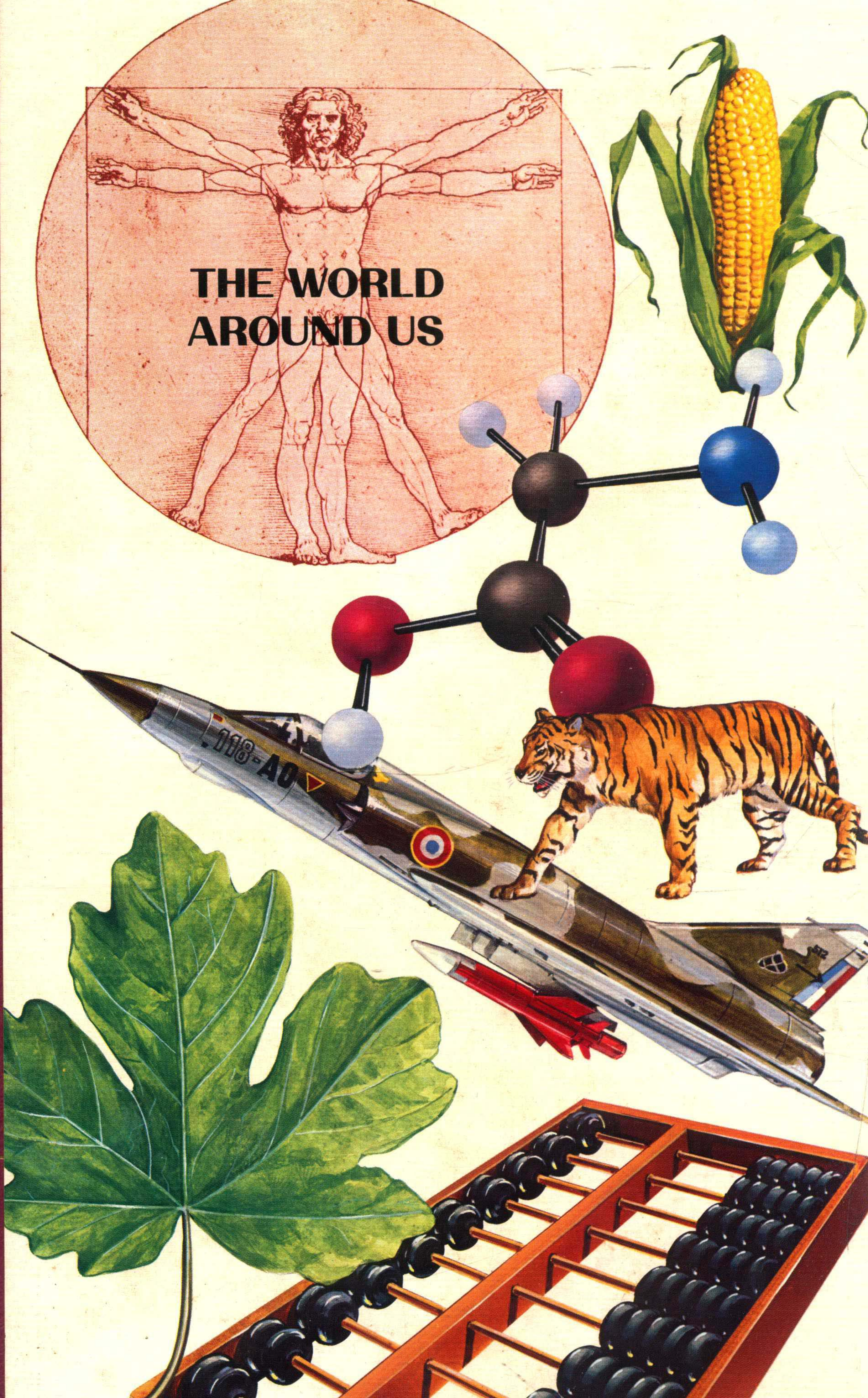
SCIENCE AND TECHNOLOGY ILLUSTRATED

THE WORLD AROUND US



Science Technology

The World Around Us

© Gruppo Editoriale Fabbri S.p.A., Milan, 1983

© 1984 by Encyclopaedia Britannica, Inc.

Copyright Under International Copyright Union

All Rights Reserved Under Pan American and Universal Copyright Convention
by Encyclopaedia Britannica, Inc.

Library of Congress Catalog Card Number: 84-80129

International Standard Book Number: 0-852229-425-5

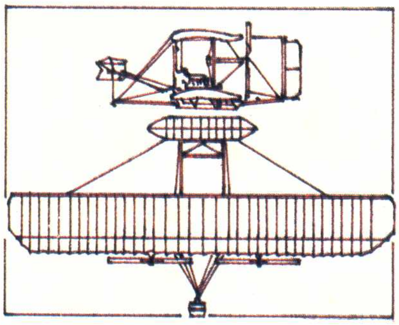
English language edition by license of Gruppo Editoriale Fabbri

No part of this work may be reproduced or utilized
in any form or by any means, electronic or mechanical,
including photocopying, recording, or by any
information storage and retrieval system, without
permission in writing from the publisher.

Title page photograph courtesy of Hale Observatories;
California Institute of Technology and
Carnegie Institution of Washington

Printed in U.S.A.

Contents



此为试读，需要完整PDF请访问： www.ertongbook.com

Science and Technology Illustrated

The World Around Us

Science Technology

The World Around Us

and Illustrated

17 68

Encyclopaedia Britannica, Inc.
CHICAGO

AUCKLAND • GENEVA

LONDON • MANILA

PARIS • ROME

SEOUL • SYDNEY

TOKYO • TORONTO

© Gruppo Editoriale Fabbri S.p.A., Milan, 1983

© 1984 by Encyclopaedia Britannica, Inc.

Copyright Under International Copyright Union

All Rights Reserved Under Pan American and Universal Copyright Convention
by Encyclopaedia Britannica, Inc.

Library of Congress Catalog Card Number: 84-80129

International Standard Book Number: 0-852229-425-5

English language edition by license of Gruppo Editoriale Fabbri

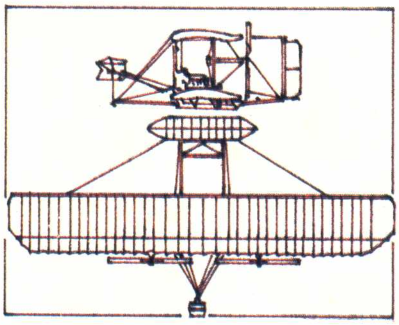
No part of this work may be reproduced or utilized
in any form or by any means, electronic or mechanical,
including photocopying, recording, or by any
information storage and retrieval system, without
permission in writing from the publisher.

Title page photograph courtesy of Hale Observatories;
California Institute of Technology and
Carnegie Institution of Washington

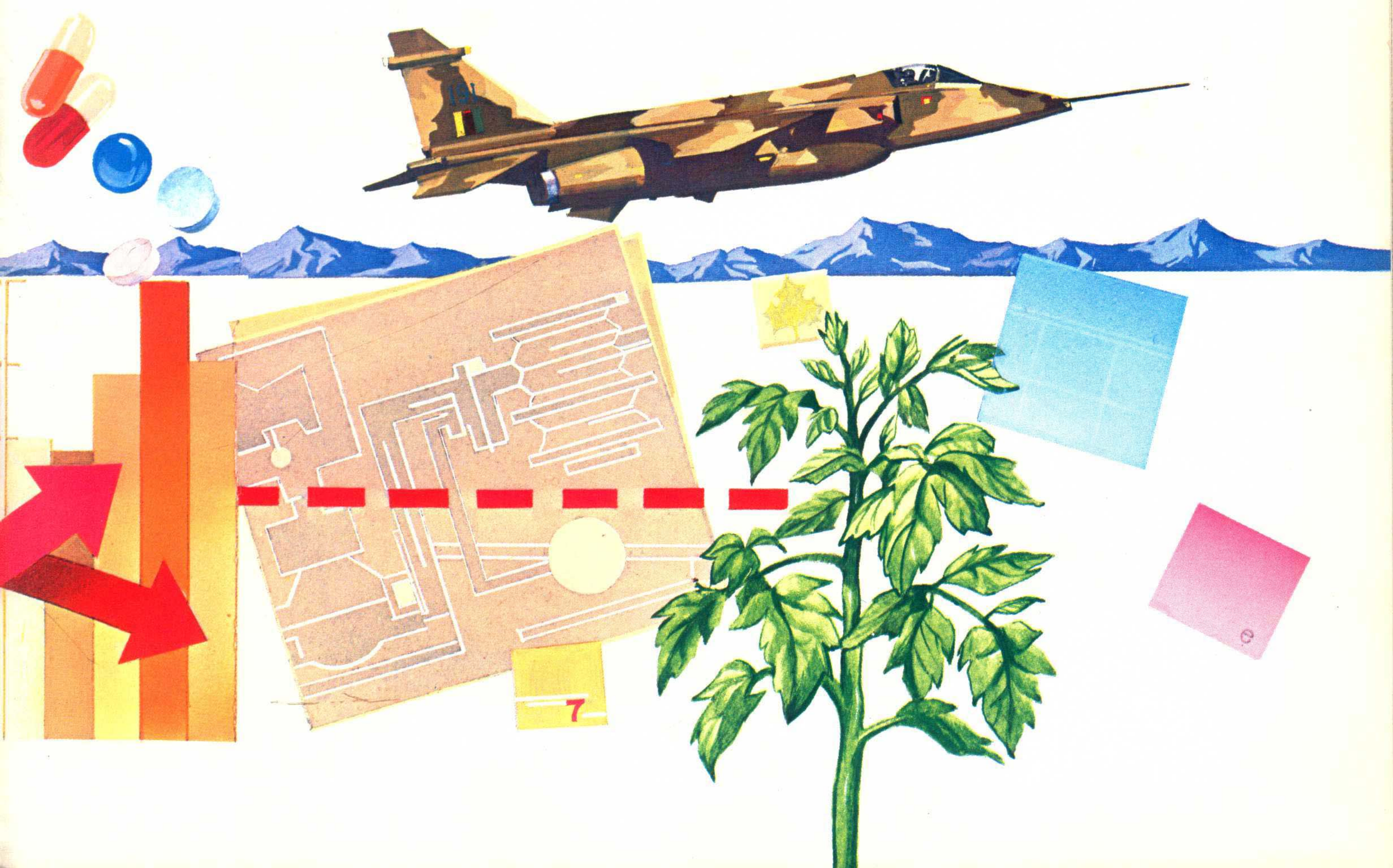
Printed in U.S.A.

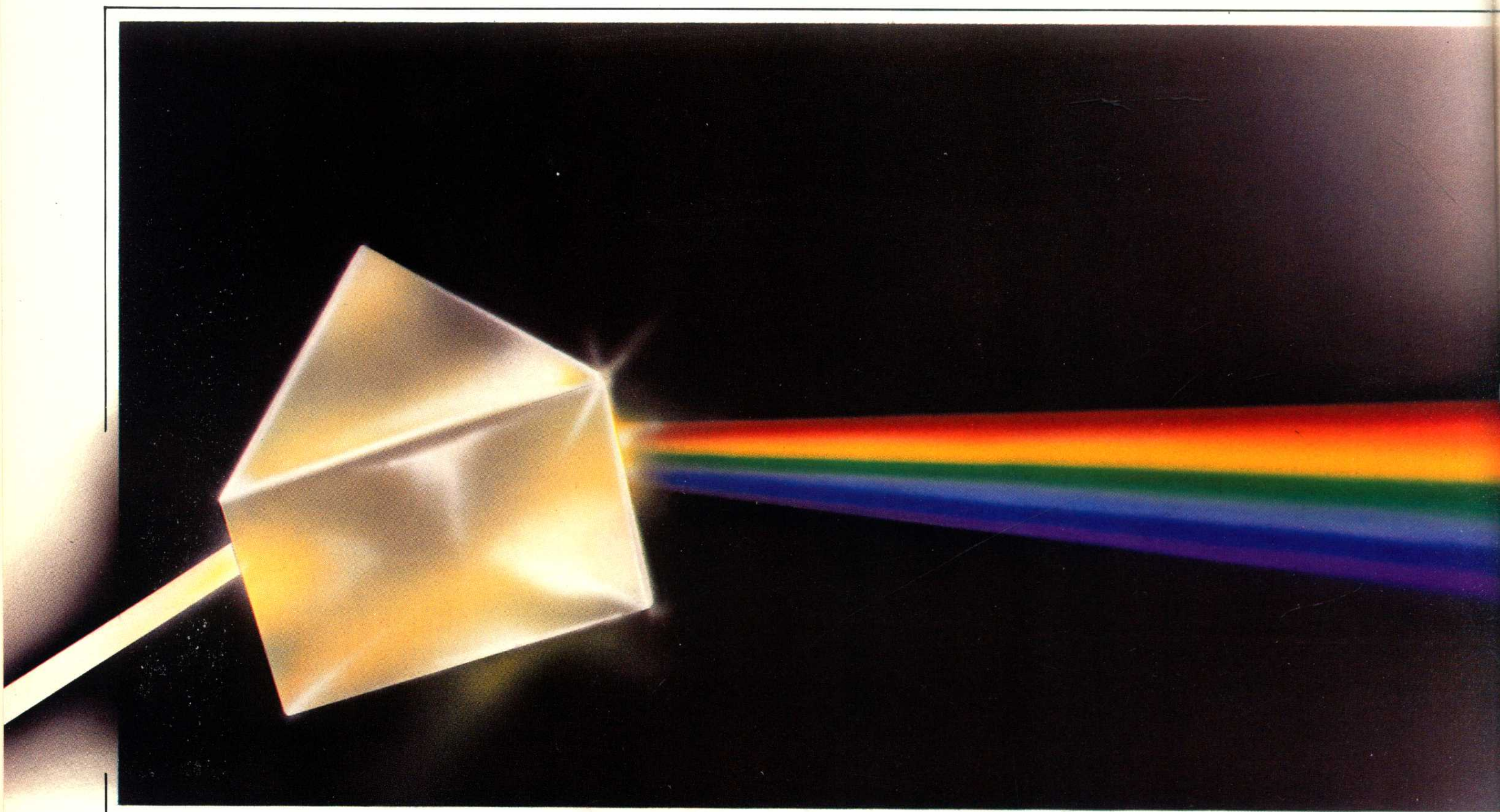
Volume 7

Contents



此为试读，需要完整PDF请访问：www.ertongbook.com





Color is not what we commonly think it is. We are accustomed to thinking of it as something very specific: The sky is blue, the grass is green, the paint on the house is red. We have probably thought that way all our lives, because our first encounter with color was probably with a crayon or watercolor set, and when we took a yellow crayon or paint and applied it to a piece of paper, it made a yellow mark.

Actually, color is something much more fascinating. Color is our perception of light. Without light, there is no color. A brilliant orange cloth in a dark room has no color; it looks black. But if we shine a white flashlight beam on it, the color flames.

Considering that mankind has been experimenting with colors for thousands of years, the fact that color is light is rather a new discovery. In reality, it represents light energy in terms of certain wavelengths and their relative intensities. Sir Isaac Newton made the discovery some 300 years ago, when he separated a sunbeam into the rainbow hues of the color spectrum with a prism and then put all the colors back together again into white sunlight by placing a second prism in front of the first. Newton's experiment caused a tremendous stir in scientific circles, because until then it had always been believed that colors were physical properties, arrived at by mixing certain kinds of pigments together, as painters did, to produce a desired hue.

Of course, anyone can take blue paint and, by mixing it with yellow paint, produce green paint. This is certainly true, but to deduce from this observation that color is physical, like a pigment, is wrong and can immediately be proved so. If a beam of red light and a beam of green light are mixed by overlapping them, they will produce a yellow light—but yellow will not be produced by mixing a red and a green pigment. Such a mixture produces the color of mud.

To understand this phenomenon, we have to go back to our basic premise: Color is light. What color we see depends on three interrelated things: the light, what it shines on, and how our eyes perceive it. Light shining on a puddle of water on an asphalt road makes the puddle look black. But if we pour a teaspoon of kerosene on it, the puddle will gleam with all the colors of the rainbow. Why? Because the kerosene forms an extremely thin film on the water, and variations in the thickness of that film produce different colors by breaking up the light into different wavelengths.

The Secret of Color

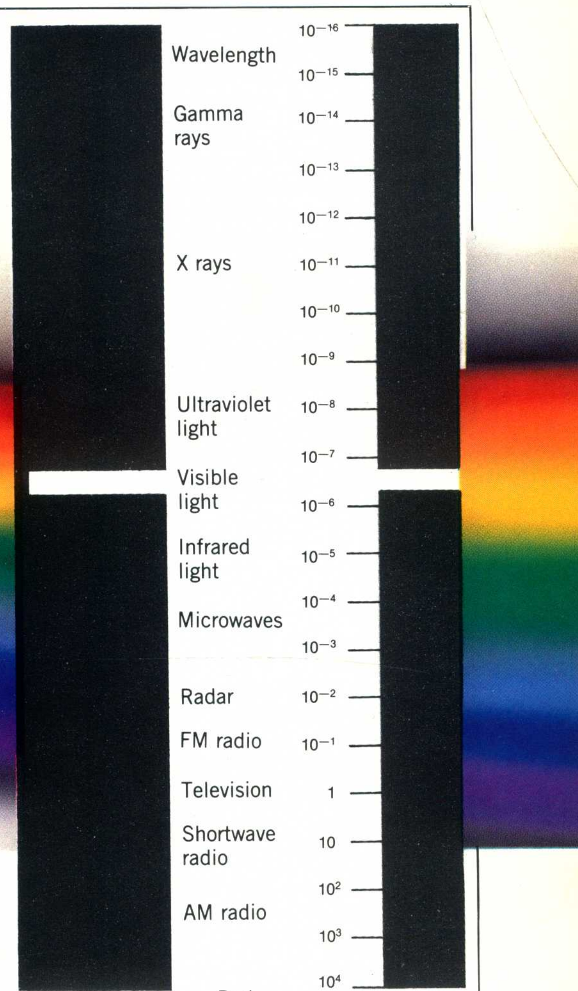
This, then, is the secret of color: It is composed of different wavelengths of light. White sunlight is made up of wavelengths ranging all the way from ultraviolet to infrared over a visible wavelength range from 380 nanometers to 720 nanometers. (A nanometer, used as a measure of light wavelengths, is one billionth of a meter.) The glass of a prism slows down the light passing through it and spaces it out into different wavelengths, each of a different color, just as a faceted diamond does.

Three colors are called primaries because any other color can be produced by mixing them. But no primary color can be produced by mixing any other colors. The three primaries are blue, yellow, and red. For purposes of manufacturing standard colors of paint, dye, or other color products, the relative amounts of each primary used in the mixture can be specified by numbers arrived at by precise measurements in standard light (that is, an agreed-on light value), thus assuring that there will be no variations among batches.

This makes it possible for painters, whether of the artistic or house variety, to buy paints in tubes and cans, which in earlier times was not possible. Painters like Leonardo da Vinci, Michelangelo, or Vermeer mixed all their paints by hand from pigments (usually their apprentices did this for them) and then matched them by eye. But large-scale paint manufacture by this means was not possible, since no two pairs of eyes see the same color the same way.

How and why does a pigment show a color? Its color is the result of how it

Most light rays from the Sun that reach the Earth have wavelengths of 0.4 to 0.7 micrometers. The mixture of all light wavelengths results in white light. If a ray of white light is passed through a prism, the light ray is divided into its component parts. The colors ranging from red to violet form the visible spectrum. *Right:* The white band across the table shows the position of visible light on the electromagnetic spectrum.

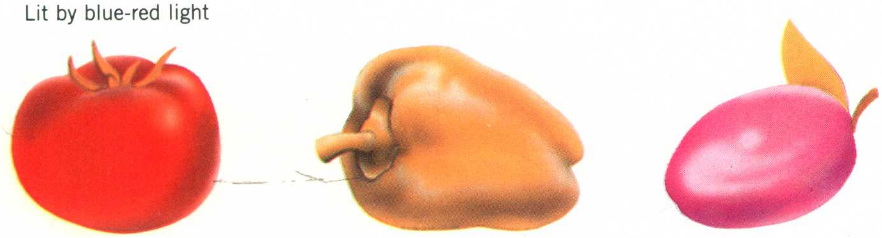


Below: Intermediate colors are obtained by mixing prime colors. Two different ways of doing this—by color subtraction and addition—are illustrated. Add red to yellow and create orange; take away blue from green and create yellow; take away a blue tone from purple and create pink. Also illustrated is additive color mixing with blue, red, and green light sources.

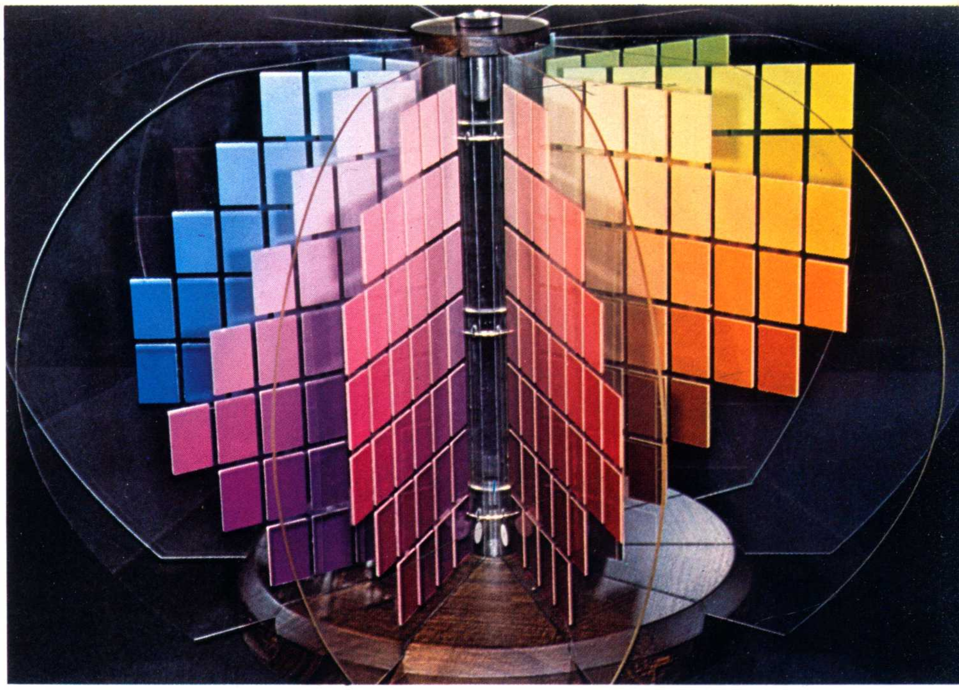
Lit by blue-green light

Lit by green-yellow light

Lit by blue-red light



transmits, reflects, or absorbs light. Some materials will transmit or reflect only certain wavelengths—let us say blue and yellow. All other wavelengths are absorbed, so that the only color appearing to us is green. Other materials might absorb different wavelengths, resulting in different colors remaining visible. Since in this case wavelengths are absorbed, or subtracted, this is known as color subtraction.



Molecules for Color

In pigments, the same applies, with molecules playing the role of subtracters. Green plants, for example, contain chlorophyll, which is made up of molecules that absorb blue and yellow wavelengths. As a result, the chlorophyll reflects green light. There are variations in the green because the wavelengths of light are not always absorbed regularly or completely, which means that our eyes register the green in different hues. Paint pigments have their molecules suspended in a transparent medium like water or linseed oil, and here absorption can be much more exact.

Another way of mixing colors is additive mixing, used to produce different color effects in stage lighting, moviemaking, or photography. In this case, light is shone through color filters. Blue and yellow can be used separately, of course, or overlapped; if overlapped, they produce green. The green can be varied in hue by differing the intensity of the light used. If the third primary color, red, is introduced into the combination, the result will be pure white light, thus proving once again Sir Isaac Newton's discovery.

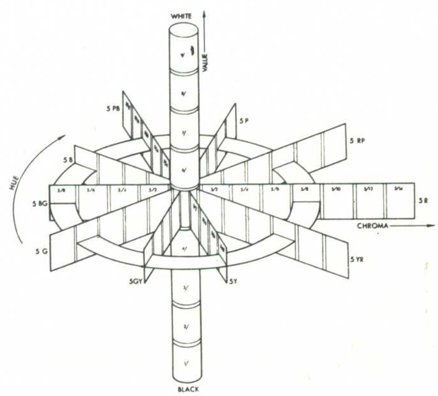
Additive mixing is used in color printing and color television. In the first step of this process, a color picture is broken up into many thousands of tiny, colored dots (they can be seen with a magnifying glass in any color print). The engraver preparing a picture for printing first photographs it through a fine-meshed screen and a filter that blocks out all colors except yellow. What is left, then, is a pattern of dots showing all the yellow parts of the picture. The process is repeated with blue-green and red; finally, black is added to provide contrast. Then the picture is printed four times on the press: first in yellow, then in blue-green, then in red, and finally in black. All these different colors overlap and intermix to reproduce the picture in all its various hues. The process for making color-TV pictures works on the same principle.

How Color Is Seen

Color can actually be seen only by humans and a select number of creatures; all other animals are color-blind. Among those who do see color are primates, butterflies, bees, fish, amphibians, certain reptiles, and some birds. Color is perceived in humans by three types of cone-shaped organs in the retina, the light-sensitive area at the back of the eye. Since color perception is a function of absorbing light of certain wavelengths, these cones are defined as absorbing the blue-violet wavelengths at one end of the spectrum, then the green wavelengths, and finally yellow and red. Colors are perceived as mixtures of these wavelengths. In certain persons, some or all of the cones are deficient; this causes color blindness, an inherited trait.

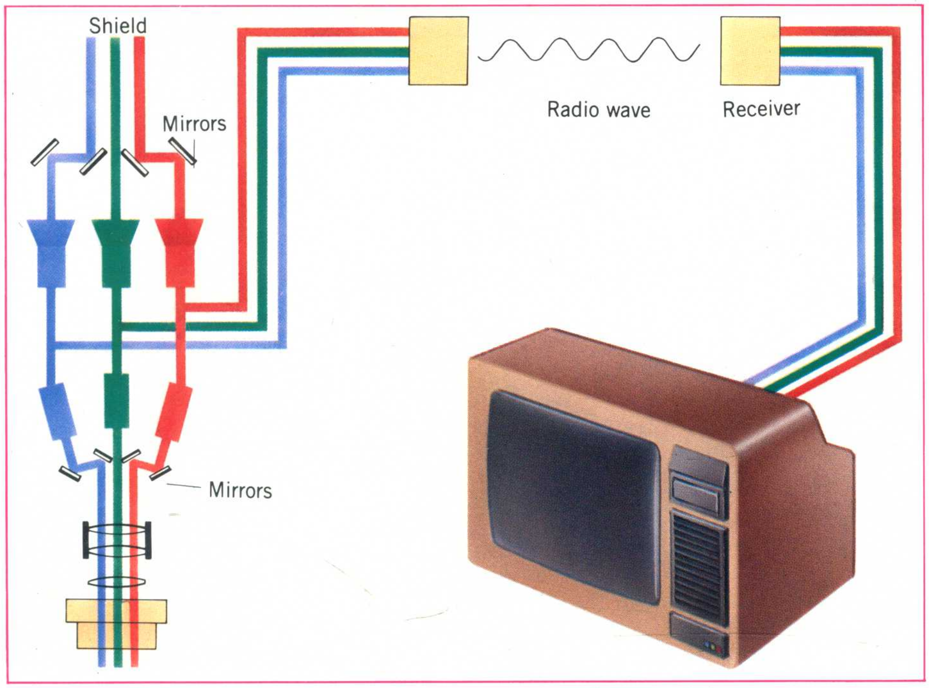
Colors have certain qualities important for how they are perceived. The aspect of color itself is called its chromaticity, which can be expressed in standard values for the purpose of manufacturing colors; the standards of the International Committee on Illumination are widely used. The method for establishing standard color values is called colorimetry and is based on the three primary colors. Colorimetry is based on objective observation of colors by an instrument called a spectrophotometer, which compares the intensity of color samples to the intensity of a standard that reflects all colors equally. The exact value of any sample can thus be accurately established, so that its color can be reproduced for manufacturing or any other purpose.

Another quality of color that needs to be defined if a color is to be accurately reproduced is its luminance, or the intensity with which it reflects light. This can be defined under standard illumination,



Above: The two color trees serve to classify colors and tints. *Top, right:* Illustration of the principle that permits color transmission by a television camera. The beam of light coming from the subject being televised is broken into 3 beams according to color. Intensity values for each of the beams are sent to the television receiver, which recomposes the image.

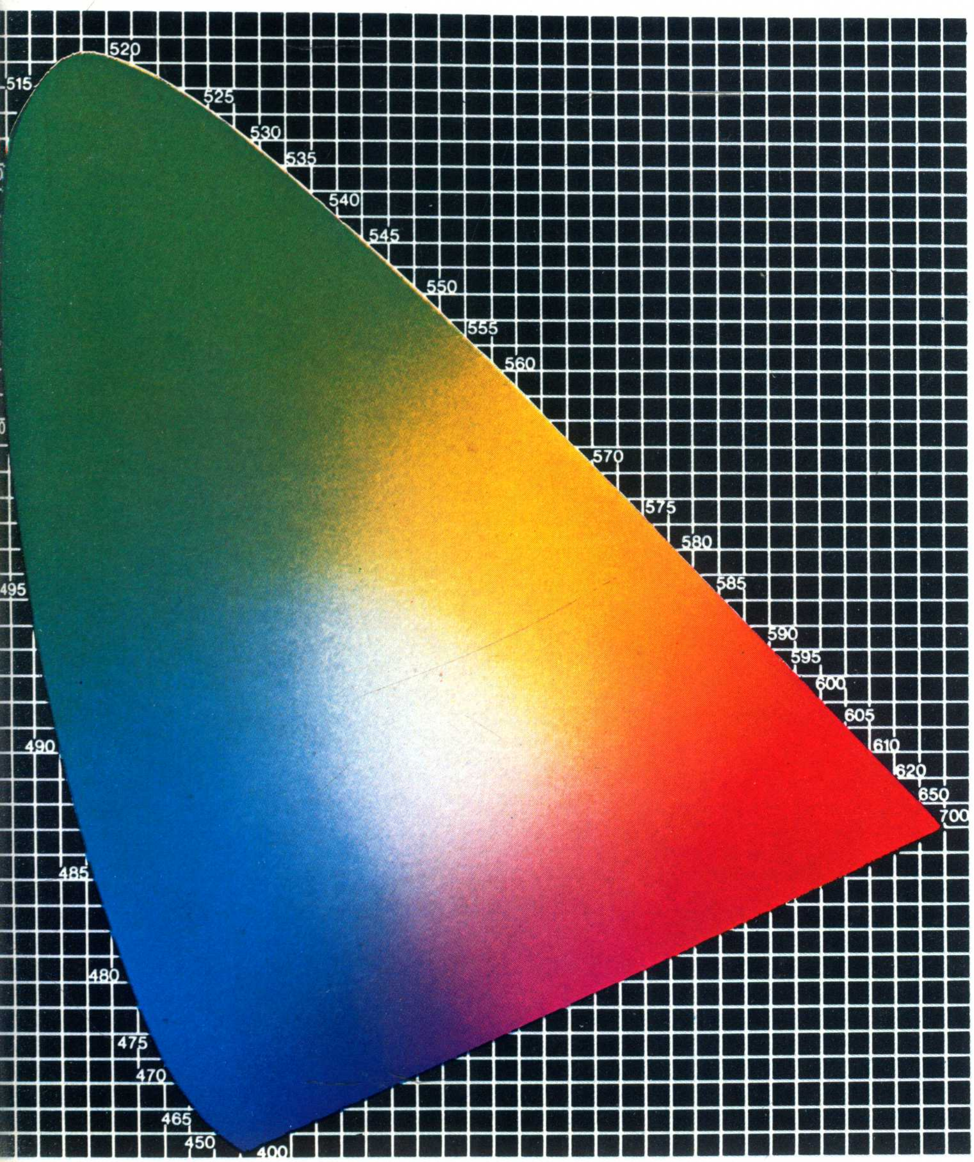
again by using a spectrophotometer. Together with its chromaticity, luminance describes the color in question completely—for example, it defines the degree of difference between a given color in a shiny or a matte finish. These definitions make it possible for interior decorators, for example, to order in quantity colors that will always match.



Brightness, Hue, and Saturation

Colors are generally referred to in terms of brightness, hue, and saturation. A bright color is an intense one, reflecting much light. Hue is a function of wavelength—so-called dominant wavelengths are red, orange, yellow, green, blue, indigo, and violet. Between these dominant wavelengths are any number of transitional hues, according to how the colors are mixed. The saturation of a color is a measure of how much white is mixed with it. Low-saturated colors are pastels, which have a lot of white mixed in—pink, for example, is red mixed with white. The opposite of a pastel is a saturated color like brown, which has little white mixed in and therefore reflects little light. The darkest, or most saturated colors, contain no white at all.

The uses to which color can be put are almost infinite. Artists use their various qualities to go far beyond the mere pictorial depiction of a subject; by contrasting colors, for example, they can evoke a mood. Rembrandt used heavily saturated colors to produce dark, somber works; Turner was a master at juxtaposing colors to produce vibrant effects like fire (red next to orange next to yellow); Vermeer produced extraordinary effects of light by mixing colors with judicious amounts of white. In the field of manufacturing, colors are enormously useful in color coding—the identification of an object or component by color—which can save untold time or labor in tracing wires, for example, in the electronics industry, or for tracing pipes in the complex plumbing of a chemical plant.



Left: Color triangle shows how intermediate colors can be classified using a trichromatic coordinate system. Each shade is identified by measuring the percentage of each of the primary colors present in a light sample and then plotting the single point on the triangle representing exactly that mixture of light.

Comet

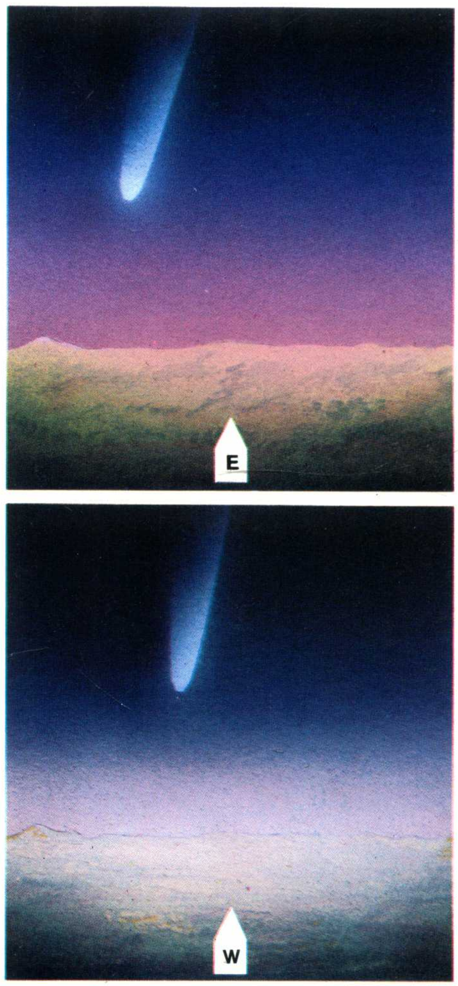
Centuries ago, comets were of even greater interest to both scientists and the general public than they are today, because practically everybody was fully convinced that they were the harbingers, that is, the forerunners, of dire disaster. Since dire disasters are never lacking in this world and comets visible to the naked eye are in short supply, whenever one of these long-tailed celestial bodies flashed dramatically into our part of the Universe, there was never any lack of deaths or destruction for crepe-hangers to blame on its baleful influence. Terrified eyewitnesses to the passage of comets never seem to have had any trouble in seeing them as blood-red and multiheaded like mythological beasts, or equipped with savage talons 100,000 miles (160,000 km) long.

Modern astronomers are less awed by comets. Fred Whipple, formerly director of the Smithsonian Astrophysical Observatory and one of the great comet-watchers (and discoverers) of all time, has said that a comet is simply a "dirty snowball"—and we might add "in an exaggerated elongated, salamilike orbit around the Sun." The "dirty snowball" epithet refers to the fact that a comet's nucleus, or head (as opposed to its streaming tail), is made up mostly of solid, frozen gases (methane, ammonia, hydrocarbons, carbon monoxide, and many others). But absurd ideas die hard, and even as late as 1973, we find a British outfit called the Children of God greeting the arrival of Comet Kohoutek with a broadsheet screaming "40 DAYS! and 'Nineveh shall be destroyed!' "—the 40 days extending from Dec. 21, 1973 ("winter's darkest day!"), until Jan. 31, 1974, when the world was supposed to come to an end. Some American astrologers recognized Comet Kohoutek as a harbinger of the Nixon administration's Watergate caper, just as 10 years before, the appearance of Comet Pereyra was taken by the gullible as being prophetic of the assassination of President John F. Kennedy.

"Hairy Stars"

The word "comet" comes from the Greek *kometes*, meaning "long-haired," a term descriptive of the streaming tail of many comets, which in some cases may stretch out into space as far as 300 million miles (500 million km), as in the case of the Great Comet of 1843. Almost all of the matter contained in a comet is concentrated in the head. When the comet is far out in space, hundreds and hundreds of millions of miles from the Sun, it is a frozen mass, roughly spherical in shape. As it nears the Sun, its frozen gases liquefy and then vaporize. The vapor, streaming out behind the head, begins to glow brightly under the influence of ultraviolet light from the Sun.

Comets are dramatically impressive when recorded on an astronomer's photographic plate, but their tails are of such thin consistency that their mass (the quantity of real matter distributed over their incredible length) gives them a density that is actually lower than the density of the most perfect vacuum that physicists have been able to produce on Earth. When Halley's Comet, the most famous of the breed, was last observed in 1910, it passed between the Earth and the Sun, but it was too transparent even to cast a shadow. Since even the biggest comets may have less than one-millionth the mass of the Earth, one astronomer has dismissed them as "bags full of nothing," possibly forgetting that even a millionth of the Earth's mass is still 6.6 $\times$ 10^{15} tons.



Above: Because of the relatively low luminosity of comets, they are best observed in conditions of half-light: in the east, at dawn; in the west, at dusk.
Right: Structure of a comet. The dust tail bends because of pressure from solar wind.

此为试读，需要完整PDF请访问：www.ertongbook.com