid structurally related to glucose which naturally occurs either attached to a hydrogen ion, forming ascorbic acid, or to a metal ion, forming a mineral ascorbate.

## Function

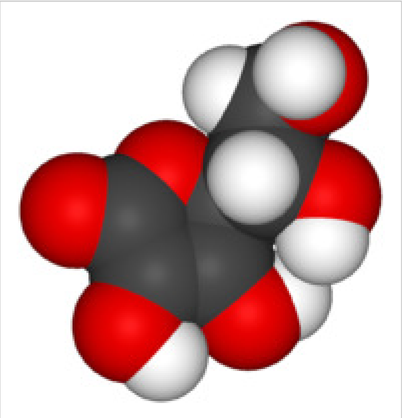
In humans, vitamin C is a highly effective antioxidant, acting to lessen oxidative stress, a substrate for ascorbate peroxidase, as well as an enzyme cofactor for the biosynthesis of many important biochemicals. Vitamin C acts as an electron donor for eight different enzymes:

- Three participate in collagen hydroxylation. These reactions add hydroxyl groups to the amino acids proline or lysine in the collagen molecule (via prolyl hydroxylase and lysyl hydroxylase), thereby allowing the collagen molecule to assume its triple helix structure and making vitamin C essential to the development and maintenance of scar tissue, blood vessels, and cartilage.
- Two are necessary for synthesis of carnitine. Carnitine is essential for the transport of fatty acids into mitochondria for ATP generation.

- The remaining three have the following functions:
  - dopamine beta hydroxylase participates in the biosynthesis of norepinephrine from dopamine.
  - another enzyme adds amide groups to peptide hormones, greatly increasing their stability.
  - one modulates tyrosine metabolism.

Biological tissues that accumulate over 100 times the level in blood plasma of vitamin C are the adrenal glands, pituitary, thymus, corpus luteum, and retina. Those with 10 to 50 times the concentration present in blood plasma include the brain, spleen, lung, testicle, lymph nodes, liver, thyroid, small intestinal mucosa, leukocytes, pancreas, kidney and salivary glands.

## Biosynthesis



Model of a vitamin C molecule. Black is carbon, red is oxygen, and white is hydrogen

The vast majority of animals and plants are able to synthesize their own vitamin C, through a sequence of four enzyme-driven steps, which convert glucose to vitamin C. The glucose needed to produce ascorbate in the liver (in mammals and perching birds) is extracted from glycogen; ascorbate synthesis is a glycogenolysis-dependent process. In reptiles and birds the biosynthesis is carried out in the kidneys.

Among the animals that have lost the ability to synthesise vitamin C are simians (specifically the suborder haplorrhini), guinea pigs, a number of species of passerine birds (but not all of them), and in apparently many major families of bats and perhaps all of them. Humans have no enzymatic capability to manufacture vitamin C. The cause of this phenomenon is that the last enzyme in the synthesis process, L-gulonolactone oxidase, cannot be made by the listed animals because the gene for this enzyme, Pseudogene ΨGULO, is defective. The mutation has not been lethal because vitamin C is abundant in their food sources. It has been found that species with this mutation (including humans) have adapted a vitamin C recycling mechanism to compensate.

Most simians consume the vitamin in amounts 10 to 20 times higher than that recommended by governments for humans. This discrepancy constitutes the basis of the controversy on current recommended dietary allowances.

It has been noted that the loss of the ability to synthesize ascorbate strikingly parallels the evolutionary loss of the ability to break down uric acid. Uric acid and ascorbate are both strong reducing agents. This has led to the suggestion that in higher primates, uric acid has taken over some of the functions of ascorbate. Ascorbic acid can be oxidised (broken down) in the human body by the enzyme ascorbic acid oxidase.

An adult goat, a typical example of a vitamin C-producing animal, will manufacture more than 13,000 mg of vitamin C per day in normal health and the biosynthesis will increase "many fold under stress". Trauma or injury has also been demonstrated to use up large quantities of vitamin C in humans. Some microorganisms such as the yeast *Saccharomyces cerevisiae* have been shown to be able to synthesize vitamin C from simple sugars.

## Deficiency

Scurvy is an avitaminosis resulting from lack of vitamin C, since without this vitamin, the synthesised collagen is too unstable to perform its function. Scurvy leads to the formation of liver spots on the skin, spongy gums, and bleeding from all mucous membranes. The spots are most abundant on the thighs and legs, and a person with the ailment looks pale, feels depressed, and is partially immobilized. In advanced scurvy there are open, suppurating wounds and loss of teeth and, eventually, death. The human body can store only a certain amount of vitamin C, and so the body soon depletes itself if fresh supplies are not consumed.

It has been shown that smokers who have diets poor in vitamin C are at a higher risk of lung-borne diseases than those smokers who have higher concentrations of Vitamin C in the blood.

## History of human understanding


James Lind, a British Royal Navy surgeon who, in 1747, identified that a quality in fruit prevented the disease of scurvy in what was the first recorded controlled experiment.

The need to include fresh plant food or raw animal flesh in the diet to prevent disease was known from ancient times. Native peoples living in marginal areas incorporated this into their medicinal lore. For example, spruce needles were used in temperate zones in infusions, or the leaves from species of drought-resistant trees in desert areas. In 1536, the French explorer Jacques Cartier, exploring the St. Lawrence River, used the local natives' knowledge to save his men who were dying of scurvy. He boiled the needles of the arbor vitae tree to make a tea that was later shown to contain 50 mg of vitamin C per 100 grams.

Throughout history, the benefit of plant food to survive long sea voyages has been occasionally recommended by authorities. John Woodall, the first appointed surgeon to the British East India Company, recommended the preventive and curative use of lemon juice in his book "The Surgeon's Mate", in 1617. The Dutch writer, Johann Bachstrom, in 1734, gave the firm opinion that *"scurvy is solely owing to a total abstinence from fresh vegetable food, and greens; which is alone the primary cause of the disease."*

While the earliest documented case of scurvy was described by Hippocrates around the year 400 BC, the first attempt to give scientific basis for the cause of this disease was by a ship's surgeon in the British Royal Navy, James Lind. Scurvy was common among those with poor access to fresh fruit and vegetables, such as remote, isolated sailors and soldiers. While at sea in May 1747, Lind provided some crew members with two oranges and one lemon per day, in addition to normal rations, while others continued on cider, vinegar, sulfuric acid or seawater, along with their normal rations. In the history of science this is considered to be the first occurrence of a controlled experiment comparing results on two populations of a factor applied to one group only with all other factors the same. The results conclusively showed that citrus fruits prevented the disease. Lind published his work in 1753 in his *Treatise on the Scurvy*.


Citrus fruits were one of the first sources of vitamin C available to ship's surgeons.

Lind's work was slow to be noticed, partly because he gave conflicting evidence within the book, and partly because the British admiralty saw care for the well-being of crews as a sign of weakness. In addition, fresh fruit was very expensive to keep on board, whereas boiling it down to juice allowed easy storage but destroyed the vitamin (especially if boiled in copper kettles). Ship captains assumed wrongly that Lind's suggestions didn't work because those juices failed to cure scurvy.

It was 1795 before the British navy adopted lemons or lime as standard issue at sea. Limes were more popular as they could be found in British West Indian Colonies, unlike lemons which weren't found in British Dominions, and were therefore more expensive. This practice led to the American use of the nickname "limey" to refer to the British. Captain James Cook had previously demonstrated and proven the principle of the advantages of carrying "Sour krout" on board, by taking his crews to the Hawaiian Islands and beyond without losing any of his men to scurvy. For this otherwise unheard of feat, the British Admiralty awarded him a medal.

The name "antiscorbutic" was used in the eighteenth and nineteenth centuries as general term for those foods known to prevent scurvy, even though there was no understanding of the reason for this. These foods included but were not limited to: lemons, limes, and oranges; sauerkraut, cabbage, malt, and portable soup.

In 1907, Axel Holst and Theodor Frølich, two Norwegian physicians studying beriberi contracted aboard ship's crews in the Norwegian Fishing Fleet, wanted a small test mammal to substitute for the pigeons they used. They fed guinea pigs their test diet, which had earlier produced beriberi in their pigeons, and were surprised when scurvy resulted instead. Until that time scurvy had not been observed in any organism apart from humans, and had been considered an exclusively human disease.

## Discovery of ascorbic acid

In 1912, the Polish-American biochemist Casimir Funk, while researching deficiency diseases, developed the concept of vitamins to refer to the non-mineral micro-nutrients which are essential to health. The name is a portmanteau of "vital", due to the vital role they play biochemically, and "amines" because Funk thought that all these materials were chemical amines. One of the "vitamines" was thought to be the anti-scorbutic factor, long thought to be a component of most fresh plant material.

Albert Szent-Györgyi, pictured here in 1948, was awarded the 1937 Nobel Prize in Medicine for the discovery of vitamin C

In 1928 the Arctic anthropologist Vilhjalmur Stefansson attempted to prove his theory of how the Eskimos are able to avoid scurvy with almost no plant food in their diet, despite the disease striking European Arctic explorers living on similar high-meat diets. Stefansson theorised that the natives get their vitamin C from fresh meat that is minimally cooked. Starting in February 1928, for one year he and a colleague lived on an exclusively minimally-cooked meat diet while under medical supervision; they remained healthy. (Later studies done after vitamin C could be quantified in mostly-raw traditional food diets of the Yukon, Inuit, and Métís of the Northern Canada, showed that their daily intake of vitamin C averaged between 52 and 62 mg/day, an amount approximately the dietary reference intake (DRI), even at times of the year when little plant-based food were eaten.)

From 1928 to 1933, the Hungarian research team of Joseph L Svirbely and Albert Szent-Györgyi and, independently, the American Charles Glen King, first isolated the anti-scorbutic factor, calling it "ascorbic acid" for its vitamin activity. Ascorbic acid turned out *not* to be an amine, or even to contain any nitrogen. For their accomplishment, Szent-Györgyi was awarded the 1937 Nobel Prize in Medicine.

Between 1933 and 1934, the British chemists Sir Walter Norman Haworth and Sir Edmund Hirst and, independently, the Polish chemist Tadeus Reichstein, succeeded in synthesizing the vitamin, making it the first to be artificially produced. This made possible the cheap mass-production of what was by then known as vitamin C. Only Haworth was awarded the 1937 Nobel Prize in Chemistry for this work, but the "Reichstein process" retained Reichstein's name.

In 1934 Hoffmann–La Roche became the first pharmaceutical company to mass-produce synthetic vitamin C, under the brand name of Redoxon.

In 1957 the American J.J. Burns showed that the reason some mammals were susceptible to scurvy was the inability of their liver to produce the active enzyme L-gulonolactone oxidase, which is the last of the chain of four enzymes which synthesize vitamin C. American biochemist Irwin Stone was the first to exploit vitamin C for its food preservative properties. He later developed the theory that humans possess a mutated form of the L-gulonolactone oxidase coding gene.

# Daily requirements

The North American Dietary Reference Intake recommends 90 milligrams per day and no more than 2 grams per day (2000 milligrams per day). Other related species sharing the same inability to produce vitamin C and requiring exogenous vitamin C consume 20 to 80 times this reference intake. There is continuing debate within the orthodox scientific community over the best dose schedule (the amount and frequency of intake) of vitamin C for maintaining optimal health in humans. It is generally agreed that a balanced diet without supplementation contains enough vitamin C to prevent scurvy in an average healthy adult, while those who are pregnant, smoke tobacco, or are under stress require slightly more.

High doses (thousands of milligrams) may result in diarrhea in healthy adults. Proponents of alternative medicine (specifically orthomolecular medicine) claim the onset of diarrhea to be an indication of where the body's true vitamin C requirement lies, though this has yet to be clinically verified.

### Government recommended intakes

Recommendations for vitamin C intake have been set by various national agencies:

- 40 milligrams per day: the United Kingdom's Food Standards Agency
- 45 milligrams per day: the World Health Organization
- 60 mg/day: Health Canada 2007
- 60–95 milligrams per day: United States' National Academy of Sciences

| United States vitamin C recommendations | |
|---|---|
| Recommended Dietary Allowance (adult male) | 90 mg per day |
| Recommended Dietary Allowance (adult female) | 75 mg per day |
| Tolerable Upper Intake Level (adult male) | 2,000 mg per day |
| Tolerable Upper Intake Level (adult female) | 2,000 mg per day |

The United States defined Tolerable Upper Intake Level for a 25-year-old male is 2,000 milligrams per day.

### Alternative recommendations on intakes

Some independent researchers have calculated the amount needed for an adult human to achieve similar blood serum levels as vitamin C synthesising mammals as follows:

- 400 milligrams per day: the Linus Pauling Institute.
- 500 milligrams per 12 hours: Professor Roc Ordman, from research into biological free radicals.
- 3,000 milligrams per day *(or up to 300,000 mg during illness)*: the Vitamin C Foundation.
- 6,000–12,000 milligrams per day: Thomas E. Levy, Colorado Integrative Medical Centre.
- 6,000–18,000 milligrams per day: Linus Pauling's personal use.

## Vitamin C high dose arguments

There is a strong advocacy movement for large doses of vitamin C based on some in vitro and retrospective studies , though large, randomized clinical trials are still lacking. Many pro-vitamin C organizations promote usage levels well beyond the current Dietary Reference Intake. The movement is led by scientists and doctors such as Robert Cathcart, Ewan Cameron, Steve Hickey, Irwin Stone and the twice Nobel Prize laureate Linus Pauling and Dr Matthias Rath. Pauling's 1986 book *How to Live Longer and Feel Better* was a bestseller and advocated taking many grams per day orally. There is some scientific literature critical of governmental agency dose recommendations. The biological halflife for vitamin C is fairly short, about 30 minutes in blood plasma, a fact which high dose advocates say that mainstream researchers have failed to take into account. Researchers at the National Institutes of Health decided upon the current RDA based upon tests conducted 12 hours (24 half lives) after consumption. Mainstream medicine remains skeptical of these claims.

### Genetic rationales for high doses

Four gene products are necessary to manufacture vitamin C from glucose. The loss of activity of the gene for the last step, Pseudogene ΨGULO (GLO) the terminal enzyme responsible for manufacture of vitamin C, has occurred separately in the history of several species. The loss of this enzyme activity is responsible of inability of guinea pigs to synthesize vitamin C enzymatically, but this event happened independently of the loss in the haplorrhini suborder of primates, including humans. The remains of this non-functional gene with many mutations, is however still present in the genome of the guinea pigs and in primates, including humans. GLO activity has also been lost in all major families of bats, regardless of diet. In addition, the function of GLO appears to have been lost several times, and possibly re-acquired, in several lines of passerine birds, where ability to make vitamin C varies from species to species.

Loss of GLO activity in the primate order supposedly occurred about 63 million years ago, at about the time it split into the suborders haplorrhini (which lost the enzyme activity) and the more primitive strepsirrhini (which retained it). The haplorrhini ("simple nosed") primates, which cannot make vitamin C enzymatically, include the tarsiers and the simians (apes, monkeys and humans). The suborder strepsirrhini (bent or wet-nosed prosimians) which are still able to make vitamin C enzymatically, include lorises, galagos, pottos, and to some extent, lemurs.

Stone and Pauling calculated, based on the diet of our primate cousins (similar to what our common descendants are likely to have consumed when the gene mutated), that the optimum daily requirement of vitamin C is around 2,300 milligrams for a human requiring 2,500 kcal a day.

The established RDA has been criticized by Pauling to be one that will prevent acute scurvy, and is not necessarily the dosage for optimal health.

## Therapeutic uses

Since its discovery vitamin C has been considered by some enthusiastic proponents a " universal panacea", although this led to suspicions by others of it being over-hyped. Other proponents of high dose vitamin C consider that if it is given "in the right form, with the proper technique, in frequent enough doses, in high enough doses, along with certain additional agents and for a long enough period of time," it can prevent and, in many cases, cure, a wide range of common and/or lethal diseases, notably the common cold and heart disease, although the NIH considers there to be "fair scientific evidence against this use." Some proponents issued controversial statements involving it being a cure for AIDS, bird flu, and SARS.

Probably the most controversial issue, the putative role of ascorbate in the management of AIDS, is still unresolved, more than 16 years after a study published in the Proceedings of National Academy of Sciences (USA) showing that non toxic doses of ascorbate suppress HIV replication *in vitro*. Other studies expanded on those results, but still, no large scale trials have yet been conducted.

In an animal model of lead intoxication, vitamin C demonstrated "protective effects" on lead-induced nerve and muscle abnormalities In smokers, blood lead levels declined by an average of 81% when supplemented with 1000 mg of vitamin C, while 200 mg were ineffective, suggesting that vitamin C supplements may be an "economical and convenient" approach to reduce lead levels in the blood. The Journal of the American Medical Association published a study which concluded, based on an analysis of blood lead levels in the subjects of the Third *National Health and Nutrition Examination Survey*, that the independent, inverse relationship between lead levels and vitamin C in the blood, if causal, would "have public health implications for control of lead toxicity".

Vitamin C has limited popularity as a treatment for autism spectrum symptoms. A 1993 study of 18 children with ASD found some symptoms reduced after treatment with vitamin C, but these results have not been replicated. Small clinical trials have found that vitamin C might improve the sperm count, sperm motility, and sperm morphology in infertile men, or improve immune function related to the prevention and treatment of age-associated diseases. However, to date, no large clinical trials have verified these findings.

A preliminary study published in the Annals of Surgery found that the early administration of antioxidant supplementation using α-tocopherol and ascorbic acid reduces the incidence of organ failure and shortens ICU length of stay in this cohort of critically ill surgical patients. More research on this topic is pending.

Dehydroascorbic acid, the main form of oxidized Vitamin C in the body, was shown to reduce neurological deficits and mortality following stroke, due to its ability to cross the blood-brain barrier, while "the antioxidant ascorbic acid (AA) or vitamin C does not penetrate the blood-brain barrier". In this study published by the Proceedings of the National Academy of Sciences in 2001, the authors concluded that such "a pharmacological strategy to increase cerebral levels of ascorbate in stroke has tremendous potential to represent the timely translation of basic research into a relevant therapy for thromboembolic stroke in humans". No such "relevant therapies" are available yet and no clinical trials have been planned.

In January 2007 the US Food and Drug Administration approved a Phase I toxicity trial to determine the safe dosage of intravenous vitamin C as a possible cancer treatment for "patients who have exhausted all other conventional treatment options." Additional studies over several years would be needed to demonstrate whether it is effective.

In February 2007, an uncontrolled study of 39 terminal cancer patients showed that, on subjective questionnaires, patients reported an improvement in health, cancer symptoms, and daily function after administration of high-dose intravenous vitamin C. The authors concluded that "*Although there is still controversy regarding anticancer effects of vitamin C, the use of vitamin C is considered a safe and effective therapy to improve the quality of life of terminal cancer patients*".

Vitamin C has been shown to lower IOP in glaucoma patients when taken in massive amounts according to the September 2007 issue of GLEAMS.

## Testing for ascorbate levels in the body

Simple tests use DCPIP to measure the levels of vitamin C in the urine and in serum or blood plasma. However these reflect recent dietary intake rather than the level of vitamin C in body stores. Reverse phase high performance liquid chromatography is used for determining the storage levels of vitamin C within lymphocytes and tissue.

It has been observed that while serum or blood plasma levels follow the circadian rhythm or short term dietary changes, those within tissues themselves are more stable and give a better view of the availability of ascorbate within the organism. However, very few hospital laboratories are adequately equipped and trained to carry out such detailed analyses, and require samples to be analyzed in specialized laboratories.

# Adverse effects

## Common side-effects

Relatively large doses of vitamin C may cause indigestion, particularly when taken on an empty stomach.

When taken in large doses, vitamin C causes diarrhea in healthy subjects. In one trial, doses up to 6 grams of ascorbic acid were given to 29 infants, 93 children of preschool and school age, and 20 adults for more than 1400 days. With the higher doses, toxic manifestations were observed in five adults and four infants. The signs and symptoms in adults were nausea, vomiting, diarrhea, flushing of the face, headache, fatigue and disturbed sleep. The main toxic reactions in the infants were skin rashes. On the other hand, Cathcart has demonstrated that sick patients, with influenza and cancer for example, do not suffer any adverse effects whatsoever until the dosage is raised to fairly high levels such as 100 grams or higher.

## Possible side-effects

As vitamin C enhances iron absorption, iron poisoning can become an issue to people with rare iron overload disorders, such as haemochromatosis. A genetic condition that results in inadequate levels of the enzyme glucose-6-phosphate dehydrogenase (G6PD), can cause sufferers to develop hemolytic anaemia after ingesting specific oxidizing substances, such as very large dosages of vitamin C.

There is a longstanding belief among the mainstream medical community that vitamin C causes kidney stones, which is based on little science. Although some individual recent studies have found a relationship there is no clear relationship between excess ascorbic acid intake and kidney stone formation.

In a study conducted on rats, during the first month of pregnancy, high doses of vitamin C may suppress the production of progesterone from the corpus luteum. Progesterone, necessary for the maintenance of a pregnancy, is produced by the corpus luteum for the first few weeks, until the placenta is developed enough to produce its own source. By blocking this function of the corpus luteum, high doses of vitamin C (1000+ mg) are theorized to induce an early miscarriage.

In a group of spontaneously aborting women at the end of the first trimester, the mean values of vitamin C were significantly higher in the aborting group. However, the authors do state: 'This could not be interpreted as an evidence of causal association.'

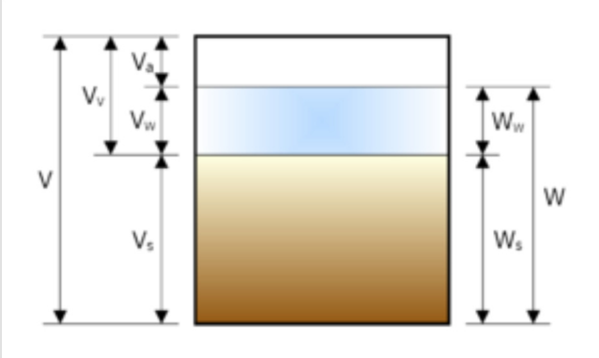
However, in a previous study of 79 women with threatened, previous spontaneous, or habitual abortion, Javert and Stander (1943) had 91% success with 33 patients who received vitamin C together with bioflavinoids and vitamin K (only three abortions), whereas all of the 46 patients who did not receive the vitamins aborted.

## Chance of overdose

As discussed previously, vitamin C exhibits remarkably low toxicity. The $LD_{50}$ (the dose that will kill 50% of a population) in rats is generally accepted to be 11.9 grams per kilogram of body weight when taken orally. The $LD_{50}$ in humans remains unknown, owing to medical ethics that preclude experiments which would put patients at risk of harm. However, as with all substances tested in this way, the $LD_{50}$ is taken as a guide to its toxicity in humans and no data to contradict this has been found.

# Water content

## 2008/9 Schools Wikipedia Selection. Related subjects: Agriculture; Geology and geophysics



Soil composition

**Water content** or **moisture content** is the quantity of water contained in a material, such as soil (called **soil moisture**), rock, ceramics, or wood on a volumetric or gravimetric basis. The property is used in a wide range of scientific and technical areas, and is expressed as a ratio, which can range from 0 (completely dry) to the value of the materials' porosity at saturation.

**Volumetric water content**, θ, is defined mathematically as:

$$\theta = \frac{V_w}{V_T}$$

where $V_w$ is the volume of water and $V_T = V_s + V_v = V_s + V_w + V_a$ is the total volume (that is Soil Volume + Water Volume + Void Space). Water content may also be based on its mass or weight, thus the **gravimetric water content** is defined as:

$$u = \frac{m_w}{m_b}$$

where $m_w$ is the mass of water and $m_b$ (or $m_s$ for soil) is the bulk material mass. To convert gravimetric water content to volumetric water, multiply the gravimetric water content by the bulk specific gravity of the material.

# Other definitions

## Degree of saturation

In soil mechanics and petroleum engineering, the term **water saturation** or **degree of saturation**, $S_w$ is used, defined as

$$S_w = \frac{V_w}{V_v} = \frac{V_w}{V_b\phi} = \frac{\theta}{\phi}$$

where $\varphi = V_v / V_T$ is the porosity and $V_v$ is the volume of void or pore space.

Values of $S_w$ can range from 0 (dry) to 1 (saturated). In reality, $S_w$ never reaches 0 or 1 - these are idealizations for engineering use.

### Normalized volumetric water content

The **normalized water content**, Θ, (also called **effective saturation** or $S_e$) is a dimensionless value defined by van Genuchten as:

$$\Theta = \frac{\theta - \theta_r}{\theta_s - \theta_r}$$

where θ is the volumetric water content; $\theta_r$ is the residual water content, defined as the water content for which the gradient $d\theta / dh$ becomes zero; and, $\theta_s$ is the saturated water content.

## Measurement

### Direct methods

Volumetric water content can be directly measured using a known volume of the material, and a drying oven. Volumetric water content, θ, is calculated using:

$$\theta = \frac{m_{\text{wet}} - m_{\text{dry}}}{\rho_w \cdot V_b}$$

where

$m_{\text{wet}}$ and $m_{\text{dry}}$ are the masses of the sample before and after drying in the oven;
$\rho_w$ is the density of water; and
$V_b$ is the volume of the sample before drying the sample.

For materials that change in volume with water content, such as coal, the water content, $u$, is expressed in terms of the mass of water per unit mass of the moist specimen:

$$u = \frac{m_{\text{wet}} - m_{\text{dry}}}{m_{\text{wet}}}$$

However, geotechnics requires the moisture content to be expressed as a percentage of the sample's dry weight i.e. % moisture content = $u$ * 100

Where
$$u = \frac{m_{\text{wet}} - m_{\text{dry}}}{m_{\text{dry}}}$$

For wood, the convention is to report moisture content on oven-dry basis (i.e. generally drying sample in an oven set at 105 deg Celcius for 24 hours). In wood drying, this is an important concept.

### Laboratory methods

Other methods that determine water content of a sample include chemical titrations (for example the Karl Fischer titration), determining mass loss on heating (perhaps in the presence of an inert gas), or after freeze drying. In the food industry the Dean-Stark method is also commonly used.

From the Annual Book of ASTM (American Society for Testing and Materials) Standards, the total evaporable moisture content in Aggregate (C 566) can be calculated with the formula:

$$p = \frac{W - D}{D}$$

where $p$ is the fraction of total evaporable moisture content of sample, $W$ is the mass of the original sample, and $D$ is mass of dried sample.

### Geophysical methods

There are several geophysical methods available that can approximate *in situ* soil water content. These methods include: time-domain reflectometry (TDR), neutron probe, frequency domain sensor, capacitance probe, electrical resistivity tomography, and others that are sensitive to the physical properties of water . Geophysical sensors are often used to monitor soil moisture continuously in agricultural and scientific applications.

### Satellite remote sensing method

Satellite microwave remote sensing is used to estimate soil moisture based on the large contrast between the dielectric properties of wet and dry soil. The data from microwave remote sensing satellite such as: WindSat, AMSR-E, RADARSAT, ERS-1-2 are used to estimate surface soil moisture .

## Classification and uses

Moisture may be present as adsorbed moisture at internal surfaces and as capillary condensed water in small pores. At low relative humidities, moisture consists mainly of adsorbed water. At higher relative humidities, liquid water becomes more and more important, depending on the pore size. In wood-based materials, however, almost all water is adsorbed at humidities below 98% RH.

In biological applications there can also be a distinction between physisorbed water and "free" water — the physisorbed water being that closely associated with and relatively difficult to remove from a biological material. The method used to determine water content may affect whether water present in this form is accounted for. For a better indication of "free" and "bound" water, the water activity of a material should be considered.

Water molecules may also be present in materials closely associated with individual molecules, as "water of crystallization", or as water molecules which are static components of protein structure.

## Earth and agricultural sciences

In soil science, hydrology and agricultural sciences, water content has an important role for groundwater recharge, agriculture, and soil chemistry. Many recent scientific research efforts have aimed toward a predictive-understanding of water content over space and time. Observations have revealed generally that spatial variance in water content tends to increase as overall wetness increases in semiarid regions, to decrease as overall wetness increases in humid regions, and to peak under intermediate wetness conditions in temperature regions .

There are four standard water contents that are routinely measured and used, which are described in the following table:

| Name | Notation | Suction pressure (J/kg or kPa) | Typical water content (vol/vol) | Description |
|---|---|---|---|---|
| Saturated water content | $\theta_s$ | 0 | 0.2–0.5 | Fully saturated water, equivalent to effective porosity |
| Field capacity | $\theta_{fc}$ | −33 | 0.1–0.35 | Soil moisture after 2–3 days after a rain or irrigation |
| Permanent wilting point | $\theta_{pwp}$ or $\theta_{wp}$ | −1500 | 0.01–0.25 | Minimum soil moisture at which a plant wilts |
| Residual water content | $\theta_r$ | −∞ | 0.001–0.1 | Remaining water at high tension |

And lastly the available water content, $\theta_a$, which is equivalent to:

$$\theta_a \equiv \theta_{fc} - \theta_{pwp}$$

which can range between 0.1 in gravel and 0.3 in peat.

### Agriculture

When a soil gets too dry, plant transpiration drops because the water is becoming increasingly bound to the soil particles by suction. Below the wilting point plants are no longer able to extract water. At this point they wilt and cease transpiring altogether. Conditions where soil is too dry to maintain reliable plant growth is referred to as agricultural drought, and is a particular focus of irrigation management. Such conditions are common in arid and semi-arid environments.

Some agriculture professionals are beginning to use environmental measurements such as soil moisture to schedule irrigation. This method is referred to as "Smart Irrigation."

### Groundwater

In saturated groundwater aquifers, all available pore spaces are filled with water (volumetric water content = porosity). Above a capillary fringe, pore spaces have air in them too.

Most soils have a water content less than porosity, which is the definition of unsaturated conditions, and they make up the subject of vadose zone hydrogeology. The capillary fringe of the water table is the dividing line between saturated and unsaturated conditions. Water content in the capillary fringe decreases with increasing distance above the phreatic surface.

One of the main complications which arises in studying the vadose zone, is the fact that the unsaturated hydraulic conductivity is a function of the water content of the material. As a material dries out, the connected wet pathways through the media become smaller, the hydraulic conductivity decreasing with lower water content in a very non-linear fashion.

A water retention curve is the relationship between volumetric water content and the water potential of the porous medium. It is characteristic for different types of porous medium. Due to hysteresis, different wetting and drying curves may be distinguished.