

Unit 6) Machines and Technology

That was Then and This is Now...

THEN

"The calculation was to go into the harvest field this morning, so the canvas was put in position, and the harvester put in running order. Then Sears went for his team, Henry's team meanwhile being hitched to the machine. Henry drove and Sears and I were to bind. The binders ride on the machine. The grain is delivered by an elevator, from the canvas on which it falls upon a table in front of the binders, who need only make the bands and bind the sheaves. Did I write 'only?' Well, that 'only' means hard work, and quick work, too, for when the grain stands thick it takes all that two men want to do to keep the table clear. I have not got the 'hang' of the thing yet, but I'll soon be able to bind tolerably fast. We went round the field once, and then they concluded the rye was too green. So I had to take the hoe again. I guess by the time this season is over I'll know how to hoe corn, even if I learn nothing else, for I have done more at that since I am here than at anything else."¹

Howard Ruede, June 22, 1877

NOW

"You know the music in 'Jaws' when the gigantic shark is about to sink his teeth into the boat? Duh-duh-duh-duh, DUH-DUH-DUH-DUH ...

That's kind of how I felt in the field on Wednesday morning. The field looked peaceful and calm, but I could hear something munching. At first, I could only hear it. I couldn't see it.

But then it started coming closer...and closer...until I could fully see the machine doing the munching. It wasn't a shark doing the chomping. It was a Jaguar (a Jaguar silage cutter, that is).

Harvesting silage is a different kind of harvest around here. For one thing, it was all over and done with in about 4 hours. That's my kind of harvest. There's not the two weeks of wheat harvest angst with uncooperative weather and interminable breakdowns. And the temperature was a pleasant 75 degrees or so, as opposed to the 100-degree days of wheat harvest.

We hired Sallabedra Harvesting to bring their silage cutter and trucks to cut 27 acres of silage.

For years, Randy's family and a neighbor family did the job themselves. When Randy was young, they had a one-row, pull-type silage cutter. Then they upgraded to a two-row, pull-type silage cutter. They each provided a tractor, one to pull the cutter and the other to use to pack the trench silo. They each provided a truck to haul the cut silage from the field to the silo. And the wives provided a harvest meal for the four- to six-man crew.

Randy says it took two days to get everything ready. It took a week to get both family's silage cut and in the silos. And then it took another two days to get everything cleaned up.

On Wednesday, the Salladredra Harvest crew started cutting at about 7:30. By 11:30, they had moved to the neighbor's field to start filling his silo.

When you put everything in perspective, I don't think Randy waxes nostalgically for the 'good ol' days' when they did it themselves. Maybe he'll 'wax' just a little when the bill comes. But...probably not."²

Kim Fritzemeier, September 9, 2010
from Kim's County Line blog

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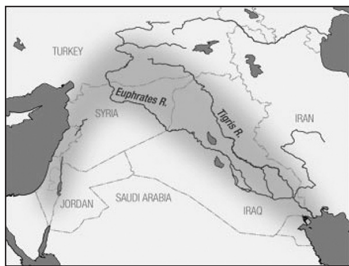
REFERENCES

TEACHER'S RESOURCES

Machines and Technology

The first agricultural revolution, the Neolithic Revolution, began around 10,000 B.C. This period was important because during this time, people transitioned from living in nomadic groups that collected food (hunter-gatherers) to agricultural settlements and societies centered around producing food through the cultivation of crops and the domestication of animals.

The Neolithic Revolution corresponds with a significant period of technological development – the transition from the Stone Age to the Bronze Age. The most significant developments appear to have taken place in the "Fertile Crescent" or the "Cradle of Civilization," an area which includes parts of modern Iraq, Syria, Iran, and Turkey. But, the transition to an agriculture-based society appears to have taken place independently in seven or eight locations around the world between 10,000 B.C. and 2,500 B.C.



The Fertile Crescent

Credit: NASA's Earth Observatory

By discarding seeds that were small or bitter tasting, people gradually bred crops that produced edible food. Seeds that matured too early and fell off before harvesting were unable to be collected and stored for planting, thus the natural selection process led to crops that retained their edible seeds longer. Cereal grasses (emmer, einkorn, and barley) were the earliest plants successfully domesticated. Five other pioneer crops domesticated during the Neolithic Revolution were lentil, pea, chickpea, bitter vetch, and flax.

THE PIONEER CROPS

The first agricultural crops were domesticated in the "Fertile Crescent" or the "Cradle of Civilization," an area which includes parts of modern Iraq, Syria, Iran, and Turkey.

The "pioneer" crops – the first agricultural plants to be domesticated – were emmer, einkorn, barley, lentil, pea, chickpea, bitter vetch, and flax.

TOOLS AND MACHINES

At first, the only tools used by humans were hand tools made of stone. The end of the Neolithic period was marked by the introduction of metal tools and other technological advancements. Until the Industrial Revolution, which began in Europe in the 1700s, power for all tools was provided by water, wind, people, or animals. During the Industrial Revolution, organic fuels based on wood were replaced with fossil fuels based on coal, which led to steam power and a supply of cheaper iron and later – steel.

As the agriculture industry adopted new technologies and used more machinery, less labor was required to produce food, freeing up labor to work in new industrial mills and factories. Because nearly everyone was involved in



Sowing Seeds

Courtesy: Florida Center for Instructional Technology

Planting Corn

Source: Library of Congress;
John Vachon, photographer



food production at that time, new machines and farming methods were often controversial. For example, the invention of the first threshing machine in England led to riots as people feared being forced to seek work in the cities and towns springing up around the new manufacturing sites.

According to the United Nations, agriculture accounts for more than 36 percent of world employment.³ The United Nations also reports that more than 70 percent of the people work in agriculture in at least 20 countries around the world.⁴ In the United States, the agriculture industry employs more than one in seven people. In Kansas, the number of people employed in agriculture and agriculture-related jobs is slightly higher at nearly one in five workers.

WORKING IN AGRICULTURE

Agriculture accounts for more than 36 percent of worldwide employment. In at least 20 countries, more than 70 percent of the population works in agriculture.

In the United States, the agricultural industry employs about one in seven people.

In Kansas, nearly one in five workers is employed in agriculture or agriculture-related jobs.

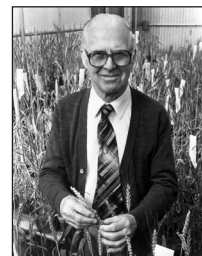
TECHNOLOGY IN AGRICULTURE

At first glance, it might seem that it does not require a lot of technology to grow plants. However, modern agriculture must make use of all available technological advancements in order to meet the demand for food and other products by the world's growing population.

Agricultural products and raw commodities have always been exported from the United States, even in colonial times. During World War II, however, food exports from the United States were critical in saving lives in Europe and supplying military efforts. After the war ended, the United States continued to supply food and agricultural products to countries in Europe and Asia while the economies in those countries recovered. As a result, the demand for American agricultural products continued to increase long after the war ended.

FATHER OF THE GREEN REVOLUTION

In 1970, Dr. Norman Borlaug became the first – and only – agricultural scientist ever awarded the Nobel Peace Prize. Dr. Borlaug, known as the "Father of the Green Revolution," is credited with saving more than one billion lives through his work developing high-yield, disease-resistant crop varieties and transforming food production in developing countries.



Credit: AgriLife, Texas A&M

FOOD PRODUCTION FACTS

Worldwide, food production more than doubled from 1960 to 1990.

From 1960 to 1990, only one percent more land worldwide was converted to agriculture.

To meet those demands for food, American agriculture had to produce more food on the same amount of land, as well as become more efficient due to the reduced availability of a labor force during the war. The development of high-yield, disease-resistant crop varieties led the "Green Revolution," a period beginning in the 1940s during which agriculture changed dramatically. In addition to improved seeds and plants, the period was marked by the development and adoption of new irrigation technologies, widespread use of improved fertilizers and pesticides, and advances in machinery used to produce food crops.

Worldwide, food production more than doubled from 1960 to 1990, even though only one percent more land was pulled into agricultural production during that same period.⁵ Famines became politically induced events, and millions of lives were saved as food production outpaced the growth of the human population. In developing countries, environmentally sensitive areas remained uncultivated, even as the countries became more self-sufficient in food production.

BIOTECHNOLOGY

In the 1990s, scientific advances in biotechnology opened the doors for even greater innovation in agriculture, as well as medicine and other industries. Based on biology, biotechnology uses biological processes to solve problems and make useful products. This includes the use of organisms such as yeast, which makes bread rise and has been used in the fermentation of alcoholic beverages for thousands of years. Modern biotechnology allows the manipulation of cellular processes at the molecular level, leading to medical and industrial breakthroughs, such as gene therapy, new vaccines, advanced diagnostic tests, pollution-eating microbes that clean up hazardous wastes, biodegradable plastics, energy-saving low temperature laundry detergents, and biofuels.

BIOTECHNOLOGY TIMELINE

1855 – Louis Pasteur proves microorganisms cause fermentation and spoilage, leading to the pasteurization of liquids like milk.

1863 – Gregor Mendel discovers how plant characteristics are passed from one generation to another, the foundation of the science of genetics.

1919 – first use of the word "biotechnology."

1941 – first use of the term "genetic engineering."

1981 – first genetically engineered plant is reported.

1982 – first biotech drug approved by the U.S. Food and Drug Administration, Humulin insulin, produced by genetically engineered bacteria for the treatment of diabetes.

1986 – first genetically engineered human vaccine is approved in the United States for the prevention of hepatitis B.

1993 – U.S. Food and Drug Administration declares that genetically engineered foods are "not inherently dangerous" and do not require special regulation.

1996 – first commercial production of biotech crops in the United States.

Source: Biotechnology Institute

HEALTH CARE AND BIOTECHNOLOGY

Worldwide, more than 250 biotech health care products and vaccines are available to patients.

There are more than 1,200 biotech diagnostic tests in use today around the world. Many of these diagnostic tests are portable; others have eliminated the need for invasive surgeries by only requiring a mouth swab or blood sample to determine treatment options.

Source: Biotechnology Industry Organization

BIOTECHNOLOGY WORDS

Biotechnology (biotech) – technology based on biological processes; the use of biological processes to solve problems or make useful products.

Agricultural biotechnology – biotechnology used to increase crop yields and productivity, improve food quality, and improve animal health. Examples: herbicide tolerant crops, virus-resistant papaya, insect-resistant cotton, and Golden Rice, a rice variety that produces beta-carotene and was developed to address vitamin A deficiencies, the world's leading preventable cause of blindness in children.

Industrial biotechnology – applying tools, such as microbes or enzymes, to manufacturing and chemical processes; may reduce the steps needed to make certain chemicals up to 80 percent or reduce energy requirements by more than 50 percent, also producing less waste and using less water in manufacturing processes. Examples: biodegradable plastics, low-temperature laundry detergents with enzymes, pollution-eating microbes used to clean up hazardous waste, and biofuels like ethanol.

Medical biotechnology – the use of biological processes to detect, diagnose, and treat diseases, as well as develop and manufacture vaccines and medicines; also includes the use of genetic information to develop individualized medical treatments. Examples: home pregnancy tests; diagnostic tests for strep throat, malaria, and specific cancers (including a form of breast cancer); vaccines for cervical cancer, rotavirus, and other infectious diseases – the second-leading cause of deaths worldwide; and medicines such as Humulin insulin, the first biotech drug approved by the U.S. Food and Drug Administration.

BIOSCIENCE IN KANSAS

In 2004, the Kansas legislature created the Kansas Bioscience Authority. The mission of the Kansas Bioscience Authority is to make Kansas the most desirable state for bioscience research, development, and commercialization.

Bioscience includes biotechnology and any of the branches of science dealing with the structure and behavior of living organisms.

PLANT BREEDING

Traditional plant breeding involving the controlled transfer of pollen from selected plants to other selected plants takes years, as the resulting seed has to be grown into plants to determine if those new plants are more desirable than the original plants. Traditional plant breeding may result in the transfer of undesirable traits that make the new plants more susceptible to damage from insects, disease, or environmental conditions like drought, wind, or cold temperatures. Now, agricultural biotechnology allows scientists to physically select characteristics at the molecular level, traits that protect plants from harmful diseases or insects, allow better control of weeds, or enhance the nutritional quality of food produced from the new plants. Only the desired traits are inserted at the genetic level, while other genes can be enhanced or subtracted without having to physically grow out the plants.



Transferring Pollen

Credit: Stephen Ausmus, USDA ARS

Globally, pests and diseases reduce food production by more than 35 percent.⁶ Weeds alone cause a 12 percent global crop loss.⁷ Biotech crops increase yields, reducing the need to pull more land into production to provide food for the rising global population. At the same time, herbicide-tolerant crops, those with genetic traits that make the plants immune to specific herbicides, allow the control of weeds that use the nutrients and water that food-producing crops need and reduce the need for tillage. Reductions in tillage provide environmental benefits that include reduced soil erosion and reduced consumption of fuel, which in turn reduces carbon dioxide emissions. In 2007, biotech crops reduced global CO₂ emissions by 31.3 billion pounds – the equivalent of removing 6.3 million cars from the road for one year.⁸ Biotech crops have also reduced the amounts and applications of insecticides, in addition to producing foods with increased nutritional value.

BIOTECH CROP WORDS

Biofuel – liquid fuel produced from biomass including ethanol, biodiesel, methanol, and reformulated gasoline components.

Biomass – plant matter, like trees, grasses, and agricultural crops, or other biological material.

Biorefinery – a facility that produces biofuels, chemicals, or bio-degradable plastics from biomass.

Biotech crops – agricultural crops developed through the use of biotechnology, including the addition, subtraction, or transfer of a gene into the genetic code of a plant.

Genetically engineered (genetically modified) – improved through the use of modern tools, such as biotechnology. All plant breeding is genetic modification, even the selection of only seeds from plants with desired traits for replanting or cross-pollination, transferring flower pollen from one plant to another to create a combination of genes from both plants.

Herbicide tolerant – immune to a specific herbicide, a chemical used to control weeds that kills plants or inhibits their growth.

Stacking traits – combining multiple desired traits into a single seed or plant.

Transgenic – the insertion of a gene from any species into the genetic code of the same or a different species.

BIOTECH CROP FACTS

Currently, pests, which include insects, weeds, and diseases, reduce global food production by more than 35 percent every year.

Corn yields in the United States have risen by more than 30 percent since 1997.

In 1998, regulatory approval of a virus-resistant papaya variety developed using biotechnology saved the Hawaiian papaya industry, which had been devastated by the papaya ringspot virus.

In 2009, more than 330 million acres of biotech crops were grown in 25 countries by 14 million farmers. Ninety percent (13 million farmers) were resource-poor farmers in developing countries.

Source: Biotechnology Industry Organization



Plant Pest: Cabbage Looper on Potato Leaves

Credit: Peggy Greb,
USDA ARS

PURE PLANT VARIETIES

Traditional plant breeding techniques typically require multiple generations of inbreeding to stabilize desired traits, producing desired characteristics such as higher yields, improved qualities for specific end uses, disease or herbicide resistance, or drought tolerance. For example, developing a new variety of winter wheat with the desired characteristics might take up to 12 years. Even then, the genetic purity of the new variety will only be 99.6 percent.⁹

Doubled haploid technology uses biotechnology to produce pure breeding lines in a single plant generation, significantly reducing the time required for new variety development. Highly specialized pollination techniques result in a haploid – a plant that possesses half the normal number of chromosomes (one chromosome, rather than the normal two, from each pair of parent plants). By inducing the chromosomes of a haploid plant to duplicate themselves in the laboratory, researchers can produce a doubled haploid – a plant containing twice the number of chromosomes it had at the start. Each pair of double chromosomes is genetically identical. The doubled haploid remains 100 percent genetically pure, allowing researchers and plant breeders to identify and evaluate specific genetic traits much more efficiently. In turn, this allows new varieties to be released for production in a much shorter time than traditional plant breeding methods. Doubled haploids can also be used to greatly accelerate the discovery and isolation of new genes.

In 2010, Heartland Plant Innovations established a doubled haploid laboratory in Manhattan, Kansas that began producing pure wheat genetic lines in 2011. These breeding lines are being produced for wheat breeders at Kansas State University, as well as researchers in other public and private institutions. Heartland Plant Innovations is a partnership between the Kansas Association of Wheat Growers, Kansas Wheat Commission, Kansas State University, and private investors.



Biotech Plant Research

Credit: Keith Weller, USDA ARS

BIOTECH CROP PRODUCTION

In 2009, the United States planted more acres to biotech crops than any other country in the world. Other leading countries were Brazil, Argentina, India, Canada, China, Paraguay, South Africa, Uruguay, and Bolivia.

In 2009, 79 percent of the world's soybean acres were planted to biotech varieties, along with 49 percent of the world's cotton acres, 26 percent of the world's corn acres, and 21 percent of the world's canola acres.

Source: ISAAA¹⁰

WORLD HUNGER FACTS

There are currently more than 1.02 billion undernourished people in the world.

More than 60 percent of the chronically hungry people in the world are women.

The United States supplies more than half of all international food aid each year.

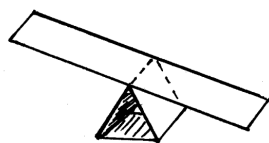
Source: Food and Agriculture Organization of the United Nations

Internationally recognized scientific organizations and regulatory agencies such as the World Health Organization, the Food and Agricultural Organization of the United Nations, the Organization for Economic Cooperation and Development, the U.S. National Academy of Science, and the Royal Society of London, have declared that biotech crops are safe for people and the environment. Over the last 20 years, biotech crops have been grown on more than 2.3 billion acres of farmland around the world.¹¹ In 2009 alone, 14 million farmers in 25 countries grew more than 330 million acres of biotech crops.¹²

In the United States, three agencies regulate biotech crops: the Food and Drug Administration, the Environmental Protection Agency, and the Animal Health and Plant Inspection Services of the U.S. Department of Agriculture. The top biotech crops in the United States in 2009 were: soybeans, corn, cotton, canola, squash, papaya, alfalfa, and sugarbeets.

Today, most people in the United States have an abundance of food options. However, there are currently more than 1.02 billion undernourished people in the world who do not get enough food to be healthy and lead active lives according to the Food and Agriculture Organization of the United Nations (FAO). FAO also reports that more than 60 percent of the chronically hungry people in the world are women.¹³ The United States continues to be the world's largest provider of international food aid and supplies more than half of all international food aid each year. Using biotechnology, future developments in food production, such as drought and flood tolerant crops, offer tools for agricultural producers to meet global needs for food.

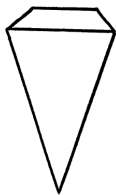
SIMPLE MACHINES



Lever



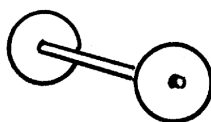
Inclined Plane



Wedge



Screw



Wheel and Axle



Pulley

Source: California Foundation for Agriculture in the Classroom

MACHINES

SIMPLE MACHINES

By definition, a machine is a device that changes force and distance or changes the direction of the force. Simple machines include the lever, inclined plane, wedge, screw, wheel and axle, and pulley.

A lever is a stiff rod that rotates around a pivot point, with downward motion at one end resulting in an upward motion at the other end – similar to a seesaw on a child's playground. The placement of the pivot point determines how much force must be used at one end to supply enough force to move something at the other end of the lever.

An inclined plane is a flat surface that is slanted, such as a ramp. The inclined plane spreads the amount of force needed to move an object out over a longer distance, making it easier to move a heavy object to a higher elevation.

A wedge is two inclined planes attached to each other. A wedge converts motion in one direction into a splitting motion that acts at right angles to the flat surfaces of the wedge. For example, a wedge may be placed under something heavy so it can be lifted or used to split something, such as splitting logs into smaller pieces of firewood.

A screw is an inclined plane wrapped around a central cylinder. The threads or grooves wrapped around the cylinder convert a rotary motion (turning or revolving) into a forwards or backwards motion.

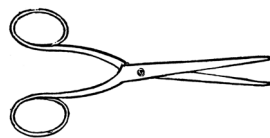
A wheel and axle consists of two circular objects of different sizes. The wheel, the larger of the two circles, is locked to the central axle so that when one is turned, the other must also turn. A short powerful force applied to turn the axle moves the wheel's edge a greater distance than the axle itself turns or, in reverse, motion at the edge of the wheel is converted into a shorter more powerful motion at the axle.

MACHINES: SIMPLE VS. COMPOUND

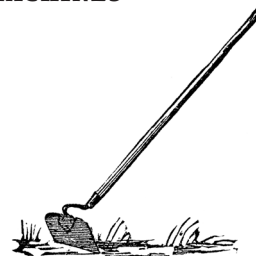
Simple machines include the level, inclined plane, wedge, screw, wheel and axle, and pulley.

When two or more simple machines work together as one machine, that is called a "compound machine."

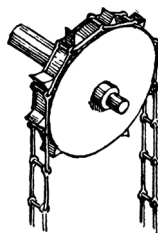
COMPOUND MACHINES



Scissors



Hoe



Chain and Sprocket (Gear)



Spade

Scissors, Hoe, and Chain and Sprocket Courtesy: Florida Center for Instructional Technology;
Spade Credit: USDA NRCS

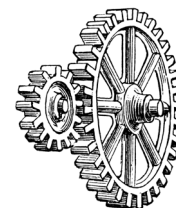
A pulley consists of a wheel and a rope or belt that moves around the circular edge of the wheel. Pulling on the rope or belt changes the direction of force applied to lifting or moving an object i.e. pulling down on one end of the rope or belt raises something at the other end or lifting one end of the rope lowers the load at the other end. Heavier loads can be lifted or moved by using two or more connected pulleys but in these situations, the rope or belt must move a greater distance than the load itself moves.

COMPOUND MACHINES

Compound machines are formed when two or more simple machines work together as one machine. In scissors, for example, two levers may be pinned together by a screw. The handle of a garden hoe is a lever, while the blade that cuts into the soil is a wedge. Bicycle pedals are attached to a lever that turns a pulley, which in turn moves the wheels and axles. Bicycle gears change the amount of force that must be applied to the pedals to turn the pulley (chain).

GEARS

Gears are wheels with teeth or pegs meshed together to increase or decrease motion and force. In any pair of gears, the larger gear rotates slower, but with more force than the smaller gear. Each gear reverses the direction of rotation from the previous gear. Gears are used to increase or decrease speed and power.



Courtesy: Florida Center for Instructional Technology

AGRICULTURAL EQUIPMENT

The basic functions of the machines employed in crop production have stayed the same for centuries: cultivating, planting, harvesting, storing, and transporting to end users (food processors, manufacturers, and consumers).

Kansas farmers choose agricultural machines to assist with these functions based on many factors, such as the crop being grown, existing soil and climatic conditions, soil and water conservation requirements, and economic issues like fuel costs and labor requirements. Some crops require specialized planting equipment due to the seed size and placement needs while other crops require specialized harvesting equipment, such as a cotton stripper or a potato digger. Plant nutrients may be made available to growing plants using a variety of application methods from liquids injected into the soil or sprayed on growing plants to particles inserted into the seedbed. Plant protection products, such as insecticides and herbicides, are also applied in a variety of ways using specialized equipment.

Agriculture continues to embrace new technologies, just like microwave ovens, personal computers, cell phones, and e-mail have become part of daily life for most families in the United States. When used as designed, these devices allow people to complete tasks using less time and energy. Agricultural producers continue to improve the agricultural machines they use and employ new technologies as they become available for many of the same reasons.

TRACTORS

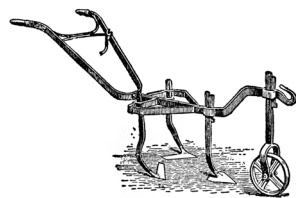
A tractor is essential to crop production because this self-propelled machine provides the power necessary to make other agricultural machinery that is not self-propelled work correctly. Typically, a tractor pulls an implement – a piece of machinery – across a field. This includes tillage equipment that mechanically manipulates the soil to provide a seedbed, planters and drills that distribute the seeds in an orderly spacing at the proper soil depth, and balers and other specialized agricultural machinery.

Tractors were preceded by horse-drawn machinery, which was maneuvered by a man walking with the horses. This type of machinery dominated crop production until the 1870s, when newer horse-drawn machinery allowed the operator to ride, rather than walk.



Planting Wheat

Credit: Anthony Luerman



Horse-drawn Cultivator (Walking)

Courtesy: Florida Center for Instructional Technology

MEASURING HORSEPOWER

The term "horsepower" was originally used to measure and compare the output of the first steam engines to the number of horses required to perform the same work. Today, even though the output of an engine is still rated according to "horsepower," horses are no longer involved in the calculations of the measurements.



Horse-drawn Cultivation (Riding)

Source: Library of Congress, Dorothea Lange, photographer

In the mid-1850s, portable steam-powered traction engines were developed. The first traction engines were stationary, placed at the edge of a field and used cables to pull a plow towards the engine from the other side of the field. Once the plow reached the side of the field with the engine, both the plow and the engine were moved and placed so that another length of the field could be plowed. While popular in the United Kingdom, these stationary traction engines were mainly used to power threshing machines in the United States, rather than plowing fields.

Self-propelled steam tractors were used in the United States in the late 1800s and early 1900s. However, in 1920, only 225 tractors were in use in the entire United States.¹⁴ In the mid-1920s, smaller lightweight tractors became more affordable, and self-propelled steam tractors were gradually phased out following the development of the internal combustion engine. By 1930, most farmers were using tractors, rather than horses, to produce crops. In 1954, the number of tractors on farms in the United States exceeded the number of horses and mules on U.S. farms for the first time.

Land used to grow feed for horses and mules then became available for crop production. Tractors also made it possible to farm more acres, increasing the size of many farms.

In the 1930s, an inventor named Harry Ferguson was hired by the government of Ireland to improve the efficiency and safety of tractors. Ferguson became the first person to use hydraulic technology in the



Steam-powered Tractor

Source: Library of Congress, Jack Delano, photographer



Tractor and 4-row Planter

Source: Library of Congress, Russell Lee, photographer



New Tractor, 1939, Sheridan County

Source: Library of Congress, Russell Lee, photographer

TRACTOR FACTS

In 1920, only 225 tractors were in use in the United States.

In 1954, the number of tractors exceeded the number of horses and mules on farms in the United States for the first time.

Machines and Technology

agriculture industry. Using fluid under pressure, hydraulic systems can lift more weight than hand-powered levers and control even large machines with great precision. Ferguson built a tractor with a hydraulic pump that could lift and lower an implement trailing behind the tractor. Once flexible high-pressure hydraulic hoses were developed, hydraulic cylinders could be mounted on the implements themselves, allowing even greater control by the tractor operator. Today, hydraulic technology has been incorporated into almost all agricultural machinery as well as machines used in many other industries.

Until the late 1940s, most tractor engines were gasoline-powered, even though diesel engines had replaced steam engines on locomotives and ships much earlier. Once available, diesel engines provided more power for tractors to pull large implements while using less fuel than gasoline engines.

The latest technologies adapted for agricultural uses include satellite based positioning and auto-guidance using global positioning system (GPS) receivers. These precision farming technologies allow placement of machines to within inches, eliminating overlap and reducing the number of passes across a field to cover the entire area.

This also reduces operator fatigue and energy consumption. Any reduction in overlap also reduces the expense of fertilizer, seed, or crop protection products. Autosteer and auto-guidance systems are now being used in agriculture for tillage, planting, fertilizer application, spraying, and harvesting.

CULTIVATING

Cultivation includes preparing the soil for planting as well as maintaining optimal growing conditions by controlling weeds, insects, and other pests. This includes tillage, which is mechanical manipulation of the soil to manage crop residues or weeds as well as



GPS Receiver
Copyright: Deere & Company



Tillage
Copyright: Deere & Company

TILLAGE WORDS

Tillage – the preparation of land for crop production.

Conservation tillage – any tillage and planting combination or sequence of tillage operations that leaves at least 30 percent of the soil surface covered by the residue of the previous year's crops.

No-till – a continuous process of crop production in which the soil is not mechanically manipulated between the harvest of one crop and the planting of the next crop. The surface of the soil and the residue from previous crops is left virtually undisturbed during planting.

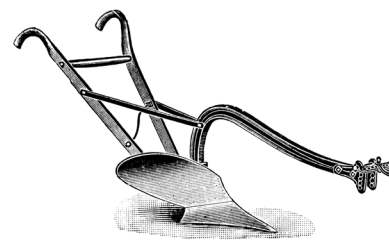
Strip till – a method of tilling and planting in narrow rows or strips (six to eight inches wide) so the soil and crop residue can be left undisturbed in-between rows; also known as zone tillage.

incorporating nutrients and crop protection products. At one time, most tillage methods consisted of breaking up the soil, chopping up any large clods or clumps of plant material, and leveling out the soil to create a smooth, finely ground seedbed. Today, Kansas farmers use a variety of tillage methods, generally choosing the minimum tillage necessary to meet crop production requirements for yield production goals while reducing water losses and soil erosion.

Although plowing was once common, today it is usually reserved for unique situations because the plow creates deep furrows that expose a large amount of soil, making the soil vulnerable to water loss thru evaporation as well as increasing the potential for water or wind erosion. In addition, other tillage operations must follow plowing to break up the large slabs of soil created by plowing and level out the soil to provide an adequate seedbed.

Agricultural equipment used to prepare the soil for planting or to control weeds might include the following:

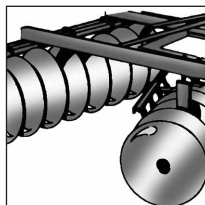
- disk (disc harrow) – sharp round blades turning on an axle to chop up weeds or plant residue from previous crops while churning the top few inches of the soil;
- undercutter (blade plow) – large wide fixed V-shaped blades (called "sweeps") that slide under the surface of the soil, cutting off the roots of weeds or positioning nutrients in the soil where crop seedlings will be able to utilize them for growth and development;
- field cultivator – narrow vertical rods or V-shaped blades (also called "sweeps" or "shovels") that work near or just below the surface of the soil, breaking up clods and smoothing out the soil for a firm seedbed or killing weeds in-between rows of growing crops; and
- applicators or sprayers – spraying equipment that applies crop nutrients or crop protection products on growing plants or on top of the soil, rather than penetrating and moving the soil.



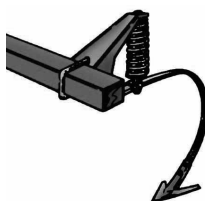
Horse-drawn Plow (Walking)
Courtesy: Florida Center for Instructional Technology



Plowing
Credit: USDA NRCS



Disk
Credit: USDA NRCS



Cultivator Sweep
Credit: USDA NRCS



Sprayer
Copyright: Deere & Company

PLANTING

In 1621, the American Indians taught the first Pilgrims to plant corn by placing corn seeds and herring (fish) in small mounds of soil. Today, agricultural producers use drills or planters to place seeds in the ground at the correct depth and appropriate spacing. Each crop has specific requirements but generally, seeds are placed into shallow soil at the depth where adequate moisture is available to begin the germination process.

The size of the seeds may determine whether a drill or planter is used to plant the crop. Drills, which have one or two seed sources (seed boxes) with several outlets that dribble seeds out continuously, are typically used to plant smaller seeds, such as wheat or alfalfa. Planters, which have seed boxes for each seed row and drop seeds one at a time, are typically used to plant larger seeds, such as corn, soybeans, and grain sorghum.

Seeds are placed into furrows created by small v-shaped "hoes" or dropped between two round sharp rotating "coulters" or "disks" that create slots in the soil for the seeds to be placed in. Traditional drills and planters rely on mechanical movements to move seeds from the seed boxes and into position for planting while "air drills" (also called "air seeders") use air pressure to distribute the seeds from large tanks to individual rows. New technologies continue to improve the accuracy of the seed placement, the ability to plant seeds while leaving the surface of the soil virtually undisturbed, and the opportunity to place plant nutrients and crop protection products into the soil while planting the seeds.

DRILLS VS. PLANTERS

A drill may have one or more seed boxes, each with several openings that allow seeds to continuously drop into the soil.

A planter has a seed box for each row to be planted and places seeds one at a time into the soil.

An air drill uses air pressure to distribute seeds from a single large tank through tubes into individual rows in the soil.



Drill

Copyright: Deere & Company

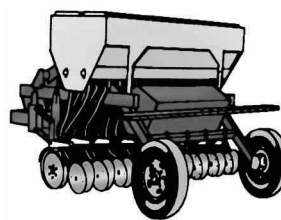


Planter

Copyright: Deere & Company

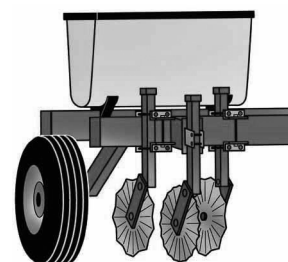
SEED SIZE COMPARISONS

	In One Cup (approximately)	Per Pound ¹⁵
Alfalfa	85,500	220,000
Corn	634	1,450
Grain Sorghum	6,125	14,000
Soybeans	1,172	2,500
Oilseed Sunflowers	1,266	6,000
Wheat	5,625	12,000



Drill Close-up

Credit: USDA NRCS



Coulters

Credit: USDA NRCS



Soybean Seed Placement

Credit: Soybean Checkoff



Air Seeder

Copyright: Deere & Company

HARVESTING

Combines

For thousands of years, crops were harvested by hand. People cut the plant stalks and stacked the plant material in large piles until the grain could be separated from the stalks. For small grains such as wheat, this was accomplished by beating the heads and collecting the grain and chaff, the dried plant materials cov-



Harvesting Wheat

Credit: Mary Anne Stoskopf

HARVEST WORDS

Bind – to bundle cut stalks (with the heads still attached) of grain together, forming sheaves..

Chaff – the dried plant material covering the seeds or kernels of grain that is discarded during the harvesting process.

Reap – to cut and gather a crop.

Sheaves – bundles of cut plants bound together, most commonly stalks of grain with the seed heads still attached.

Shocks – bundles of sheaves set upright in a field, usually to assist with drying.

Thresh – to separate the seeds from plant stalks (straw), chaff, and other plant material.

Winnow – to separate the grain from the chaff, typically by using air to blow away the lighter chaff.

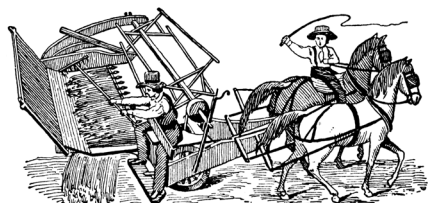
ering the seeds. Next the grain was winnowed out (separated from the chaff by using air to blow away the lighter chaff). In 1754, a Scottish engineer, Andrew Meikle, invented the first mechanized thresher, which separated the grain from the stalks (straw), chaff, and other plant pieces. However, the first threshers were small and the stalks had to be fed into the machines by hand.



Harvesting Wheat by Hand

Source: Library of Congress;
Dorothea Lange, photographer

In 1831, Cyrus McCormick of Virginia invented a reaper, which was a horse-drawn machine with a turning wheel that moved a blade back and forth to cut plant stalks. The stalks, which collected on a platform that was part of the machine, were swept off and into piles by a person walking beside the reaper. The binder was invented in 1880. This advancement on the reaper also bundled the cut stalks and tied the bundles with wire before they were dropped off the machine. The bundles were collected and stored until the threshing machine came to that farm.



Reaper

Courtesy: Florida Center for Instructional Technology



Binder

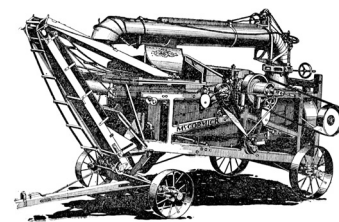
Credit: USDA NRCS

Gathering Bundles of Wheat

Source: Library of Congress;
Ben Shahn, photographer



The first threshing machines were large stationary machines placed in a central location at a farm. Power was supplied by a steam engine or tractor connected to the threshing machine by a long belt. Bundles of wheat were brought to the machine and the wire or string ties had to be removed before the bundles could be pitched into the threshing machine. These threshing machines mechanically separated the grain from other plant materials and allowed the grain to be funneled into wagons or large bags. Threshing was a very labor-intensive process requiring a large work crew and additional people to feed those workers.



Threshing Machine

Courtesy: Florida Center for Instructional Technology



Power for Threshing Machine

Source: Library of Congress;
Ben Shahn, photographer



Threshing Wheat, 1937

Source: Library of Congress;
Arthur Rothstein, photographer

A combine does the work of both the reaping and threshing machines. The world's first self-propelled combine was invented in 1886 and used in wheat fields in California. However, the first combines required several people to operate the machinery and almost all were pulled by a team of horses. Later, tractors were used to pull the combines. The first combine that could be operated by one person was invented in 1935. In 1944, self-propelled combines were first mass-produced in the United States to help address the need for expanded food production during World War II despite the shortage of available labor.

COMBINE FACTS

A combine performs two functions: harvesting plant materials and separating seeds from other plant materials. In other words, the machine "combines" the reaping and threshing functions performed by separate machines in the past.

The world's first self-propelled combine was invented in 1886.

The first combine that could be operated by a single person was invented in 1935.

The large detachable piece at the front of the combine which cuts the plant stalks or strips the heads of grain from the stalks is called a header. Different headers can be attached to the same machine to use for different types of crops.

The new harvesting technologies made wheat a more popular crop than corn, which was still being picked by hand in the 1930s and 1940s. The rows of corn were spaced so that a horse-drawn wagon could move between the rows. A person walking through the field twisted each ear of corn off the corn stalk and tossed it into the wagon. At one time, many social events were built around corn husking, removing the outer leaves covering an ear of corn. Temporary storage, often called a "corn crib," was used to allow the corn kernels to dry down while still attached to the corncobs. As needed, the ears of corn were fed into a corn sheller to separate the kernels from the corncobs. The first corn shellers were turned by hand or powered by foot pedals.

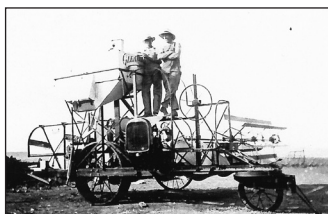
Advances in corn harvesting equipment may have been delayed by the development of a corn binder that cut and bound corn stalks, similar to the binders used for wheat. Corn drying equipment for use inside grain storage bins was not developed until after World War II, also limiting the need for machines that could both harvest and shell the corn.

The first corn pickers were pulled by or mounted on tractors, but by the 1950s, self-propelled corn pickers could snap and remove the ears from the cornstalks, remove the husks from the ears, and shell the corn while in the field. Combines can be adapted for corn harvesting by adding attachments called "corn heads." A corn head



Combine Pulled by Tractor

Source: Library of Congress;
Marion Post Wolcott, photographer



New Combine, 1936

Courtesy: Stoskopf Farms



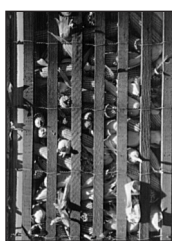
Harvesting Corn, 1939

Source: Library of Congress;
Arthur Rothstein, photographer



Husking Corn

Source: Library of Congress;
Marion Post Wolcott, photographer



Corn Crib, 1939

Source: Library of Congress;
Arthur Rothstein, photographer



Shelling Corn

Source: Library of Congress

THE HARVEST BRIGADE

During World War II, the world needed all the food that U.S. farms could produce. However, there was a labor shortage and both gasoline and steel were being rationed, leading to concerns about how additional crops could be harvested.

In 1944, the Massey Harris manufacturing company convinced the U.S. government to allocate them additional steel in order to build 500 self-propelled combines. Those combines were sold to operators on the condition that they would agree to cut at least 2,000 acres of wheat per machine that year.

The "Harvest Brigade" spawned a whole new industry – "harvesters for hire," known today as "custom cutters" or "custom harvesters."

uses pointed wedge-shaped extensions at the front of the combine to guide the rows of corn stalks into the points of V-shaped areas where rollers strip the ears and husks away from the stalks and leaves. A conveyor-like system moves the ears of corn into the combine. Inside the machine, the kernels are stripped from the corncobs and stored in the combine's grain tank while all the cobs, husks, and other leftover plant materials are deposited back onto the field. The base of the combine's grain tank is sloped, forcing the grain to flow towards the bottom. When the grain is unloaded, an auger pulls the grain out of an opening in the bottom of the grain tank. As it turns, the screw-like auger carries the grain high enough to be dropped into a waiting truck or grain cart.



Corn Picker, 1939

Source: Library of Congress;
Arthur Rothstein, photographer



Harvesting Corn

Credit: Mary Anne Stoskopf



Unloading Wheat into Grain Cart

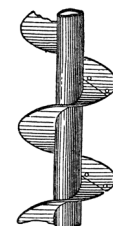
Credit: Anthony Luerman



Unloading Wheat

Credit: Anthony Luerman

Auger
Courtesy: Florida
Center for
Instructional
Technology



Unloading Corn

Credit: Mary Anne Stoskopf

Machines and Technology

Today, combines are used to harvest a variety of grains, oilseeds, and other seed crops. Corn heads and other "headers" can be attached at the front of the main body of the same machine, allowing one combine to harvest many different crops. Computerized moisture testing equipment provides immediate information to the combine operator. Computerized yield monitors provide yield per acre data, which may be used to create field maps using GPS receivers and geographic information systems (GIS) computer technologies. When that same field is planted to the next crop, yield maps may be used to vary the rate (amount) of fertilizer, crop protectants, or seed at different locations within the field.



Harvesting Sunflowers

Credit: National Sunflower Association



Harvesting Grain Sorghum

Credit: Mary Anne Stoskopf



Digital Yield Monitor

Credit: Scott Bauer, USDA ARS



Combine Cab

Copyright: Deere & Company

Making Hay

The harvest of a crop for hay, such as alfalfa, takes two different machines as a drying time is required between the cutting and baling steps. A self-propelled swather, also known as a windrower, or a mower conditioner (which is pulled by a tractor) cuts the plants and gathers the plant material into windrows, long narrow piles that run the length of the field. Once the plant material has dried to a moisture level where it can be safely stored, a baler is used to compact the plant material into bales. The type of baler used determines the shape of the bales – round or square – and the size.

From the very beginning, making hay was labor intensive and physically challenging. In the 1930s, automatic balers that compressed hay and straw into small square bales were developed and mass-produced. However, collecting the bales from the field and



Swathing Hay

Credit: Mary Anne Stoskopf

HAY BALERS

The first hay baler was a stationary "hay press" invented in the 1850s.

In the late 1800s, horses (rather than men) provided the power to compress hay into square bales.

By the 1930s, attachments were added to balers that allowed the machine to pick up loose plant materials and compress those into square bales. The first "field balers" were pulled by horses.

In the 1930s and 1940s, twine tying and knotting inventions revolutionized the harvesting of hay and straw, requiring only one person to operate both the hay baler and the tractor pulling the baler.

The first large round baler was invented in 1972.



Baling Hay

Copyright: Deere & Company



Mowing Hay

Source: Library of Congress

Baler, 1944

Source: Library of Congress;
Pauline Ehrlich, photographer



Harvesting Hay, 1937

Source: Library of Congress;
Russell Lee, photographer



moving them into storage areas (usually barn lofts) still required hard physical work and large work crews.

In 1972, an agricultural equipment manufacturer named Gary Vermeer invented a large round baler that revolutionized the handling, storage, and feeding of hay. A round baler feeds a stream of cut plant material into a large chamber where long rubber belts or chains force the hay to wrap around itself and form a continuous circle of hay. Once the bale reaches a pre-determined size, the baler automatically wraps the bale with twine or protective sheeting before kicking it out of the chamber. Since the round shape of the bales helps them to shed water, the bales can be moved to the edge of the field and stored.

Agricultural equipment manufacturers continue to seek new ways to reduce the labor and energy required to bale, store, handle, and feed hay. As a result, there are many size choices in both square and round balers on the market today.

**Round Baler**

Copyright: Deere & Company

ALFALFA BALES

Small Square Bale:

60-90 pounds
14 inches by 14 inches
x 30–36 inches long

Round Bale:

1500 pounds
5 feet wide, 5 1/2 feet tall

Large Square Bale:

2000 pounds
4 feet by 4 feet x 8 feet long

**Small Square Baler**

Copyright: Deere & Company

Other Harvesting Machines

Specialized machines are used to harvest many crops. For example, a cotton stripper removes the bolls from cotton plants, leaving the plant stems standing in the field. A potato digger lifts potatoes from the soil and uses conveyors to elevate the potatoes and drop them into the truck that will transport them to storage or processing. Forage harvesters are used to cut and chop standing plants, such as corn or annual forages, into fine pieces for silage or greenchop. Shakers are used to drop mature nuts to the orchard floor where pecan harvesters pick them up. Most specialty crops require specialized harvesting equipment.

**Cotton Stripper**

Copyright: Deere & Company

STORING

Grain Elevators

Grain elevators are a common sight in Kansas. These prairie skyscrapers are essential to moving grains and oilseeds from crop producing areas to consumers.

When Kansas was first settled, each farm needed storage for the grain produced on that farm. Any extra grain was loaded into a horse-drawn wagon and hauled to the nearest town or flour mill to be sold. When the first railroads were constructed across Kansas in the 1860s and 1870s, the railroad companies encouraged the construction of grain elevators close to the fields where the grain was being produced. These small local grain elevators served as collection points for grain. They are still known as "country houses" today. The railroads profited when the grain was loaded into railcars and shipped to larger grain elevators, known as "terminal elevators" or flour mills. Today, those larger grain elevators, which are located in Salina, Hutchinson, Wichita, and Kansas City, mainly receive grain by truck and move the grain to flour mills and other processing facilities, rather than export facilities.

**Offerle, Kansas, 1916**

Source: Library of Congress

The dust that naturally results from the handling of grain is flammable and highly explosive. The first grain elevators were built of wood and many were destroyed by fire. Tile blocks were also used to construct elevators. Beginning in the 1950s, most of the grain elevators seen in Kansas today were constructed of concrete. These concrete structures consist of several tall cylinders called storage bins or silos and a square "head house" built at the top of the cylinders.

SIZING UP GRAIN ELEVATORS

Most of the concrete grain elevators in Kansas were built in the 1950s.

Typically, the silos (round-shaped cylinders or storage bins) are 100 to 120 feet tall, approximately the same height as a 10- or 12-story building.

The head house, built at the top of the silos, adds another 25 to 40 feet to the overall height of the typical grain elevator.

GRAIN ELEVATORS

Country House – a local grain elevator that serves as a collection point for grain produced on farms within an immediate area.

Terminal elevator – historically, a larger grain elevator that collected grain from many country houses before selling and shipping the grain to an export elevator or a processor. Today, the larger grain elevators typically receive grain by truck and ship grain by rail or truck directly to flour mills and other processing facilities.

Export elevator – a large grain elevator that sells and ships grain to customers in other countries, typically located on a port or river.

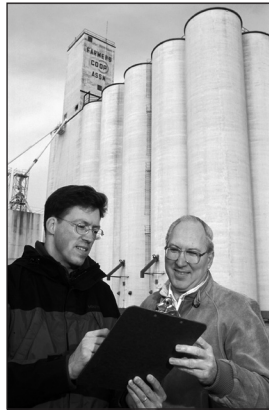
Machines and Technology

The storage bins are usually 100-120 feet tall, approximately the same height as a 10 or 12-story building. The head house adds another 25-40 feet to the overall height of the grain elevator.

The basic functions of the grain elevator are to receive grains and oilseeds, clean and dry the grain if necessary, distribute the grain into temporary storage, and move the grain out of storage for transporting to other grain elevators or destinations.

Grain elevators receive grain by truck. The trucks are weighed and the grain is sampled and tested for quality. The truck proceeds to a grated pit, where the grain is unloaded and falls into a concrete pit. That pit has one sloped side that causes the grain to slide down, exit the pit, and slide into a lower pit called the "boot pit." A large continuous belt with cups attached to it runs from the bottom of the boot pit up into the head house. Here the grain falls out of the cups, which might range in size from a shoebox to a small bucket. The grain falls into a spout that directs the grain into a storage bin or onto a conveyor belt that moves the grain to a specific bin.

When it is time to move the grain out of a storage bin, the grain exits at the bottom of the bin and is moved by conveyor belt or gravity back into the boot pit. The grain is elevated and distributed to a different storage bin or directed to an unloading spout. Each storage bin in a grain elevator may be emptied and re-filled two to four times every year.



Grain Elevator

Credit: Peggy Greb, USDA ARS



Receiving Grain

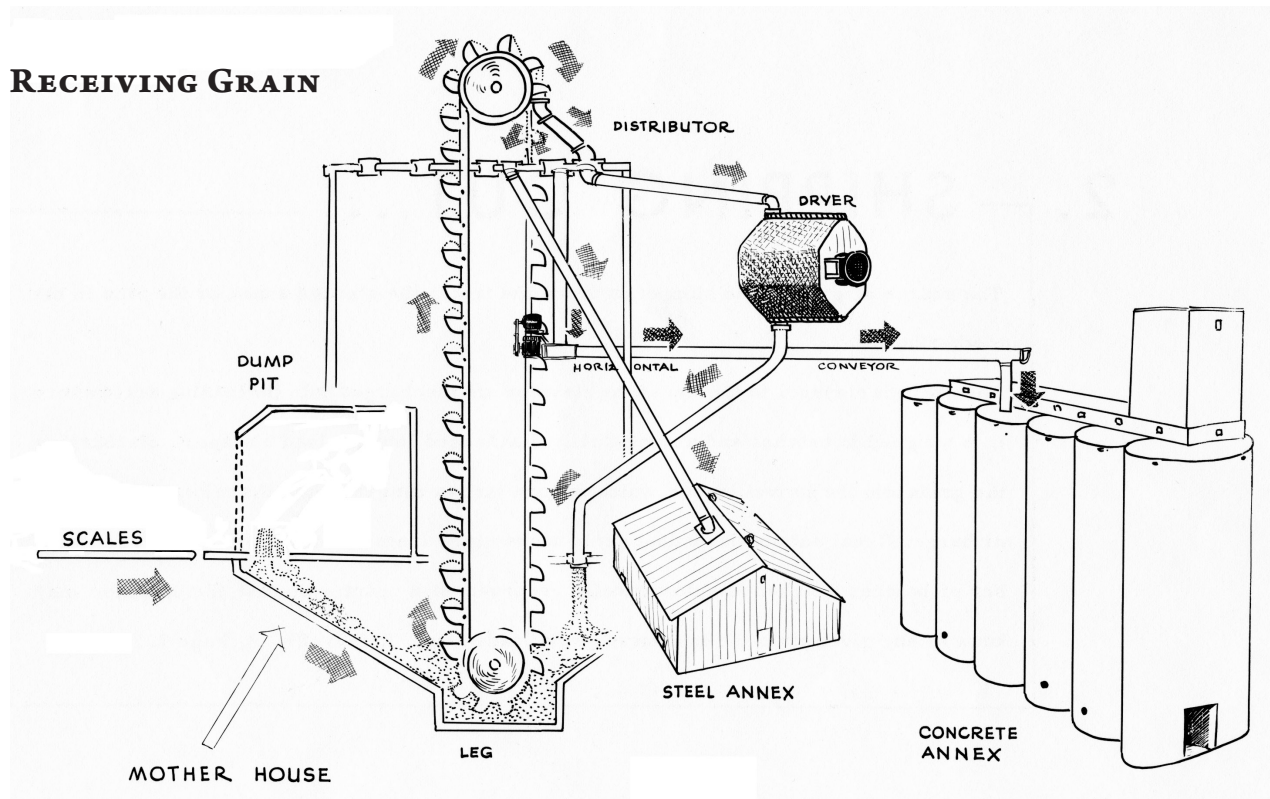
Credit: Bill Spiegel, Kansas Wheat Commission



Unloading Soybeans

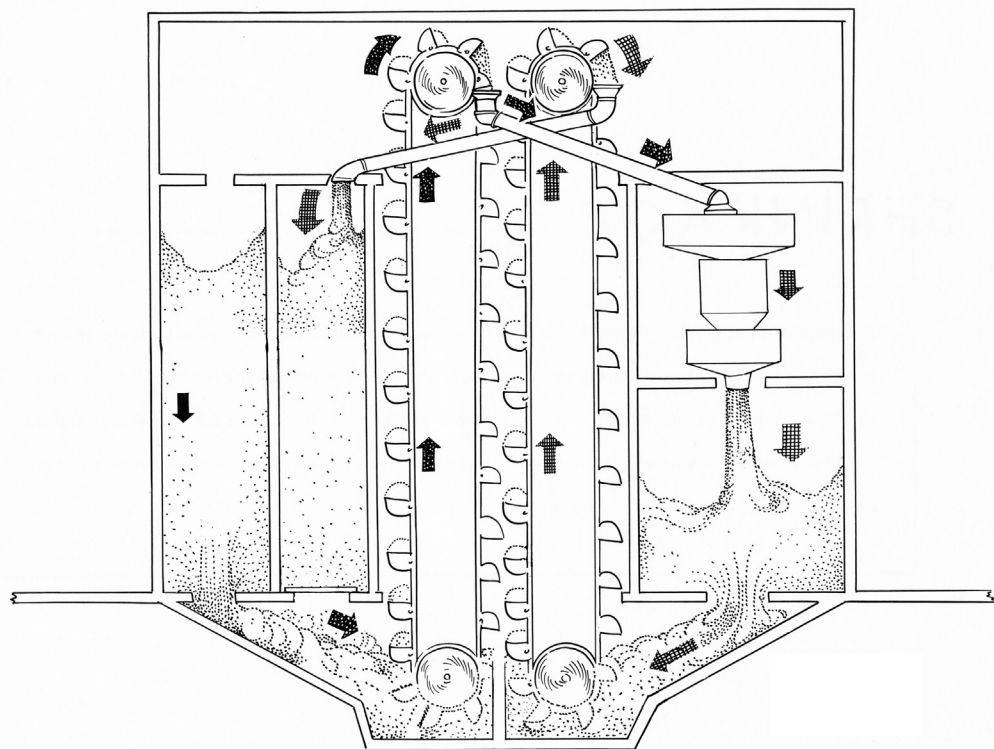
Credit: Soybean Chackoff

RECEIVING GRAIN



Courtesy: Frisbie Construction Company

MOVING GRAIN INSIDE THE ELEVATOR



Courtesy: Frisbie Construction Company

While the grain elevator appears to be one continuous unit from the outside, the storage bins may contain different grains or one grain, such as wheat, may be separated according to quality characteristics into several storage bins. Quality characteristics that are monitored include the type (hard white wheat vs. hard red winter wheat or oilseed vs. non-oil sunflowers), variety, protein or oil content, moisture content, and foreign matter content (weed seeds, leaves, or other items that may not have been removed thru the threshing process inside the combine). These quality characteristics determine whether the grain elevator will accept the grain for storage. They also determine the price that a farmer receives for delivered grain, as well as how the grain will be handled, processed, and which products will result from the processing.

Crops are measured and priced by weight as well as quality. At a grain elevator, trucks are weighed before and after they unload. The difference between the two weights determines the amount of grain the farmer will be paid for and allows the grain elevator to track the volume of grain flowing into each storage bin. Wheat, corn, and soybeans are sold by the bushel. Grain sorghum and sunflowers are sold by the "hundredweight" (100 pounds).

While the basic functions of a grain elevator have not changed over the years, many of the tasks performed at grain elevators are now computerized and controlled remotely. Grain samples are collected from grain trucks using robotic probes. Electronic scales record weights and automatically figure the quantity of grain delivered by trucks or railcars. Grain prices can be updated instantaneously at local elevators around the country using satellite and internet-based communication systems. These efficiencies benefit crop producers and help provide lower food costs for consumers.

Other Storage

At times, the amount of grain produced exceeds the storage capacity of the local grain elevator. Grain may be temporarily piled outside on a flat surface or on a flat surface inside a building. It requires additional equipment and labor to pick grain up off a flat surface so this type of storage is not used unless it becomes necessary. Some grains and oilseeds cannot be piled uncovered outside as the



Wheat in a Grain Bag

Credit: Bill Spiegel, Kansas Wheat Commission



Round Bales

Credit: High Plains Journal

CROP SALES

Sold by the Bushel

corn – 1 bushel is equal to 56 pounds
soybeans – 1 bushel is equal to 60 pounds
wheat – 1 bushel is equal to 60 pounds

Sold by the Hundredweight (100 Pounds)

grain sorghum
sunflowers

Machines and Technology

piles will not shed water and moisture from rain or melting snow could cause the seeds to begin sprouting or rotting.

Due to size and volume, most large square and round hay bales are stacked and stored outside. Small square bales are usually moved inside for storage because they cost more to produce and handle.

Specialty crops like fruits, vegetables, and nuts have specific handling and storage requirements designed to enhance food quality and safety.

TRANSPORTING

Because Kansas is located in the center of the contiguous United States, the state is situated in the middle of most transportation routes in this country. Goods and people move through Kansas on both east-west and north-south corridors.

Agriculture is transportation intensive. Prior to the 1980s, the agricultural economy throughout Kansas and the Midwest focused on the production of raw agricultural commodities. After reaching a delivery point on a rail line, grain moved by railcar to processing plants or export facilities. In the 1980s, the focus began to shift to building processing facilities closer to the source of the raw materials, resulting in the movement of more farm products to local processing facilities or regional markets. While grain and other raw agricultural products continue to be shipped out of the region, the amount of processed food and grain milling products moving from Midwestern states to more distant destinations or international markets continues to climb.

Intermodal shipping is also on the rise. Intermodal refers to using multiple transportation methods (rail, ship, truck) to move freight. Containerized cargo (freight contained in a shipping container) often utilizes more than one mode of transportation. The freight itself is not handled when the method of transportation is changed, like when the container is moved from a truck onto a railcar or from a railcar onto a ship. Refrigerated containers came into use in the 1980s, along with other specialized containers. Kansas grains and oilseeds are usually shipped in large volumes as "dry bulk" rather than in shipping containers. However, each year, nearly 25 million containers and trailers are moved using intermodal transportation according to the Intermodal Association of North America. Computer tags allow each individual shipping container to be tracked as it moves through the transportation systems.



Exporting Grain:
(l to r: railcars, barge, cargo ship)

Credit: Julia Debes, U.S. Wheat Associates



Loaded Cargo Vessel

Source: U.S. Army Corps of Engineers

Intermodal – the transfer of products involving multiple modes of transportation.

Source: Intermodal Association of North America

FOOD-RELATED ENERGY USE

In the United States, transportation accounts for 14 percent of all food-related energy consumption.¹⁶

SHIPPING CONTAINERS

Containerized cargo (freight) is enclosed in a shipping container. The freight inside the container is not handled when the mode of transportation is changed, like when the container is moved from a truck onto a railcar or from a railcar onto a ship.

Shipping containers are eight feet wide, eight feet or more high, and 20 feet or more long.

Each year, nearly 25 million containers and trailers are moved using intermodal transportation.



Credit: Julia Debes, U.S. Wheat Associates

Source: Intermodal Association of North America

International Trade

All countries participate in international trade, exchanging one item for another across national borders. Goods that move into a country across its border are called imports while goods that move out of a country across its border are called exports. A country's balance of trade is the difference between the value of that country's exports and imports.

In the United States, the first colonies were dependent on imports, but the colonists soon learned to survive by gathering and producing their own food. They even grew tobacco and other crops that were exported to Europe. As the country grew, people kept moving westward and the markets focused on moving supplies and food back and forth across the country, which was cheaper than shipping food and goods across the oceans.

World War II created a demand for agricultural products and food produced in the United States. International trade has continued to grow and the United States continues to export more agricultural products than it imports. According to the U.S. Department of

AG EXPORT FACTS

The United States is the world's leading exporter of farm products.

The United States has been a net exporter of agricultural products since 1959, meaning the country has exported more agricultural products than have been imported.



Grain Terminals on the Willamette River in Portland, Oregon

Credit: Julia Debes, U.S. Wheat Associates

Agriculture's Economic Research Service (USDA ERS), the United States is the world's leading exporter of farm products and has been a net exporter of agricultural products since 1959. In 2009, the U.S. exported agricultural products valued at nearly \$99 billion, while importing about \$72 billion worth of agricultural products, resulting in a positive trade balance in agricultural products of almost \$27 billion. In contrast, total imports exceeded total exports by about \$667 billion that same year.¹⁷

While some people in the United States can shop for a wide variety of food through farmer's markets and other outlets for foods produced locally, many people do not have access to those choices or cannot afford those items. Many foods necessary to a healthy diet are not produced locally or available during all seasons. For example, Kansas does not produce pineapples, bananas, or salmon while Hawaii and Alaska do not produce wheat. In Kansas, fresh fruits and vegetables might be available for only a short time. The rest of the time, consumers must depend upon foods produced in other states or countries unless they are skilled at preserving fresh food safely and have the necessary time and equipment to do so.

The international trade in agricultural commodities allows global access to a variety of foods year-round and provides a positive contribution to the economies of both the United States and agricultural states like Kansas.

Railroads

In the 1860s and 1870s, the railroads expanded across Kansas, making it much easier to move agricultural products from Kansas farms to more distant markets and consumers. By 1917, every county in Kansas was served by a railroad and there were 26 different railroads operating over 9,367 miles of track in the state.¹⁸

Before World War II, railroads dominated the transportation system in the United States and around the world – moving people, agricultural products, livestock, manufactured goods, and other

consumer products. In the 1950s and 1960s, the United States focused on the development of a national highway transportation system. The growth of the highway system increased the competition between railroad and truck traffic, one factor in the consolidation of railroad companies and track abandonment. By 1999, however, all but two counties in Kansas were still being served by at least one railroad line.

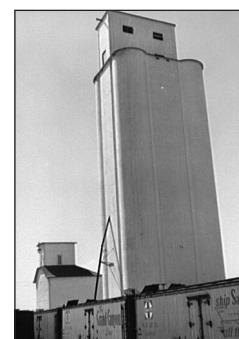
Today, the Kansas Department of Transportation reports that Kansas still has the nation's sixth largest rail-freight network. Railroads operate more than 4,700 miles of track in Kansas. However, Class I railroads operate less than 3,000 rail miles in Kansas. These nationally networked railroads usually operate in many different states and concentrate on hauling freight over long distances. Most rural areas of Kansas that still have rail service must depend on shortline railroads, which utilize segments of track headed for abandonment by the large railroads. Shortline railroads operate in limited regional or local areas, providing service over shorter distances.

Changes to the freight rail system also required changes to the grain delivery system. As a result, companies that buy and sell grain have built large high-speed train loading facilities in locations along the main lines of the Class I railroads. These facilities are able to load "unit" or "shuttle" trains of 100-110 railcars in less than 15 hours. Typically, this grain is destined for export elevators along the Texas Gulf, Mexico, or U.S. flour mills.

In Kansas, shortline railroads transport grain to larger elevators (located in Salina, Hutchinson, Wichita, and Kansas City), unit train loading facilities, flour mills, ethanol plants, or feedlots in Kansas, Oklahoma, and Texas. However, the current infrastructure used by the shortline railroads is not capable of handling the increasing size of grain railcars. New larger grain cars can have loaded weights of 286,000 pounds, compared to the 263,000 pounds carried by the railcars they are replacing.

Shuttle Train

Credit: IGP at K-State



Kiowa, Kansas, 1943

Source: Library of Congress;
Jack Delano, photographer



RAILROADS IN KANSAS

Kansas has the nation's sixth largest rail-freight network, with more than 4,700 miles of track in the state.

Class I railroads are nationally networked railroads that haul freight over long distances. In Kansas, Class I railroads use less than 3,000 miles of track.

Shortline railroads operate in limited regional or local areas, providing service over shorter distances.

The size of grain railcars is increasing. New larger grain cars can load weights of 286,000 pounds, compared to older grain cars that could carry 263,000 pounds each.

Source: Kansas Department of Transportation

TRADE WORDS

Trade – the activity of buying and selling or exchanging one item for another.

Balance of trade – the difference between the value of a country's exports and that country's imports.

Exports – goods that move out of a country for sale or trade.

Imports – goods that move into a country for sale or trade.



Moving Grain by Rail

Credit: Jim Shroyer, K-State Dept. of Agronomy

The freight rail system remains a vital component of the transportation system in Kansas and is critical in moving grain produced on Kansas farms to domestic and foreign markets. Other products from Kansas crops, like sunflower oil and soy oil, also move over Kansas railroads.

Trucks

Roads provide the only physical connection between farms and the markets for agricultural products. Roads are necessary for the delivery of products and services to farms and to access crop fields. With more acres of available cropland than any other state except Texas, Kansas agriculture depends on access to well-maintained public roads. Rural roads comprise nearly 91 percent of the public road miles in Kansas¹⁹ and are essential to the state's economy even though many of those roads are lightly traveled. According to the Kansas Department of Transportation, Kansas ranks third among the 50 states in the number of public road miles with 140,270 miles of public roads in the state. Only Texas and California rank higher.



Grain Trucks

Credit: Anthony Luerman

FACTS ABOUT KANSAS ROADS

Kansas ranks third of the 50 states in the amount of public road miles, behind Texas and California.

There are 140,270 miles of public roads in Kansas.

In Kansas, nearly 91 percent of the public road miles are classified as rural roads.

Source: Kansas Department of Transportation

Gasoline-powered trucks and automobiles began to replace horse-drawn transportation in the 1920s but roads in rural areas were either nonexistent or unreliable. The first roads, which were built and maintained by the farmers themselves, were often reduced to mud when it rained or became impassable with limited maintenance. Semi-trucks, which combine a towing unit (truck or "tractor") with one or more trailers, were first introduced in the 1920s.

Major technological innovations during World War II allowed individual farmers to increase production by becoming more efficient and reducing labor requirements.

Many of those employed off the farm to support the war effort did not return to the farms. Farmers continued to embrace new technologies that replaced labor-intensive agricultural practices and contributed to an improved quality of life in the rural areas. Improved genetics and the use of fertilizers and crop protection products increased crop yields in the United States following World War II. As the speed and capacity of harvesting equipment continued to expand, the size of the trucks used to deliver crops to markets also increased.



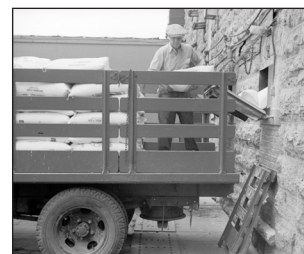
Truck, 1910

Source: Library of Congress



Truckload of Beef, 1923

Source: Library of Congress



Trucking Sacks of Flour, 1939

Source: Library of Congress;
John Vachon, photographer



Freight Truck, 1938

Source: Library of Congress;
John Vachon, photographer

TRUCK FACTS

All trucks, including trucks used on farms, must comply with federal and state regulations on weight, length, height, and width.

The first semi-trucks were introduced in the United States in the 1920s.

Semi-trucks combine a towing unit called a "tractor" with one or more trailers.

Grain trailers have "hoppers" built into the floor of the trailer. When a hopper is opened to unload grain, the sloped floor of the trailer directs the flow of the grain to the hopper.

In the United States, truck traffic overtook rail traffic in the 1960s.



Grain Trailer

Credit: Anthony Luerman

In the 1950s and 1960s, improved roads, larger and better trucks resulting from knowledge used by manufacturers to supply the military during World War II, and the invention of refrigeration units that could be mounted on truck trailers made truck traffic more competitive. Truck traffic overtook rail traffic in the 1960s.

In agriculture, trucking took over the movement of agricultural products to markets, processors, and consumers. After being loaded, a truck could deliver food and other agricultural products quickly and to the exact location where the products were needed. Refrigerated trucks expanded the markets for foods that needed to be kept chilled or frozen until reaching the consumer, such as fruits, vegetables, or meat.

All trucks must comply with federal and state regulations on weight, length, height, and width. When moving grain and other agricultural commodities, trucks usually reach their weight limit before they are completely filled. The trucking industry employs many new technologies including electronic scales to weigh loads; GPS tracking of trucks and freight to provide security, prevent theft, and save energy by navigating traffic routes; and satellite-based internet access and communication.



Corn Harvest

Credit: Mary Anne Stoskopf

Barges

Rivers were the first transportation highways. Today, even though they do not navigate in the state's rivers, barges and ocean-going ships are critical to the movement of agricultural products to and from Kansas farms.



Mississippi River Grain Barges

Credit: IGP at K-State

Reservoirs and rivers in Kansas supply water for navigation in the Missouri and Arkansas Rivers, both of which eventually drain into the Mississippi River. The Verdigris and Arkansas rivers are part of the McClellan-Kerr Arkansas River Navigation System (MKARNS), which is a 445-mile inland waterway linking Oklahoma and surrounding states with the nation's 25,000 mile inland waterway system.

THE TULSA PORT OF CATOOSA

The McClellan-Kerr Arkansas River Navigation System (MKARNS) includes the Verdigris and Arkansas rivers, which eventually drain into the Mississippi River.

The Tulsa Port of Catoosa, located near Tulsa, Oklahoma, is the largest port on the MKARNS.

The port has two grain-handling facilities. The major product handled by those facilities is hard red winter wheat.

The capacity of a standard hopper barge used for transporting grain on the MKARNS and Mississippi River system is three million pounds (1,500 tons).

Source: U.S. Army Corps of Engineers



Grain Barges

Credit: IGP at K-State



Loading Soybeans onto Barge

Credit: Soybean Checkoff

Unloading Kansas Wheat at Houston Export Elevator

Credit: IGP at K-State

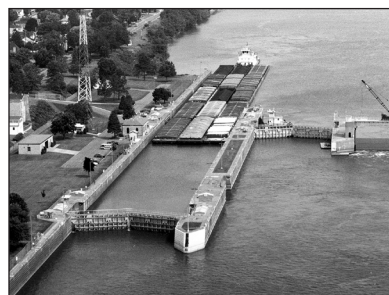


The largest port on the MKARNS is the Tulsa Port of Catoosa, located near Tulsa, Oklahoma. Freight moves by barge, rail, and truck through this port, which is ice-free and operational year-round. Hard red winter wheat is the major product handled by the port's two grain-handling terminals, which also handle soybeans, oats, grain sorghum, and millet. These grain-handling facilities can load a grain barge in as little as 2.5 hours. The capacity of a standard hopper barge, the flat-bottomed type of barge used for transporting grain on the MKARNS and Mississippi River system, is three million pounds (1,500 tons).

On the MKARNS, a "full tow" consists of eight barges, lashed together and pushed from behind by a single towboat. It would take 480 semi-trailer trucks to move an equivalent amount of cargo carried by a full tow.²⁰ The size of the tows is limited by the size of the locks through which the barges must move on the waterway systems. On the lower Mississippi River where there are no locks, tows of 30 or more barges are not uncommon.




Occasionally, wheat from northwest Kansas is shipped to the Pacific Northwest by rail. The Columbia River channel is deeper than that of the Mississippi River system, allowing the use of larger grain barges that can be unloaded from below. Those grain barges hold approximately 3,500 tons of grain, nearly 2.5 times the amount carried by the flat-bottomed grain barges used on the Mississippi River system.

Onboard the towboats, computerized navigational and communication tools provide information on changing weather conditions, channel locations, and the position of other vessels on the river.

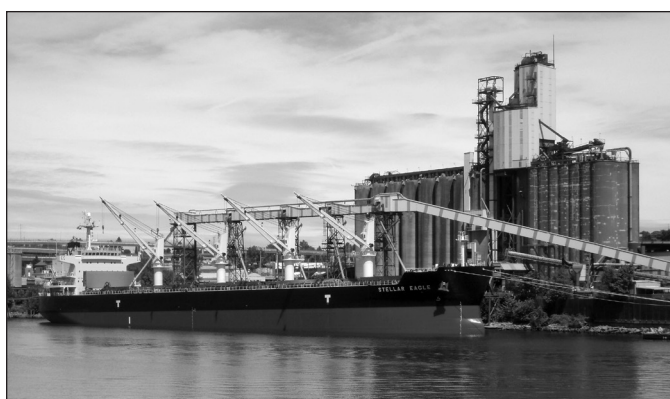


Grain Barges, Mississippi River

Credit: Carol Arney, USACE

SHIPPING COMPARISONS		
	=	
	=	
1 BARGE EACH BARGE CARRIES 1,500 TONS 52,500 BUSHELS 453,000 GALLONS		15 RAILCARS EACH RAILCAR CARRIES 100 TONS 3,500 BUSHELS 30,240 GALLONS
		58 LARGE SEMI-TRUCKS EACH SEMI-TRUCK CARRIES 26 TONS 910 BUSHELS 7,865 GALLONS

Source: U.S. Department of Transportation



Loading Grain for Export
 Credit: Mary Anne Stoskopf

Cargo Ships

Cargo ships carry freight from one port to another and handle the bulk of international trade. Cargo ships include container ships used for intermodal transportation systems, dry bulk carriers, and liquid bulk carriers (tankers). In addition to capacity and weight, cargo ships are categorized according to dimension, which often refers to which canals or canal locks the ships can travel through. For example, Panamax ships are large ocean-going vessels able to pass through the Panama Canal. Overall, the international shipping industry transports about 90 percent of the world's trade.

The first bulk carrier was built in 1852. Dry bulk carriers are designed to transport large quantities of unpackaged cargo, such as grain. The cargo holds, built-in storage areas, may transport more than one commodity at the same time – either in separate cargo holds or by layering commodities in-between tarps or plywood barriers.

Seven of the top ten seaports in the United States are located on the Gulf of Mexico. Generally, Kansas grain products destined for export are transported to ports in Houston, Galveston, or Beaumont, Texas from unit train facilities.

At most ports, remote computers control the loading of grain onto cargo ships. Computers also control most operations carried out on board ships, including navigation, communication, and tracking of the cargo.

SHIPPING FACTS

The international shipping industry transports about 90 percent of the world's trade.

Seven of the top ten seaports in the United States are located on the Gulf of Mexico.

By cargo volume, the Port of Houston is one of the top ten busiest ports in the world.

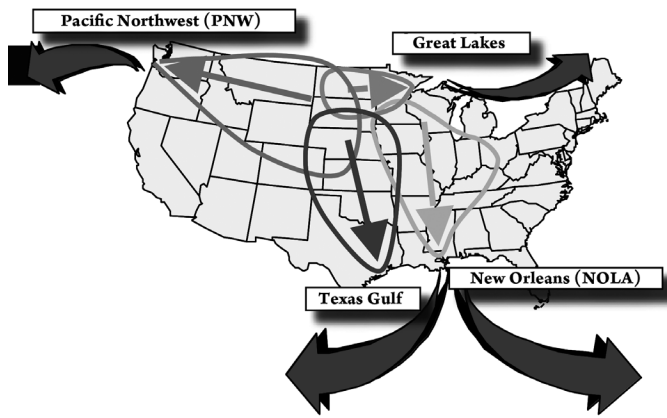


Grain Export Elevator
 Credit: Julia Debes, U.S. Wheat Associates



Loading Cargo Hold
 Source: IGP at K-State

U.S. GRAIN EXPORT PORTS



Source: IGP at K-State

PROCESSING

Agricultural products rarely leave the farm and reach the consumer without some type of handling and processing. For Kansas grains and oilseeds, there are many steps between the raw agricultural commodity and the food and consumer products they make possible.

Milling

Milling is the process of grinding seeds and sifting the particles to produce flour. For more than 8,000 years, people have been grinding grains to make bread and other foods. Early milling tools were made of stone, including the saddlestone as well as the mortar and pestle. These methods required hours of physical labor to process the grain into coarsely ground flour but the end product also contained stone powder and stone fragments. As a result, people's teeth were damaged and worn from eating grain foods containing the bits of stone.



**Hal Ross Flour Mill,
Kansas State University**

Source: IGP at K-State



Saddlestone

Source: Library of Congress

Mortar and Pestle

Source: Library of Congress



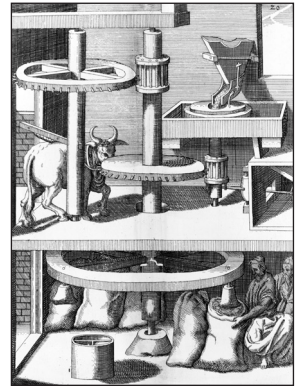
**Millstones,
Shellenberger Hall,
Kansas State University**

Credit: Tiffany Poet, KFAC

MILLING

Milling – the process of grinding seeds and sifting the particles to produce flour.

Early mills used two horizontal round stones that were rubbed against each other. The grain was poured between the stones, which slid back and forth against each other. Grooves were cut into the bottom stone, which directed the flour and seed particles out the sides of the stone. The next advancement came when levers were added so that the top stone could be turned, increasing the amount of grain that could be ground and leading to the use of larger stones. These mills were first powered by people, then animals like oxen and horses. Water power was first introduced by the Romans about 100 B.C., but wind-driven milling took nearly another thousand years to develop.



Grinding Grain, 1600s

Source: Library of Congress

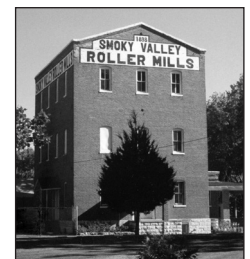


Wind-powered Flour Mill

Source: Library of Congress; Jet Lowe, photographer

HISTORIC KANSAS FLOUR MILLS

Traces of early dams and flour mill sites can still be found across Kansas. Once a year, the Smoky Valley Roller Mill at Lindsborg hosts a "Millfest." This flour mill is located on the Smoky Hill River on the site of an earlier mill built in 1872. The current flour mill was built in 1898 and operated until 1955, with restoration completed in 1981. Other Kansas mills built in the 1870s that are still open to visitors include the 1875 Drinkwater & Schriver Flour Mill at Cedar Point on the Cottonwood River and the Old Oxford Mill in Sumner County, built on the Arkansas River in 1874.

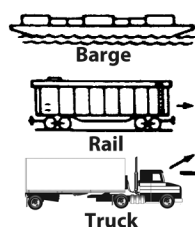


Smoky Valley Roller Mill

Photo by Tom Jaderborg; Courtesy
Old Mill Museum, Lindsborg

HOW FLOUR IS MILLED

It starts here . . .



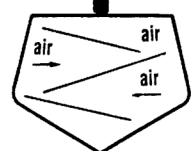
Elevator
Storage and care of wheat.



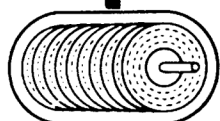
Product Control
Chemists inspect and classify wheat. Blending is often done at this point.



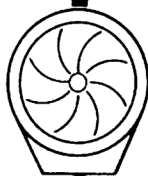
Separator
Reciprocating screens remove stones, sticks, and other coarse or fine materials.



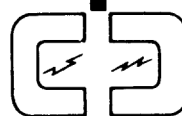
Aspirator
Air currents remove lighter impurities.



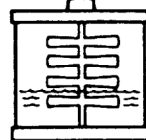
Disc Separator
Barley, oats, cockle, and other foreign materials are removed.



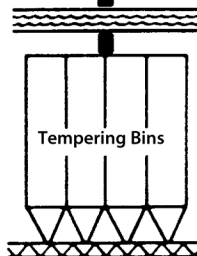
Scourer
Beaters in screen cylinder scour off impurities and roughage.



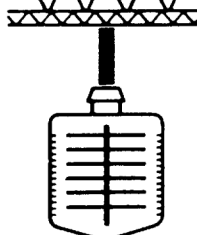
Magnetic Separator
Iron or steel articles are removed.



Washer-Stoner
High speed rotors circulate wheat and water. Stones are removed.



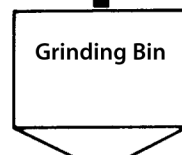
Tempering
Water toughens outer bran coats for easier separation, softening or mellowing endosperm.



Blending
Types of wheat are blended to make specific flours.



Entoleter
Impact machine breaks and removes unsound wheat.



First Break
Corrugated rolls break wheat into coarse particles.

Credit: K-State Research and Extension

In Kansas, early settlers used the power of the water flowing in rivers and streams to operate grist and flour mills and sawmills. The first mill in the state was located at Auburn, operating around the clock – as a sawmill during the day and grinding corn at night.²¹ The public parks at Valley Falls display millstones from nearby early mills, including one erected in 1855 on the Grasshopper River (later renamed the Delaware River) that the father of William F. (Buffalo Bill) Cody was a partner in. In the early days of Kansas, the federal government also established five mills at military posts and two at Indian missions.²²

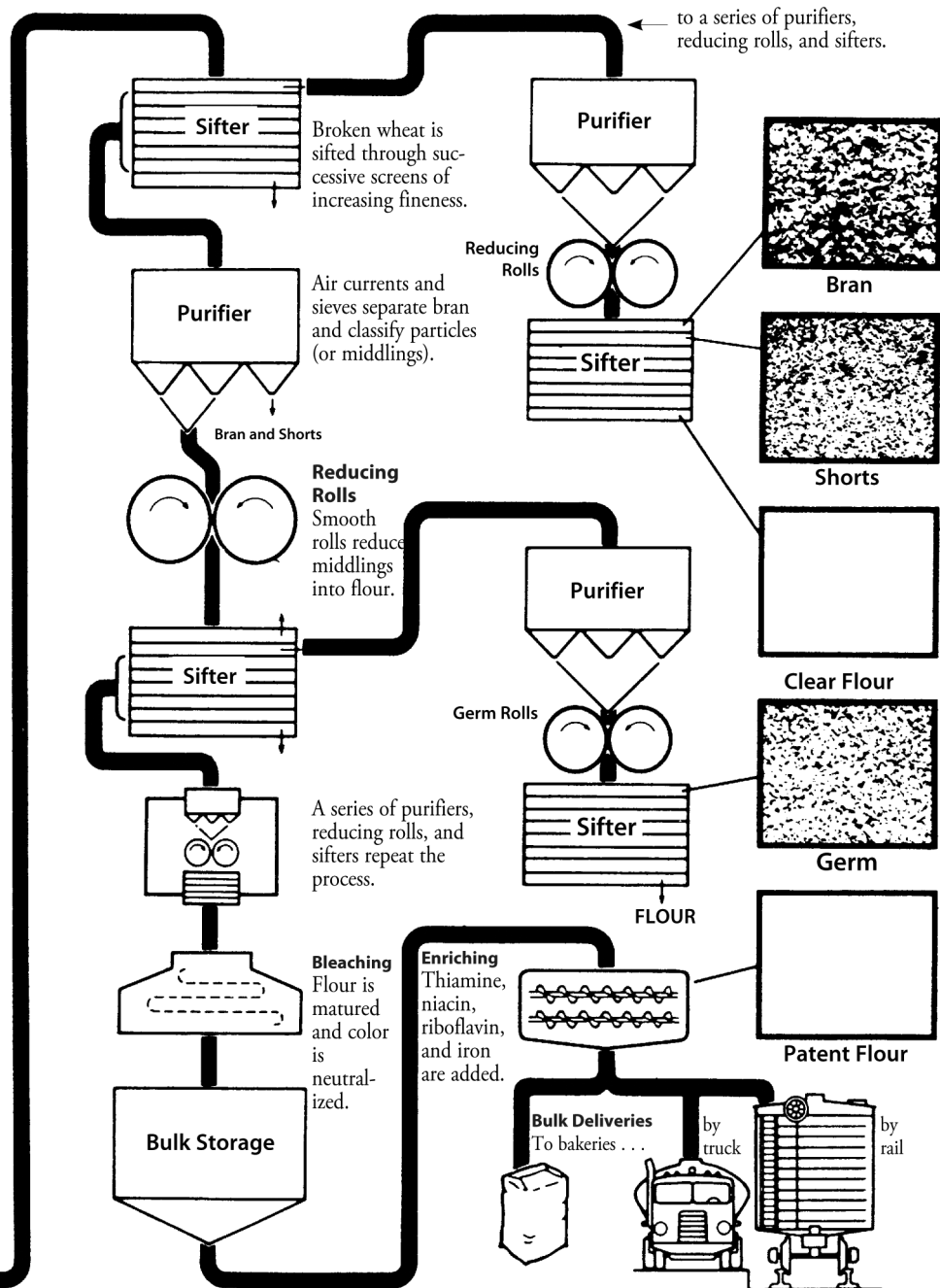
In the 1870s, millstones were replaced with pairs of horizontal cylindrical steel rollers that rotated in opposite directions. Like the millstones, the grooves in the rollers needed to be dressed (regrooved) and repaired but those processes were faster and less



Close-up of Mill Rolls

Credit: IGP at K-State

HOW FLOUR IS MILLED



expensive than regrooving and repairing the large heavy millstones. The grinding action of the millstones also produced more heat than when grain was ground with the rollers because the rollers permitted a more gradual grinding process that produced more flour from the same quantity of wheat. The steel rollers, known as "mill rolls," also produced a cleaner, more consistent flour.

Today, milling efficiency continues to improve with advancements in milling equipment, computerization, and scientific testing of grain properties. While the grain is still in storage, small lab samples are turned into flour that is tested for baking qualities. These test results



Milling

Credit: IGP at K-State

KANSAS MILLING FACTS

Among the 50 states, Kansas ranks first in wheat flour milling capacity. However, Kansas is currently second in the amount of actual wheat flour milled.

determine which grains will be blended together and milled for specific food processors. For example, a pizza company might request a flour that produces a dough that can be stretched and handled many times before being baked while a bakery might prefer flour that produces a dense loaf of bread. Each food manufacturer or food processing company has specific flour requirements that the miller must meet.

The first step in the milling process is cleaning the seed. All foreign matter – particles of plants, insects, dirt, stones, and even tiny bits of metal that flaked off as the grain was being harvested, moved, or stored – must be removed. Magnets, moving screens, and air currents are used to clean the grain.



Lines Within Grain Cleaning Operations

Credit: IGP at K-State

Then the grain is tempered – moistened with water to toughen the outer seed coat and make it easier to separate from the softer endosperm contained in the seed. The endosperm is the starchy food source for the seed's germ (embryo). As the milling process continues, the seeds move through a series of rollers that flake off the outer seed coat, often called the "bran." Specialized sifting screens separate the particles of endosperm from the outer seed coat and remove the germ. As gravity and air move the endosperm through sifting screens with smaller and smaller openings, only the finest smallest particles of flour are left behind. The flour is packaged once sifting is completed. Although the process varies slightly for different grains, the principles of separating the endosperm from the seed coat and germ are essentially the same.

Whole grain foods are produced using flour that includes the seed coat and germ, as well as the endosperm. During milling, the seed coat and germ are still separated from the endosperm but they are

MILLING PRODUCTS

Flour – the finely ground endosperm of kernels of grain that have been separated from the kernels' bran and endosperm during the milling process.

Whole grain flour – flour that includes the bran (seed coat) and germ, as well as the endosperm.

Bran – the seed coat (hard outer layer) of grain; may be milled from any cereal grain, including wheat, rice, corn, oats, barley, and millet.

Germ – the embryo necessary to grow a new plant from the seed; is usually separated out because it contains fat, which may turn rancid if stored improperly or for a long period of time.

Cornmeal – flour ground from dried corn.

Cornstarch – powder obtained from the endosperm of the corn kernel.



Roller Mills

Credit: IGP at K-State



Mill Pipes

Credit: IGP at K-State



Sifting Screens

Credit: IGP at K-State



Air Purifier

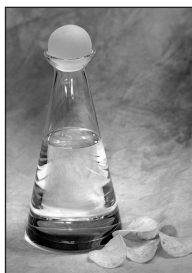
Credit: IGP at K-State

added back into the flour before it is packaged. The seed coat may need additional rolling and sifting to reach the desired particle size for the whole grain flour.

Extracting Oil

Oil is extracted from seeds through either mechanical or solvent extraction. Mechanical extraction involves physically squeezing oil out of seeds, typically heated or cooked seeds because less physical force is needed to press oil out of warm seeds than cold seeds. Solvent extraction, once reserved for seeds with lower oil content, is now used to extract the oil in nearly all the soybeans processed in the United States as well as most other oilseeds.

Regardless of which extraction method is used, the process typically includes cleaning, drying, dehulling, size reduction, and heating. Rotating or vibrating screens, magnets, and other devices clean the seeds prior to processing by removing all foreign materials, including plant stems, sticks, leaves, sand, dirt, stones, and metal shavings. The moisture content of the seeds is reduced by drying to maintain the quality of the seeds during storage as well as facilitate dehulling (also referred to as "shelling"). Most oilseeds are dehulled prior to oil extraction, meaning the hulls or seed coats are removed. This increases the efficiency of the extraction process. If the hulls are not removed, additional steps must be taken during the refining process (following oil extraction) to remove



Sunflower Oil

Credit: National Sunflower Association

AVERAGE OIL CONTENT OF SEEDS (BY WEIGHT)

sunflower – 42-43%
canola – 38-45%
soybean – 18-19%
cotton – 18%
corn – 3.8%

OIL EXTRACTION: MECHANICAL VS. SOLVENT

Mechanical – physically squeezing oil out of whole seeds.

Solvent – percolating an organic solvent through flattened dehulled seeds to collect oil, which is then separated from the oil-solvent solution by a chemical process.

OILSEED PROCESSING WORDS

Conditioning – increasing temperature and moisture content using steam; also known as tempering.

Coproduct – an additional product resulting from the production of the primary product, for example soybean meal is a coproduct from the production of soy oil.

Crush – the process of extracting oil from oilseeds; often used in reporting data.

Dehulling – removing the outer seed shell, as in a sunflower seed or cottonseed, or the outer seed coat of the kernel as in a soybean; also referred to as shelling.

Flaking – stretching and flattening seeds down to a thickness of 10-12 thousandths of an inch.

Immersion – extracting oil by submerging oilseed flakes in solvent.

Miscella – solution of oil and solvent.

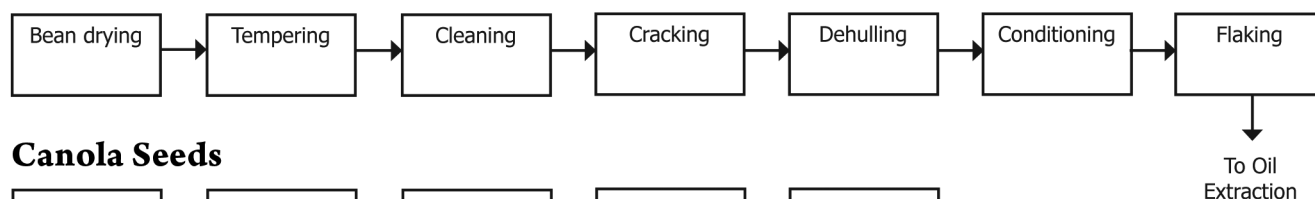
Percolation – spraying oilseed flakes with a solvent that captures the oil as the solvent passes through the flakes.

Tempering – (see conditioning)

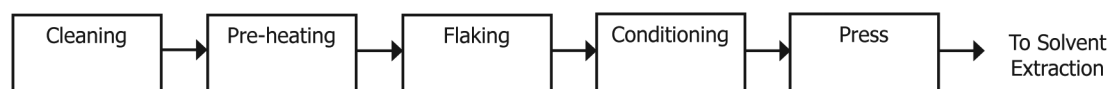
Toasting – heating seed residue to vaporize any remaining solvent.

PREPARING SEEDS FOR OIL EXTRACTION

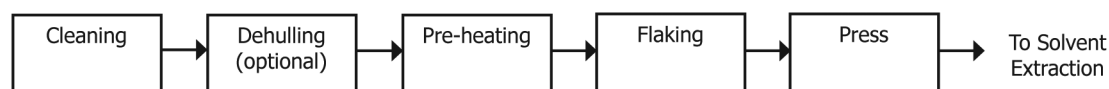
Soybeans



Canola Seeds

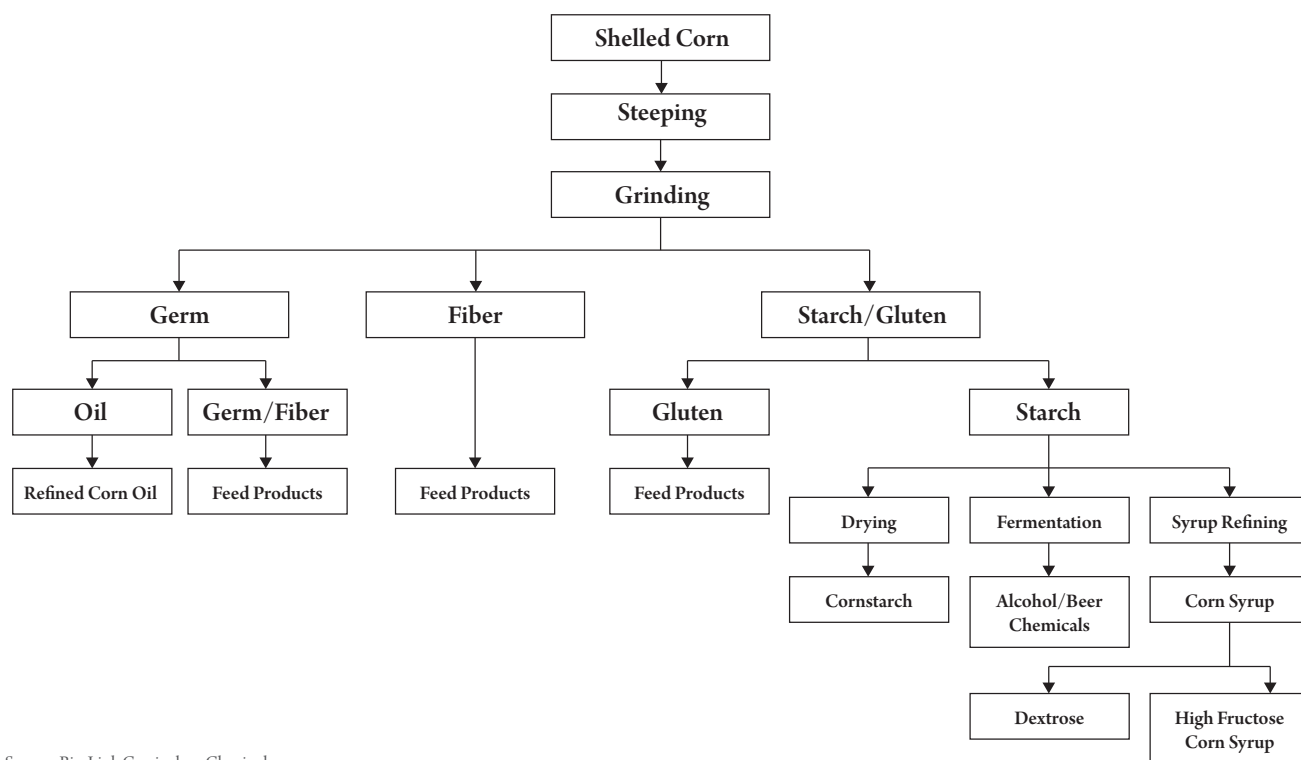


Sunflower Seeds



Source: Oklahoma Cooperative Extension Service

CORN OIL – WET MILLING PROCESS



Source: Bio-Link Curriculum Clearinghouse

undesirable compounds naturally present in the hulls that end up in the extracted oil. While canola seeds and corn germ do not require size reduction to aid oil extraction, most seeds are cracked or flaked following dehulling. However, to prevent any deterioration in the quality of the oil, the oil must be extracted from cracked or flaked seeds within 24 hours.

Depending on the type of oilseed, the seeds may be cooked or conditioned (tempered) to facilitate the release of oil from the seed's cells. This also inactivates enzymes and gives seeds the proper elasticity for processing. Cooking times and cooking temperatures vary with the type of seed but cooked seeds must be pressed immediately after cooking. Tempering (conditioning) increases the temperature and moisture content of the seeds by using steam, rather than actually cooking the seeds.

Mechanical Extraction

The mortar and pestle was one of the earliest tools used to press oil out of seeds. The oil was collected as it drained out a small hole in the bottom of the mortar. Devices using levers and wedges to physically squeeze the oil out of seeds came next, followed by the ram press. The olive oil industry still uses the ram press to squeeze oil out of the seeds by crushing the olives together.

In the 1950s, the screw press replaced the ram press for most mechanical extractions of oilseeds. A screw press feeds seeds into a horizontal cage or barrel enclosing a screw. The diameter of the screw increases so that the pressure increases on the oilseeds as they move along the length of the press towards a restricted opening. Slots along the length of the barrel allow the oil to drain off and be collected. The



Mortar and Pestle

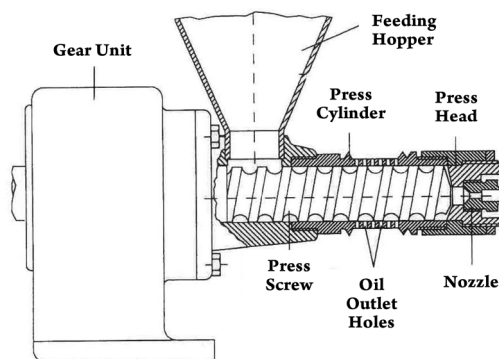
Courtesy: Florida Center for Instructional Technology

CORN OIL

In most oilseeds, oil develops in the endosperm as a food source for the embryo. However, corn oil is extracted from the germ (embryo) rather than the endosperm.

Corn oil results from a wet milling process, in which the corn is steeped (submerged in a mild acidic solution), coarsely ground, and passed through a separator. Once separated, the lighter-weight germ is removed, washed, and any water is removed. Then the germ is dried and the oil is extracted.

SCREW PRESS



Source: ATTRA – National Sustainable Agriculture Information Service

"cake" (what remains of the seed) is discharged at the end of the barrel. Oilseed cake contains residual oil, giving it a high energy content when used in livestock feed mixtures.

Solvent Extraction

Commonly used in Europe in the 1800s, solvent extraction is the most efficient technique to capture oil from oilseeds. Less than one percent of the oil remains in the seed residue after extraction is completed. When using solvent extraction, most oilseeds are flaked – stretched and flattened while passing through pairs of rollers that are forced together by hydraulic cylinders while turning in opposite directions. Flaking ruptures the cellular structure of the seeds and increases the surface area of the seeds, which increases the contact with the solvent so that the oil can be more easily extracted.



Soybean Flakes

Credit: Soybean Checkoff

Once the flakes are down to a uniform thickness of 10-12/ thousandths of an inch, they pass through an extractor. There are two types of extractors: immersion and percolation. Immersion (completely submerging the flaked oilseeds in a tank of solvent) is less common because it is more difficult to separate the oil and solvent at the end of the extraction process. During the percolation process, a solvent is sprayed over a bed of flaked seeds. The solvent drains through the bed, washing the oil out of the seeds as it passes through the flakes and producing an oil-solvent solution called "miscella." To separate the oil from the solvent, the solution is heated indirectly with steam in a distillation process. Since the solvent vaporizes at a lower temperature than the oil, the solvent vapors are collected, condensed, and recycled to the extractor. Meanwhile, the oil is drained off and



Soybean Oil

Credit: Kansas Soybean Commission

MEAL VS. CAKE

Cake – seed residue from the mechanical extraction of oil.

Meal – seed residue from the solvent extraction of oil.

further refined as needed to produce the desired end product. The seed residue is toasted – heated to a temperature high enough to evaporate any remaining solvent but not high enough to affect the nutritional value of the "meal."

The residue that remains after oil is extracted from oilseeds is called either "meal" (solvent extraction) or "cake" (mechanical extraction). Because mechanical extraction is not as efficient at removing the oil, oilseed cake contains more oil than meal. Meal, however, is higher in protein than cake. Both coproducts are used in livestock feed mixtures, depending on the livestock species and nutrient requirements.

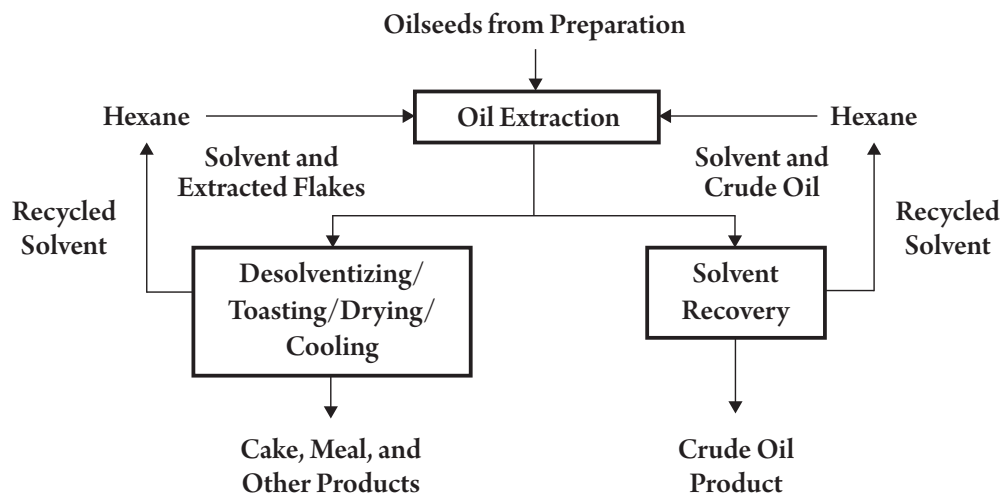
Other Processing

When processing grain and oilseeds, the entire seed is rarely used in a single final product and the processing generates waste. Most processing companies have found beneficial uses for those waste products, resulting in valuable coproducts such as soybean meal. Cottonseed oil is actually a coproduct resulting from the processing of cotton for fiber (ginning).

People have been processing grains, oilseeds, and other plant materials into nonfood products for thousands of years. American Indians used sunflowers for medical uses and to produce purple dyes. Cornhusks and other plant materials were braided and woven into masks, moccasins, sleeping mats, and baskets.

Today, biotechnology and other technological advancements allow plant breeders to produce plants with specific quality traits that make the processing of seeds and other plant materials more efficient, saving time and energy as well as lowering processing, manufacturing, and consumer costs.

SOLVENT EXTRACTION USING HEXANE



Source: Oklahoma Cooperative Extension Service

STRIKING A BALANCE

The strength of a nation is often based on its ability to provide ample quantities of high-quality low-cost food to its own people. In the United States, agricultural producers continue to meet that challenge, laying the foundation for our country to remain strong and pursue innovation in other fields. Many people in the world do not have that opportunity.

The latest projections by the Food and Agriculture Organization of the United Nations (FAO) indicate global agricultural production must grow by 70 percent by 2050 in order to feed an anticipated 2.3 billion increase in the world's population.²³ The FAO also projects that globally, 90 percent of the required increase in food production must come from increasing yields on existing farmland. According to U.S. Secretary of Agriculture Thomas Vilsack, 95 percent of the world's farms are only one to two hectares,²⁴ areas equivalent to only 40-80 yards on a U.S. high school's football field.

Since the 1980s, opponents to the adoption and widespread use of new technologies have sought public support, often at the expense of saving lives in developing countries. Dr. Norman Borlaug and other prominent agricultural scientists have argued that adopting new technologies to produce more food from less land preserves wild habitats, thus preventing environmental degradation and depletion of natural resources. While the debate continues, worldwide, a child dies every six seconds due to hunger and related causes. Striking a balance between protecting natural resources and the use of new technologies to produce food is more critical than ever. ■

GLOBAL FACTS

*Worldwide, a child dies every six seconds
due to hunger and related causes.*

*A high school football field in the United States is
larger than 95 percent of the world's farms.*

*Global agricultural production must grow by 70 percent
by 2050 in order to feed an anticipated 2.3 billion
increase in the world's population.*

*According to the United Nations, 90 percent
of the required increase in food production must come from
increasing yields on existing farmland.*



**Wheat Harvest
in Afghanistan,
July 2010**

Credit: Scott Fetherston



**Crop Fields in
Afghanistan, July 2010**

Credit: Scott Fetherston

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TEACHER'S RESOURCES

The Kansas Foundation for Agriculture in the Classroom (KFAC) offers lesson plans and other educational resources on the KFAC website: www.ksagclassroom.org.

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