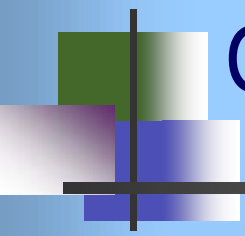
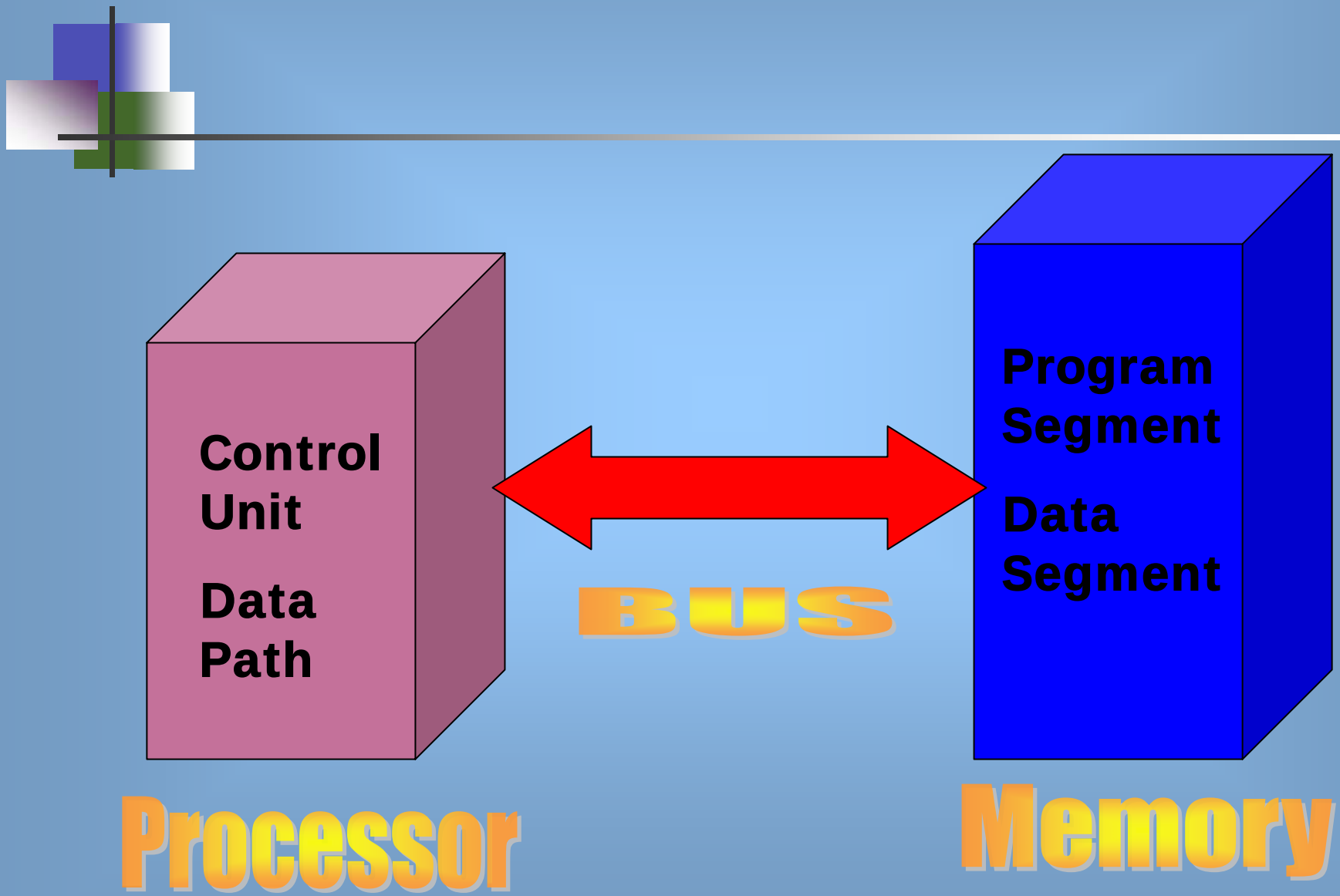


Chapter 3

The Von Neumann Computer System: Processor, Bus and Memory

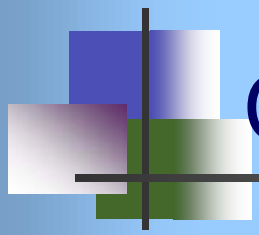

Control
Unit
Data
Path
BUS
Program
Segment
Data
Segment
Processor
Memory

Learning Objectives

- Understand how data and programs are represented to a computer and be able to identify a few of the coding systems used to accomplish this.
- Explain the functions of the hardware components commonly found inside the system unit.
- Explain how systems can be expanded in order to attach new peripheral devices or add new capabilities.

Learning Objectives, *cont'd.*

- Describe how the computer system's CPU and memory components process program instructions and data.
- Name and evaluate several strategies that can be used today for speeding up the operations of computers, and some strategies that may be used in the future.



Overview

- This chapter covers:
  - How a computer system represents data & program instructions
  - How the CPU and memory are arranged in the system unit
  - Strategies to speed up a computer

Digital Data Representation

- Computers today are mostly *digital computers*—devices that can only understand two states.
- The two states of a digital computer are typically represented by 0s and 1s.
- Natural-language messages are translated to the computer into **binary** form.

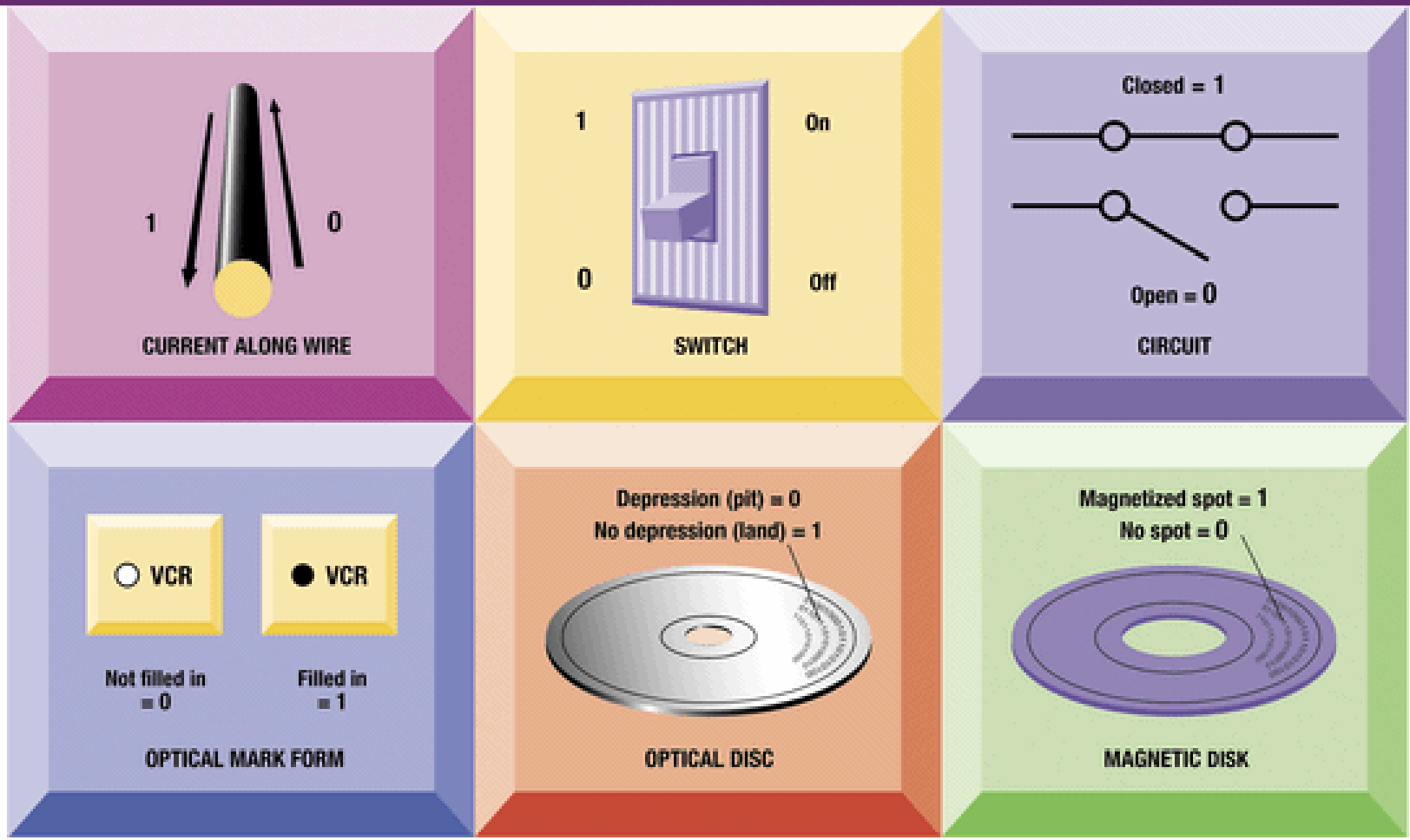
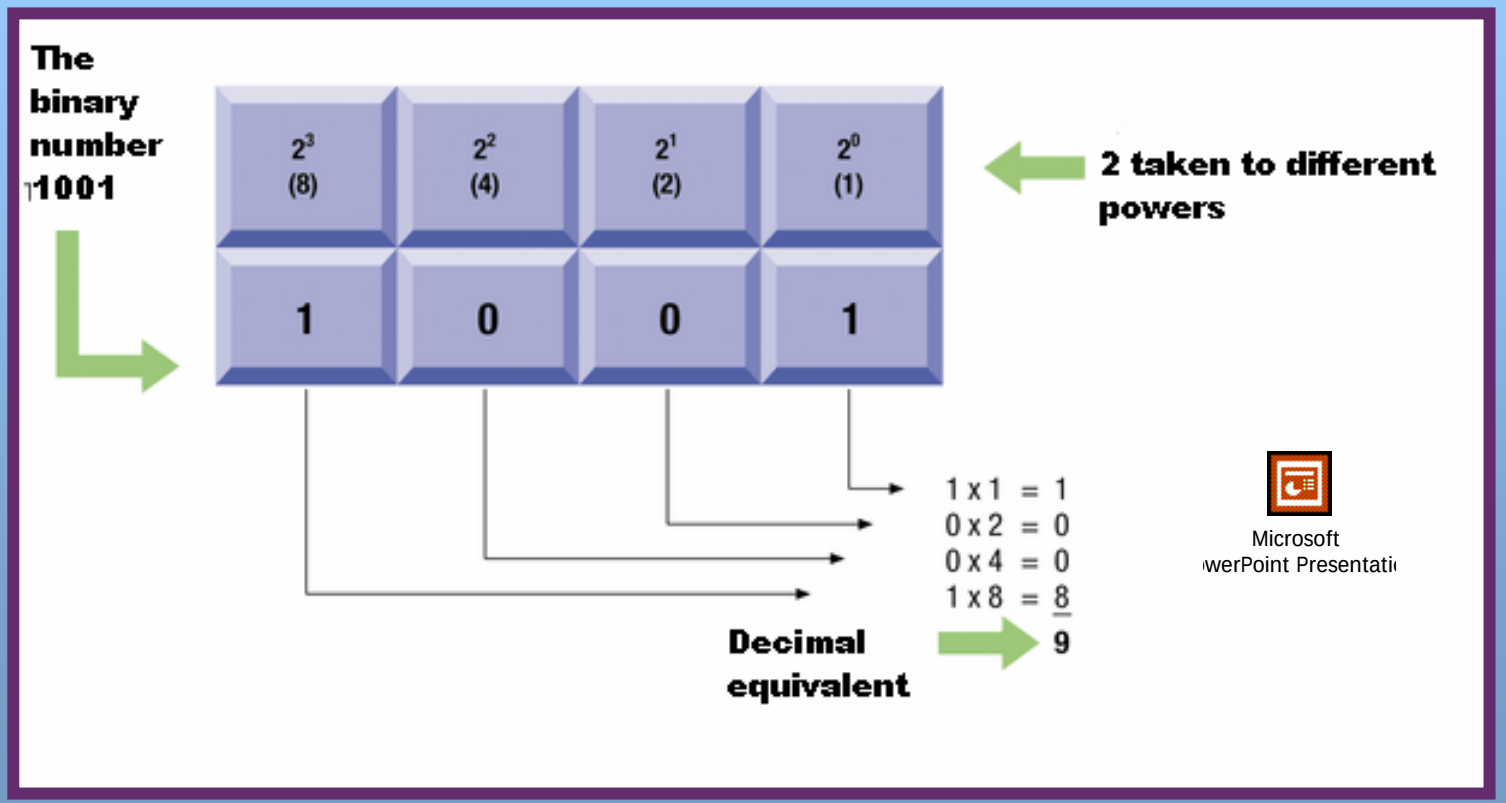


FIGURE 3-1
The binary nature of electronics.

The Binary Numbering System

- The **binary numbering system** represents all numbers using just two symbols (0 and 1).



Coding Systems for Text-Based Data

- **ASCII** and **EBCDIC**
  - Fixed-length codes that can represent any single character of data as a string of eight bits
- **Unicode**
  - A 16-bit code that can be used to represent text-based data in virtually any written language

Byte Terminology

- Byte - a string of eight bits

kilobytes (KB) thousands of bytes
megabytes (MB) millions of bytes
gigabytes (GB) billions of bytes
terabytes (TB) trillions of bytes
petabyte (PB) about 1 quadrillion bytes
exabyte (EB) about 1 quintillion bytes

Parity Bit

- In fixed-length coding systems a **parity bit** is often automatically added at the end of each character to enable computer systems to check for transmission errors.

- In *odd-parity* systems, the parity bit makes the number of 1-bits in a byte to be an odd number; using *even parity*, the number of 1-bits is an even number.

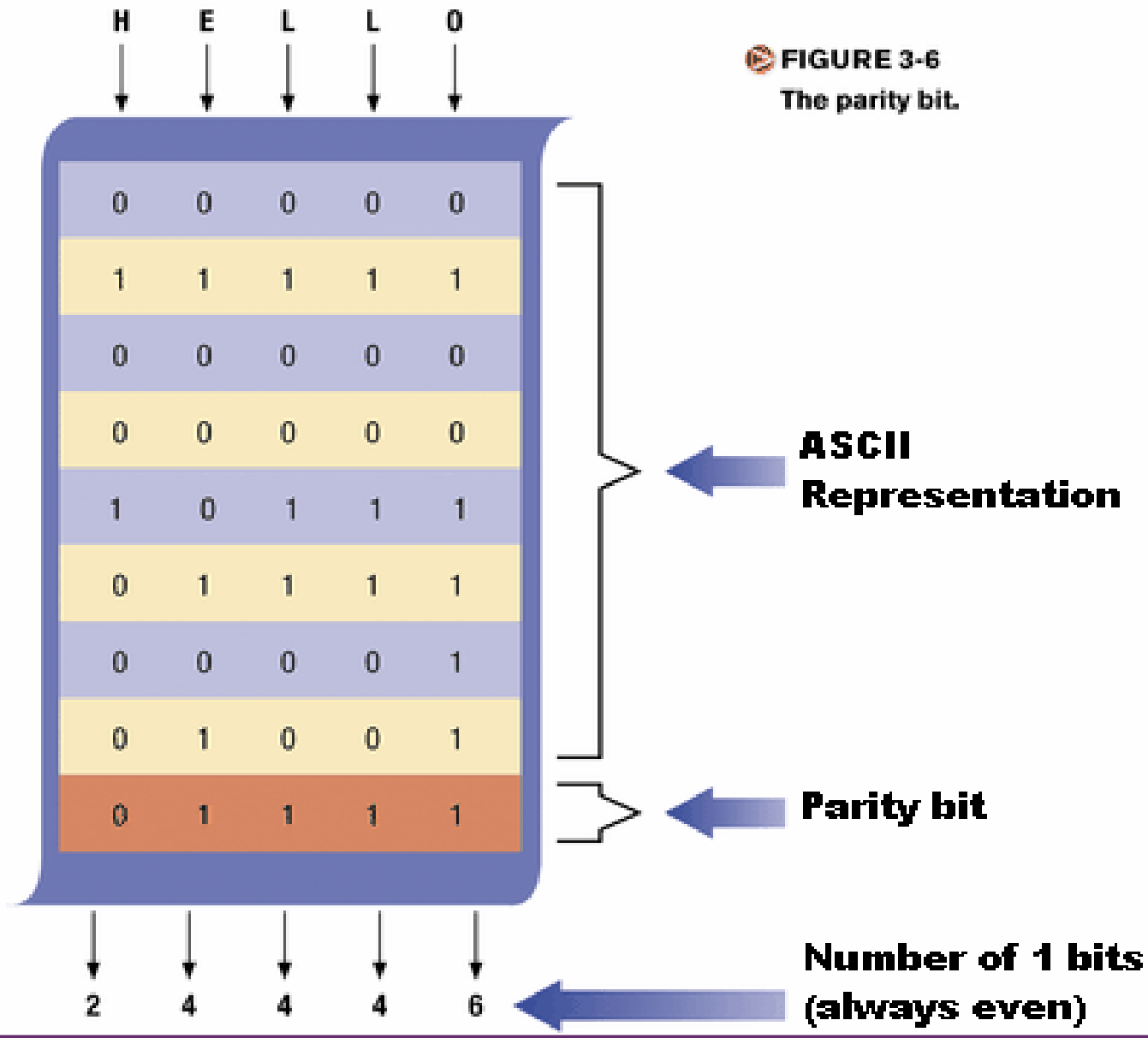
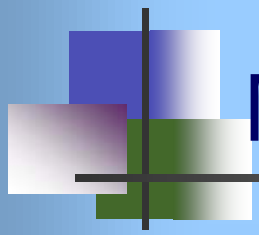


FIGURE 3-6
The parity bit.

Coding Systems for Other Types of Data

- Graphics data
- Audio data
- Video data



Machine Language

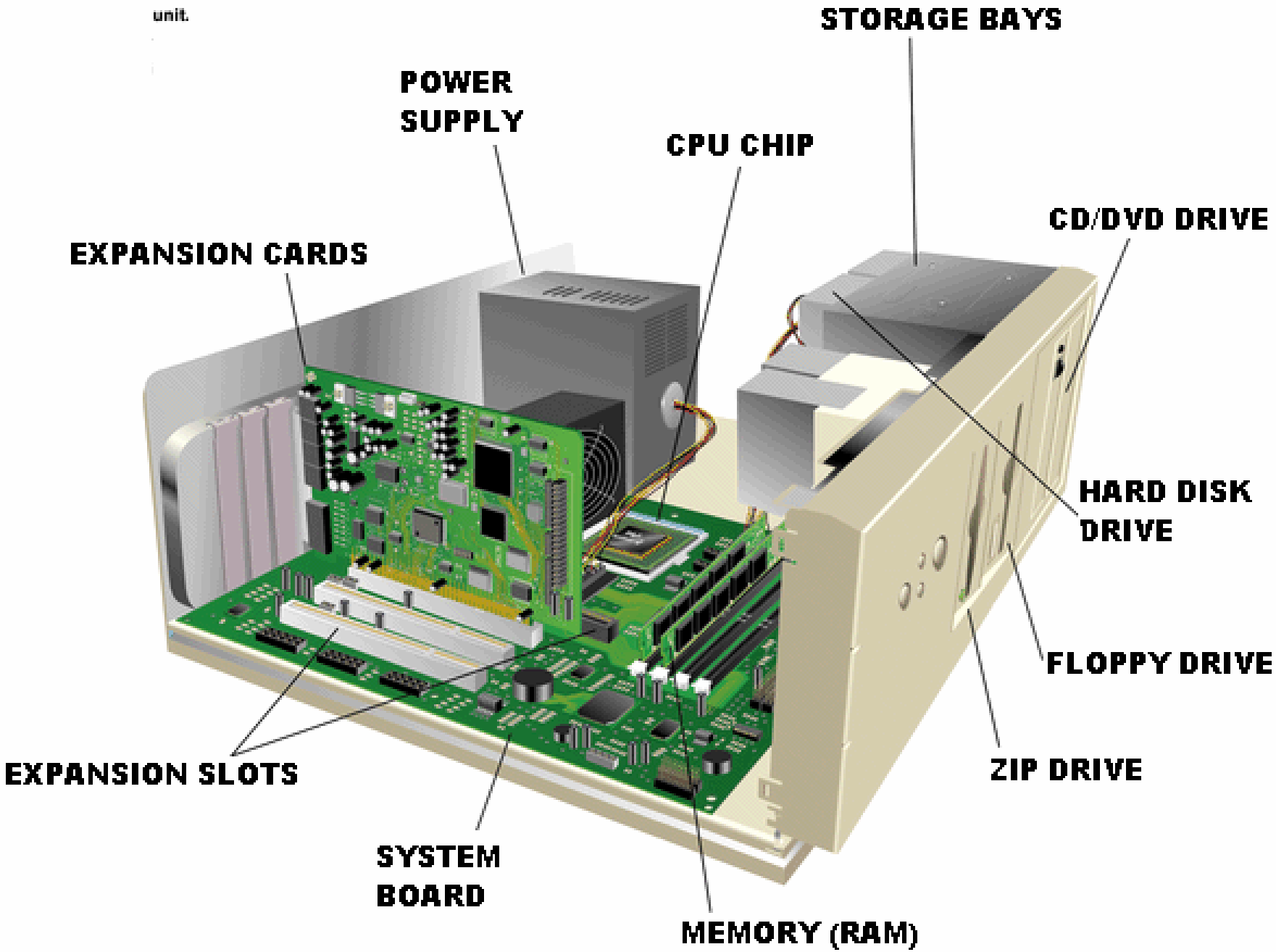
- **Machine language** is the binary-based code used to represent program instructions.
- The basic set of machine-language instructions that a CPU can understand is that CPU's *instruction set*.
- Most programmers rely on *language translators* to translate their programs into machine language for them.

Inside the System Unit

- The **system unit** of a PC is the case that houses processing hardware and other hardware.

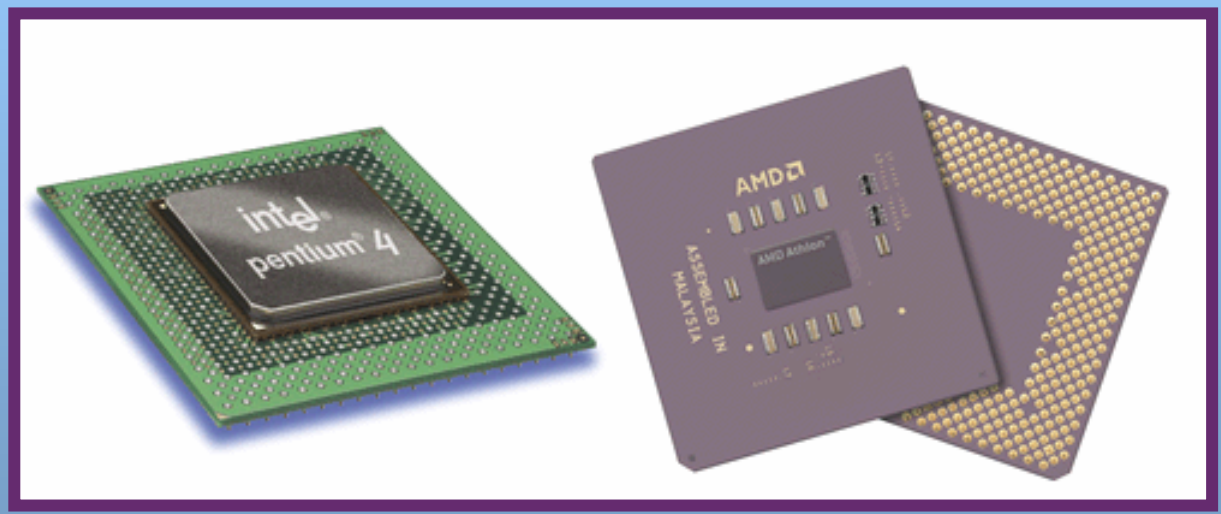
- All of the hardware contained within the system unit is connected to the **system board** or **motherboard**.

FIGURE 3-8
Inside a typical PC system unit.



CPU

- The **microprocessor** (**CPU** chip) contains a variety of circuitry and components and is connected to the motherboard.

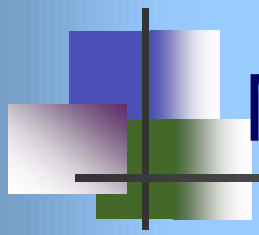


CPU, *cont'd.*

- Processing speed is measured in *megahertz (MHz)* or *gigahertz (GHz)*.
- A computer *word* is a group of bits or bytes that may be manipulated and stored as a unit.
- Other factors that affect the speed of the computer include *RAM*, *cache memory*, *bus width*, and *bus speed*.

Memory: RAM & ROM

- RAM is *volatile*
- ROM is nonvolatile



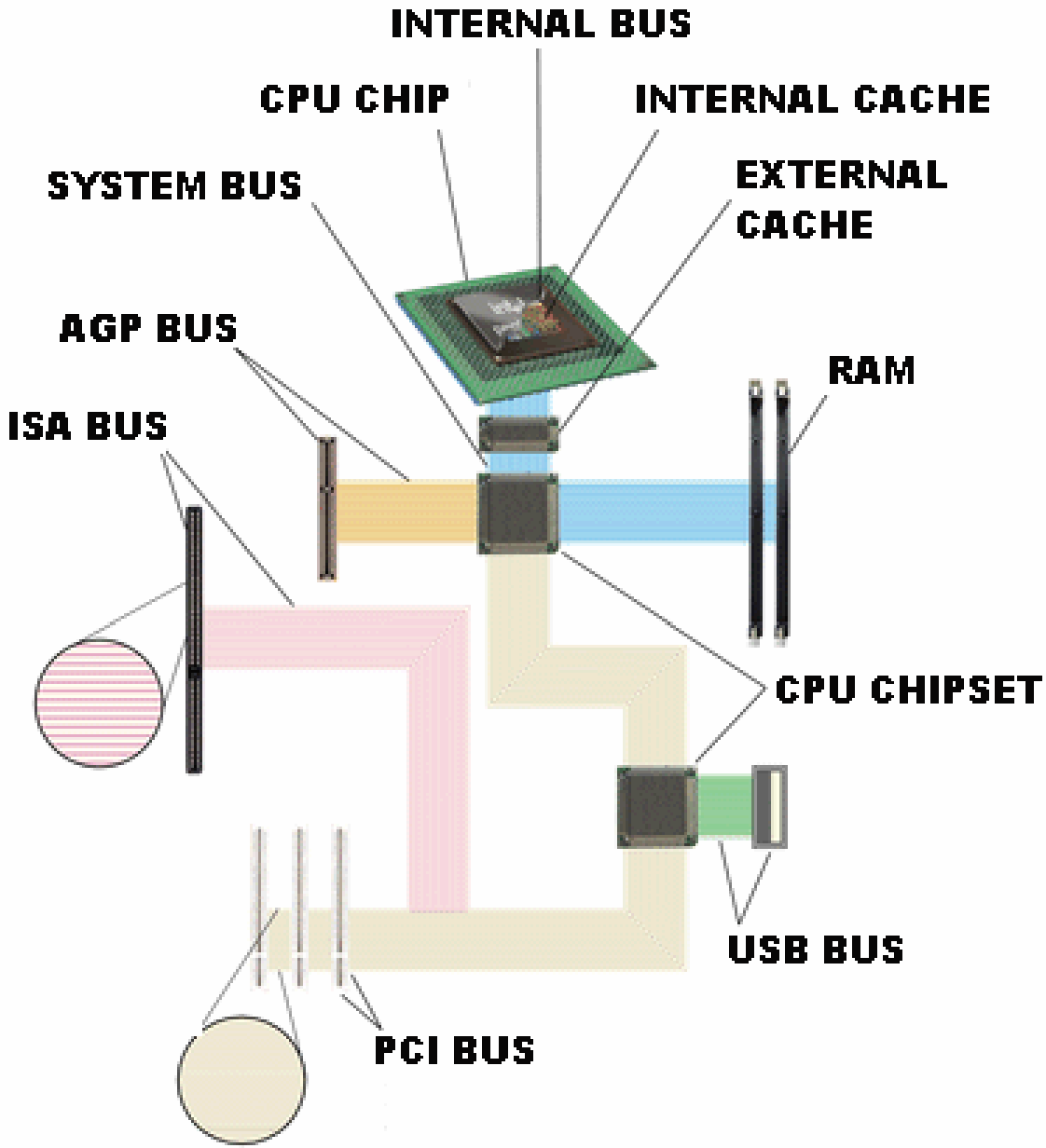
Memory

- Cache memory
- Registers
- ROM
- Flash memory

Buses

- **Buses** are electronic paths that data travels around on a computer system.
- *Internal buses* move data around within the CPU.
- *Expansion buses* establish links with peripheral devices.

BUSES


INTERNAL BUS
CPU CHIP
INTERNAL CACHE
SYSTEM BUS
EXTERNAL CACHE
AGP BUS
RAM
ISA BUS
CPU CHIPSET
USB BUS
PCI BUS

System Expansion

- Expansion cards for desktop PCs
  - Video-graphics board, fax/modem board, or sound card
- PC cards: expansion for notebook & other portables
- Expansion for handhelds and mobile devices
  - USB port, SD cards, MM cards, and Springboard modules

Ports

- Common ports:
  - Serial
  - Parallel
  - SCSI
  - USB
  - Firewire
  - Network
  - MIDI
  - IrDA

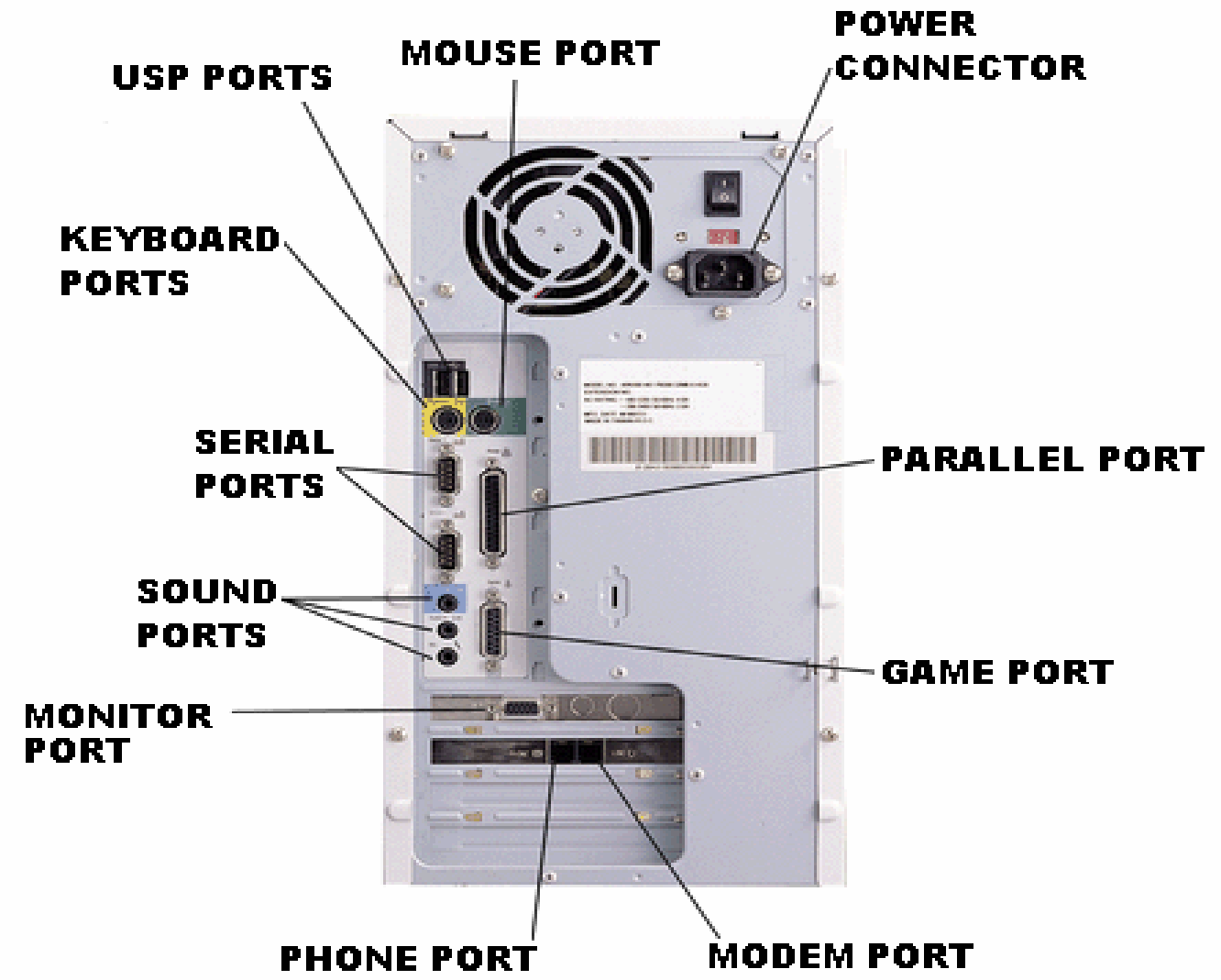


FIGURE 3-16
Ports and connectors.

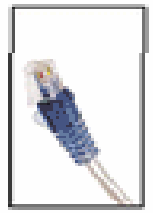
Serial

PS/2

USB

Power

Network



Telephone

Parallel

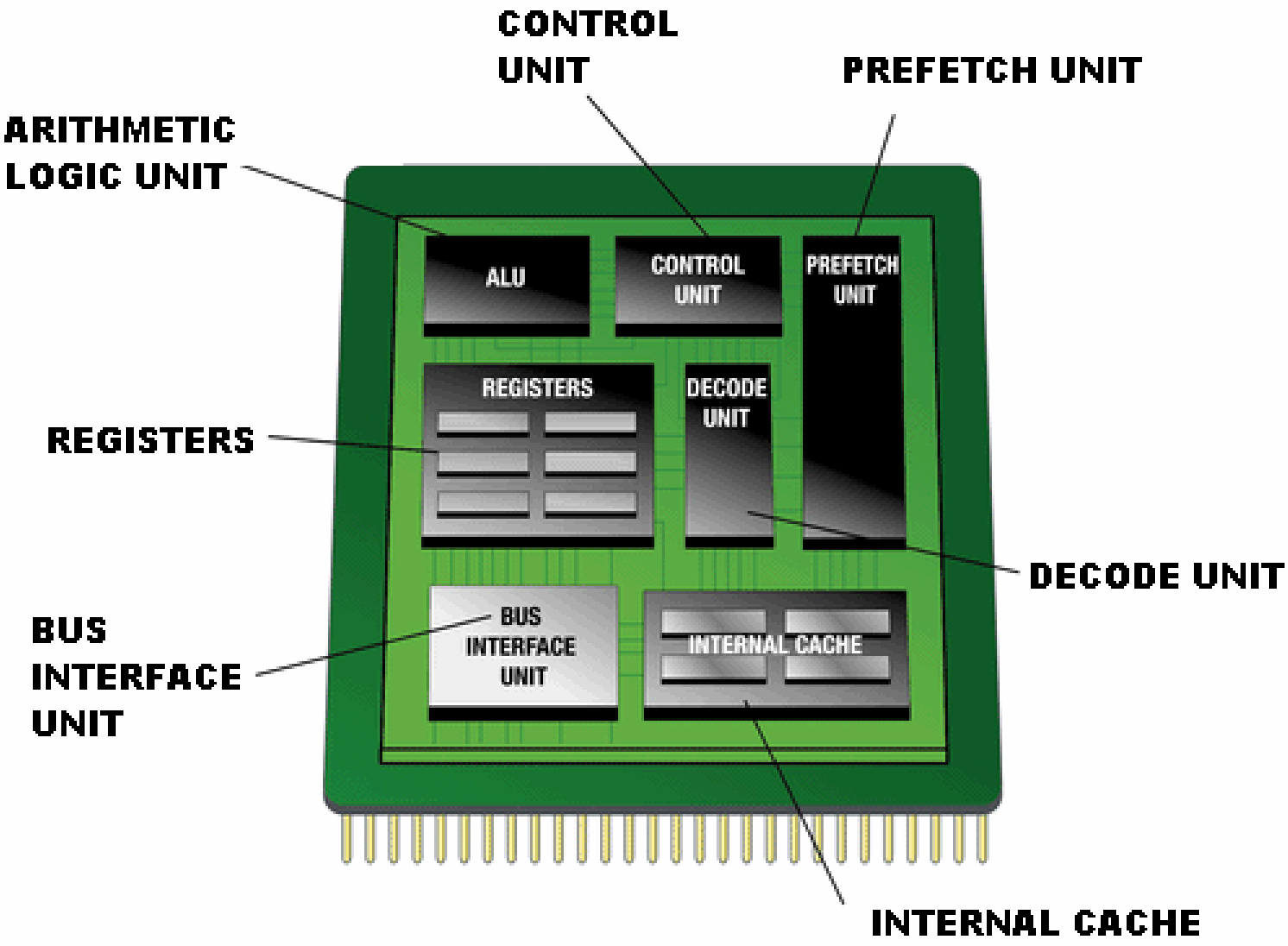
Monitor

PLUGS

Typical CPU Components

- Arithmetic/logic unit
- Control unit
- Registers
- Decode unit
- Prefetch unit
- Internal cache
- Bus interface unit

FIGURE 3-18
The CPU chip and its principal components.

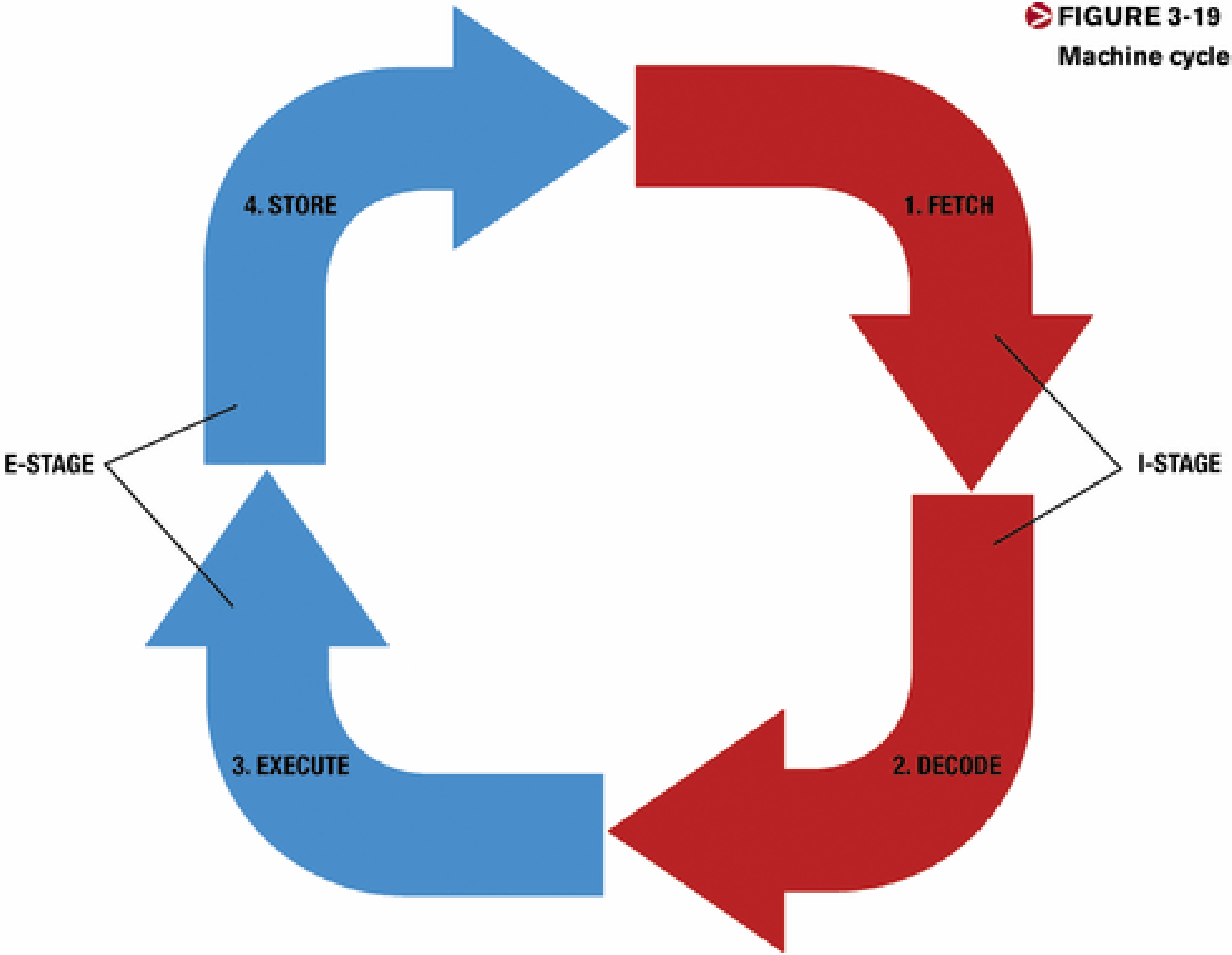


The System Clock and the Machine Cycle

- The **system clock** ticks on a regular basis to help synchronize the computer's components.

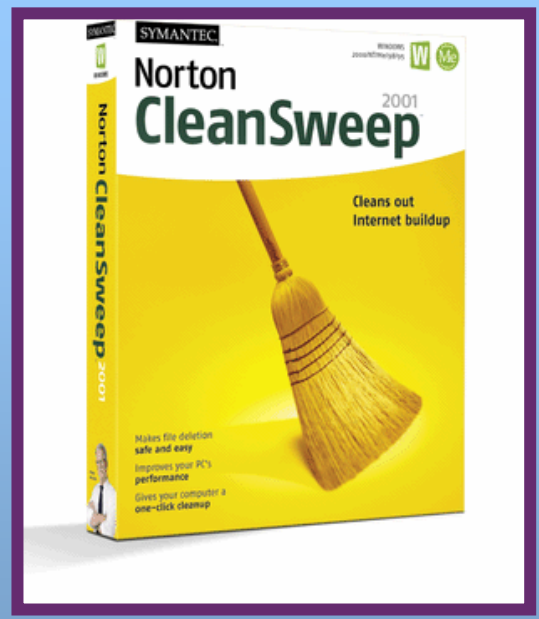
- The **machine cycle** is the series of operations involved in the execution of a single, machine-level instruction.
  - Instruction stage
  - Execution stage

FIGURE 3-19
Machine cycle.



Speeding Up Your System Today

- Add more memory.
- Perform system maintenance.
- Buy a larger or second hard drive.
- Upgrade your Internet connection.
- Upgrade your video card.
- Upgrade your CPU.



Strategies for Making Computers Speedier

- Moving circuits closer together
- Increasing register size
- Faster and wider buses
- Improved materials
- Improved instruction set design
- Pipelining
- Multiprocessing and parallel processing

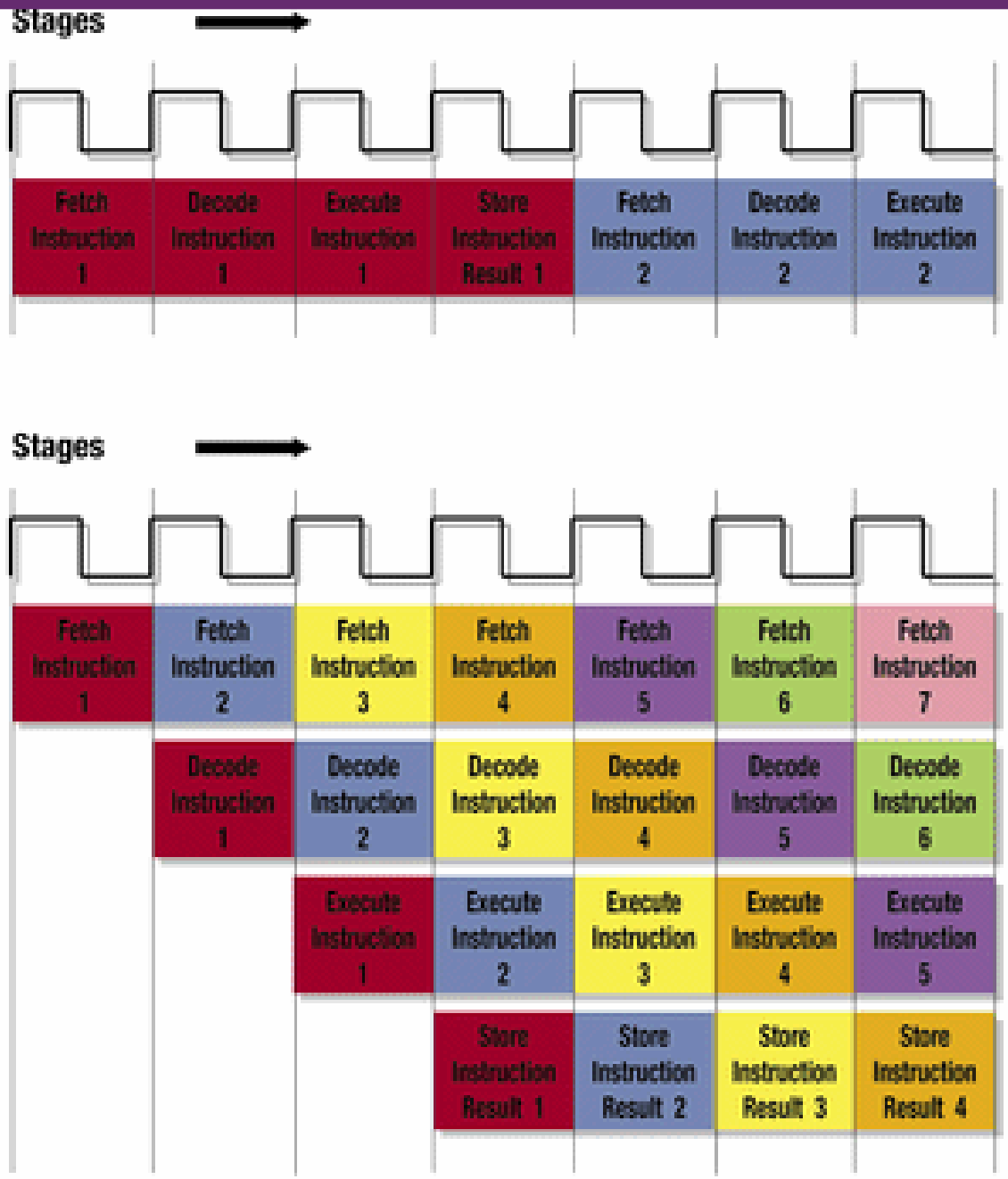


FIGURE 3-23
Pipelining.

Future Trends

- Organic computers
  - Biotechnology
- Nanotechnology
  - Computer chips thousands of times smaller than today's
- New materials
  - Copper, optical processing, superconductive materials