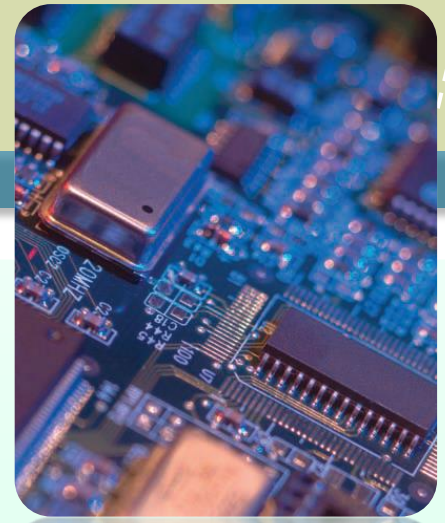
Hardware: The CPU & Storage

Chapter 4

Chapter Topics



UNIT 4A: Processing: The System Unit, Microprocessors, & Main Memory

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4.2 Representing Data Electronically

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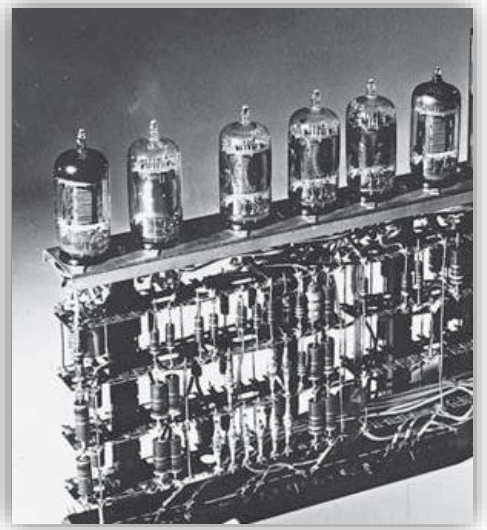
UNIT 4A: Processing: The System Unit, Microprocessors, & Main Memory

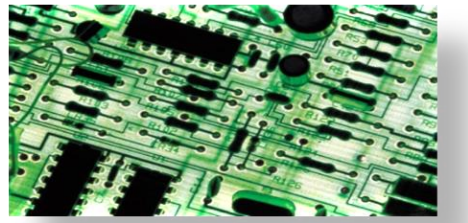
- Electronic circuitry has remained basically the same over recent years.
- A **circuit** is a closed path followed or capable of being followed by an electric current.
- Vacuum tubes used wire circuits inside them to facilitate the flow of electrons.
- Transistors have replaced vacuum tubes.



4.1 Microchips, Miniaturization, & Mobility

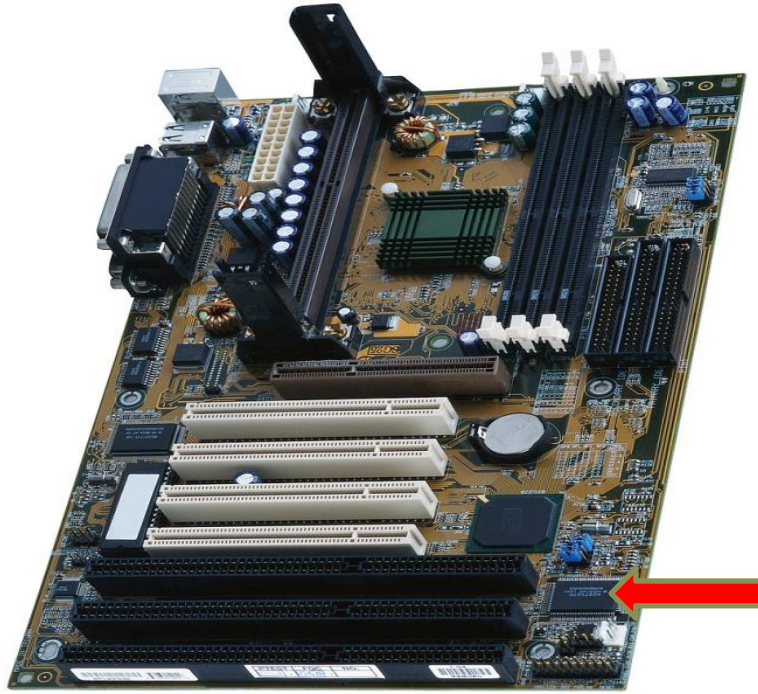
The Since the early 1970s, microchips have gotten smaller and smaller yet more and more powerful and faster.

- A transistor is a tiny electronic switch that can be turned "on" or "off" millions of times per second.
- Transistors form part of an integrated circuit: all the parts of an electronic circuit embedded on a single silicon chip.
- Integrated circuits are solid state (no moving parts).



Si Silicon
Atomic Number: 14
Atomic Mass: 28.09

- **Silicon:** A semiconductor made of clay and sand.
- **Semiconductor:** A material whose electrical properties are intermediate between a good conductor and a nonconductor of electricity.
  - Perfect underlayer for highly conductive, complex circuits.
  - Microchips (Microprocessors) are made from semiconductors.
- **Chip:** A tiny piece of silicon that contains millions of microminiature integrated electronic circuits.



- **Miniaturization**
  - **Microchips**
    - Store and process data in electronic devices
  - **Microprocessors**
    - The miniaturized circuitry of an entire computer processor (“brain”) on a single chip
    - Contains the central processing unit (**CPU**), which processes data into information
- The development of microchips and processors has enabled the development of small, mobile electronic devices.

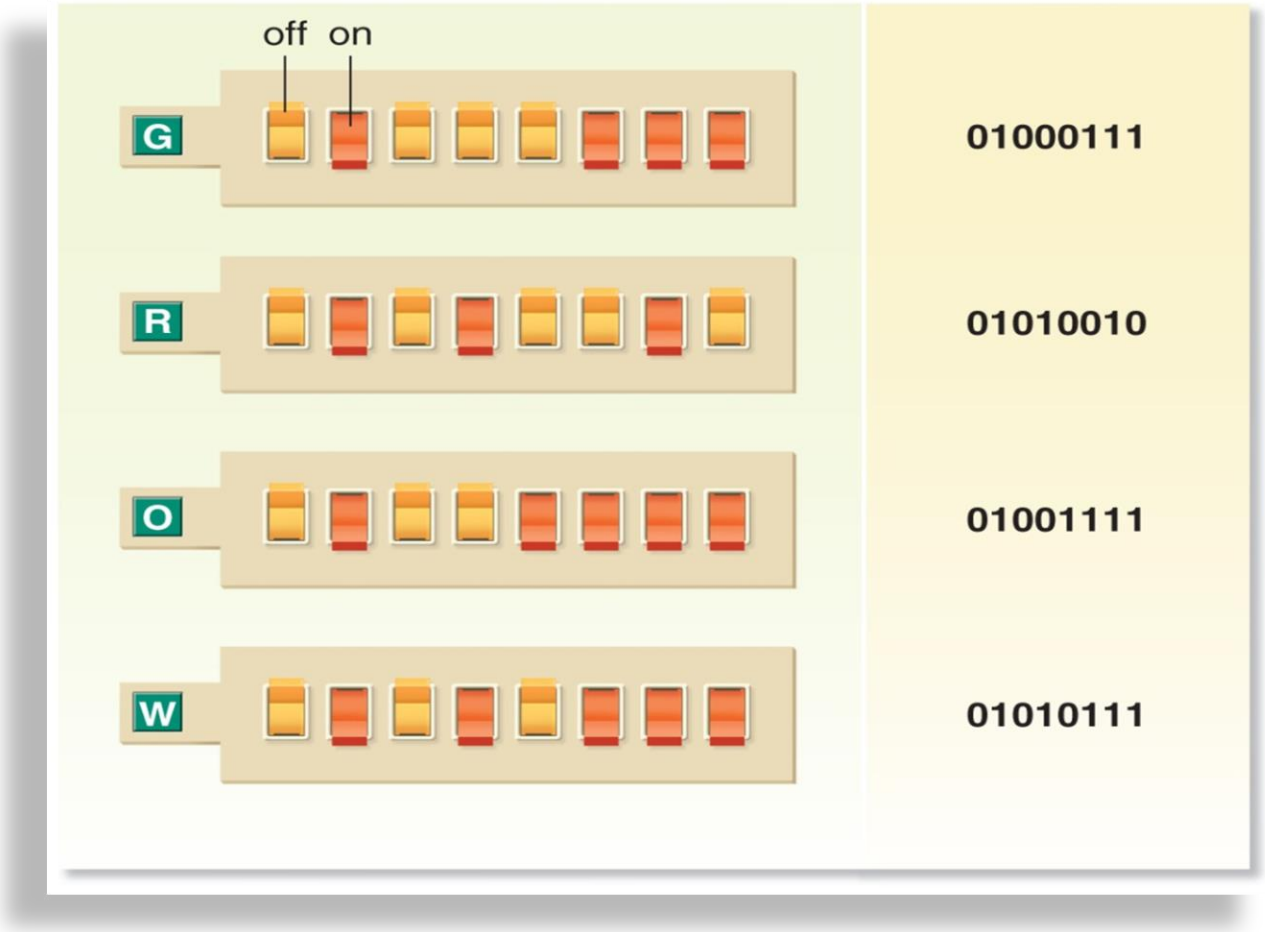
- System Unit

- The case that contains the computer's electronic components used to process data.
  - PCs: Tower or desktop; monitor is separate.
  - Laptops: Monitor is attached to the system unit, like a clamshell.
  - Tablets: Usually includes a touch-screen interface.
  - Smartphones: Handheld system units.

4.2 Representing Data Electronically

Data is represented in a computer by binary code.

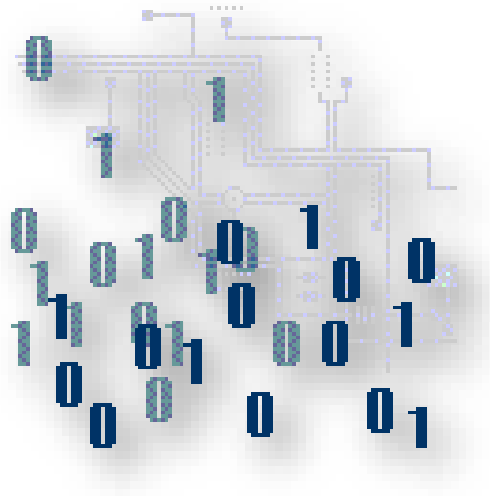
Binary System: the basic data-representation method for computers uses just two numbers: 0 and 1, representing the off/on states of electricity or light pulses.



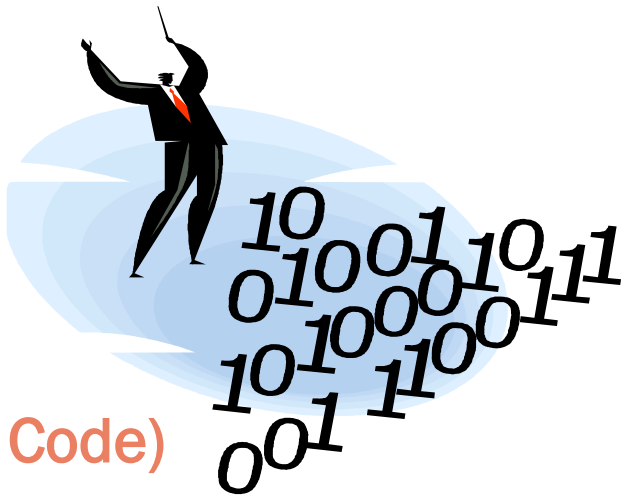
Measuring Capacity

All data and program instructions in the computer are represented as binary.

- **Bit:** each 0 or 1 is a bit
- **Byte:** a group of 8 bits = 1 character, digit, or other value
- **Kilobyte (KB):** 1,000 (1,024) bytes
- **Megabyte (MB):** 1 million (1,048,576) bytes
- **Gigabyte (GB):** 1 billion (1,073,741,824) bytes
- **Terabyte (TB):** 1 trillion (1,009,511,627,776) bytes
- **Petabyte (PB):** 1 quadrillion bytes
- **Exabyte (EB):** 1 quintillion bytes



- Binary coding schemes assign a unique binary code to each character.
  - ASCII (American Standard Code for Information Interchange)
    - Requires 7 or 8 bits per character, depending on the version
    - 8-bit Extended ASCII provides 256 characters
    - Commonly used for microcomputers
  - Unicode
    - Requires 16 bits per character
    - Handles 65,536 characters—used for Chinese and Japanese
  - EBCDIC (Extended Binary Coded Decimal Interchange Code)
    - Requires 8 bits per character
    - Used for IBM mainframes



Character	ASCII-8	EBCDIC	Character	ASCII-8	EBCDIC
A	0100 0001	1100 0001	N	0100 1110	1101 0101
B	0100 0010	1100 0010	O	0100 1111	1101 0110
C	0100 0011	1100 0011	P	0101 0000	1101 0111
D	0100 0100	1100 0100	Q	0101 0001	1101 1000
E	0100 0101	1100 0101	R	0101 0010	1101 1001
F	0100 0110	1100 0110	S	0101 0011	1110 0010
G	0100 0111	1100 0111	T	0101 0100	1110 0011
H	0100 1000	1100 1000	U	0101 0101	1110 0100
I	0100 1001	1100 1001	V	0101 0110	1110 0101
J	0100 1010	1101 0001	W	0101 0111	1110 0110
K	0100 1011	1101 0010	X	0101 1000	1110 0111
L	0100 1100	1101 0011	Y	0101 1001	1110 1000
M	0100 1101	1101 0100	Z	0101 1010	1110 1001
0	0011 0000	1111 0000	5	0011 0101	1111 0101
1	0011 0001	1111 0001	6	0011 0110	1111 0110
2	0011 0010	1111 0010	7	0011 0111	1111 0111
3	0011 0011	1111 0011	8	0011 1000	1111 1000
4	0011 0100	1111 0100	9	0011 1001	1111 1001
!	0010 0001	0101 1010	;	0011 1011	0101 1110

- Machine Language: **The computer's "native language"**
  - A binary-type programming language (0s and 1s) built into the CPU that is run directly by the computer.
  - Each CPU type has its own machine language; thus each computer's machine language is brand-dependent.
  - **Language Translators**: The computer's system software converts higher-level language instructions and data into machine language so that the processor can "understand" what to do.

Using Information Technology, 11e

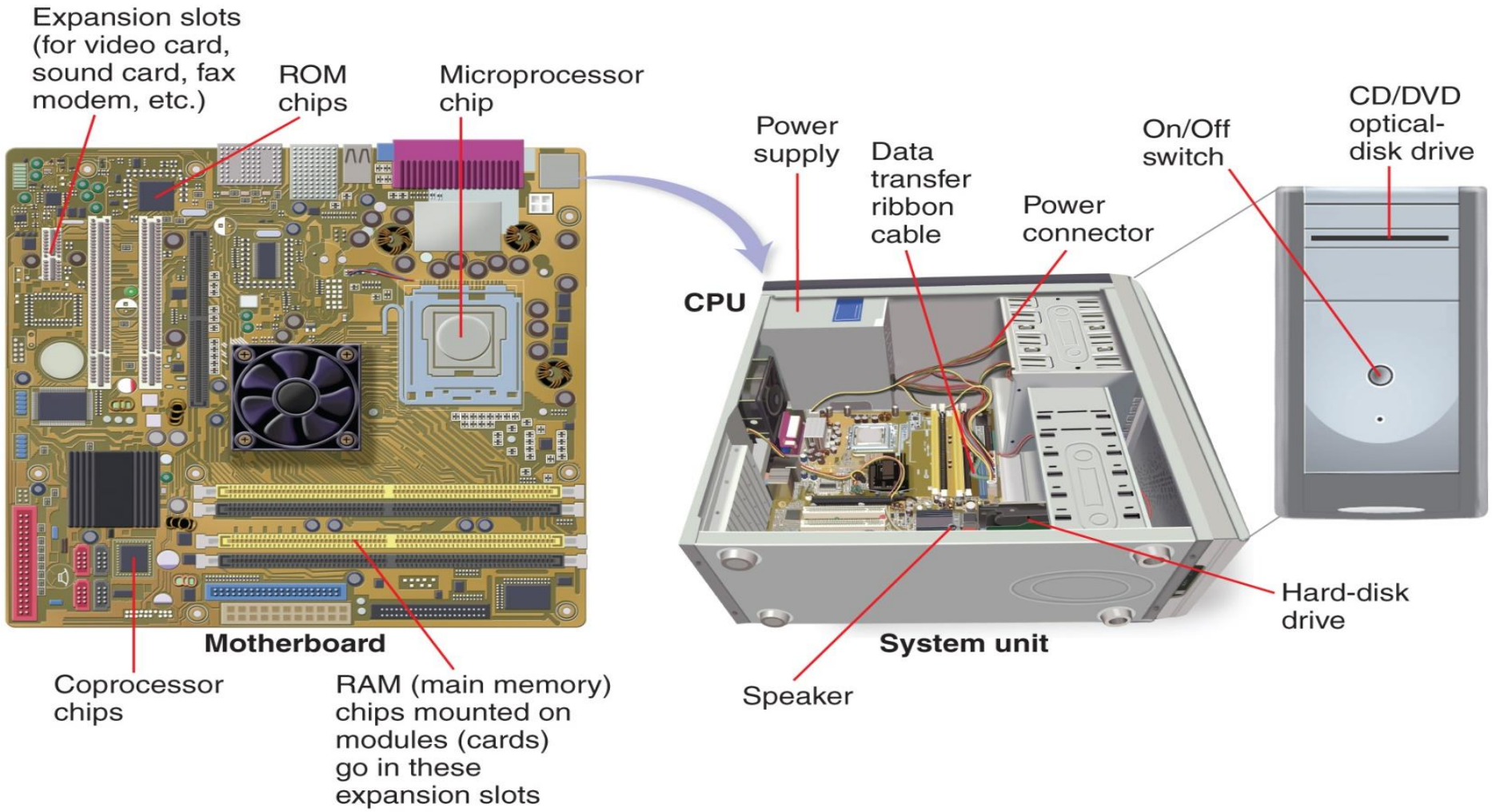
4.3 Inside the System Unit

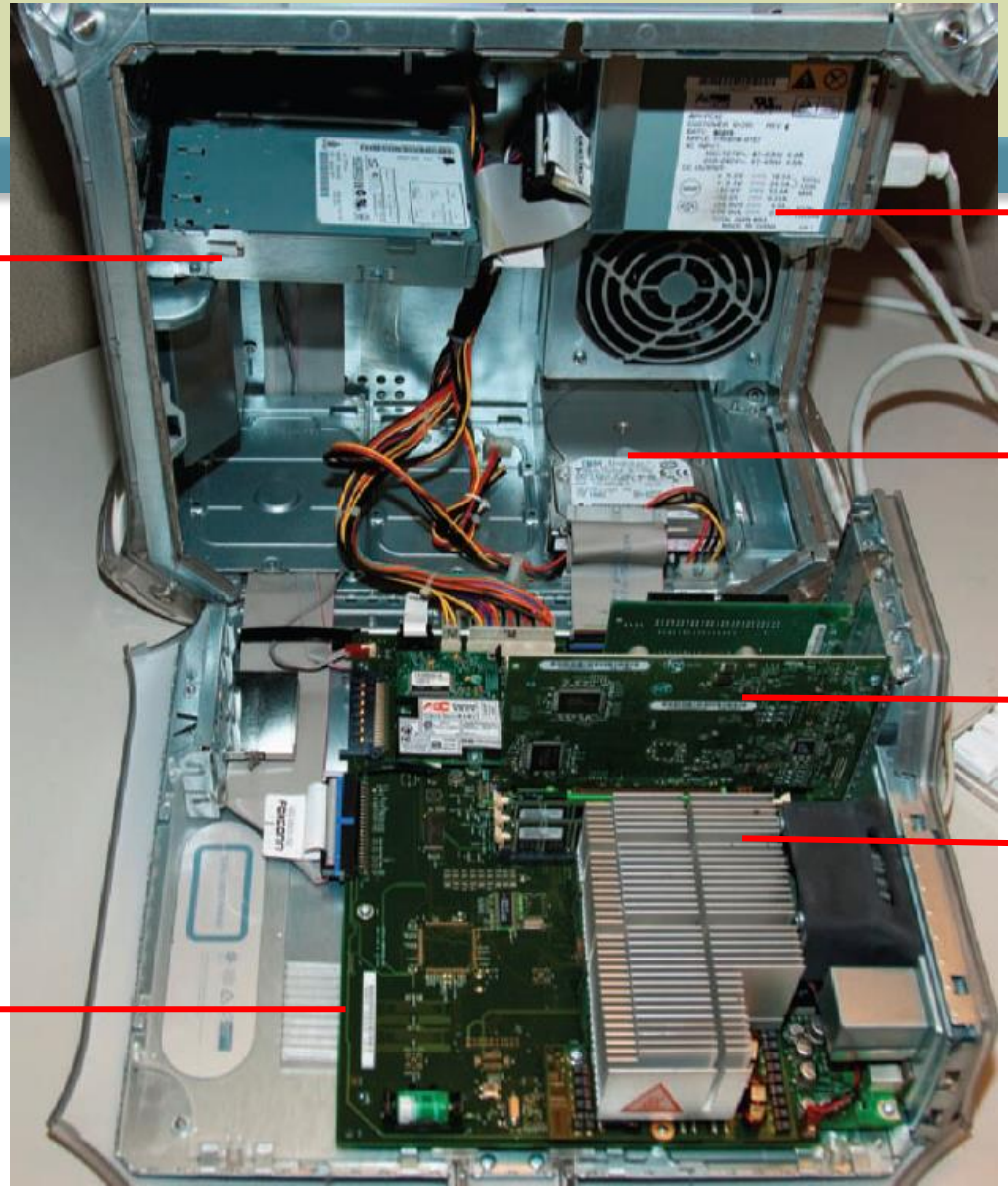
Power Supply, Motherboard, & Microprocessors

Terms	Definitions
Bay	Opening in the computer cabinet used for the installation of electrical equipment.
Power Supply	This converts AC to DC to run the computer.
Surge Protector	Protects the computer from being damaged by power spikes. Plug your computer into one.
UPS	Uninterruptible Power Supply. Battery-operated device that provides power for a limited time when there is a blackout.
Motherboard	Main system board of the computer (also *systemboard*).
Microprocessor	Miniaturized circuitry of a computer processor.
Chipset	Groups of interconnected chips on the motherboard that control information flow between the microprocessor and other system components connected to the motherboard.

One View of a Motherboard

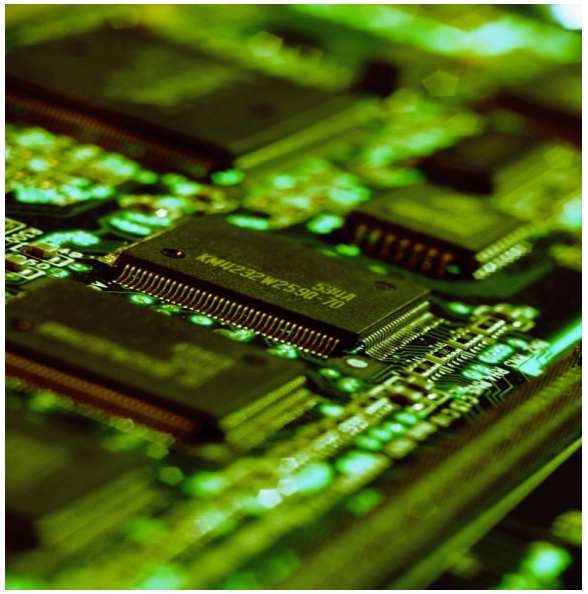
Another View of a Motherboard





A Mac motherboard

- Traditional microcomputer microprocessors are **Intel** and **AMD**.
- **Multicore processors** (**2, 4, 6, 8**) have more than one processor "core" on a single silicon chip, which allows computers to run faster.
  - Special processors are made for portable devices.
  - A **graphics processing unit (GPU)** is a specialized processor used to manipulate three-dimensional (3-D) computer graphics.

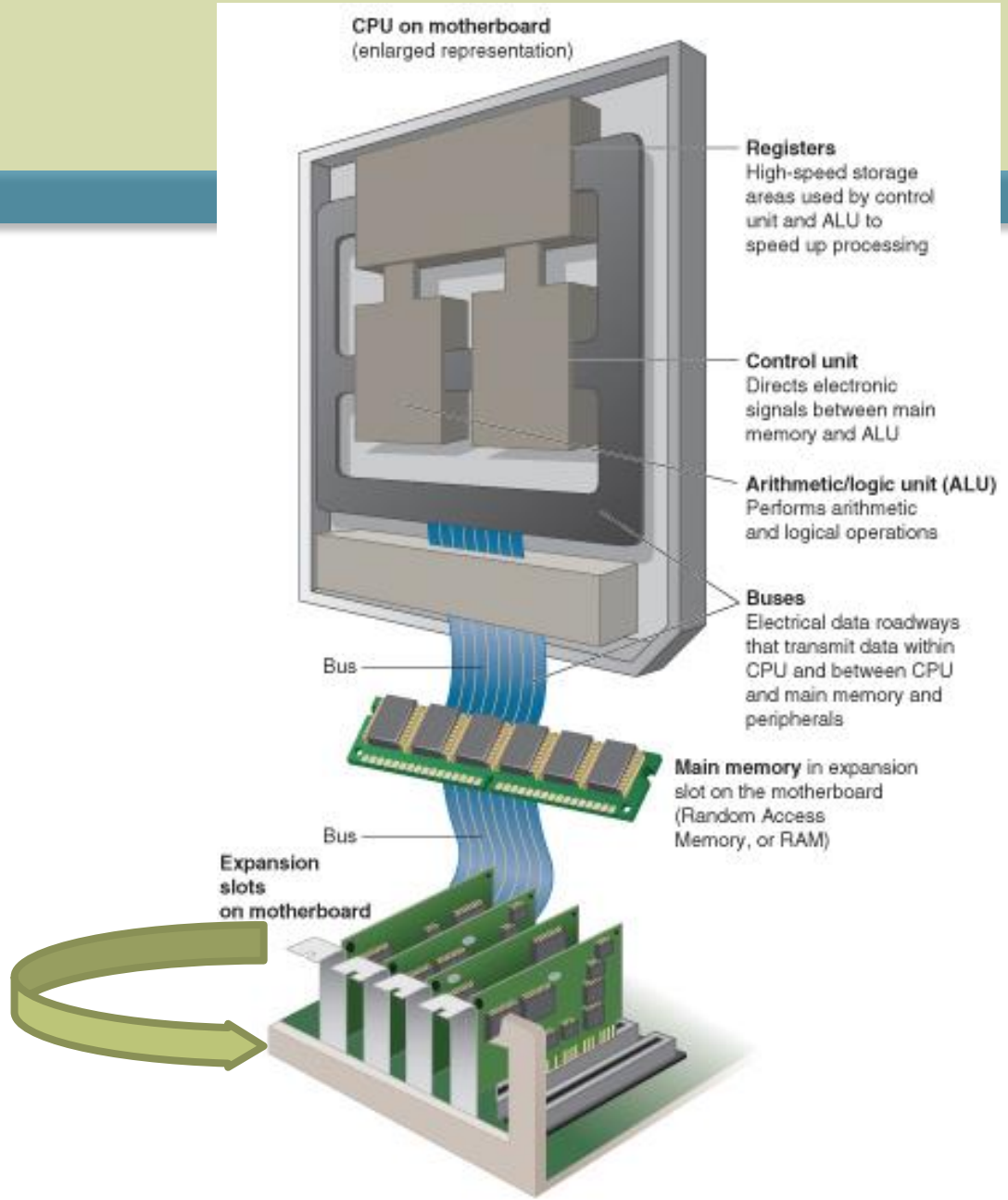


Processing Speeds

- Every microprocessor contains a system clock, which controls how fast all the operations within a computer take place (the chip's processing speed).
- Older CPU processing speeds are in megahertz.
  - 1 **MHz** = 1 million cycles per second
- Current CPU processing speeds are in gigahertz.
  - 1 **GHz** = 1 billion cycles per second
- The faster a CPU runs, the more power it consumes, and the more heat it generates.

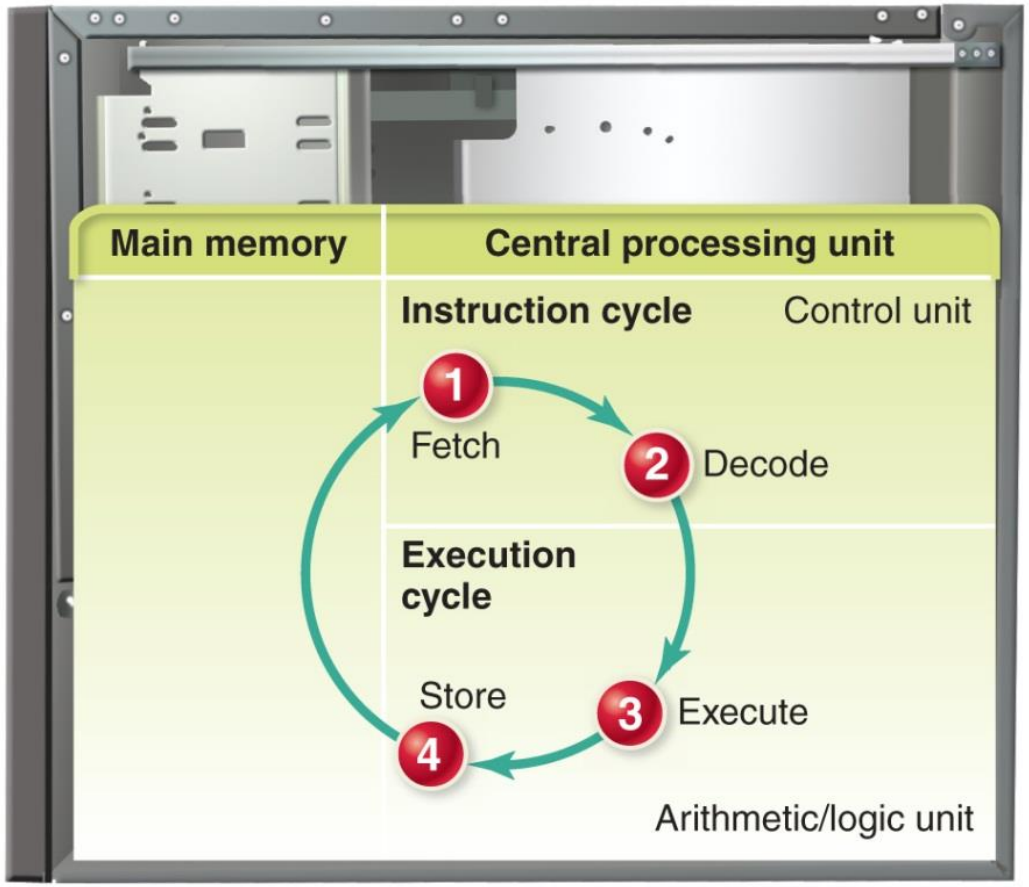
4.4 The Central Processing Unit & the Machine Cycle

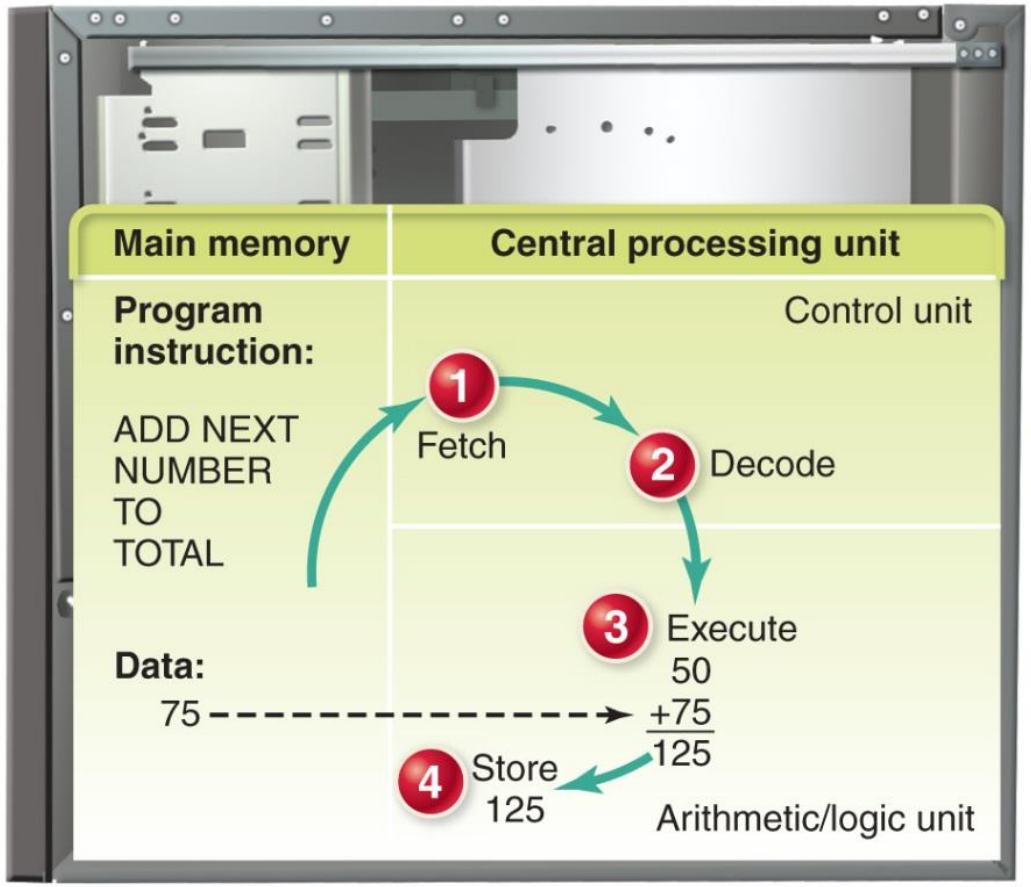
- The CPU, for central processing unit, is the “brain” of the computer; it follows the instructions of the software (program) to manipulate data into information.
- The CPU consists of two parts—(1) the control unit and (2) the arithmetic/logic unit (ALU), both of which contain registers, or high-speed storage areas.
- All are linked by a kind of electronic “roadway” called a bus.



- The control unit deciphers each instruction stored in the CPU and then carries out the instruction. It directs the movement of electronic signals between main memory and the arithmetic/logic unit. It also directs these electronic signals between main memory and the input and output devices.
- For every instruction, the control unit carries out four basic operations, known as the machine cycle. In the machine cycle, the CPU (1) fetches an instruction, (2) decodes the instruction, (3) executes the instruction, and (4) stores the result *(see next slide)*..

Each time the central processing unit executes an instruction, it takes a series of steps. The complete series of steps is called a machine cycle.

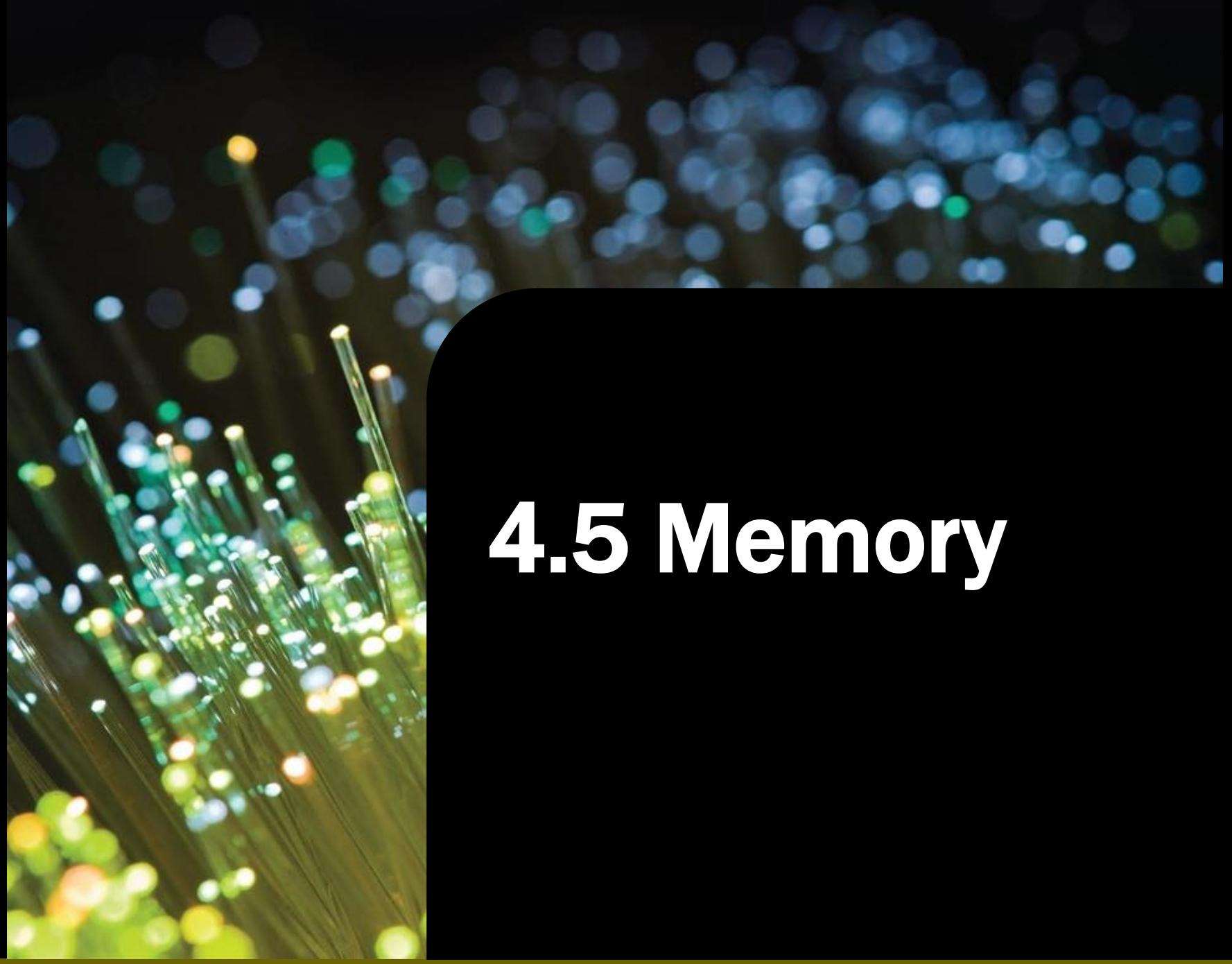




- The arithmetic/logic unit (ALU) performs arithmetic operations and logical operations and controls the speed of those operations.
- *Arithmetic operations* are the fundamental math operations: addition, subtraction, multiplication, and division.
- *Logical operations* are comparisons--the ALU compares two pieces of data to see whether one is equal to (=), greater than (>), greater than or equal to (>=), less than (<), less than or equal to (<=), or not equal to (≠) the other.

- The control unit and the ALU also use registers, special CPU areas that enhance the computer's performance.
- Registers are high-speed storage areas that temporarily store data during processing. They may store a program instruction while it is being decoded, store data while it is being processed by the ALU, or store the results of a calculation.
- All data must be represented in a register before it can be processed.
- The number of registers that a CPU has and the size of each (number of bits) help determine the power and speed of a CPU.

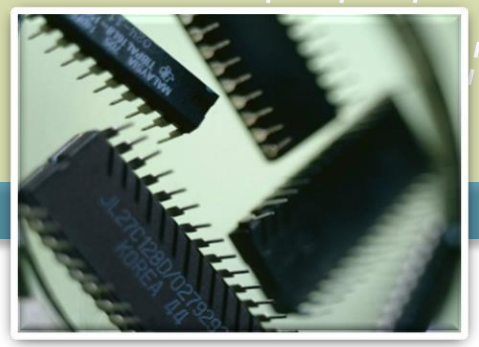
- **Buses** are electrical data "roadways" through which bits are transmitted within the CPU and between the CPU and other components of the motherboard.
- In most computers, the bus width is the same as the computer's **word size,** the number of bits that the processor can process at any one time. The more bits in a word, usually the faster the computer. A 32-bit-word computer will transfer data within each microprocessor chip in 32-bit chunks. A 64-bit-word computer is faster, transferring data in 64-bit chunks at a time. (Most, but not all, 32-bit software will run on a 64-bit system, but 64-bit software will not run on a 32-bit system.)



4.5 Memory

Memory

- Two type of storage: primary and secondary.
  - Primary storage = “memory,” “main memory,” “RAM”; this type of memory is temporary and volatile.
  - Secondary storage = hard disks and flash memory units; this type of memory is relatively permanent and nonvolatile.



Memory Chips

RAM

ROM

CMOS

Flash

Explanation

Random Access Memory chips are volatile and hold:

a. Software instructions
b. Data before & after the CPU processes it

Read Only Memory

a. Cannot be written on or erased without special equipment
b. Are loaded at factory with fixed (permanent) start-up instructions (BIOS), that tell the computer how to load the operating system

Complementary Metal Oxide Semiconductor

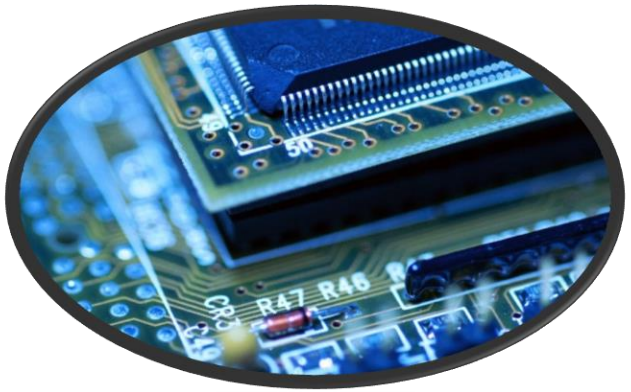
a. Powered by a battery
b. Contains time, date, calendar, boot password

Nonvolatile memory that can be erased and reprogrammed more than once

a. Doesn't require a battery
b. Used in newer PCs for BIOS instructions

Speeding up Processing: Cache

- The CPU works much faster than RAM, so it often must wait for information
- **Cache** temporarily stores instructions and data that the processor uses frequently to speed up processing
  - **Level 1** cache is part of the microprocessor
    - Holds 8 to 128 KB
    - Faster than Level 2 cache
  - **Level 2** cache is external cache
    - Holds 64 kb to 16 MB
  - **Level 3** cache is on the motherboard
    - Comes on very high-end computers
    - Holds 2 to 8 MB



- Virtual Memory—also used to speed up processing.
  - This type of memory is unused hard disk or optical (CD) space that the processor uses to extend the capacity of RAM.
  - The processor goes first to L1 cache, then L2 cache, then RAM, then virtual memory.
  - Each type of memory is slower than its predecessor.

4.6 Expansion Cards, Bus Lines, & Ports

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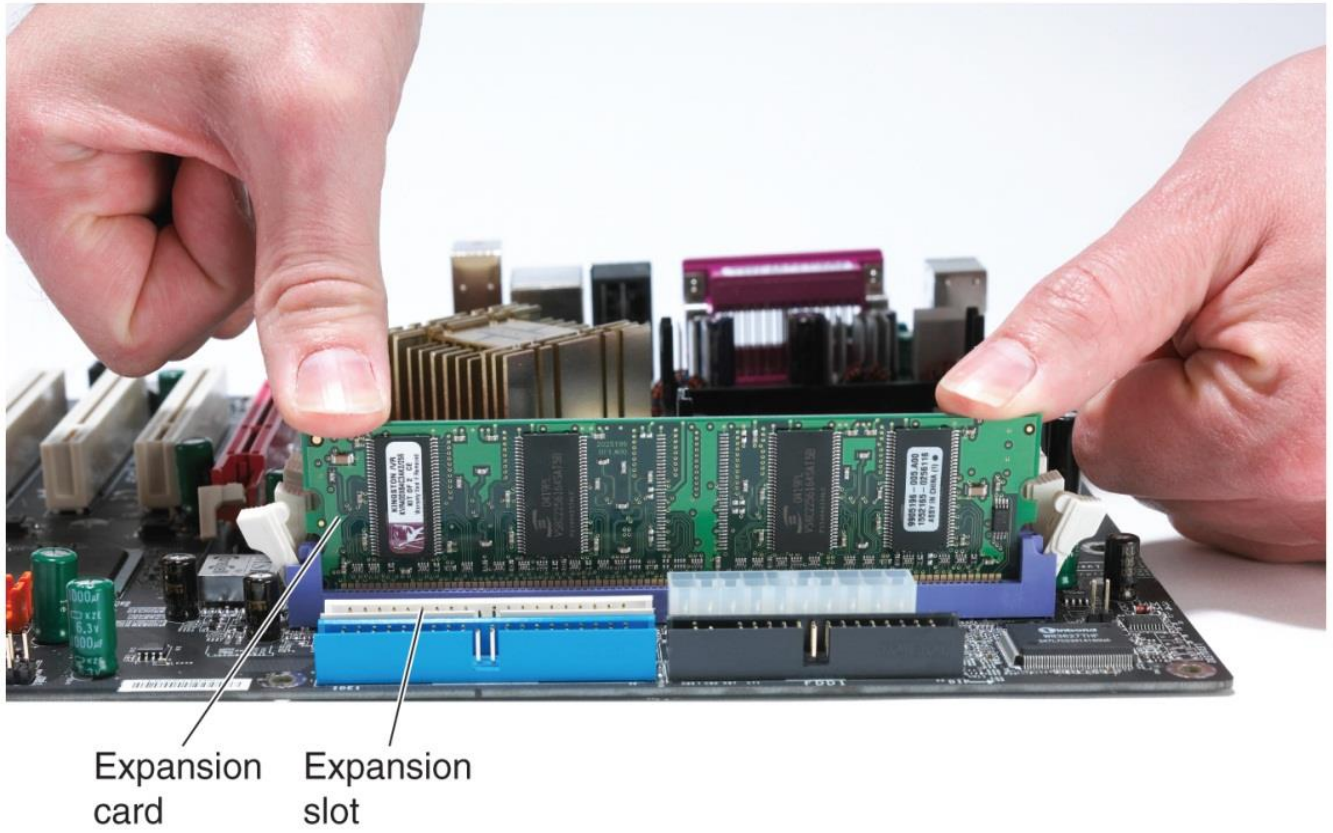
Expansion cards plug into slots on the motherboard that are connected by buses to ports that the user can access.

- **Expansion cards** are circuit boards that provide more memory or that control peripheral devices (for *graphics, sound, video, network interface, wireless connection,* etc.).
- **Buses** connect the expansion cards to ports.
- A **port** is a connecting socket or jack on the outside of the computer unit or device into which are plugged different kinds of cables that connect peripheral devices.

Expansion Cards: If a computer uses *closed architecture,* no expansion cards can be added; if the computer uses *open architecture,* expansion cards can be inserted in expansion slots inside the computer, connected to the motherboard.



An expansion bus is not the same as the frontside bus:

- **Frontside bus:** The bus that connects the CPU within itself and to main memory.
- **Expansion bus:** Buses that connect the CPU with expansion slots on the motherboard and thus via ports with peripheral devices.

Types of expansion buses:

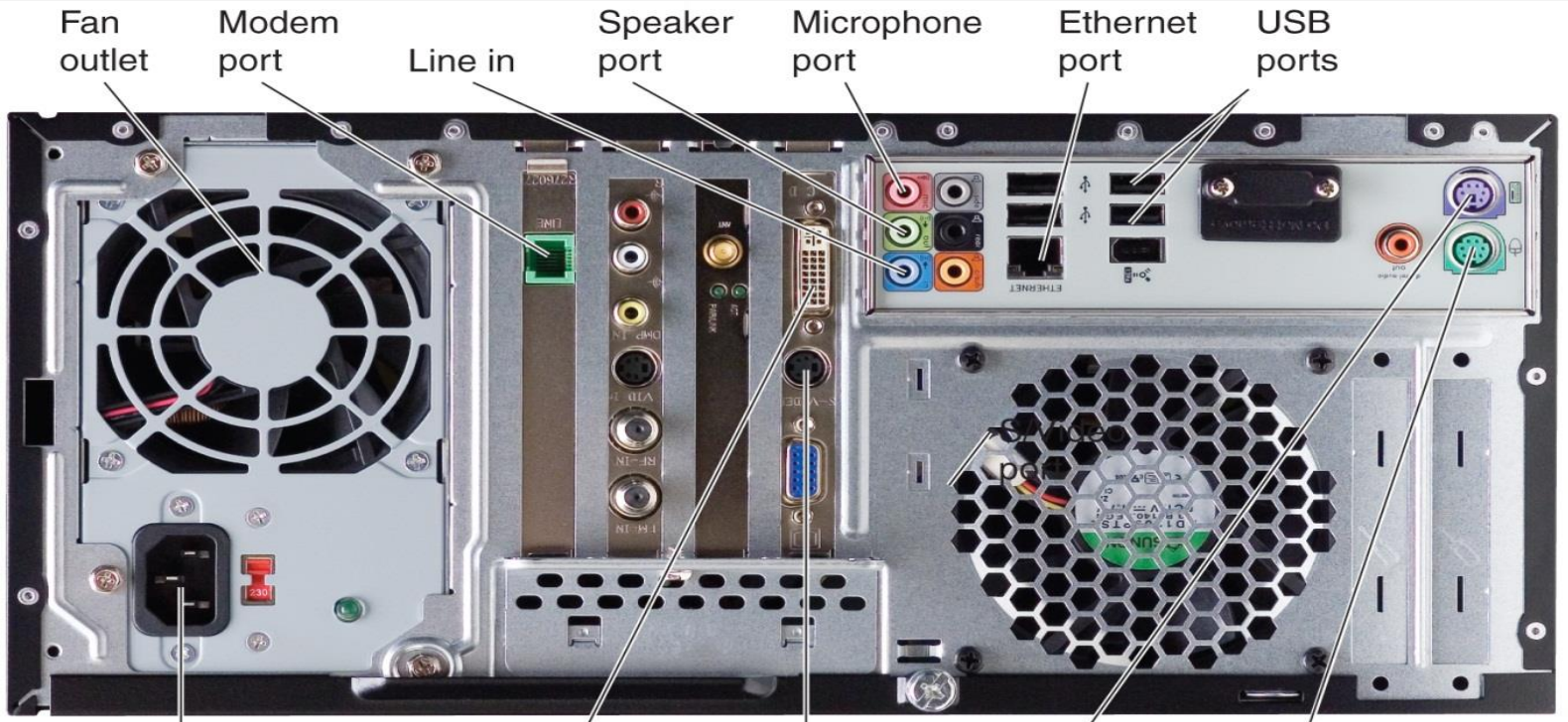
- **PCI:** High-speed bus that has been widely used to connect PC graphics cards, sound cards, modems, and high-speed network cards.
- **PCI Express:** Doubles the speed of the original PCI bus . PCIe is the latest standard for expansion cards available on mainstream personal computers.
- **Accelerated Graphics:** Transmits data at twice the speed of a PCI bus and is designed to support video and 3-D graphics.
- **Universal Serial Bus (USB):** Does away with the need to install cards in expansion slots. USB devices can connect one to another outside the system unit, and then the USB bus connects to the PCI bus on the motherboard.
- **Firewire:** Resembles the USB bus but is used for more specialized purposes, such as to connect audio and video equipment to the motherboard.

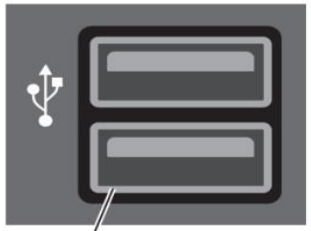
A port is a socket for some kind of plug, of which there are many types.

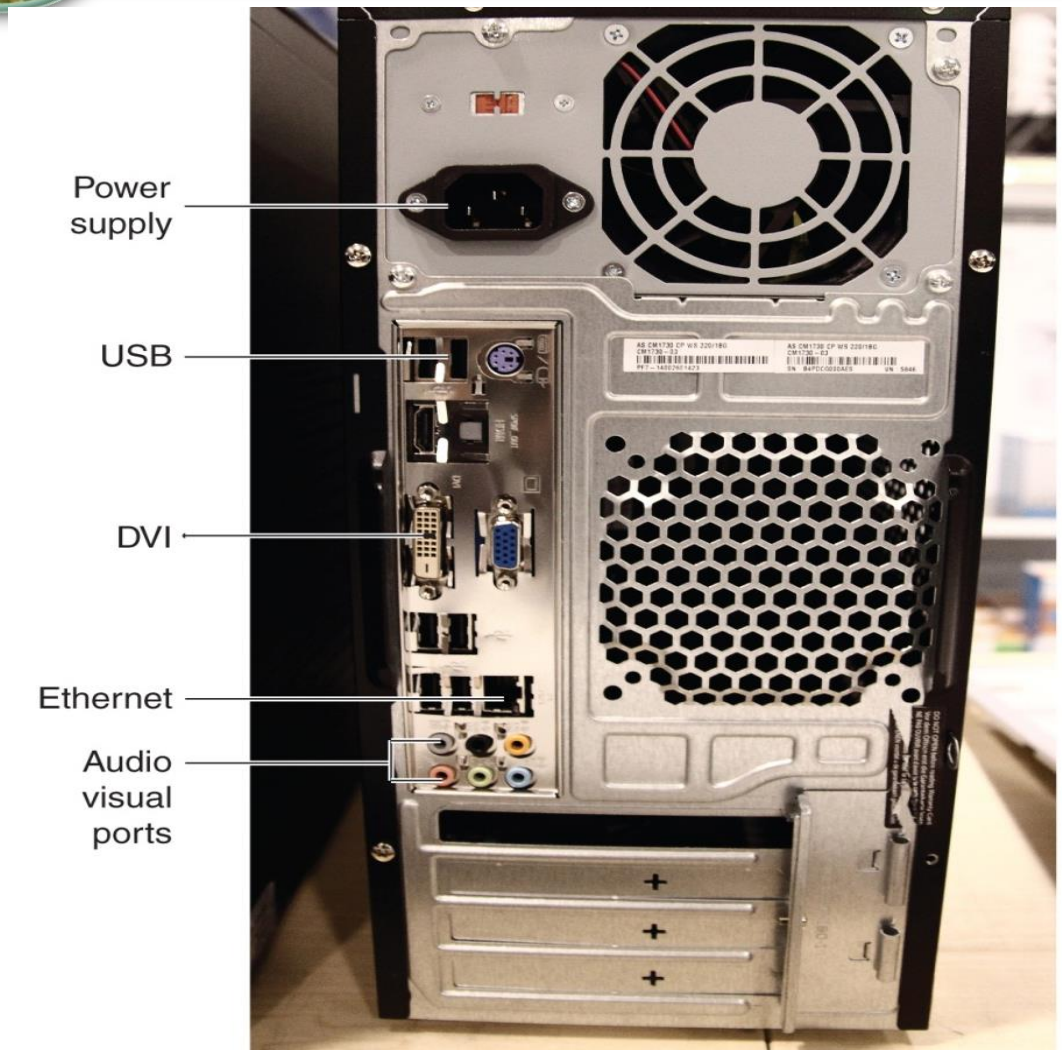
Port Type	Description
Serial port	Used to transmit data slowly over long distances a. Sends data sequentially, one bit at a time b. Used to connect older keyboards, mouse, monitors, dial-up modems
Parallel port	For transmitting data quickly over short distances a. Transmits 8 bytes simultaneously b. Connects printers, external disks, tape backups
USB port 	Universal Serial Bus high-speed hardware standard for interfacing peripheral devices, such as scanners and printers, to computers without a need for special expansion cards or other hardware modifications to the computer. USB is replacing many varieties of serial and parallel ports.

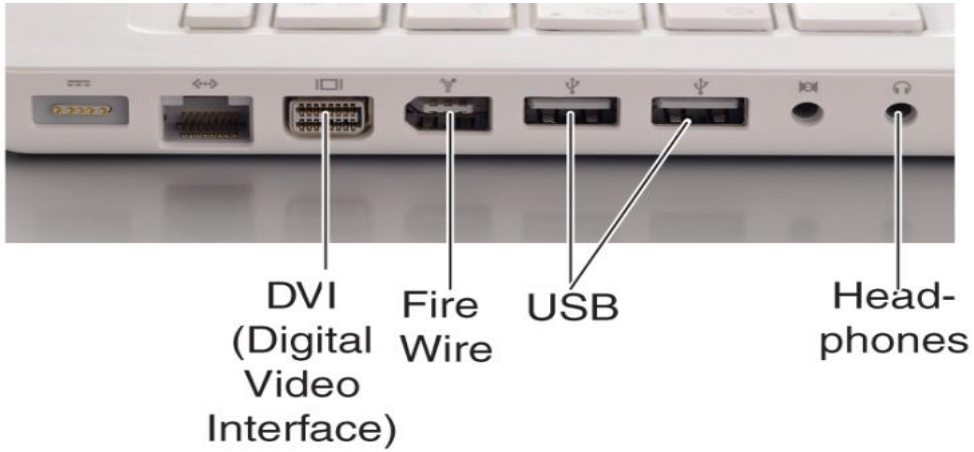
Specialized Expansion Ports

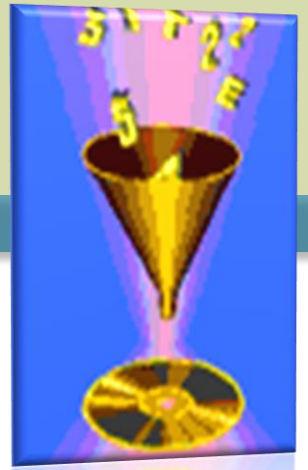
Port Type	
• FireWire	Intended for multiple devices working with lots of data and requiring fast transmission speeds, such as DVD drives, digital video cameras, and gaming consoles.
• Ethernet	Supports a network standard for linking a wired local area network and connecting it to a DSL or a cable modem for high-speed Internet access.
• Graphics	Connects digital monitors and multimedia digital devices, such as TVs and DVD players.
• eSATA	External Serial Advanced Technology Attachment; allows the attachment of an eSATA hard disk, which has fast data transmission speeds.
• Bluetooth	Connects devices that use short-range radio waves that transmit up to 30 feet.
• IrDA	Transfers data via infrared light waves between directly aligned devices, as between a smartphone and a desktop computer.
• HDMI	High-Definition Multimedia Interface; carries both video and audio signals and is used for connecting HDTVs, DVD players, and game consoles to computers, laptops, and other devices.
• MIDI	Musical Instrument Digital Interface; used to connect electronic musical instruments to a sound card that converts the signals to digital instructions that can be saved or manipulated.





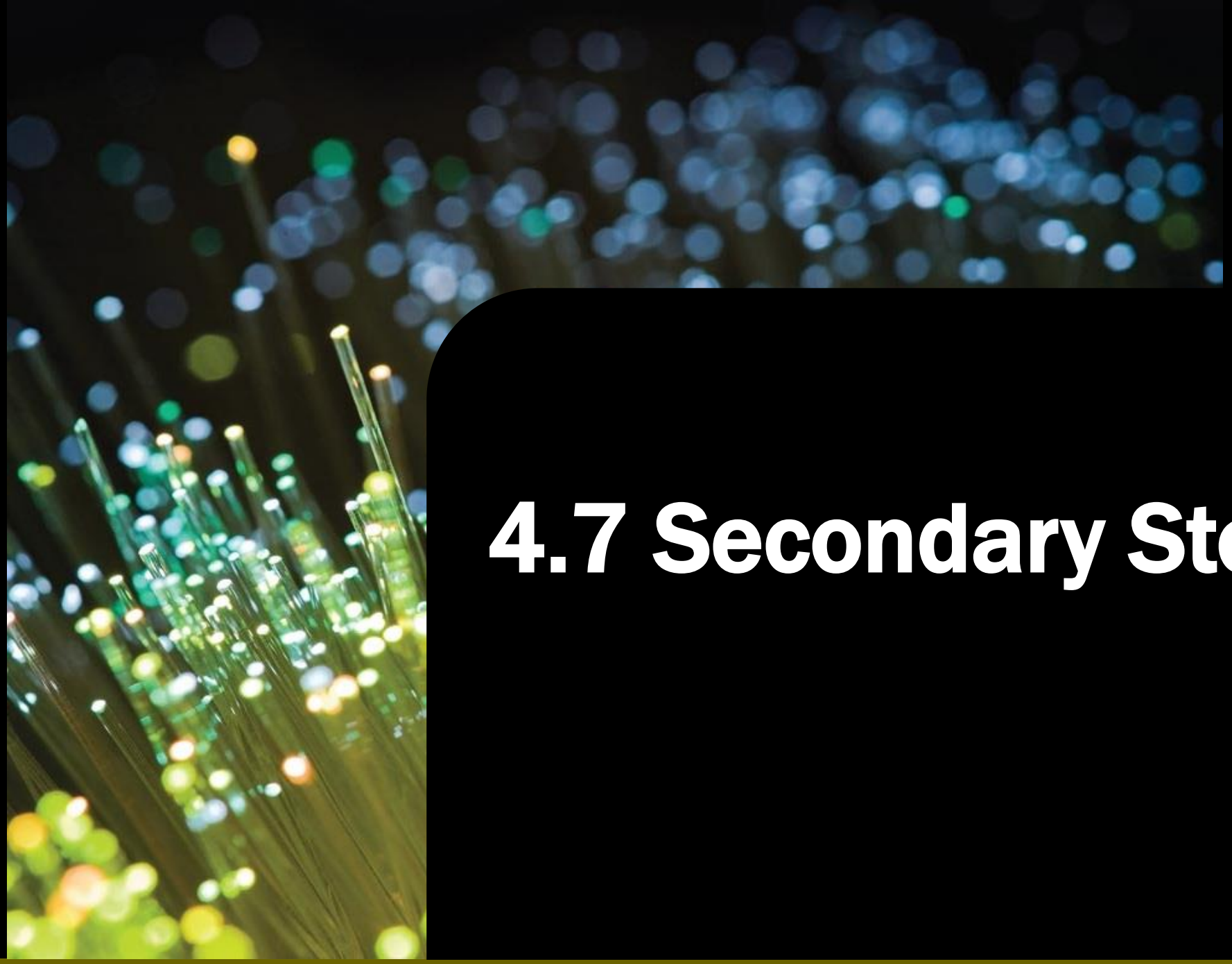




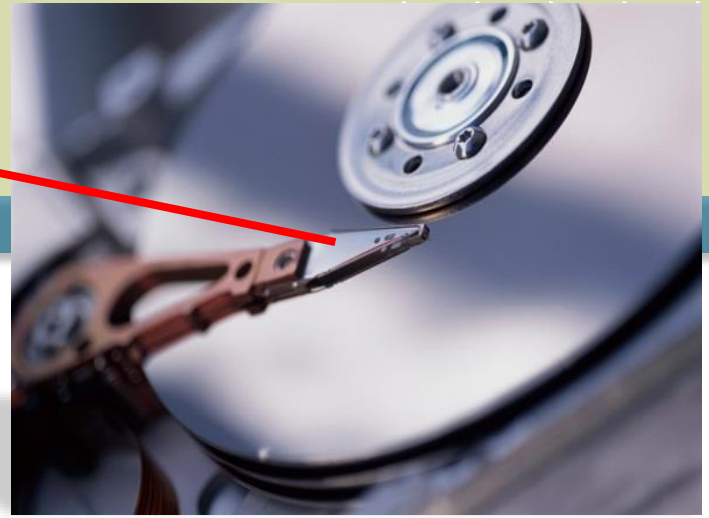


UNIT 4B:

- Secondary storage hardware includes devices that permanently hold data and information as well as programs.
- Online, or cloud, storage is also available, but we still use secondary storage hardware.

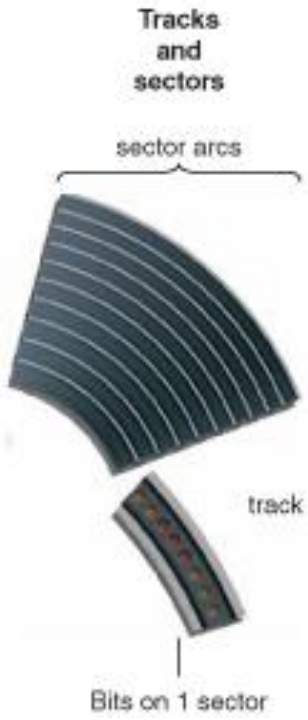


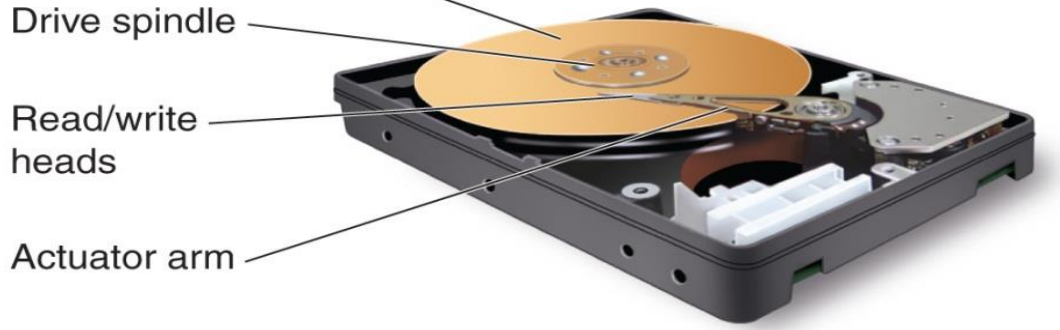
4.7 Secondary Storage

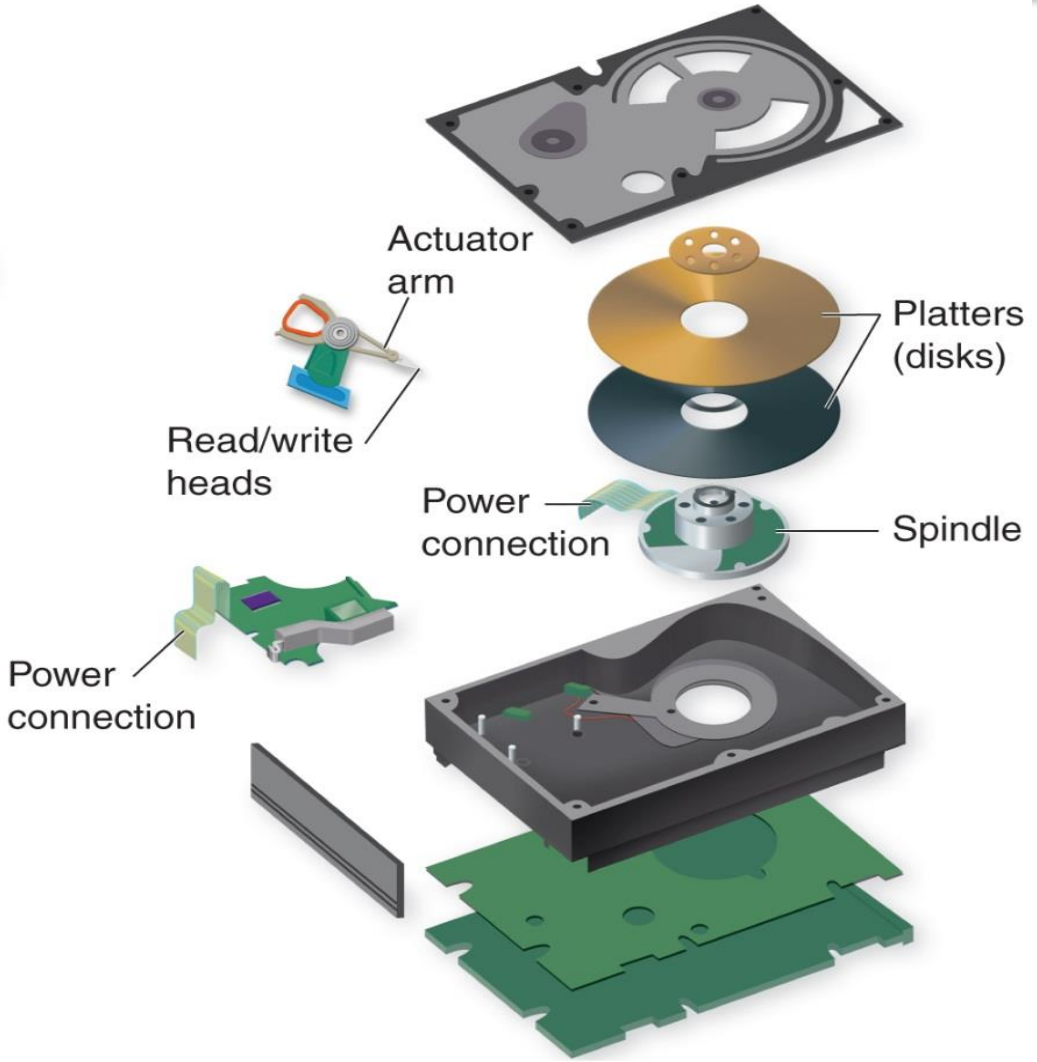


Hard Disks: Still the major secondary-storage for desktop/tower computers.

- Thin, rigid metal, glass, or ceramic platters covered with a substance that allows data to be held in the form of magnetized spots.
  - The more platters there are, the higher the drive capacity.
  - Store data in tracks, sectors, and clusters.
  - Formatting creates a file allocation table that maps files to clusters.
  - Drive heads ride on .000001" cushion of air, and can crash!
  - Important data should always be backed up!

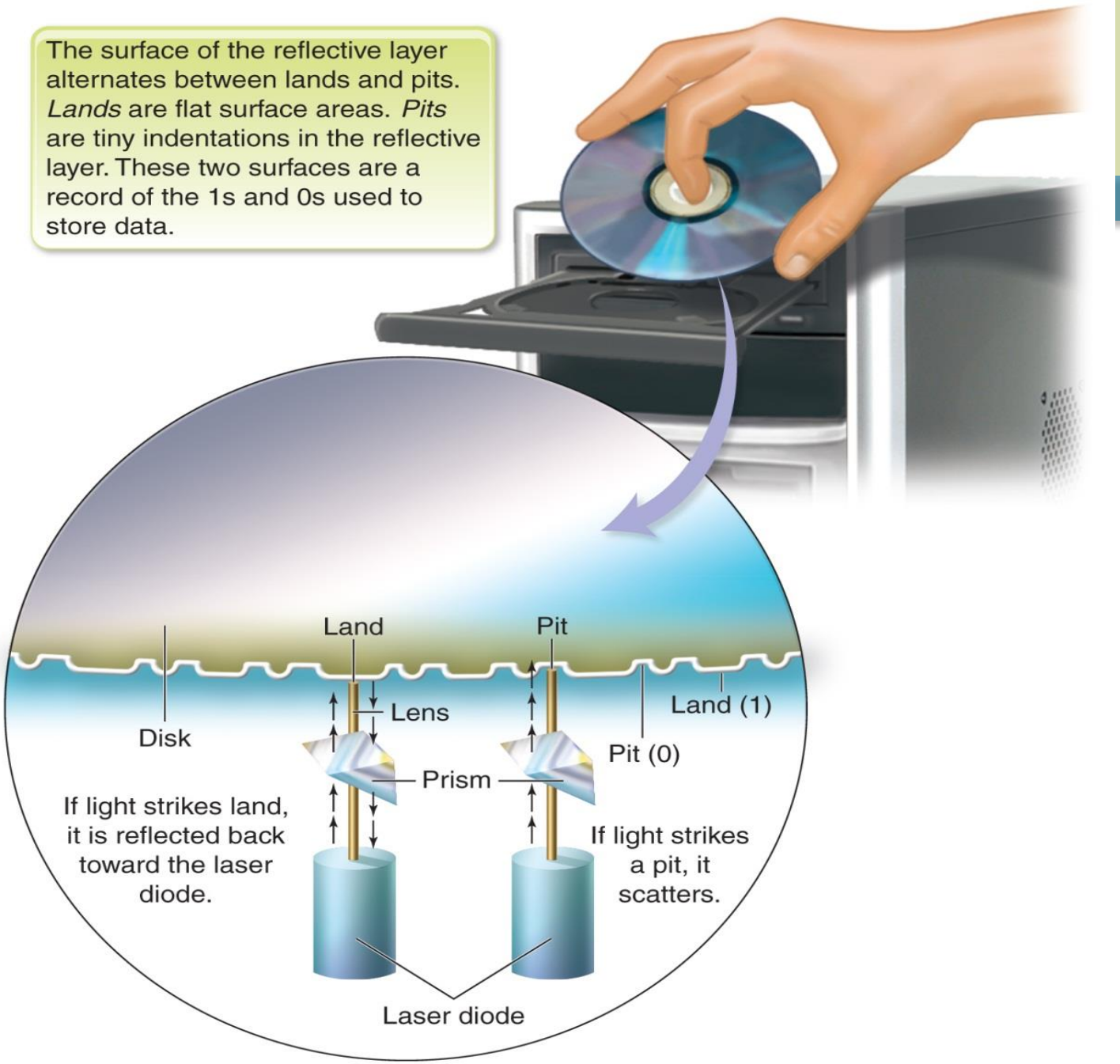






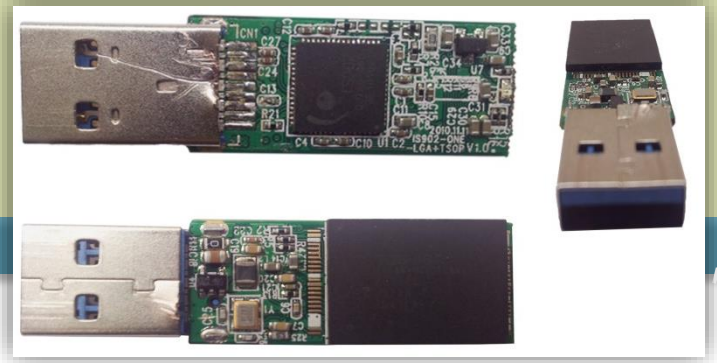
- Hard Disks (*continued*)
  - Hard Disk Types:
    - **Nonremovable hard disk** – Also known as a fixed disk; is housed in the microcomputer system unit and is used to store nearly all programs and most data files. Usually consists of several metallic or glass platters, from 1 to 5.25 inches (most commonly 3.5 inches) in diameter, stacked on a spindle, with data stored on both sides. Read/write heads, one for each side of each platter, are mounted on an access arm that moves back and forth to the right location on the platter.
    - **External hard disk** – Freestanding disk drive (portable); usually connected via USB.
    - **RAID** – redundant array of independent disks; for large computer systems.

The surface of the reflective layer alternates between lands and pits. *Lands* are flat surface areas. *Pits* are tiny indentations in the reflective layer. These two surfaces are a record of the 1s and 0s used to store data.



- **Optical Disks**
  - CDs (compact disks) and DVDs (digital versatile/video disks) are optical disks.
  - DVDs hold more data then CDs do.
  - Data is written and read using lasers, not a disk read/write head.
    - **CD-ROM** is Compact Disk Read-Only Memory; content is prerecorded.
    - **CD-R** (compact disk-recordable) is used for recording only once.
    - **CD-RW** (compact disk-rewritable)is an erasable optical disk that can both record and erase data over and over again.

- Optical Disks (*continued*)
  - **DVD** is a CD-style disk with extremely high capacity.
  - **DVD-R** (DVD-recordable) is used for recording only once.
  - **DVD-RW, DVD-RAM, DVD+RW** are reusable DVDs.
  - Blu-ray is an optical-disk format used to record, rewrite, and play back high-definition (HD) video, as well as to store large amounts of data.



Flash & Solid-State Storage

- Flash memory and solid-state memory have become the most important form of mobile secondary storage.
- Disk drives (hard disks or CDs/DVDs) all involve some moving parts—and moving parts can break. By contrast, **flash memory** has no moving parts; it is "solid state." Flash memory is also nonvolatile—it retains data even when the power is turned off.
- Flash memory media are available in three forms:
  - Some tablets, laptops, desktops, and servers feature a solid-state drive (SSD), which uses flash memory to store data, instructions ,and information.
  - Flash memory cards, or flash RAM cards, are removable and reusable storage media that are inserted into a flash memory slot in a digital camera, notebook, smartphone, or other mobile device.
  - A USB flash drive consists of a finger-size module of reusable flash memory that plugs into the USB ports of nearly any microcomputer.

Smart Card: pocket-size card with integrated circuits.

- Resembles a credit card but contains a microprocessor and memory chips
  - May function on three levels: credit, debit, and/or personal information
  - Storage capacity: around 10 MBs
  - Contact smart cards
    - Must be swiped through card readers
    - Can wear out from use
  - Contactless smart cards
    - Read when held in front of a low-powered laser

- Online Secondary Storage (Cloud Storage)
  - Allows you to use the Internet to back up your data
    - Sign up with a vendor and receive access to software and applications that allow you to upload your data to that company's server

4.8 Future Developments in Processing & Storage

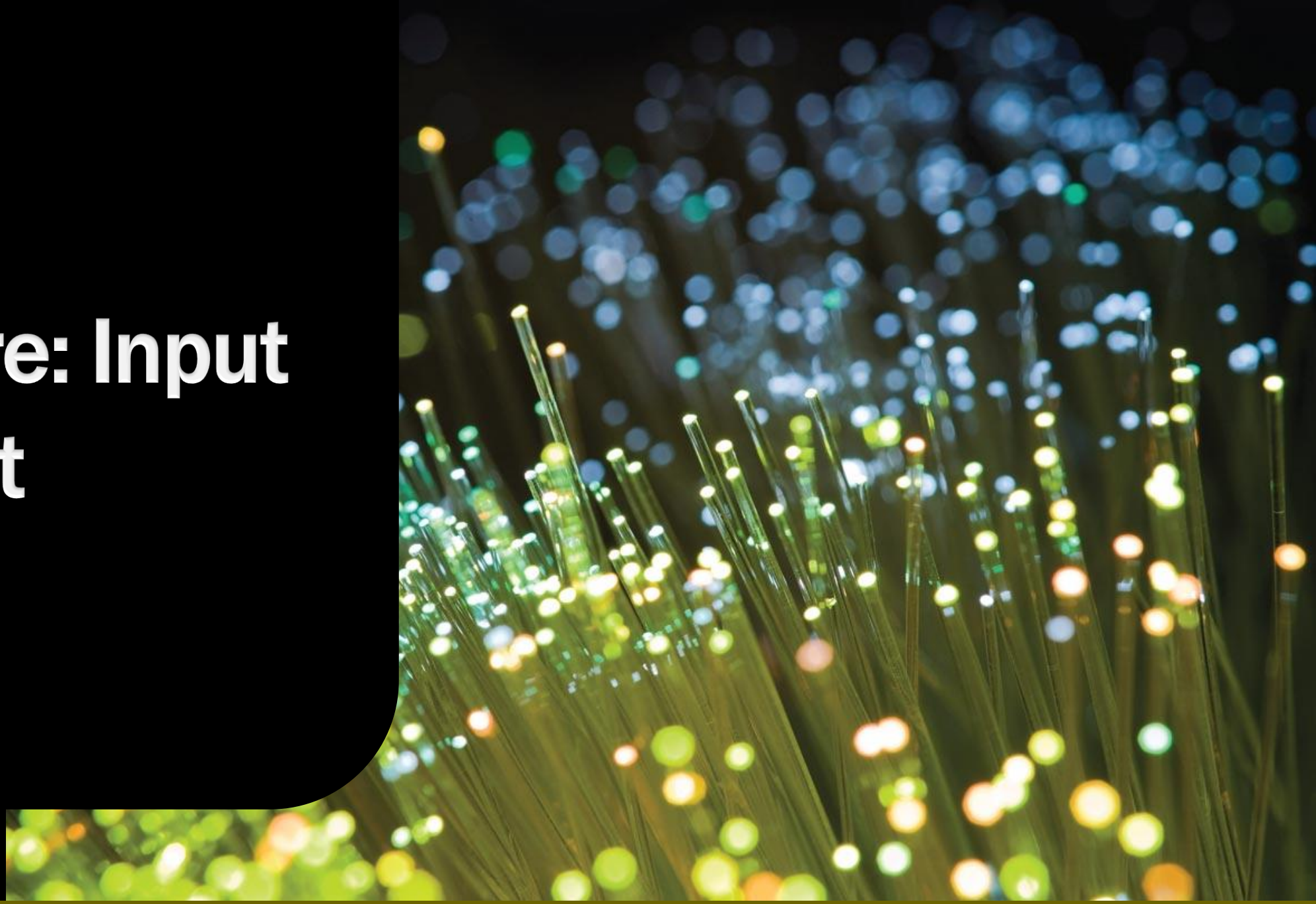
Description of Processing Technology

Nanotechnology	• Tiny machines work at a molecular level to make nanocircuits
Optical computing	• Uses lasers and light, not electricity
DNA computing	• Uses strands of synthetic DNA to store data
Quantum computing	• Based on quantum mechanics and stores information using particle states
Better batteries	• Wireless charging of batteries, longer-lasting batteries

Future Developments in Secondary Storage

- Higher-density disks
  - Perpendicular recording technology: stacking magnetic bits vertically on the surface of a platter (instead of horizontally, as usual)
- Molecular electronics– storage at the subatomic level

Hardware: Input & Output



Chapter 5

Chapter Topics

UNIT 5A: Input Hardware

5.1 Keyboards
5.2 Pointing Devices
5.3 Source Data-Entry Devices
5.4 The Future of Input

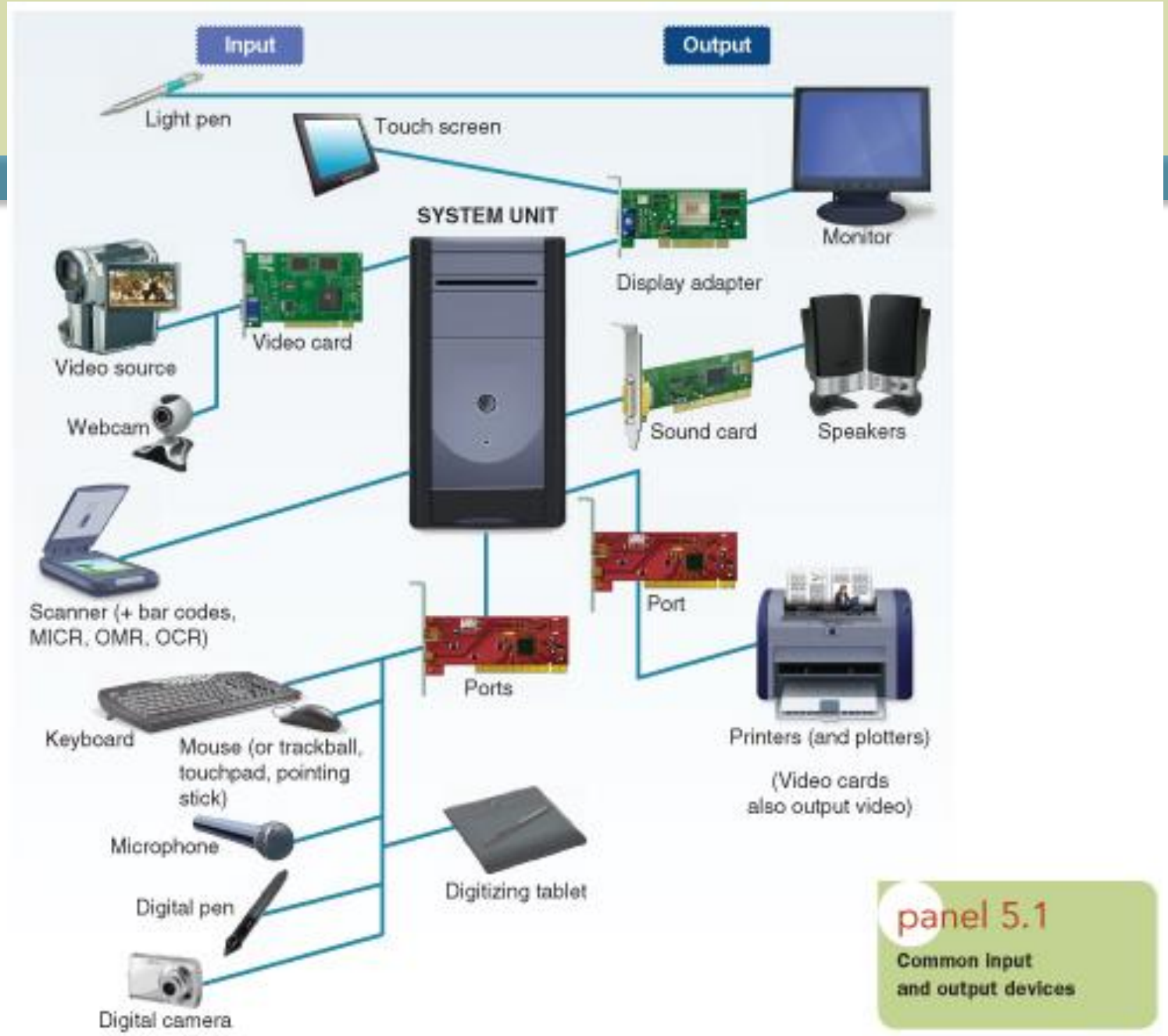
UNIT 5B: Output Hardware

5.5 Softcopy Output: Display Screens
5.6 Hardcopy Output: Printers
5.7 Mixed Output: Sound, Voice, & Video
5.8 The Future of Output
5.9 Quality of Life: Health & Ergonomics

- **Input Hardware**
  - Devices that translate data into a form the computer can process
  - Translates words, numbers, sounds, and pictures into binary 0s and 1s (off or on electrical signals or light pulses)
- **Output Hardware**
  - Devices that translate information processed by the computer into a form humans can understand
  - Translates binary code into words, numbers, sounds, and pictures

UNIT 5A: Input Hardware

- The three major types of input hardware are keyboards, pointing devices, and source data-entry devices.



panel 5.1
Common input and output devices

5.1 Keyboards

- **Keyboards**: convert letters, numbers, and characters into electrical signals
  - English keyboards differ from foreign language keyboards
- How keyboards work:
  - You press a key
  - This interrupts the current flowing through the circuits
  - Processor determines where the break occurs
  - It compares the location of the break with the (x,y) character map for the language on the keyboard's ROM chip
  - A character is stored in keyboard memory

(*continued*)

- Keyboards (*continued*)
  - The character is then sent to PC as a data stream via wire or wireless connection
  - OS interprets its own operating-system-specific commands and sends the others to the application for interpretation
  - Most keyboards are QWERTY – named for the first six letters on the top left of the keyboard.
  - Keyboards are either tactile (physical) or touch screen (virtual)

Keyboard types

- 104 – 108 keys desktop standard
- 80 – 85 keys for laptops
- Wired
  - Connect to CPU via a serial or USB port
- Wireless use either
  - IR (infrared) technology
  - Radio Frequency (RF) technology

Terminal Types

- **Dumb Terminals**
  - a.k.a. Video Display Terminal (VDT)
  - Has display screen and keyboard
  - Can do input and output only – *no data processing*
- **Intelligent Terminals**
  - Has screen, processor, keyboard, and memory
  - Can perform some independent functions
  - Automated teller machine; point-of-sale terminal; mobile data terminal

5.2 Pointing Device

Pointing devices include the mouse and its variants, the touch screen, and various forms of pen input.

Pointing devices control the position of the cursor or pointer on the screen and allow the user to select options displayed on the screen.

- **Mouse** is the principal pointing device.
  - *Mechanical mouse:* a ball inside the mouse touches the desktop surface and rolls with the mouse.
  - *Optical mouse:* uses laser beams and special chips to encode data for the computer.
  - The mouse controls the **mouse pointer** on the screen – for example, an arrow, rectangle, pointing finger.
  - When the mouse pointer changes to an I-beam, that indicates that text can be entered.
  - The mouse has one to five buttons, used for various functions, such as clicking on and dragging items on the screen.

Pointing Devices (*continued*)

- **Trackball**
  - A movable ball mounted on top of a stationary device
  - Good for locations where a mouse can't move around enough
- **Touchpad**
  - To use: slide your finger over this small flat surface
  - Click by tapping you finger on the surface
  - May require more practice to use than a mouse
  - Used on laptops

- **Pointing stick**
  - Located between the keys on a laptop keyboard, a pointing stick is a pressure-sensitive device that allows the user to control the pointer by directing the stick with one finger.

Pointing Devices (*continued*)

- **Touch Screens**
  - A video display screen sensitized to receive input from a finger touch.
  - Used in ATMs, information, kiosks, reservation kiosks, voting machines, cellphones, tablets, and e-books.
- **Multitouch Screens**
  - Display screens that allow two or more fingers or other gestures such as pinching motions to be recognized as input at any one time. It allows pinching and stretching gestures on the screen to control zooming.
- **Pen input**
  - Uses a pen-like stylus for input.
  - Uses handwriting recognition to translate cursive writing into data (handwriting recognition).

Pointing Devices (*continued*)

- **Light pen**
  - A light-sensitive penlike device that uses a wired connection to a computer terminal
  - Bring the pen to the desired point on the display screen and press a button to identify the screen location
  - Used by graphics artists, engineers, and in situations that require covered hands
- **Digitizer**
  - Uses an electronic pen or puck to convert drawings and photos to digital data
  - Digitizing tablets are often used in architecture

Pointing Devices (*continued*)

- **Digital Pen**
  - Writing instrument
  - Writers can write on paper
  - A tiny camera in the pen tip captures the writing
  - A microchip in the pen converts the pen to digital ink
  - The writing is sent as an image file to the computer
  - Some versions require special paper

5.3 Source Data-Entry Devices

- **Scanning & Reading Devices**—Source data-entry devices that create machine-readable data and feed it directly into the computer (no keyboard is used)
  - **Scanners**

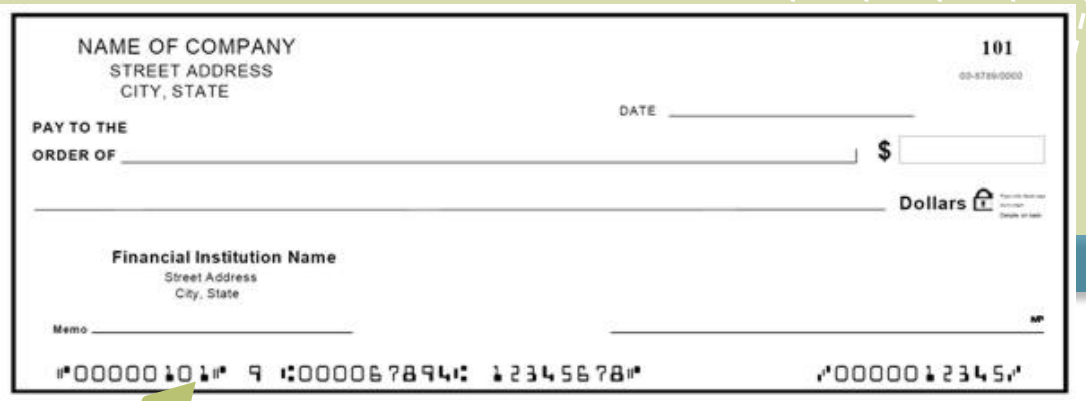
    - Use light-sensing equipment to translate images of text, drawings, and photos into digital form
    - Image scanners are used in electronic imaging
    - Resolution refers to the image sharpness, measured in dots per inch (dpi)
    - Flatbed scanners work like photocopiers – the image is placed on the glass surface, then scanned
    - Other types are sheet-fed, handheld, and drum

Bar-Code Readers (source data entry)

- Photoelectric (optical) scanners that translate bar code symbols into digital code
  - The digital code is then sent to a computer
  - The computer looks up the item and displays its name and associated information
- Bar code types
  - 1D (regular vertical stripes) holds up to 16 ASCII characters
  - 2D (different-sized rectangles) can hold 1,000 to 2,000 ASCII characters
  - 3D is “bumpy” code that differentiates by symbol height
    - Can be used on metal, hard rubber, other tough surfaces

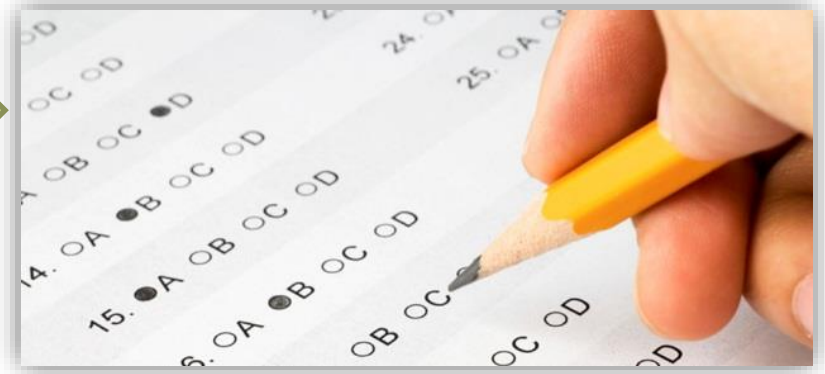
Radio-Frequency Identification (RFID)

- Based on an identifying tag bearing a microchip that contains specific code numbers. These code numbers are read by the radio waves of a scanner linked to a database.
- *Active RFID tags* have their own power source and can transmit signals over a distance to a reader device.
- *Passive RFID tags* have no battery power of their own and must be read by some sort of scanner.
- RFID tags of both types are used for a wide range of purposes and are starting to replace bar codes in many situations.



Mark Recognition Readers (source data entry)

- **MICR** – magnetic-ink character recognition
  - Uses special magnetized inks
  - Must be read by a special scanner that reads this ink
  - Used on bank checks
- **OMR** – optical mark recognition
  - Uses a special scanner that reads bubble (pencil) marks
  - Used in standardized tests such as the SAT and GRE

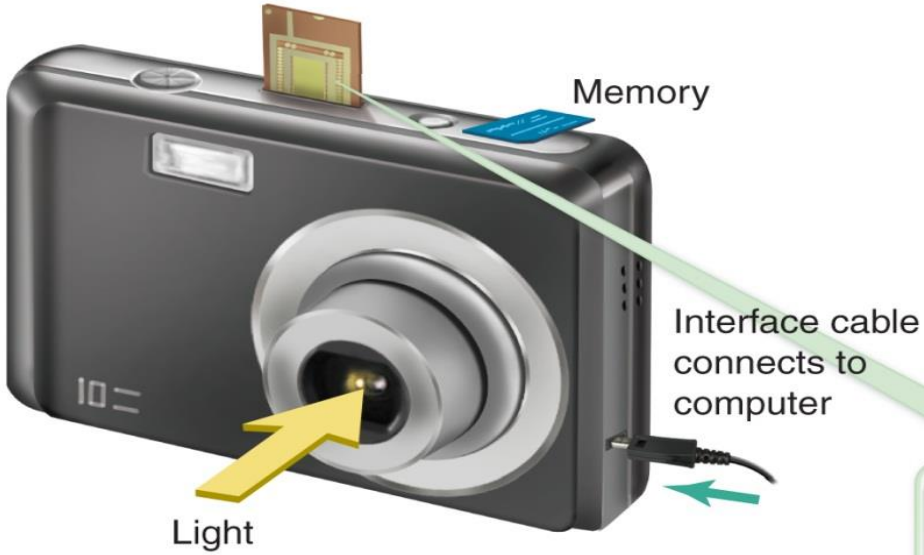


- **OCR** – optical character recognition
  - Converts scanned text from images (pictures of the text) to an editable text format

Image-Capture Devices

- Digital Cameras
  - Use a light-sensitive processor chip to capture photographic images in digital form and store them on a small disk in the camera or on flash memory cards.
    - Most can be connected to a PC by USB; smartphones include digital cameras.
- Webcams
  - Video cameras attached to a computer to record live moving images then post them to a website in real time.
  - Can be attached externally or built into the computer/device.
  - Frame-grabber video card
    - Can capture and digitize 1 frame at a time
  - Full-motion video card
    - Can convert analog to digital signals at rates up to 30 frames per second
    - Looks like a motion picture

Digital Camera



1. Light enters the camera through the lens.

2. The light is focused on the charge-coupled device (CCD), a solid-state chip made up of tiny, light-sensitive photosites. When light hits the CCD, it records the image electronically, just like film records images in a standard camera. The photosites convert light into electrons, which are then converted into digital information.

3. The digital information is stored in the camera's electronic memory, either built-in or removable.

4. Using an interface cable, the digital photo can be downloaded onto a computer, where it can be manipulated, printed, placed on a web page, or emailed.

A look at CCDs

The smallest CCDs are 1/8 the size of a frame of 35mm film. The largest are the same size as a 35mm frame.

- Lower-end cameras start with 180,000 photosites.
- Professional cameras can have up to 6 million photosites.

Audio-Input Devices

- Record analog sound and translate it into digital files for storage and processing
- Two ways to digitize audio (often via microphone)
  - Sound Board
    - An add-on board in a computer that converts analog sound to digital sound, stores it, and plays it back to speakers or amp
  - MIDI Board
    - Stands for Musical Instrument Digital Exchange
    - Uses a standard for the interchange between musical instruments, synthesizers, and computers

- Speech-Recognition Systems
  - Use a microphone or telephone as an input device. Converts a person's speech into digital signals by comparing against 200,000 or so stored patterns.
    - Used in places where people need their hands free – warehouses, car radios, stock exchange trades.
    - Helpful for people with visual or physical disabilities that prevent them from using other input devices.

Speech Recognition

Speech
A person who's going to use speech-recognition software usually must first go through an *enrollment*. This consists of the person dictating text that is already known to the software for 10 minutes to an hour. From this sampling, the software creates a table of *vocal references*, which are the ways in which the speaker's pronunciation of phonemes varies from models of speech based on a sampling of hundreds to thousands of people. *Phonemes* are the smallest sound units that combine into words, such as "duh," "aw," and "guh" in "dog." There are 48 phonemes in English. After enrollment, the speaker dictates the text he wants the software to transcribe into a microphone, preferably one that uses *noise-cancellation* to eliminate background sounds. The quality of the microphone and the computer's processing power are the most important hardware factors in speech recognition. The speaker can use continuous speech, which is normal speech without pauses between words.

Signal Processing
The sound wave is transformed into a sequence of codes that represent speech sounds.

1. Phonetic Models
Describe what codes may occur for a given speech sound.
In the word *how*, what is the probability of the "ow" sound appearing between an H and a D?

2. Dictionary
Defines the phonetic pronunciation (sequence of sounds) of each word.
How does it work
haw daz it werk

3. Grammar
Defines what words may follow each other, using parts of speech.
How does <it> [work]
adv vt pron v

Recognition Search
Using the data from 1, 2, and 3, the computer tries to find the best matching sequence of words as learned from a variety of examples.

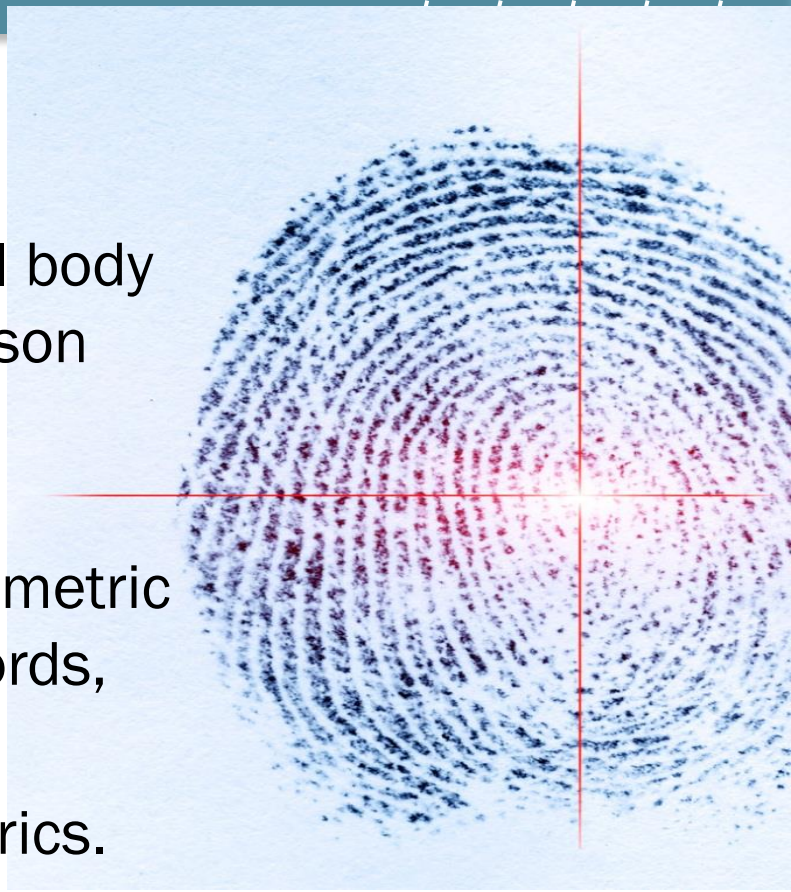
Output
Computer recognizes word string and prints it on the screen.

Sensors

- Input device that collects specific data directly from the environment and transmits it to a computer.
- Can be used to detect speed, movement, weight, pressure, temperature, humidity, wind, current, fog, gas, smoke, light, shapes, images, earthquakes, etc.

Biometric-Input Devices

- **Biometrics** is the science of measuring individual body characteristics, then using them to identify a person through a fingerprint, hand, eye, voice, or facial characteristics.
- Example: notebook computers equipped with biometric sensors that read fingerprints, instead of passwords, before allowing access to networks.
- Airport and building security systems use biometrics.

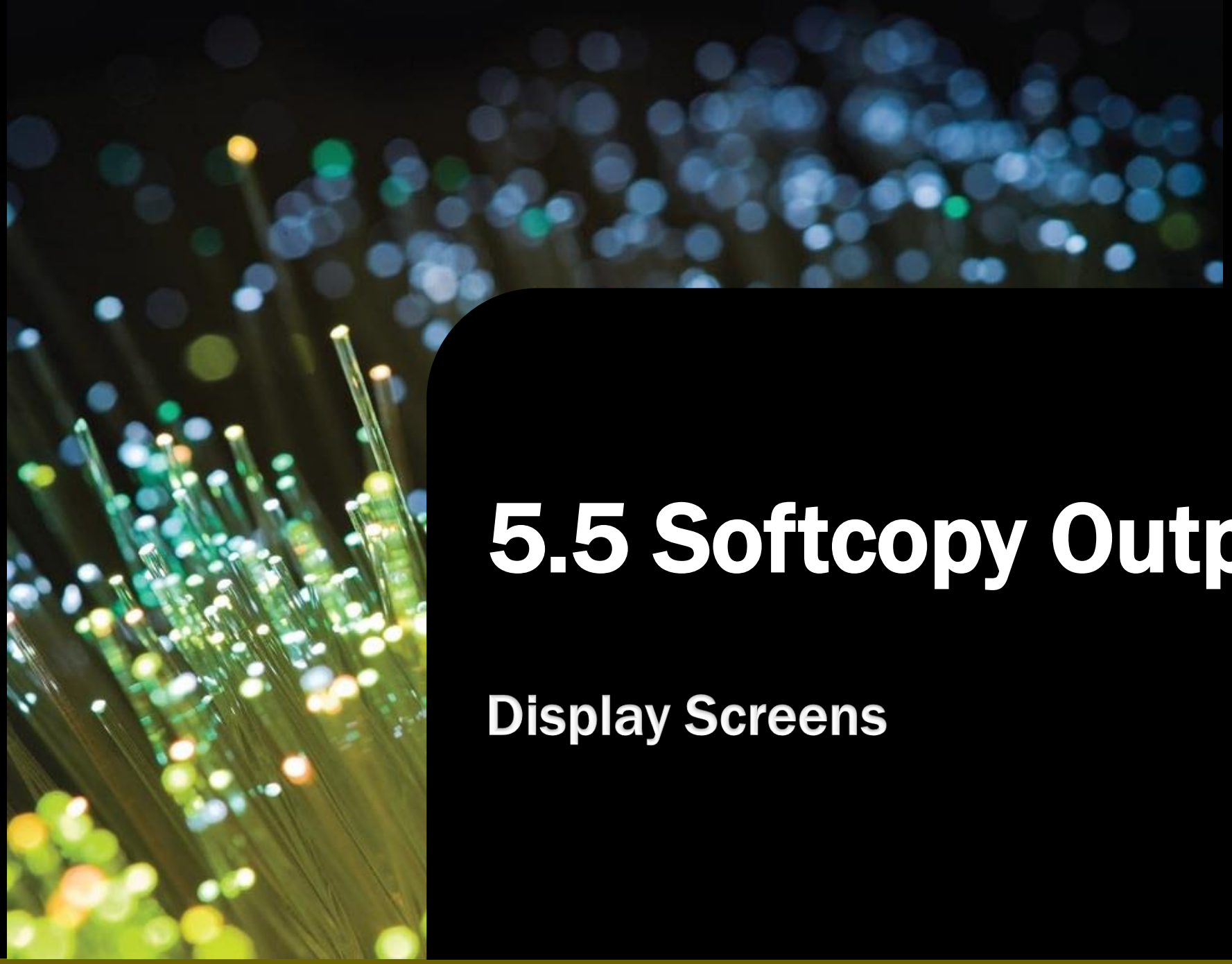


5.4 The Future of Input

- Data will be input from more and more locations.
- Use of source data entry will increase.
  - Better input devices for people with disabilities
  - Better speech recognition
  - Better touch and gesture-recognition input
  - Pattern recognition and improved biometrics
  - Brainwave input devices

UNIT 5B: Output Hardware

- **Softcopy** = data shown on a display screen or is in audio or voice form; it exists only electronically. This kind of output is not tangible; it cannot be touched. You can touch disks on which programs are stored, but the software itself is intangible.
- **Hardcopy** = tangible output, usually printed. The principal examples are printouts, whether text or graphics, from printers. Film, including microfilm and microfiche, is also considered hardcopy output.



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5.5 Softcopy Output

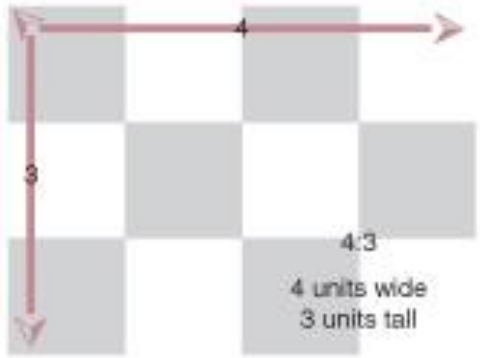
Display Screens

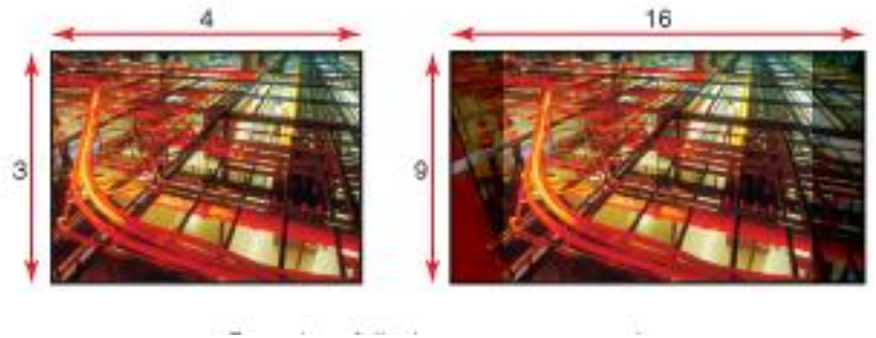
Features of display screens to consider include screen dimension, screen clarity, and color and resolution standards.

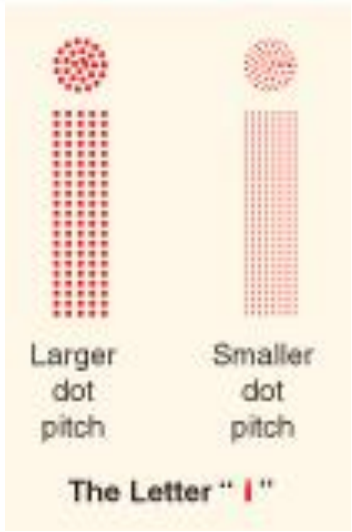
Screen size & aspect ratio

- The active display area is the size of a computer screen measured diagonally from corner to corner in inches.
  - Desktop computers are commonly 15–30 inches (laptops 12–18 inches, tablets 8.4–14.1 inches, and smartphones 2.5–4.1 inches).

- The aspect ratio is the proportional relationship of a display screen's width and height.
  - Standard displays have a 4:3 aspect ratio (4 units wide to 3 units high); wide-screen displays have 16:9 or 16:10.

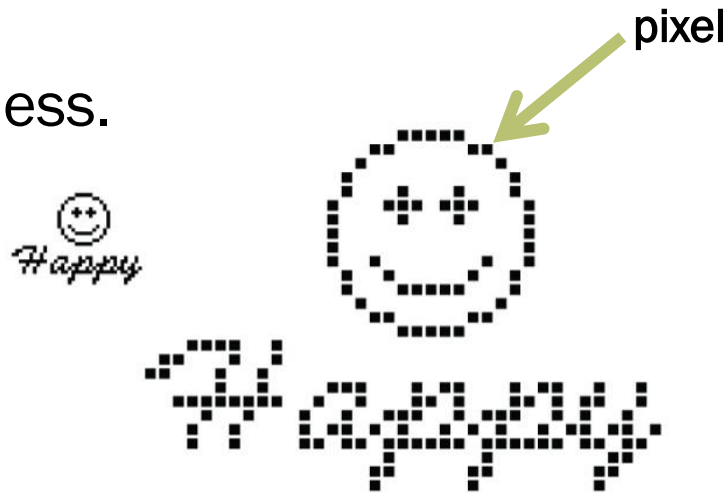






Screen Clarity

- Dot pitch (dp) is the amount of space between adjacent pixels (square picture elements) on screen.
  - The closer the pixels, the crisper the image.
  - Get .25 dp or better.
- Resolution refers to the image sharpness.
  - The more pixels, the better the resolution.
  - Expressed in dots per inch (dpi) .

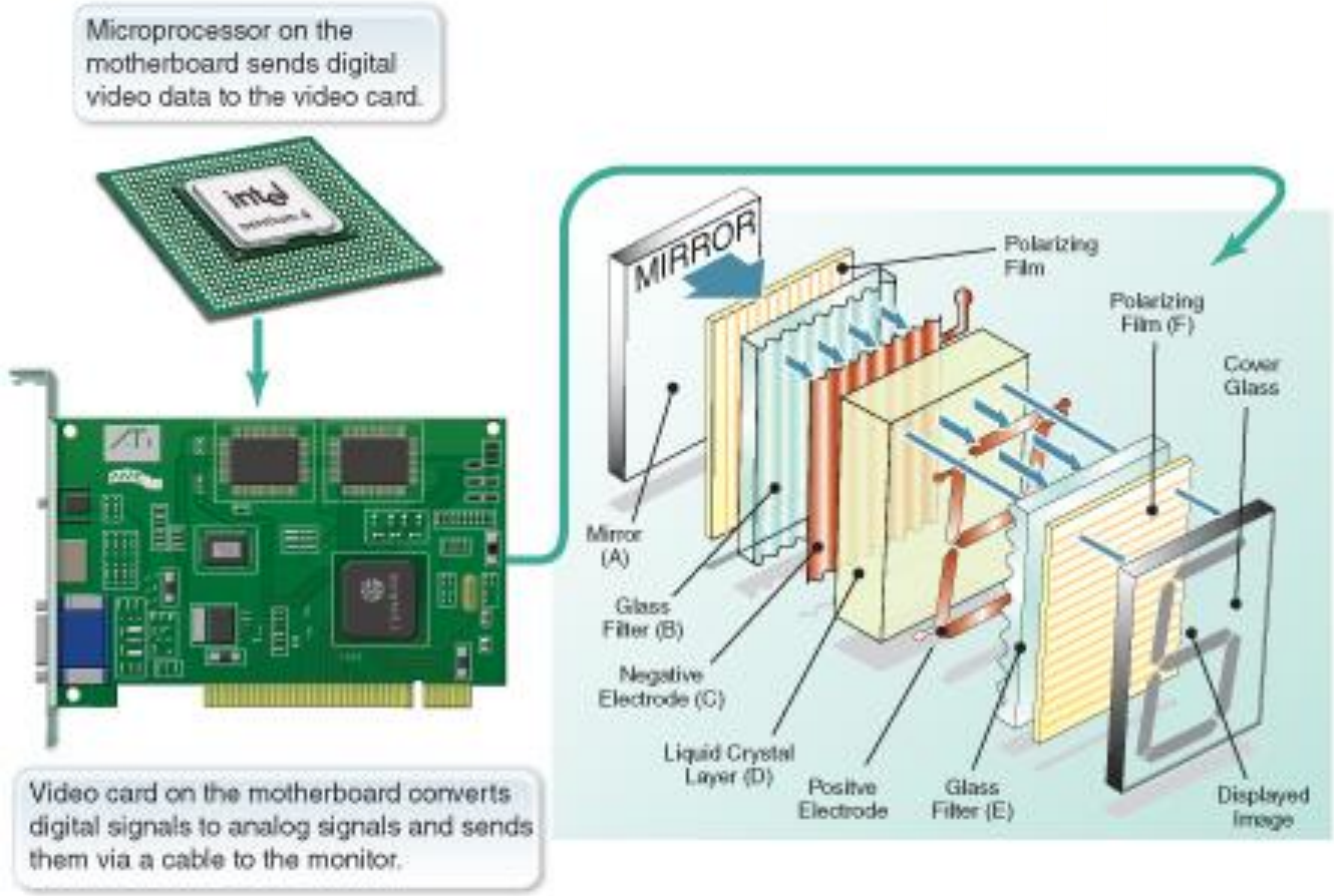


Screen Clarity (*continued*)

Standard bit depths for color
8-bit—256 colors
16-bit—65,536 colors
24-bit—16,777,216 colors

- Color depth (bit depth) is the number of bits stored in a dot (pixel).
  - The higher the number the more true the colors.
  - 24-bit color depth is better than 8-bit color depth, but it needs more video card memory.
- Refresh rate is the number of times per second the pixels are recharged – a higher rate gives less flicker.

- Microcomputers come with graphics cards (video cards) that work with the screen.
- Graphics cards have their own memory (**VRAM**), which stores each pixel's information.
- The more VRAM, the higher the resolution you can use.
- Desktop publishers, graphics artists, and gamers need lots of VRAM.



Types of Display Devices

- The most common type of display **flat-panel displays** are made of two plates of glass separated by a layer of a substance in which light is manipulated.
- One type of flat-panel display is the **liquid crystal display (LCD)**, **in which molecules of liquid crystal line up in a way that alters their optical properties, creating images on the screen by transmitting or blocking light.**

Other types of displays:

- **Plasma displays:** A layer of gas is sandwiched between two glass plates, and when voltage is applied, the gas releases ultraviolet light, which activates the pixels on the screen and forms an image. Although expensive, plasma monitors offer brighter colors and screen sizes up to 150 inches wide; however, they usually do not last as long as other display types.
- Cathode-ray tube (CRT) and others: Falling out of use.
- Multiple screens: Splitting the monitor display area into multiple screens, to view different documents at once.

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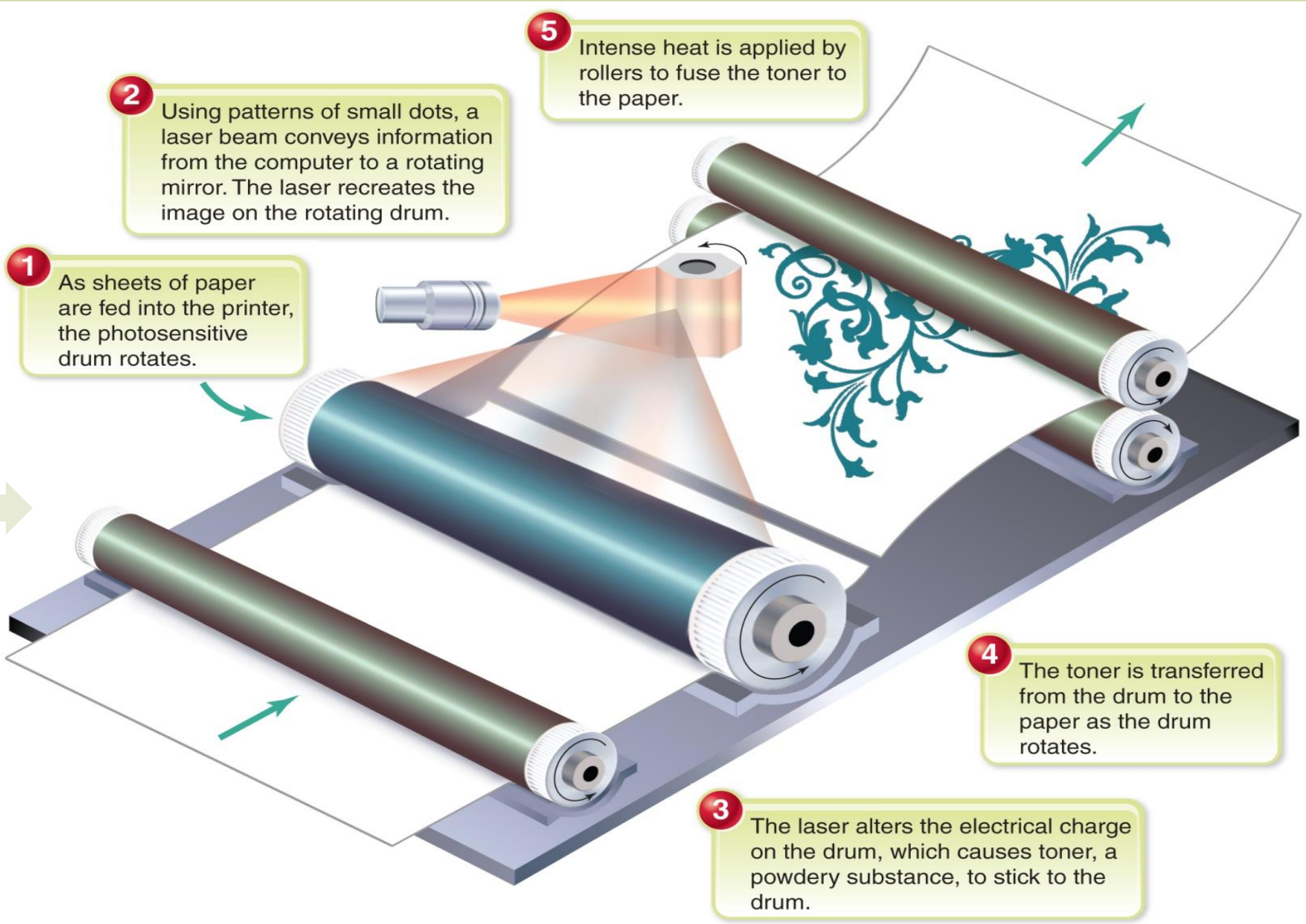
5.6 Hardcopy Output

Printers

- Printers print text and graphics on paper or other **hardcopy** materials.
- Printer resolution is measured by **dpi (dots per inch)**; 1,200 x 1,200 is the most common for microcomputers.
- Printers are either impact or nonimpact – **impact printers** (dot-matrix printer) print by striking the paper directly; **nonimpact printers** (such as laser printers and inkjet printers) do not have direct contact with the hardcopy medium.

- Like a dot-matrix printer, a **laser printer** creates images with dots. However, as in a photocopying machine, these images are produced on a drum, treated with an electrically charged inklike toner (powder), and then transferred from drum to paper.
- Laser printers run with software called a **page description language (PDL)** , which tells the printer how to lay out the printed page and supports various fonts.
- A laser printer comes with one or both types of PDL: PostScript or PCL (Printer Control Language. In desktop publishing, PostScript is the preferred PDL.
- Laser printers have their own CPU, ROM, and memory (RAM), usually 16 megabytes (expandable generally up to 512 megabytes for higher-cost printers).
- When you need to print out graphics-heavy color documents, your printer will need more memory.

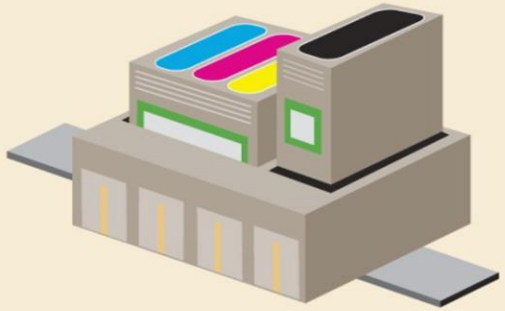
Laser Printer



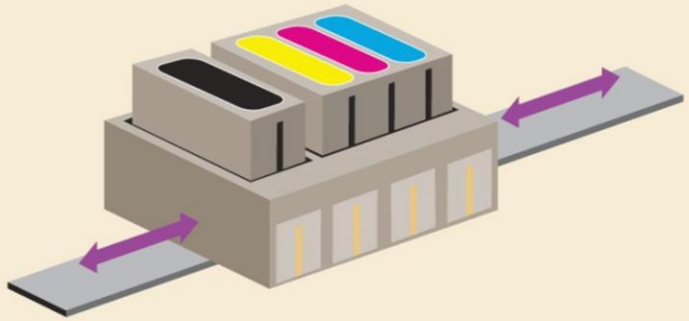
- **Inkjet printers** spray onto paper small, electrically charged droplets of ink from four or more nozzles through holes in a matrix at high speed.
- Like laser and dot-matrix printers, inkjet printers form images with little dots. Inkjet printers commonly have a dpi of 4,800 x 1,200; they spray ink onto the page a line at a time, in both high-quality black-and-white text and high-quality color graphics.

Inkjet Printer

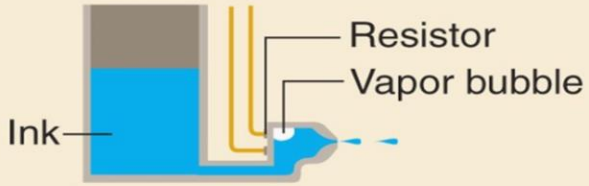
1. Four removable ink cartridges are attached to print heads with 64 firing chambers and nozzles apiece.



2. As the print heads move back and forth across the page, software instructs them where to apply dots of ink, what colors to use, and in what quantity.

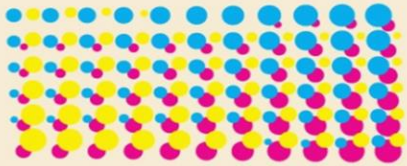


3. To follow those instructions, the printer sends electrical pulses to thin resistors at the base of the firing chambers behind each nozzle.



4. The resistor heats a thin layer of ink, which in turn forms a vapor bubble. That expansion forces ink through the nozzle and onto the paper at a rate of about 6,000 dots per second.

5. A matrix of dots forms characters and pictures. Colors are created by layering multiple color dots in varying densities.



Nonimpact printers also include:

- **Thermal printers**: Low- to medium-resolution printers that use a type of coated paper that darkens when heat is applied to it; typically used in business for bar-code label applications and for printing cash register receipts.
- **Thermal wax-transfer printers**: Print a wax-based ink onto paper. After it becomes cool, the wax adheres permanently to the paper. Because of their waterfastness, these labels find uses in industrial label printing.
- **Photo printers**: Specialized machines for printing continuous-tone photo prints , with special paper and color dyes.

Multifunction printers

- Printers that combine several capabilities:
  - Printing
  - Scanning
  - Copying
  - Faxing
- Cost less and take up less space than buying the four separate office machines.
- But if one component malfunctions, so will the other functions.

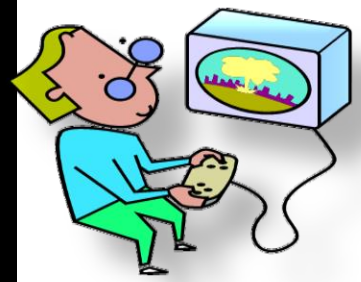
Plotters : Designed for large-format printing

- Specialized output device designed to produce large high-quality, 3-D graphics in a variety of colors.
- Used by architects, engineers, and map-makers.
  - **Pen plotters** use one or more colored pens.
  - **Electrostatic plotters** lie partially flat on a table and use toner as photocopiers do.
  - **Large-format plotters** are large-scale inkjet printers used by graphic artists.

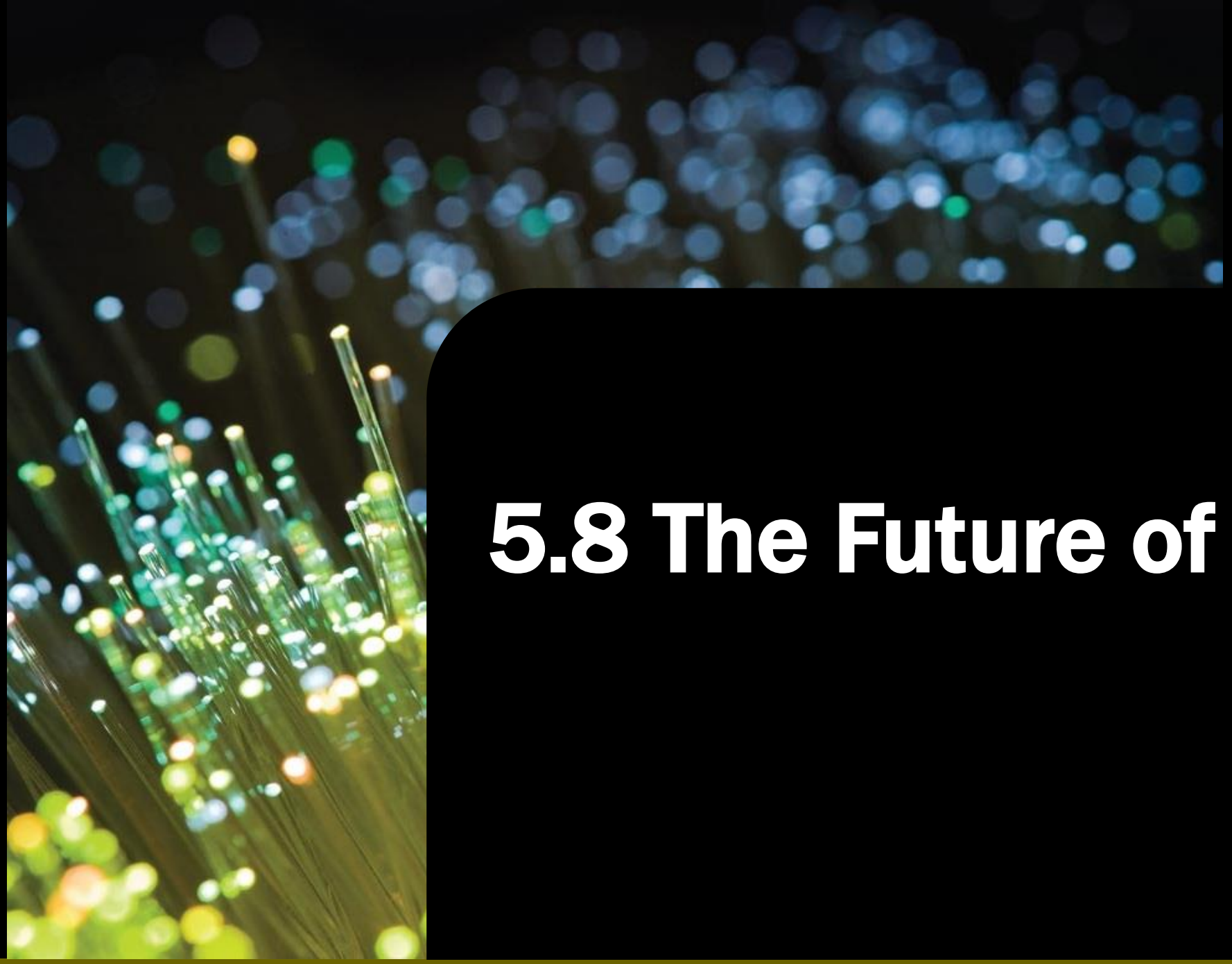
5.7 MIXED OUTPUT: SOUND, VOICE, & VIDEO

- Mixed Output: Sound, Voice, & Video

  - **Sound output**—produces digitized sounds, even “3-D” sound.
    - You need a sound card and sound software.
    - Good speakers can improve the sound.
  - **Voice output**—converts digital data into speechlike sounds.
    - Used in phone trees, cars, toys and games, GPS systems, and TTS (text-to-speech) systems for hearing-impaired people.



  - **Video output**—photographic images played quickly enough to appear as full-motion.
    - Requires powerful processor and video card.
    - Video files are large, so a lot of storage is needed, too.
    - **Videoconferencing** is a form of video output.



5.8 The Future of Output

- More unusual forms of output
- More data used in (Big Data)
- More realistic output
  - Better and cheaper display screens
  - Printers that use less ink
  - Movie-quality video for PCs
  - Increased use of 3D output

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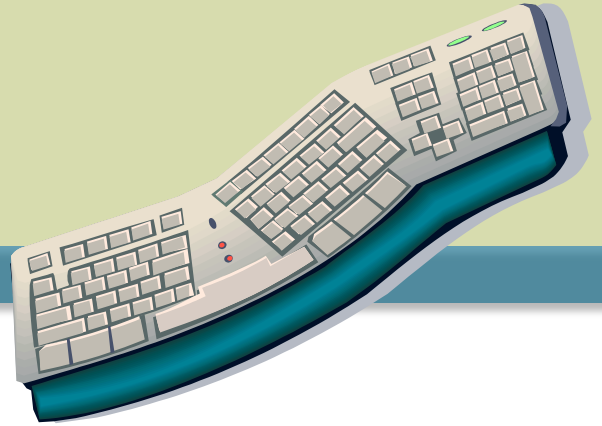
5.9 Quality of Life

Health & Ergonomics

- Health Matters
  - Overuse injuries and repetitive stress injuries:
    - Result when muscle groups are forced through fast, repetitive motions.
    - May effect data-entry operators who average 15,000 keystrokes an hour.
    - May effect computer users whose monitor, keyboard, and workstation are not arranged for comfort.
    - **Carpal tunnel syndrome:** Caused by pressure on the median nerve in the wrist, through short repetitive movements.
    - Eyestrain, headaches, back and neck pains can be problems.
    - Electromagnetic fields may be harmful.



Ergonomics is the methodology of designing a workplace to make working conditions and equipment safer and more efficient.

- Keyboards must be placed at the correct height depending on each worker's size; detachable keyboards are useful.
- Monitor refresh rates must be fast enough to avoid eyestrain.
- Monitor heights must be correct for comfortable viewing; use a tilting screen.
- Wrist rests may help avoid carpal tunnel syndrome.