# Chapter 17 HOW LIGHT BEHAVES

Light is familiar to us as the information carrier which our eyes detect and therefore, that which enables us to see. This is a good working definition, but it tells us very little what light really is, how it behaves, and why it behaves as it does. We will take up such issues in the present and the following seven chapters.

While light is a very complicated phenomenon, there is quite a bit we can say about it without complicated mathematics. For laboratory work you have two of the best light detectors there are right in the front of your head. Also, many properties of light like reflection which comes under study in this chapter, are already familiar to you on at least an intuitive notion, but your intuition will always provide a useful inroad into anything related to light. You can always ask yourself, "What do I see?"

In this chapter we will be introduced to two of the most important properties of light: its characteristic speed and the phenomenon of reflection. The treatment of these concepts combine with an introductory discussion in the text to provide a necessary basis for your understanding of more complicated, and more interesting properties of light.

## PERFORMANCE OBJECTIVES

After completing this chapter you will:

1. be able to answer the following questions:

   a. How does light get started?

   b. From what kinds of material does it come?

   c. What happens to light when it hits an object?

   d. Are there devices, other than the eyes, which are sensitive to light?

   e. Does light go in straight lines?

   f. Does light appear simultaneously at different places or does it travel with some definite speed?

   g. How do we determine the location of an object that we see?

2. be able to state the primary and secondary colors of light.

3. be able to differentiate between color addition and color subtraction.

1. Film: INTRODUCTION TO OPTICS 23 MIN (Film notes provided.)

2. Suppose a person exactly like you or your instructor suddenly appeared out of the floor. This person however has no eyes and knows nothing about light. In one page or less, write how you would explain to this person what light is. Have instructor evaluate your ideas.

3. Read: Section 17-1 Sources of Light page 353
   Section 17-2 Transparent Materials page 354
   Section 17-3 Reflection page 357
   Section 17-4 Light Sensitive Devices page 359

4. Does colored glass add or subtract something from white light?

5. Problems: page 358: #4 #5 #6 #7
   page 369: #18 #19

   Ask instructor to set up Sunset Demonstration.

6. Obtain a green power source, light bulb, socket, and spectroscope. Plug the socket into the 0-120 volt outlet of the power source, set the rheostat dial (the dial on the front of the power source) to zero, plug in and then switch on the power source. Adjust the voltage from 0 to 120 volts by turning the rheostat. While doing this, observe the color change first with your eyes and then using a spectroscope.

7. Problems: page 369: #22 #23

8. Read: Section 17-5 How Light Travels page 359
   Section 17-6 The Speed of Light page 360

9. What is the speed of light in:

   a. m/sec? b. cm/sec? c. miles/sec?

10. Problems: page 362: #10 #11

11. Read: Section 17-7 Shadows page 362
    Section 17-8 Light Beam, Pencils, and Rays page 363
    Section 17-9 How We Locate Objects page 367

12. Problems: page 363: #12 #13 #14
    page 369: #24 #25 #27

13. Two street lamps, 20 meters apart and 20 meters above the ground, are placed 15 meters in front of a brick wall, which is 20 meters long and 10 meters high as shown on an enclosed sheet. Locate the regions of dense shadows and partial shadows. To check your work, use apparatus that the instructor has set up for this purpose.

14. Color, a topic not included to any great detail in this text is a very interesting topic. Below are listed some activities that may interest you. All are optional.

    a. Complete enclosed 10-question quiz titled "A COLORFUL QUIZ". An answer sheet is also provided.

14. b. Further examine:

    1. Singerman Color Apparatus which is used to demonstrate:

        a. Color Addition

        b. Color Fatigue

        c. Complementary Shadows

    2. Blinkin-Dwight Filtergraph which is used to demonstrate subtractive color mixing.

    3. Black Light which is used to locate Fluorescent objects.

    c. Booklet - COLOR TREE - BY Interchemical Corporation

    d. Booklet - LIGHT AND COLOR - by General Electric

    e. Articles in this packet:

        1. Color Photography

        2. How Polaroid Color Film Works

    f. Booklet - HUMAN VISION - Carolina Biological

    g. Color Blindness Test Book - Using Pictures

    h. Color Blindness Test Materials - Using yarn

    i. Investigation: Color Test

15. Why do you suppose that Kodak would get extremely upset if you as a film maker (i.e. film for cameras) marketed your product in yellow boxes?

16. Look at soap advertisements on T.V. and see if they advertise cleaner, whiter, brighter, nice smelling or whatever clothes.

17. No quiz or test for this chapter. Proceed to chapter 18 which pertains to reflection and images.

## ANSWERS CHAPTER 17

4. Subtract
5. (4) S.A.B. (5) moon illuminated by light reflected from the earth
   (6) S.A.B. (7) Is right side up (18) (19) S.A.B. (ask for demo.)
7. (22) $9.9 \times 10^5$ m (23) S.A.B.
9. (a) $3 \times 10^8$ m/sec (b) $3 \times 10^{10}$ cm/sec (c) 186,000 mi/sec
10. (10) (a) 500 sec (b) $4.1 \times 10^{16}$ m
    (11) (a) $1.6 \times 10^{-2}$ sec (b) $4.0 \times 10^8$ m
12. (12) yes if screen is moved back far enough
    (13) increase distance between source and obstacle or decrease distance between obstacle and screen
    (14) (24) S.A.B. (25) (a) S.A.B. (b) $1.4 \times 10^9$ m (37) S.A.B.
15. Ask instructor

## TEACHER'S GUIDE TO THE PSSC FILM

# INTRODUCTION TO OPTICS (23 min.)

E. P. Little, PSSC

The aim of this film is to introduce the student to some of the more important aspects of the behavior of light; to those experimental observations which support the idea that light propagates in straight lines, and to various ways in which the direction of propagation may be changed.

**Summary:**

The sharpness of the shadow of an opaque object illuminated by a small source is presented as the basic evidence for the rectilinear propagation of light. The fuzziness of shadows cast by objects illuminated by large light sources is demonstrated and explained. It is then shown that even with a very small source, close examination of the shadow - especially near the edges - discloses the phenomenon of diffraction. Thus the statement that light travels in straight lines is one of limited validity.

The change of direction of propagation of light is demonstrated by scattering from smoke particles, by specular reflection, and by refraction. Reflection from a thin soap film is shown to demonstrate interference - not referred to by name - and the phenomenon of total internal reflection is also shown and discussed.

**Points for Discussion and Amplification:**

(a) In the first experiments on the sharpness of shadows, one must distinguish clearly between the fuzziness arising from the finite size of the source and the effects of diffraction. To do this one might first discuss the effect of source size with the help of simple geometrical examples (see pages 12-3, 4, and 5 of the Teacher's Guide) and then look at diffraction only for the case of a point source. By a point source is meant one whose linear dimensions are very small compared to those of the object casting the shadow and to all the other distances involved in the observation. Diffraction occurs at the edge or edges of the illuminated body and shows that one can indeed "see around a corner," although only a little bit. This deviation from strict rectilinear propagation of light must be accounted for by a theory of light.

(b) In talking about reflection, refraction and scattering as phenomena illustrating the change of direction or propagation of light, it may be well to emphasize that all these effects depend on the interaction of light and matter, and especially that they depend sharply on the physical properties of the materials employed. This is in sharp contrast to diffraction, which does not so depend on the material body used and thus discloses something about the nature of light itself.

# Introduction to Optics - (2)

It may help to point out that diffuse reflection can be considered a special case of scattering. Scattering, reflection and refraction are all aspects of the same fundamental physical process - that of the response of matter to light incident on it.

(c) The reflection from the soap film and the resulting interference pattern, thought of as the addition of reflected light from two surfaces of the film, disclose a remarkable property of light. Two light beams added together under the right conditions can produce darkness, i.e. they can nullify each other. This is something one must eventually consider. (Section 19-9 of the text.)

(d) For students interested in making soap films that will last so they can be studied or photographed, all that is needed is a concentrated solution of any liquid detergent enclosed in a small box. The advantage of the closed box is that the air inside becomes saturated with water, and the higher the humidity the more difficult it becomes for the film to evaporate.

(e) Point out that refraction is always accompanied by reflection. The increase of intensity of reflected light and the accompanying decrease in the intensity of the refracted light as the beam approaches grazing angle of incidence or the critical angle, while interesting, is not essential to the story of this film.

(f) The last experiment, producing a single image from three pinhole images with the help of a lens, should be discussed in terms of the action of the lens refracting the light beams from the three pinholes in such a way that they coalesce and form a single image on the ground glass (page 14-11, Teacher's Guide).

(g) The film opens with the observation, "You are about to start the study of light. Naturally, many of you will want to know what light is. You probably feel that if you know what light is, you can tell what it will do. But this is not the way to start the study of anything. What you should do first is to find out how light behaves. As you learn how it behaves you will gradually form a concept of what light is."

It would be well to insert the word "scientific" in front of "study" in the fourth sentence of this quotation. People do pursue other avenues of seeking knowledge, which are exemplified in the studies of religion and philosophy.

# COLOR PHOTOGRAPHY

For convenience of study, the chapter on color photography is divided into several parts.

THEORY
- a) Light - the primary colors, color separation
- b) The tricolor technique
- c) The subtractive color process
- d) Color temperature

PRACTICE
- a) Lighting for color photography
- b) Color correction filters
- c) Processing color films

## LIGHT

Light is the energy which by its action upon the organs of vision produces sight. (Webster) It travels in waves, the length of which can be measured in millimicrons. To affect the human eye, these wave lengths must be within the approximate range of 400 to 700 millimicrons. White light is the total addition of all the wave lengths of the visible spectrum. Colored light is any part of the visible spectrum less than the total. In the discussion of color photography, we will consider only the visible spectrum since the other wavelengths of energy which can affect a photographic emulsion (e. g. ultraviolet or x-rays) have only a detrimental effect on the emulsion.

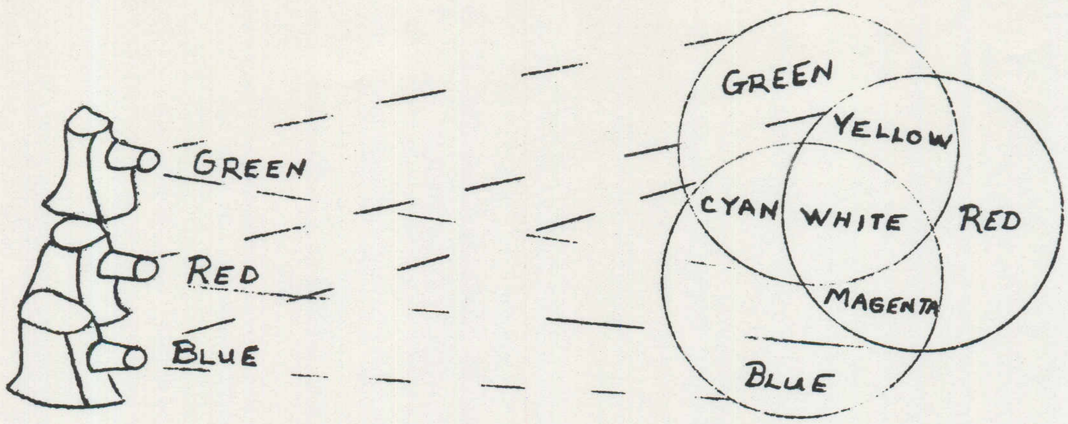
### The Selective Absorption of Light

Most objects in nature have the ability to absorb certain wave lengths of light while reflecting others. We say these objects are "colored." A white object reflects all colors equally. A red object reflects most of the red light which strikes it while absorbing most of the green and blue light. In the case of transparent objects, the light which is not absorbed is transmitted through the object to the eye. No object in nature has a perfect reflection or absorption of any color. Therefore, a little of each color is reflected from all objects and some of each color is absorbed.

## THE PRIMARY COLORS

The primary colors are formed by dividing the spectrum into three approximately equal parts. These primary colors are blue (400 to 500 millicrons approximately), green (500 to 600 millimicrons approximately), and red (600 to 700 millimicrons approximately.

To avoid confusion, remember the photographer uses light primaries Red, Green, Blue, while the artist uses pigment primaries Blue-green (cyan), Magenta, and Yellow. The three primary colors may be projected upon a white screen to give white light and complementary colors.




Two primary colors projected upon a white screen will give the complementary color of the third primary color.

Blue light plus red light projected upon a white screen yields magenta, the complement of green.

Blue light plus green light projected upon a white screen yields cyan. Cyan is the complementary color of red. (Cyan is a term coined to indicate this particular color).

Red light plus green light projected upon a white screen yields yellow, the complementary color of blue.

THE TRI-COLOR SEPARATION TECHNIQUE

This technique for the production of color pictures photographically was demonstrated by Clerk Maxwell in 1861. It consisted of photographing a scene making three separate negatives, one each through a red, a green, and a blue filter. The negatives were processed in the usual way and positive transparencies (lantern slides) made of each. Since the blue filter absorbed all the colors coming from the subject except blue, only the blue rays affected the negative. The positive lantern slide made from this negative was dense where there was no exposure and thin where there was a heavy exposure. It, therefore, permitted light to pass in proportion to the amount of blue light reflected in the original scene. In the same way, the picture made through the green filter recorded only the green of the scene and the red filtered negative recorded the red of the scene. The lantern slides were projected on a single screen using three projectors mounted side by side so that the three images were superimposed. When the filters used to make the original negatives were placed in front of the projectors, a full color picture resulted. This method of separating the visible spectrum into three approximately equal parts and recording each part separatly is the basis of modern color photography, except that instead of using three separate films, we obtain the separation in different layers of a multilayer film.

THE SUBTRACTIVE COLOR PROCESS

The subtractive color process utilizes selective absorption by the complimentary colors, each of which is capable of absorbing one primary color. White light projected through a yellow filter yields yellow. (The blue is removed) White light projected through a magenta filter yields magenta. (The green is removed) White light projected through a cyan filter yields cyan. (The red is removed) White light projected through a yellow filter, then through a cyan filter yields green. (Blue and red are removed) White light projected through a yellow filter, then through a magenta filter yields red. (Blue and green are removed) White light projected through a cyan filter, then through a magenta filter yields blue. (Red and green are removed) White light projected through all three filters yields black. (Blue, green, and red are removed leaving no light)

The film used in the subtractive color process, called an Integral Tripack, consists of three emulsions coated upon a film base, each film layer being separated from its neighbor by a layer of gelatin. The emulsion nearest the film base is a special panchromatic emulsion. The middle layer is an orthochromatic emulsion. The top layer is a blue sensitive emulsion. The gelatin layer between the top (blue sensitive) emulsion and the middle (green sensitive) emulsion is dyed yellow to absorb all blue light.

blue sensitive emulsion & yellow dye former
yellow dyed gelatin
green sensitive emulsion & magenta dye former
clear gelatin
red sensitive emulsion and cyan dye former

film base

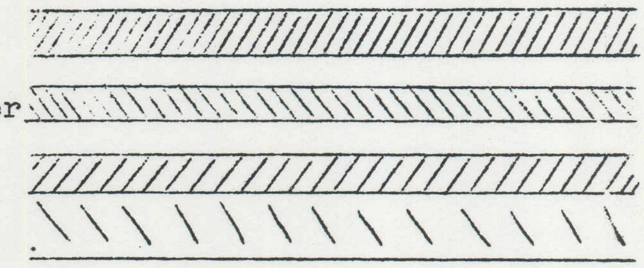


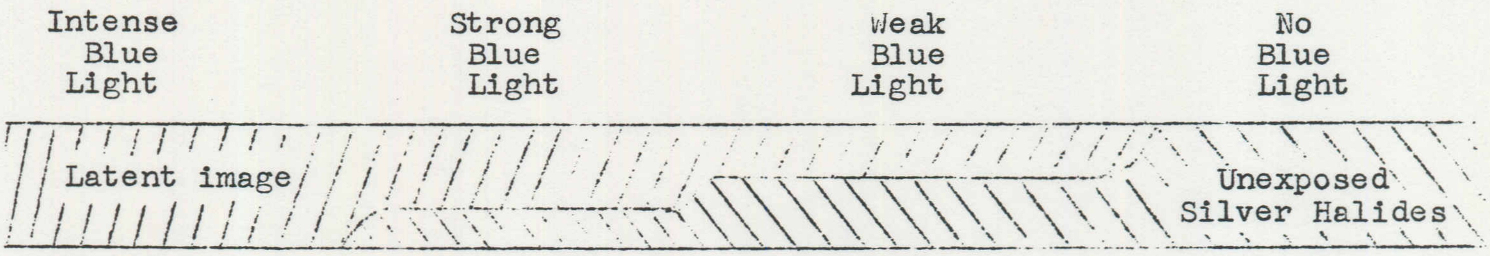
DIAGRAM OF A REVERSAL
COLOR FILM

Incorporated in each of the emulsions is an organic dye former. This compound is capable of being changed into a colored dye by the action of oxidation products formed by the reaction of the color developer solution and light struck silver bromide. It will be noted that the dye is formed only where the re-exposed silver bromide is developed forming a positive image.. No dye is formed during the first development (the negative image) since the oxidation products of the first developer do not react with the color former.

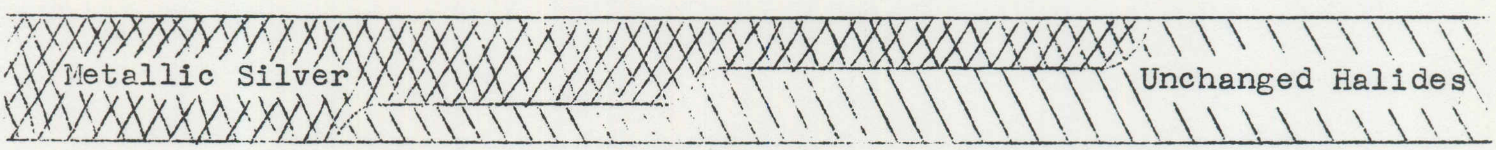
The dye former in each emulsion layer is of such a nature that it yields one of the complimentary colors. The dye former in the top (blue sensitive) layer yields yellow. The dye former in the middle (green sensitive) layer yields magenta. The dye former in the bottom (red sensitive) layer yields cyan.

To simplify the study of what occurs in a color film, consider one emulsion layer of the film by itself. What occurs in this layer also occurs in the other two except that they react to different colors. The top layer, being color blind, records only the blue light which strikes it and is not affected by other colors.

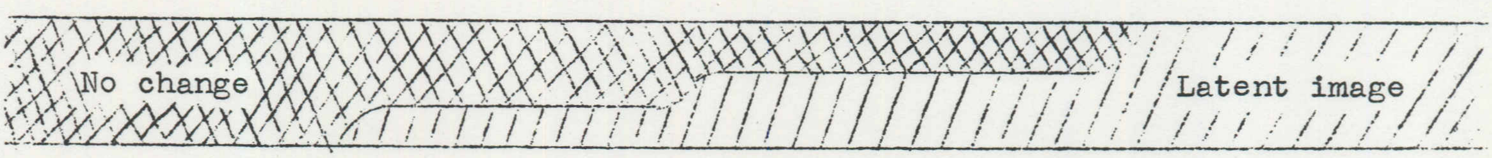
It controls the amount of blue light which reaches the screen on projection. The more yellow dye present, the less blue light reaching the screen. This layer could, therefore, be called the "minus blue" layer. In the same way, the middle layer which recorded the green image could be called the "minus green" layer and the bottom layer is the "minus red" layer. In the following outline, the short stops, hardening and washes are omitted for brevity:



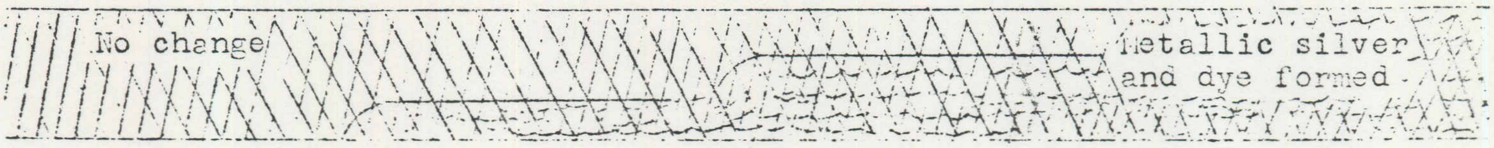

1. Exposure in a camera results in a latent image being formed.



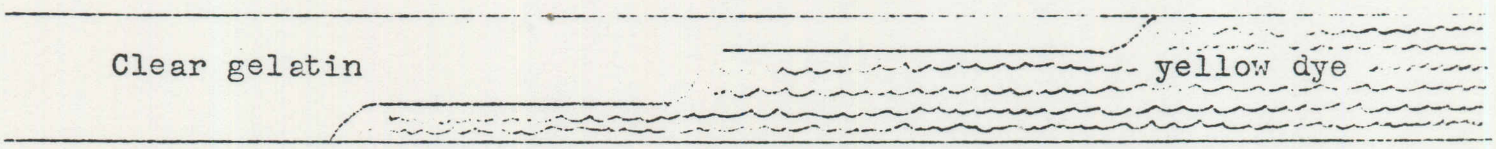

2. In the first development, a negative silver image is formed but no dye is deposited.



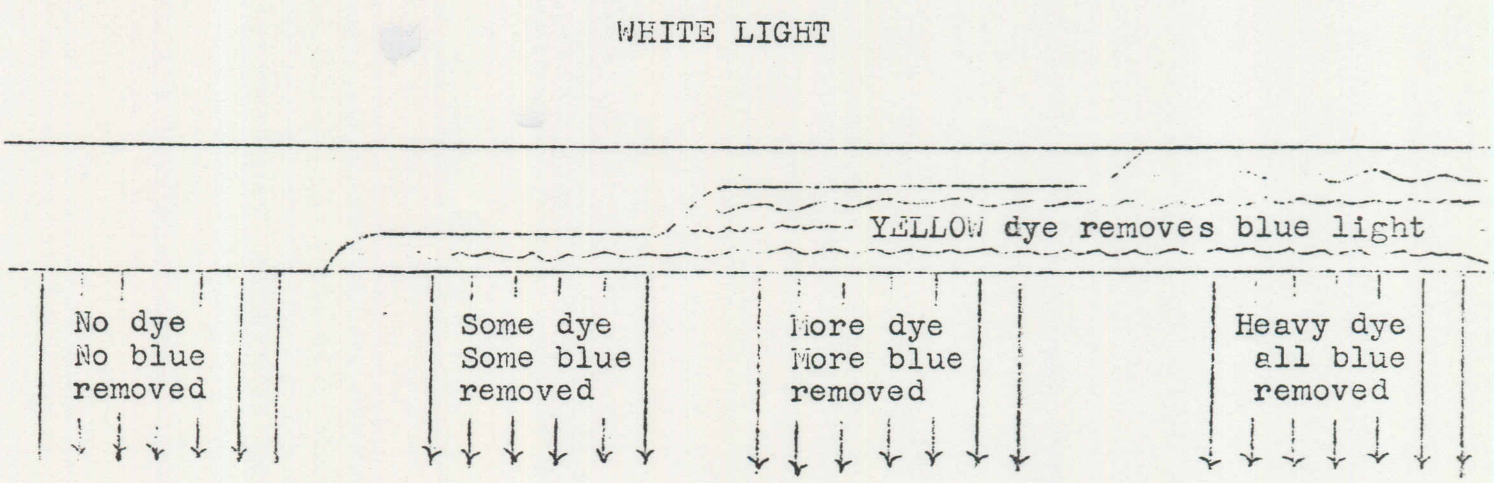

3. Reexposure fogs all of the remaining halides.




4. Color development produces positive silver image and a dye image both being deposited in the same place and in the same proportions.

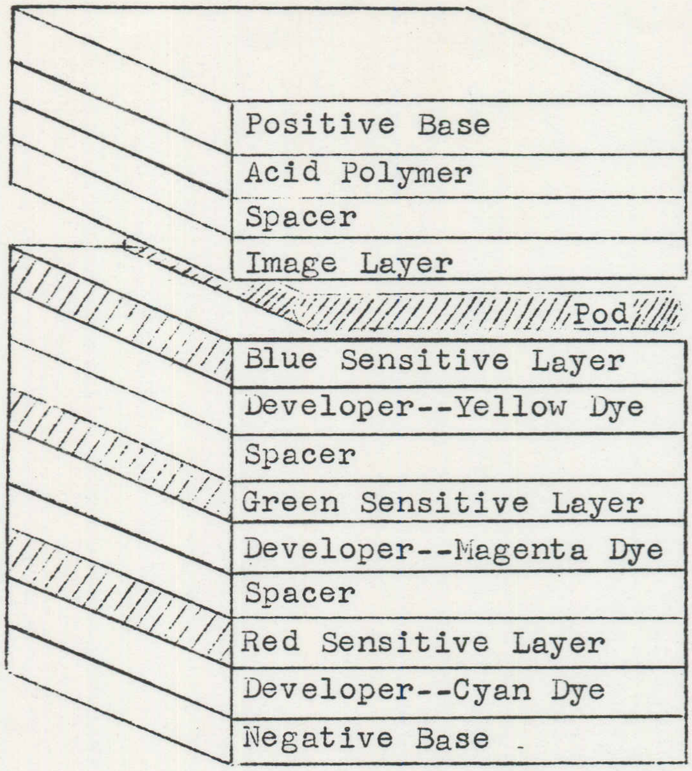



5. Bleaching and clearing removes both the positive and negative silver images, but none of the dye image.




6. White light projected through this layer loses its blue component in proportion to the density of the yellow dye.

HOW POLAROID COLOR FILM WORKS




Polaroid color film is a 13-layer sandwich of ingredients, shown above in a huge cross-section model. Its nine lower layers represent the film's negative which records the image focused by the camera's lens. The four upper ones are the positive paper on which the negative image is, in turn, printed. In the middle of the sandwich is a long skinny envelope called a pod, containing reagent jelly--the "goo." When the film is pulled through the camera after exposure, rollers spread the goo thinly between negative and paper. The released goo triggers the processing.

In the negative are three layers of silver grains sensitive respectively to the blue, green and red parts of the spectrum. Next to each is a layer of the newly devised chemicals combining a developer and dye. During processing these dyes migrate to the image layer (just above the goo), where they form a color picture.

How the dyes are directed to migrate is the key operation. It is a complex process, perhaps best demonstrated by the example of the two layers at the top of the negative in the model--the blue-sensitive layer, a layer sensitive only to blue light, and thelayer below it which contains developer linked to yellow dye. Yellow is a color opposite to blue--a complementary color. When the blue-sensitive layer is exposed to light, its silver grains keep the complementary yellow dye from moving up to the positive. But it freely lets the two other dyes in the negative, magenta and a blue-green called cyan, go through to the top. There they combine to form blue in the image. Similarly the green-sensitive layer blocks its opposite, magenta, and the red layer blocks its opposite, cyan. Once in the positive, the dyes are held fast in the image layer, where the acid polymer and spacer layers carry out a chemical reaction to seal them in the finished picture.

(Vol. 54, No. 4 January 25, 1963 Life Magazine)

# A COLORFUL QUIZ

Pastel pint for little girls and powder blue for little boys--those are the colors that parents choose. If it were up to the children, their preference might be much different. (Answers on the back.)

## QUESTIONS

1. At what age is the lens of your eye most sensitive to the transmission of blue and violet colors?
   (a) 40 years (b) 21 years (c) 6 years

2. What color walls are best for a person with high blood pressure?
   (a) pink (b) blue (c) yellow

3. What color of toys or clothes delights a child under six the most?
   (a) red (b) green (c) blue

4. Which parts of your eye gives you color perception?
   (a) cones (b) rods (c) blind spot of the retina.

5. Approximately how many colors are considered different commercially?
   (a) 5,000,000 (b) 500,000 (c) 50,000

6. If a surgeon is operating, what color should the walls of the operating room be in case he looks up?
   (a) white (b) green (c) yellow

7. In an atomic blast, you would be LEAST protected from burns if you were wearing
   (a) gray suit (b) white suit (c) black suit

8. What causes the rainbow in a soap film?
   (a) Interference (b) Diffraction (c) Refraction

9. The color most visible to you is:
   (a) red (b) orange (c) yellow

10. Which light would you use to pep up a party?
    (a) rose incandescent (b) blue fluorescent (c) yellow incandescent

ANSWERS A COLORFUL QUIZ

1-c A young child with normal vision has very clear eye lenses. As one ages, the lens becomes slightly pigmented. This process reduces the absorption of short wave lengths of light for transmission to the retina. The cornea and the fluids in the eye also have an effect, but that of the lens pigment is greater. The nerve area near the central fovea of the retina is covered with some pigment too, which prevents over-stimulation of the retina by light rays, especially ultra-violet and violet.

2-b Blue is the most cooling and relaxing color. A European uses blue in the surroundings of a patient with high blood pressure and red in those patients with low blood pressure. It uses amber yellow for those with mental trouble. The warm colors (red, orange, etc.) stimulate. The cool colors (blue, green, etc) soothe.

3-a Children and primitive people respond strongly to pure colors. Of these, children like red best and blue least. A child under 6 chooses red always unless he has been conditioned against it by an unhappy association. Yet parents dress their children in pinks and blues when the truth is the kid wants red!

4-a The cones are largely concerned with day vision. They are most sensitive in the foveal pit, where about 50,000 are packed. They give you high visual acuity and color vision. Rods in the retina (some cones, too) are effective in night vision. In dim light, color perception is not reliable. There is some evidence that the cones in the central fovea are not sensitive to the blue end of the spectrum, so rods may play a part in color vision at this end.

5-b Business and industry recognize about 500,000 colors. Actually the normal eye under the best viewing conditions can recognize surface colors estimated in the millions. For simplicity, the National Bureau of Standards method for giving precise meaning to the names of colors list 267.

6-b The walls should be green. When you stare at red, you see green, its complementary color, on a white wall. This effect is the "after image". A surgeon looking at red blood would see a green after-image on a white wall if he glanced up. If the wall were green, however, the after image of green would be negligible, and his vision would recover quickly when looking back at red blood.

7-c The darker your clothes, the worse your burns would be. Dark clothes absorb light. Light ones reflect it. Light absorbed is converted into heat. Hiroshima victims who were wearing prints had the pattern of the print etched into their flesh in deep burns where the print pattern was dark but only surface burns where the print tones were light.

8-a When light falls on a soap film, some is reflected from the outer surface, and some is reflected from the inner surface. Depending upon the thickness of the soap film at the moment, the two reflected components for a particular wave length may come to your eye opposite in phase and cancel each other. What you see is the rest of the white light-a display of colors. Because the soap film constantly changes in thickness, various colors appear as various wave lengths are interfered with.

9-c Yellow has the greatest visibility. Research proves many people dislike yellow however; 40% have an aversion to it, but less than 10% to red, green, or blue. Most men and women like blue best. Because yellow is so good for visibility, school buses are usually yellow. Children's raincoats are often bright yellow. Industry uses yellow on machinery projections and low beams. Highways have double yellow lines.

10-a According to color specialists, rose or magenta-red light bulbs work like a charm at any party. Everyone sees everyone else through "rose-colored glasses". Even the food looks better in a warm light. At a canteen with different lights on opposite sides of the room, the side with warm lights always filled up. The other side did not. Under cold light, the margarine looked green, but it became rich butter under the mellow fluorescent!

# INVESTIGATION: CHAPTER 17 LET THERE BE COLOR 1

A. Using the end of the light box fitted for holding filters, direct a beam of white light on to each of the colored cards in the kit. Place a red, orange, yellow, green, blue, violet, cyan, magenta, and yellow filter separately in the white beam and record the observed color of the card when illuminated by the different colored beams.

The color of an object is explained by stating that white light is composed of many colors and that a white object reflects all of these colors. Thus a red object absorbs all the colors except red, which it reflects, making the object appear red.

If however, the red is filtered out of the incident light by using a blue-green (or cyan) filter, then the red object absorbs the incident cyan color and reflects nothing.

Check your observations against this theory.

| Color of Light On Object | Color of Object When Its Color is: | | | | | |
|---|---|---|---|---|---|---|
| | Red | Orange | Yellow | Green | Blue | Violet |
| Red | | | | | | |
| Orange | | | | | | |
| Yellow | | | | | | |
| Green | | | | | | |
| Blue | | | | | | |
| Violet | | | | | | |
| Cyan | | | | | | |
| Magenta | | | | | | |

Familiarize yourself with the colored filters and cards and predict how the following colors should appear:

a. A blue object, illuminated by red and seen with the naked eye.

b. A red object, illuminated by orange and seen through a yellow filter.

c. A blue object, illuminated by red and seen through a yellow filter.

d. A red object, illuminated by orange and seen with the naked eye.

e. A red object, illuminated by orange and seen through a blue filter. etc.

B. Illuminate the various cards with white light, and holding the filter close to your eyes, observe the cards. Record your observations.

| Color of Filter In Front of Eye | Color of Object When Color of Object is: | | | | | |
|---|---|---|---|---|---|---|
| | Red | Orange | Yellow | Green | Blue | Violet |
| Red | | | | | | |
| Orange | | | | | | |
| Yellow | | | | | | |
| Green | | | | | | |
| Blue | | | | | | |
| Violet | | | | | | |
| Cyan | | | | | | |
| Magenta | | | | | | |

C. Using the side positions together with the end of the light box, project three colored beams on to a white card. Make the first set of colors red, blue, and yellow. (Note...Place the weakest color in the end position of the light box and the stronger colors at the sides. This compensates for loss of intensity during reflection from the side mirrors.) Move the mirrors to cause the beams to overlap and record your observations. Use the other filters and work out all possible combinations.

| Color of one Filter | Color of Region of Overlap when the other Filter is Color: | | | | | |
|---|---|---|---|---|---|---|
| | Red | Green | Blue | Cyan | Magenta | Yellow |
| Red | Red | | | | | |
| Green | | Green | | | | |
| Blue | | | Blue | | | |
| Cyan | | | | Cyan | | |
| Magenta | | | | | Magenta | |
| Yellow | | | | | | Yellow |

D. What combinations give white light, or close to it when mixed? Combinations that do this are called COMPLEMENTARY COLORS.

______________ + ______________ ______________ + ______________

______________ + ______________ ______________ + ______________

______________ + ______________ ______________ + ______________

Add three colors to make white, then remove any one of them by moving its mirror. How does the color left on the screen compare to that removed?

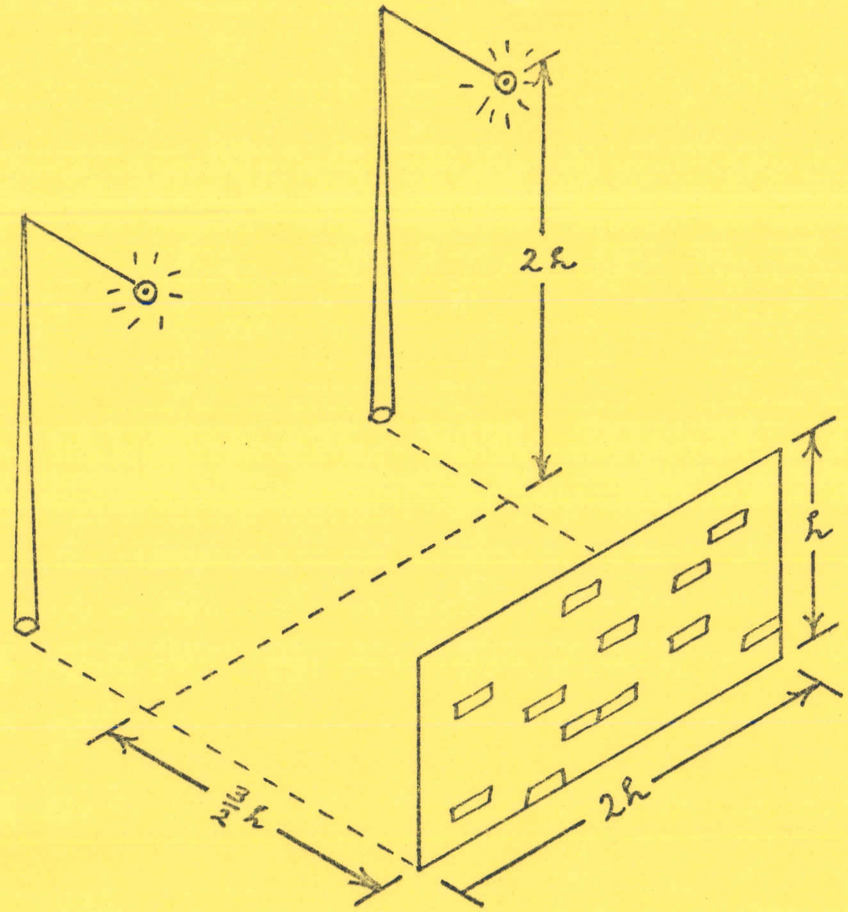
The three colors used are 1 __________ 2 __________ 3 __________

The complementary color for 1 is ________________

The complementary color for 2 is ________________

The complementary color for 3 is ________________

Note....You will not be asked to turn in a written laboratory report for this investigation. However, there will be a quiz, some of it based on observations at the conclusion of this activity.



2h
h
2h
$\frac{3}{2}h$

TEST - Chapter 17 Name____________________

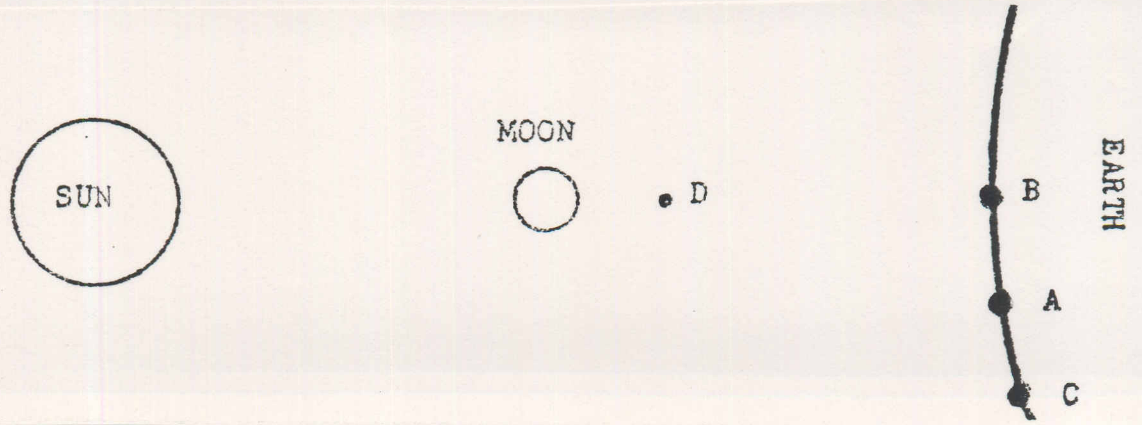
1. What was the conclusion reached as a result of our discussion of the question, "What is light?"?

2. The speed of light is $3.0 \times 10^8$ m/sec. If it takes light 8.3 minutes to reach the Earth from the sun, what is the distance between the Earth and the Sun?

3. The minimum distance between Earth and the planet Pluto is known to be $5.74 \times 10^{12}$ meters. What is the minimum time to send a message to Pluto and receive an answer?

4. Explain why some shadows are sharp and others are fuzzy. Draw a diagram to illustrate your answer.

5. Make a sketch showing what a person would see when looking toward the Moon from points A, B, C, D in the diagram below.




Bonus...Assuming ideal viewing conditions and a distance of three meters per floor in a tall building. If you see sunset at 9:00 p.m. on the tenth floor, what time will it be when people on the 110th floor see the same sunset? (You may ask your instructor for needed information. He may or may not answer, however.) (Answer on the back.)