niques such as the polymerase chain reaction are now being used to monitor individuals for early disease recurrence. With this technique it is possible to identify a single malignant cell among 100,000 to 1,000,000 normal cells, a task not possible before. In this way, appropriate therapy can be instituted early in order to prolong individual's survival. The polymerase chain reaction can also be applied to screen bone marrow specimens of individuals with cancer for the presence of malignant cells before autologous transplantation.

**Prenatal diagnosis of hereditary disease.** In recent years, the molecular biologic changes underlying many genetic diseases have been elucidated. Currently, we know of more than 4000 hereditary disorders associated with an abnormality in a single gene. The genes responsible for many of these diseases have been identified, making it possible to screen for abnormal genes early in fetal development.

Some of the better characterized diseases include cystic fibrosis, Duchenne muscular dystrophy, Huntington's disease, myotonic dystrophy, and adult polycystic kidney disease. These diseases can be diagnosed prenatally in cases where there is a family history of the disorder. Prenatal diagnosis is achieved through chorionic villus sampling, a procedure that can be performed as early as weeks 10–11 of gestation. Chorionic villus sampling involves biopsy and evaluation of a small portion of placental tissue. Since the placenta contains tissue of fetal origin, it is genetically identical to the developing fetus. Molecular biologic techniques such as Southern blotting and the polymerase chain reaction are then applied to the chorionic villus sample to screen for the presence of the abnormal gene in question.

**Diagnosis of infectious diseases.** Until recently, the diagnosis of infectious disease depended on the identification of the responsible organism in culture, or on the identification of organism-specific antibodies in the blood of the affected individual. Because culture of some organisms, particularly fungi, viruses, and some bacteria, may take weeks, institution of appropriate therapy was sometimes delayed. In addition, in the case of organisms that cannot be grown in culture, diagnosis was presumptive, dependent on the concentration of antibodies, on symptoms, or on biopsy findings. The development of specific molecular biologic assays for many infectious organisms (see **table**) has solved some of these diagnostic problems.

The techniques most commonly employed for identification of infectious organisms are in-place hybridization and the polymerase chain reaction. These techniques can be performed rapidly enough that results are often available before the organism appears in culture. In addition, in-place hybridization and, especially, the polymerase chain reaction, are extremely sensitive and are capable of identifying organisms that are present in very small numbers, as is often the case with the bacteria that cause tuberculosis and the human immunodeficiency virus (HIV).

**Infections for which molecular diagnosis is possible**

| Organism | Representative associated diseases |
|---|---|
| Viruses | |
| Cytomegalovirus | Multiple effects in immunosuppressed patients |
| Herpes viruses | Genital herpes; fever blisters |
| Human papillomavirus | Venereal infections; warts; association with some forms of cancer |
| Epstein-Barr virus | Mononucleosis; association with some forms of cancer |
| Human immunodeficiency virus (HIV) | Acquired immune deficiency syndrome (AIDS) |
| Hepatitis B virus | Hepatitis B |
| Hepatitis C virus | Hepatitis C |
| Measles virus | Measles |
| Rhinovirus | Common cold |
| Bacteria | |
| *Mycobacteria* | Tuberculosis; infections in immunosuppressed patients |
| *Chlamydia* | Venereal infections; eye infections |
| *Helicobacter pylori* | Gastritis; peptic ulcer |
| *Neisseria* | Gonorrhea; meningitis |
| Others | |
| *Sporozoa* | Malaria |
| *Pneumocystis* | Pneumonia in AIDS patients |
| *Rickettsia* | Rocky Mountain spotted fever; Q fever |
| *Toxoplasma* | Toxoplasmosis |

For background information SEE ACQUIRED IMMUNE DEFICIENCY SYNDROME (AIDS); CANCER (MEDICINE); CLINICAL PATHOLOGY; DEOXYRIBONUCLEIC ACID (DNA); DISEASE; GENE AMPLIFICATION in the McGraw-Hill Encyclopedia of Science & Technology.

*Cecilia M. Fenoglio-Preiser; Amy E. Noffsinger*

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## Coal mining

For mining, teleoperation refers to the distant control of mining machinery from a protected operator compartment located out of the line of sight to the extraction site. Successful teleoperated mining systems have recently been developed to extract the extensive coal reserves in highwalls, that is, coal seams uncovered during surface strip mining operations or exposed in mountaintop ridges.

**Highwall mining.** The U.S. Bureau of Mines has estimated that there are 18,000 mi (29,000 km) of exposed highwalls in Appalachia and that a highwall coal reserve of $2 \times 10^{10}$ tons ($1.8 \times 10^{10}$ metric tons) exists for a highwall mining system that can penetrate 850 ft (260 m). Significant highwall reserves consist of low-sulfur coal that is highly desirable for steam and metallurgical applications. Until recently, these reserves were left basically intact, because mining methods were unavailable or were hampered by inadequate safety, low productivity, and adverse environmental factors.

Highwall mining technology provides access to coal reserves at the interface between surface and underground mining. New highwall mining systems are safe, productive, and environmentally acceptable. These systems allow highwall penetration up to 1200 ft (366 m) and coal recovery ratios of about 60%. Much of the success of the new highwall mining systems is attributed to the technology of teleoperation.

**Teleoperation.** This technology allows equipment operators, who are not present at the area where the coal extraction occurs, to safely monitor and control the highwall mining systems.

In a typical teleoperated highwall mining system, coal is extracted by developing parallel entries in the exposed coal seam from the bench area adjoining the highwall (**Fig. 1**). The overburden above the coal seam is supported by pillars between the extracted entries. A teleoperator, located in a protected enclosure on the bench, controls the operation of the highwall mining system and is assisted by other workers. No workers are allowed in the developed entries, which increases safety, simplifies the mining process, and reduces costs. For example, barring workers from the extracted entry eliminates the requirement to install artificial roof supports in the strata above the entries. The standard operating procedure is to extract the coal and retrieve the equipment from the hole as quickly as possible. Concerns during highwall mining include ventilation to remove dust and explosive gases and procedures to extract the mining equipment in case of a breakdown.

A very successful design for a highwall mining system became available commercially in 1981. The original design was a hydraulic model that evolved to a more powerful and sophisticated electrical design introduced in 1985. An improved system was introduced in 1992, after having been systematically developed and tested in three Appalachian states. The new highwall mining systems have achieved success largely because of modern electronics, especially miniaturized cameras, and refinements in blasting and blast-hole alignment methods (used during the creation of the highwall) that increase the stability of the highwall.

**Highwall mining system extraction.** Highwall coal extraction is usually done with a continuous mining machine modified for distant remote control. A continuous mining machine, used extensively in underground deep mines, is a massive tracked machine equipped with a rotating drum that is fitted with tungsten carbide cutters. The position of the cutting drum is controlled by the operator, so that its penetration rate into the coal face and its cutting height can be varied to suit conditions. Continuous mining machines also include mechanisms to gather and direct cut coal onto a conveyor that transports it from the extraction face to the outby end of the machine (toward the shaft or entry of the mine).

Highwall mining systems use a variety of equipment to transport cut coal from the end of the continuous mining machine to the highwall bench. In some instances, continuous haulage systems have been developed for underground mining, with

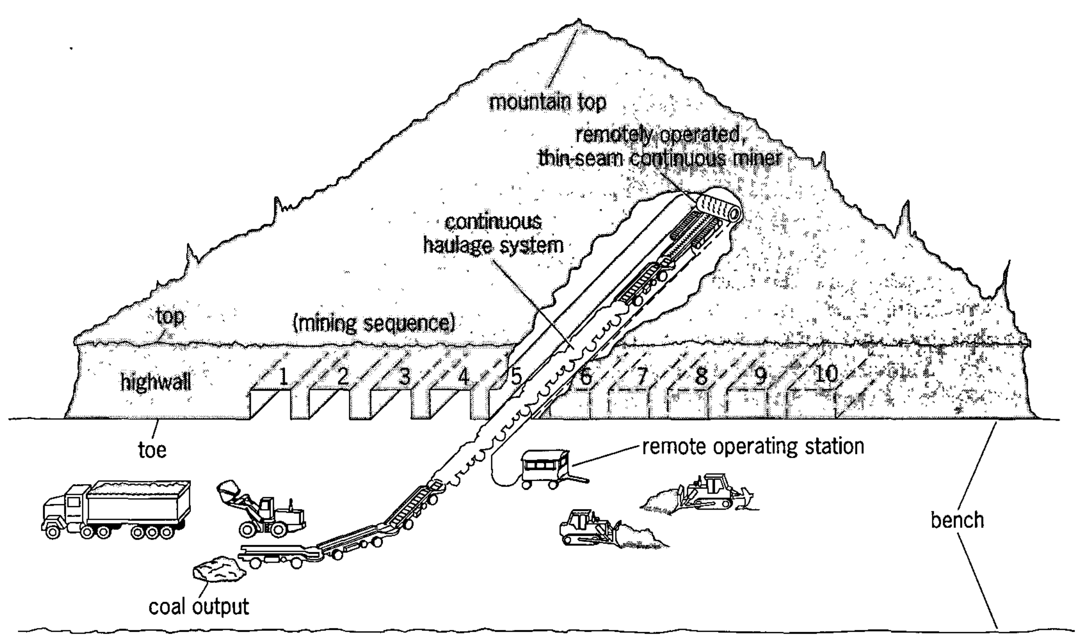


Fig. 1. Teleoperated highwall mining system.

joined vehicles carrying either conveyor chains or belts that have been adapted to this purpose. For other highwall mining systems, coal haulage systems have been developed specifically for the application; these use rigid pushbeam sections to convey the coal. Pushbeam sections are segmented structures, approximately 40 ft (12 m) long, that are designed both to contain the conveying mechanisms and to transmit compressive forces. To move the coal, one design uses internal augers and another uses conveyor belts. For both systems, bench-based machines progressively add the pushbeams until the desired depth of highwall penetration is obtained.

**Teleoperator control.** The teleoperator for the highwall mining system must be provided with sufficient information to control the mining operations, although the operator is located a great distance from the extraction face and cannot see it directly. Video systems are normally the operator's primary means of monitoring a highwall mining system in a teleoperated environment. Such video systems are usually multicamera, multimonitor, closed-circuit configurations. Typically, two or three cameras are mounted at strategic locations on the equipment to allow remote monitoring of critical operations and conditions, such as the roof type and condition, the boundary between the coal and rock above the seam, the cutter bit paths in the roof, and the color of the generated dust. Usually one video monitor is assigned to each camera. Sometimes, by using a video special-effects generator, simultaneous images from two cameras are presented on one monitor as a main and a smaller inset picture.

**Sensors.** Sound systems can extend the operator's sensory perception during teleoperation of a highwall mining system. Initial attempts using microphones mounted on the equipment were of little use, because loud noises generated by machines such as pump motors and conveyors masked other ambient sounds. The U.S. Bureau of Mines obtained much better results by using accelerometers (sensors that detect and produce electrical signals) coupled to the cutting head boom of the continuous mining machine. Teleoperators using this sound system reported that the accelerometer-based sound was very useful for determining coal/rock interfaces, aiding the operator in keeping the mining operations within the coal seam.

A variety of other sensors have been used with highwall mining systems to increase the information presented to the teleoperator. These sensors monitor operating parameters of the continuous mining machine and haulage equipment that include electrical motor currents, hydraulic fluid levels, the mine methane level, and the orientation (pitch and roll) of the continuous mining machine. Sensors are normally selected to furnish the operator with adequate information to control the mining system and to monitor the operational condition of its major subsystems.

Newer designs of highwall mining systems use computers to communicate operator control commands and sensor data between the operator's control station and the mining equipment. Such systems usually provide the teleoperator with more detailed, perhaps processed, information on conditions within the mined entry and on important machine parameters. Some systems with computers incorporate or allow for automated cutting cycles. Continued advancements in computer systems and sensors, particularly coal interface detectors, are likely to result in future generations of highwall mining systems with more automation capabilities.

Fig. 2. Workstation for a teleoperated highwall mining system.

**Ergonomics.** The success of a teleoperated highwall mining system can depend on the operator-to-machine interface. Because the teleoperator is required to control the mining system for extended periods, it is important to engineer the workstation to accommodate the needs of the operator. **Figure 2** shows an ergonomically designed remote operator's control room developed by the U.S. Bureau of Mines for a teleoperated system. For this application, the operator controls the continuous mining machine, major functions of the haulage equipment, and some functions of highwall-based support equipment. Operator comfort is an important element of the design. The operator can change seating and body positions, while still having full access to control and monitoring equipment. The operator, in a semireclining position on a special, adjustable task chair, has access to clustered control and readout instrument panels and multiple video monitors. Sensory information from the continuous mining machine and haulage equipment is presented on color-coded bar-graph displays on an adjustable, swing-away console in front of the operator. Main controls for the continuous mining machine are grouped on a small hand-held module, while secondary controls are located on an adjustable floor-mounted panel next to the operator's task chair. Dual 19-in. (483-mm) color video monitors are housed in a custom cabinet at the optimum viewing distance. Aural information from the continuous mining machine is received over stereo headphones.

**Advanced technology.** The advent of advanced technology, particularly in sensor and control methodologies, is the basis for a successful application of the new teleoperated highwall mining systems. Because most new highwall mining systems use continuous mining machines to drive the extraction entries, no cutting power losses are associated with increased highwall penetration. For most systems, entry depth does not influence the power available for coal haulage at the face. However, having the power available to cut and haul from deep within the highwall is of little value without the capability to stay within the coal seam and to minimize ground falls. Advanced sensor and control subsystems allow a teleoperator to make informed decisions on what needs to be done and to control the equipment.

**Prospects.** Teleoperation has made deep-penetration highwall mining practical; the control method has been adopted by all the major manufacturers of highwall mining systems. Continued sensor, computer, and mining-specific advances should improve teleoperation technology, increasing its ability to mine coal safely and productively from highwall and other coal reserves.

For background information SEE COAL MINING; HUMAN-FACTORS ENGINEERING; INSTRUMENTATION; MINING in the McGraw-Hill Encyclopedia of Science & Technology.

*August J. Kwitowski*

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## Cognition

The origins of human cognitive abilities, such as perception, memory, thinking, and problem solving, have been the focus of much interest in psychology, biology, philosophy, and the emerging discipline of cognitive science. In the early 1960s, speculation, inferences from adult abilities, and a few observations of infants formed the bases of study of infant cognition. With the development of experimental methods for inferring what infants perceive and know, longstanding assumptions about the beginnings of thought have been challenged.

**Methodological advances.** Human infants do not crawl until about 6–7 months of age, reach effectively until 4–5 months, or speak until much later. The lack of observable responses makes studying infant abilities difficult, and has led observers to underestimate what infants know. Infants do actively fixate visual displays. Thus, a primary advance in studying infant cognition has focused on their visual attention span (length of looking time). In the visual preference method, discrimination abilities and preferences of infants are tested by presenting two displays side by side and recording fixation preferences. In the habituation/dishabituation method, repeated presentation of one display leads to decreased attention. However, with a subsequent presentation of novel display attention rebounds. Even without habituation, presentation of an event that is perceived as bizarre or anomalous may lead to greater visual attention than a control event involving similar objects. By using these facts about infant attention many inferences about infant cognitive abilities can be made.

**Infant perception.** A classical view contended that the senses of newborns provide them only with sensations, particular qualities unique to each sense, such as brightness in vision or pitch in hearing. These sensations are due to activity in sensory receptors; by themselves they indicate nothing about objects or events in the outside world. Perception, or knowledge about the world, could be attained only by a long learning period, in which input from various senses and remembered sensations become associated with each other. Through such associative learning, the objects and events in the outside world come to be known. By this account, most of the first year of life is spent learning to perceive. As recently as the mid-1960s, many pediatricians believed that newborns were functionally blind.

Recent research presents a different picture. The senses of an infant place the infant in meaningful contact with the outside world from birth. Early sensitivity to properties of depth, three-dimensional objects, motion, and events can be demonstrated for infants as easily as sensitivity to sensory qualities such as color or pitch. Some limitations on the precision of perception are resolved by maturational processes that improve sensory resolution during the first several months of life, and others by the development of attentional skill in using perceptual systems. However, the general picture is consistent with an ecological view that the senses evolved to provide knowledge about the environment. Acquiring such knowledge does not depend on learning to interpret sensations but rather on brain mechanisms sensitive to spatial and temporal patterns of information in incoming stimulation. Some specific areas of early competence are described below.

***Objects.*** A primary question concerning visual abilities involves the detection from reflected light of the unity and boundaries of physical objects in the world. Experiments suggest that some basic mechanisms for detecting object boundaries are in place well before infants acquire experience from crawling or grasping. Likewise, there is evidence for the perception of three-dimensional form of objects within the first several months of life. In both cases, infants seem to use only a subset of the information available to adults, that is, earliest competence depends on information carried by motion. An adult may perceive the boundaries of objects quite well in station-

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