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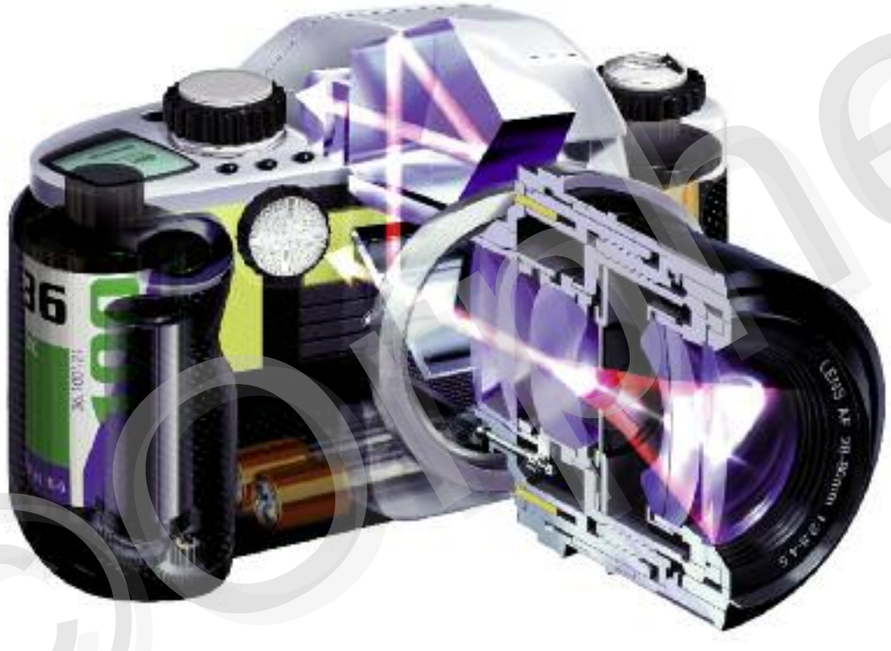

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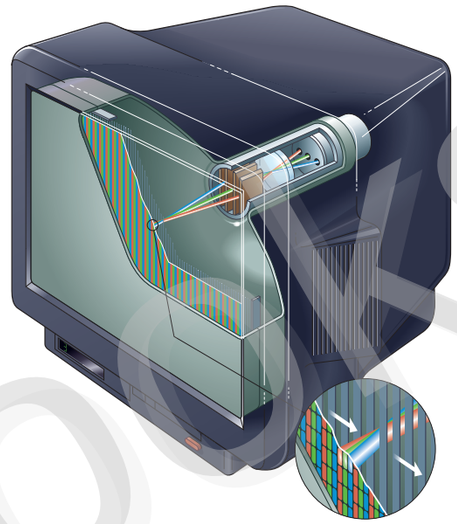


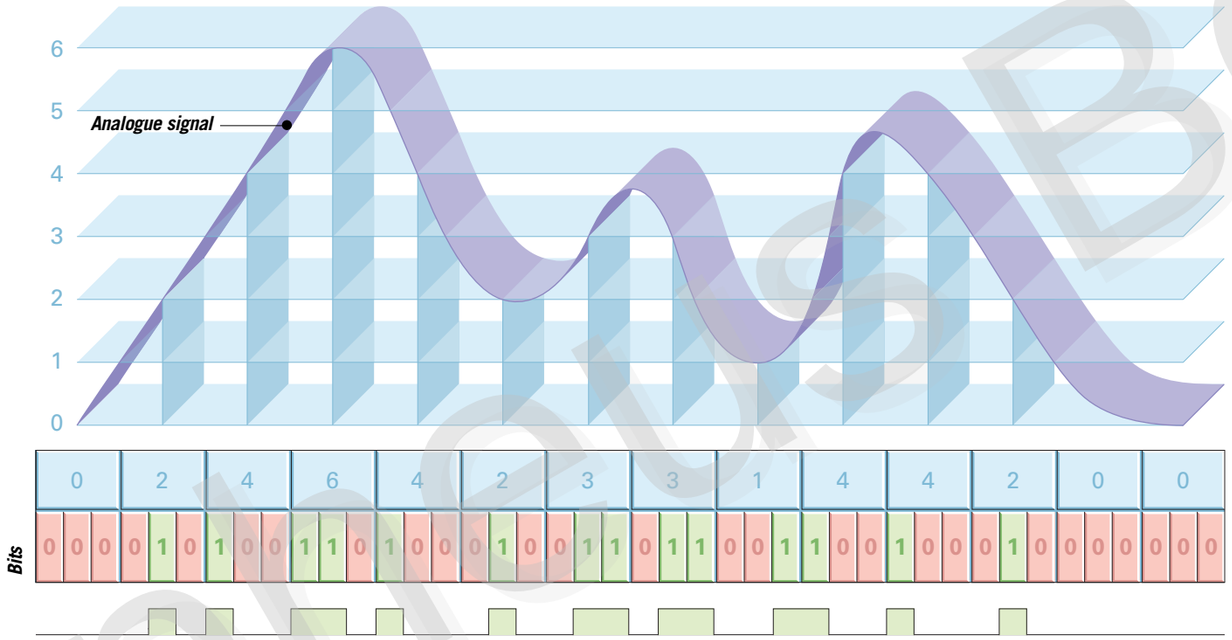
ELECTRONICS

Digital Electronics

IN MANY ELECTRONIC circuits, such as those in radios, the current can be of any strength. These circuits are called analogue circuits. In digital circuits, the current can have only two strengths—on and off. Digital circuits are used in devices in which the flow of electricity represents information, such as computers.

BINARY					DECIMAL
16	8	4	2	1	
0	0	0	0	0	0
0	0	0	0	1	1
0	0	0	1	0	2
0	0	0	1	1	3
0	0	1	0	0	4
0	0	1	0	1	5
0	0	1	1	0	6
0	0	1	1	1	7
0	1	0	0	0	8
0	1	0	0	1	9
0	1	0	1	0	10
0	1	0	1	1	11
0	1	1	0	0	12
0	1	1	0	1	13
0	1	1	1	0	14
0	1	1	1	1	15
1	0	0	0	0	16

Numbers are represented in digital circuits using the **binary number system.** This uses only the digits 0 and 1 and so can easily be represented in electronic circuits by turning currents on or off. In the decimal system (numbers we use in everyday life: 1, 2, 3, etc.), the digits of a number represent ones, tens, hundreds and so on. In the binary system *(see illustration below left),* the digits represent ones, twos, fours, eights and so on. In digital circuits, each 0 or 1 is called a bit. A four-bit binary "word" can represent decimal numbers up to 15 (one 8, one 4, one 2 and one 1).

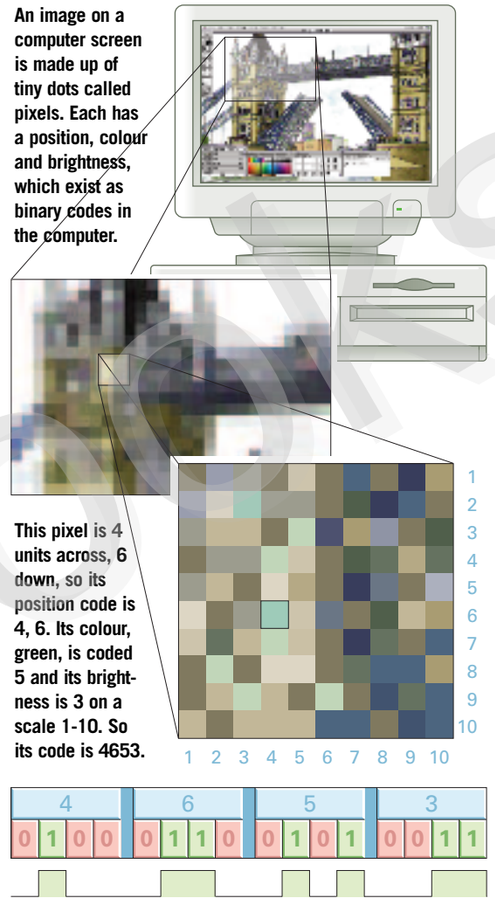


An analogue electrical signal is converted to a digital one. The bits become electrical pulses: on (1) or off (0).

Almost any sort of information (from simple letters to complex moving images) can be represented by numbers, which in turn can be represented in binary form. This means that any sort of information can be represented in digital electronic circuits. Computers *(see page 8)* rely on this fact to store numbers, words, pictures and sounds. They use circuits called logic circuits to process and manipulate the information.

Many types of analogue information must to be turned into digital form before they can be handled by digital circuits. This process is called digitization *(see illustration below).* For example, in a microphone, a sound, which is created by waves of air pressure, is turned into a changing electric current, called an analogue signal, that represents the changes in pressure. This is turned into a digital signal by an electronic circuit called an analogue-to-digital converter. It repeatedly measures the analogue signal, turning it into a continuous stream of binary numbers.

In telephone systems *(see page 12),* the sound of your voice is digitized, normally at the telephone exchange, before it travels across the telephone network. Before it arrives at the telephone of the person you are talking to, it is turned back to an analogue signal (which is needed to work the speaker) by a digital-to-analogue converter. The same thing happens in a CD player, because sound is recorded in digital form on a CD *(see page 28).*



The pixel code is stored as a binary number, which, inside the computer, exists as electrical signals. 1 means an electrical pulse, 0 means no electrical pulse.

Digital Pictures

Anything that appears on a computer's monitor is called computer graphics. These can be as simple as plain white text on a black screen, or as complicated as animated three-dimensional images. Whatever the graphics are, they are made up of small coloured squares called pixels (short for picture elements) in a grid pattern.

The concentration of pixels in a picture is called resolution. High-resolution graphics can be viewed on a large screen without the pixels being visible. Graphics can have a different range of colours, too. In eight-bit graphics, each pixel is represented by eight bits, and so can be any one of 256 colours.

MICROSCOPES

A MICROSCOPE is an instrument that magnifies very small objects, allowing the viewer to see detail in the object that is invisible to the naked eye. Microscopes are used mostly, but not only, in biology and medical research.

There are two main types of microscope—optical microscopes and electron microscopes. In an optical microscope, the image of the object is created by light. The simplest optical microscope is a magnifying glass, which contains a single lens. The lens gathers and bends light coming from the object, making the object look larger than it really is. Compound microscopes have more than one lens. A standard compound microscope has two groups of lenses. The first group, called the objective, gathers light from the object and focuses it to create a magnified image of the object. The second group, called the eyepiece, magnifies this image.

French microbiologist Louis Pasteur *(above)* studies bacteria under a microscope.

The first compound microscope was probably built by Dutch spectacle-maker Zacharias Janssen in about 1590. Early microscopes had poor-quality lenses and gave blurred images. In the 1670s another Dutchman, Anton van Leeuwenhoek, began making simple, single-lens microscopes. He was the first person to see microorganisms, such as bacteria and amoebae.

KEY
1 *Eyepiece lenses*
2 *Adjustment controls*
3 *Objective lenses*
4 *Multiple nosepiece*
5 *Specimen on slide*
6 *Stage*
7 *Condenser (focuses light beam)*
8 *Condenser control*
9 *Light beam*
10 *Mirror*

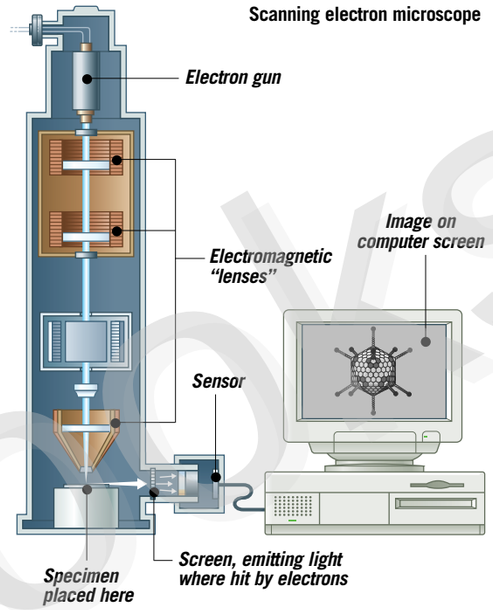
A typical compound optical microscope with three interchangeable objective lenses, providing magnifications from about 50 times to about 200 times.

ELECTRON MICROSCOPES

Optical microscopes can only magnify objects up to 2000 times. Greater magnifications do not reveal any more detail. Electron microscopes can magnify objects more than a million times. In an electron microscope, a beam of tiny particles called electrons does the same job as light in an optical microscope. It is fired at the object and then focused by electromagnetic "lenses" on to a screen that emits light where the electrons hit it.

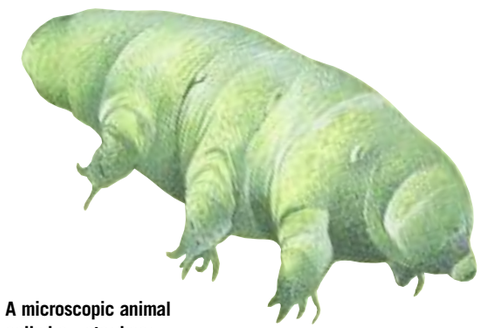
This SEM image of the head of a fruit fly, enlarged about 135 times, has been coloured so that its features can be seen clearly.

There are two main types of electron microscope. In a transmitting electron microscope (TEM), the beam of electrons is fired through an extremely thin slice of the specimen under investigation. In a scanning electron microscope (SEM), a very narrow beam of electrons is fired at the surface of the specimen. The beam scans across the surface of the specimen and a sensor detects the electrons bouncing off. In this way, a three-dimensional image of the specimen is gradually built up.



The images created by electron microscopes are called electron photomicrographs. An example of one is shown here *(left)*. They may be viewed on television screens using video cameras, or digitized and viewed on computer screens.

The first electron microscope, which could magnify objects up to 400 times, was built in 1932 by German engineers Ernst Ruska and Max Knoll. The newest type of electron microscope is the scanning tunnelling electron microscope (STM). It can magnify up to 100 million times, which is enough to see individual atoms.



A microscopic animal called a water bear, magnified about 150 times with an scanning electron microscope.