AT-20

Photography in Your Science Fair Project

INTRODUCTION

These web pages will give you detailed instructions on how to more effectively use photography in your science fair project. The suggestions on how to improve your photographs actually apply more broadly than just to a science fair project. If you follow these suggestions, your own personal or vacation pictures will be better. Also, these suggestions will help you run better scientific experiments. Because the data gathering step of many scientific experiments must be carried out with the use of photography, these suggestions will apply to experiments you carry out throughout your life. If you learn these techniques and use them in your experiments, you will be a better scientist or engineer.

These web pages will describe techniques on how to use photography to gather the raw data in an experiment, to record how the experiment was carried out, and to clearly present the results and conclusions of your experiment. Some experiments can only be carried out with the use of photography, while others are much easier to carry out if photography is used. Almost all experiments can be more clearly explained with photography.

Throughout these web pages, the emphasis is on conventional photography using a camera and photographic film. For most people (and most applications), this is still the least expensive and easiest way to use photography in an experiment. However, the techniques described here apply equally well to digital or video cameras. When using these newer technologies, you will have to present your images on a computer monitor or you will have to make hard-copy images such as thermal prints, inkjet prints, or slides. Likewise, with a conventional film image, it is easy to scan the film and convert the film image to digital image for use in a computer and display on a computer monitor. Clearly, conventional and digital photography are coming closer together and in many cases the choice of which to use in a particular experiment comes down to questions of what equipment is available to you or what will give you better results for the particular experiment you are running.

As you will see as you read these web pages, the use of a camera, which has f-stop and shutter controls, which you can set, will give you more flexibility in taking the photographs. This greater flexibility will sometimes allow you to capture the optimum image needed in your experiment. Therefore, you will find these types of cameras described more often. Also, cameras with interchangeable lenses will allow you more freedom to capture the image that is best in your experiment. Both digital and conventional film cameras are made with these features and can be used. However, automatic exposure cameras, fixed lens cameras, and even one-time-use cameras may be very effectively used in many experiments. The differences are flexibility and freedom of control of the captured image. The techniques described in these web pages are applicable to all of these cameras.

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Eastman Kodak Company INTEL International Science and Engineering Fair Award

For those regional science fairs affiliated with the Intel International Science and Engineering Fair (ISEF), Eastman Kodak Company offers a special award to the student making the most effective use of photography in a science fair project. The project itself need not be concerned directly with the science of photography. Especially good photographic documentation, outstanding photographic display techniques, imaginative incorporation of photography in undertaking the project, appropriate photographic illustration of the subject, photography used for data collection or data analysis, etc. make a project eligible for consideration.

The award consists of a Kodak camera kit and Kodak photographic publications. A matching award will also be sent to the science department or sponsoring teacher of the school in which the student is enrolled.

PHOTOGRAPHS HELP
YOUR SCIENCE FAIR PRESENTATION

An experienced science-fair-judge puts it this way: "Most exhibits utilize photography with the main impetus to record data." Many of the exhibits would be much less effective if they didn't have photographic support.

"The pictures represent convincing documentation or key data collection step of the research. In fact, some exhibits wouldn't exist at all if it weren't for photography."

These four pictures were taken in available light by Kevin Urie, Denver, Colorado, for his exhibit, "Incidence of Parasites Found in Canine Feces Sampled from Public Parks and Private Residences in the Denver Area." At an international science fair, Kevin's exhibit won awards from the American Veterinary Medical Association and the U.S. Air Force.

Another judge adds:

"There are two aspects to using photography in an exhibit, and it's important for a participant to understand the distinction. The first is that the student has used photography simply to illustrate the method. These can be excellent pictures, but they aren't really mainstream to the methods or results of the project. However, picturing the method is very desirable because of the communicating power of a photograph. Often, 10 good pictures can describe a project more quickly and succinctly than 10,000 words—and you can see how important this is to a judge who is comparing and contrasting a particular exhibit against dozens or perhaps hundreds of others."

"The second aspect is that photography is used as a recording tool. For example, if you're measuring the flight of a rocket or recording the movement of Jupiter's moons, you'd really have to use photography in order to make the measurements. In other words, we photography judges distinguish between photography as a recording tool and photography as a communications tool. And one question we ask ourselves when looking at an exhibit is 'Could that exhibit exist if there weren't any photographs?"

A third judge adds:

"The inescapable conclusion is that photography and many science fair projects are nearly inseparable."

Let's summarize some of the roles of photography:

- *Photographs are necessary as an analysis or measuring tool.* For example, close-up photography and infrared and ultraviolet photography can be used to ascertain the age, the authenticity, and the possibility of alterations of stamp collections or other paper documents.
- *Photographs are desirable as a project-recording technique and as a subsequent communication medium.* Mounted enlargements can form a vital part of a display showing investigative procedures and project results in a pretest/posttest mode. Photography is very efficient as a time recorder; there is no better way to record an event than to take a picture of it.
- *Color slides can be an important element in lecture and demonstration procedures.* It isn't often feasible to transport delicate or heavy laboratory apparatus or bulky specimens to a presentation; whereas, it's very convenient to use slides as a communication tool to an audience.
- *Photographic print illustrations may be helpful, or actually necessary, if your paper is to be submitted for publication.* In addition, illustrations are often required in submitting a documented abstract prior to an actual presentation.

It's not difficult to understand Eastman Kodak Company's interest and concern about science fair photography. We want you to gather accurate data quickly with pictures and create pictures that will help communicate your message effectively, whatever your subject, whatever your idea.

We welcome you to the fascinating world of scientific photography.

GENERAL PICTURE-TAKING TECHNIQUES

An examination of thousands of photographs used in science fair exhibits indicates that the problems commonly encountered in picture-taking fall into three categories: lighting, exposure, and sharpness.

In addition, when photographing, keep these three related-composition suggestions in mind:

- *If you're not close enough, your pictures aren't good enough.*

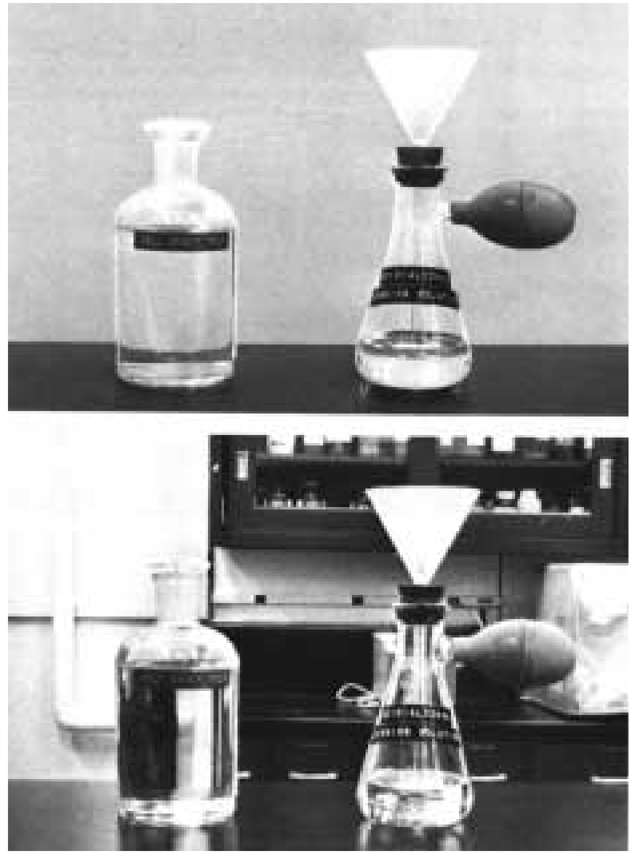
  Don't leave a lot of wasted space around the subject—move the camera closer until the subject really fills the frame.

- *Have all the areas of your picture working for you.*

  Any object included in the picture area should contribute to the message. If it doesn't, remove it before you shoot.

- Keep the backgrounds simple.

  Note that getting close to the subject helps to solve some of the background clutter by simply eliminating it. Furthermore, the closer the camera is to a subject, the more the background is likely to be out of focus. The background problem can be solved simply by using a plain sheet of cardboard placed behind the subject. For best color prints, use a background that is neither light nor dark, and that is not strongly colored, but be sure that it contrasts some with the objects being photographed.



The only difference between these pictures is the use of a light cardboard background to eliminate the clutter. A simple background helps the photograph to communicate more clearly.

Selecting Display Pictures. Select only the best storytelling photographs for your exhibit from those you have taken during the course of your investigation. But beware of the common tendency to include too many small prints. It's far better to have a few 8 x 10-inch enlargements of the most important pictures. You can overwhelm the judges with an exhibit plastered with tiny prints. Some exhibitors used close to 100 pictures, but there are simply too many to be comprehended by the passersby. In addition, keep in mind that a 3 x 5-inch print may be fine to look at when held in the hand, but it's too small to be observed adequately when located on exhibition panels that may tower higher than the viewer.

Be sure to arrange your best enlargements in a left-to-right, top-to-bottom order (because that's how most people scan a printed communication). It would be a good idea either to number the viewing order or to connect the prints with bright-colored arrows to help direct the viewer's gaze.

It's a good idea at this point to make a preliminary layout of your exhibit photographs. Tape them temporarily onto a door, or a wall utilizing the same space as on actual exhibit panels. Step back to 8 or 10 feet and reassess the arrangement and visual impact of each picture. Get an objective opinion from friends and instructors. Are your picture captions easily readable at this viewing distance? Would the judicious use of color pep up your exhibit? Are the lines of your charts and graphs heavy enough to be clearly seen at that distance? Could the individual elements of the exhibit be rearranged to capture more attention or make the project clearer and more concise?

Outdoor Lighting

Direct Sunlight. Best for landscapes, cityscapes, and other wide-angle shots of distant subjects. It's also necessary for pictures of shallow underwater subjects.

Be aware of the difference that the time of day can make in the direction of the sunlight. For example, suppose you want to photograph the face of an eroded cliff that showed geological layering. You should choose a time of day when the sun rays are shining across the face of the cliff, illuminating its texture dramatically.

Sunlight can also be used successfully for small-object photography. Try to position the subject so that the sun is striking it *from the side*. You can use a large white cardboard reflector to reflect some light back into the shadows. This will show details in the shadows and avoid a harsh and contrasty appearance in the picture.

The cardboard reflector should be placed just outside the camera field of view. Perhaps a friend could hold it exactly where you want it, or you could devise a method of standing it upright with pointed stakes.

Hazy, Overcast, and Shade Lighting. Best for close-ups of people and suitable for small nature close-ups (also helpful when photographing objects that have shiny surfaces or cast confusing shadows). It's especially good for in-the-woods pictures where the low-lighting contrast is far preferable to sunny-day lighting with its bright spot highlights. Try to exclude as much of the colorless sky area from your composition as possible on a gray-sky day.

Indoor Lighting

Some modifications to the above method are needed for point-and-shoot cameras and one-time-use cameras. With either type of camera, if it has a flash and the objects being photographed are less than 8 feet from the camera, place two thicknesses of tissue paper or a handkerchief over the flash so it does not overpower the ambient light, but still provides some fill light to the shadowed areas. One-time-use cameras usually are fixed focus (work best at longer distances) and fixed exposure (work better in brighter light). With these cameras, it would be better to arrange your setup so that direct sunlight falls on the objects being photographed, and to be sure that your camera is at least 4 feet from the objects. If you own a point-and-shoot camera, check your owner's manual to see if it is an autofocus model (and if so, note its minimum focusing distance) and whether it has exposure control (if there is only one shutter speed and one aperture listed, then there is no exposure control). Don't photograph objects closer than the minimum focusing distance (or 4 feet if fixed focus) and use direct sunlight if there is no exposure control.

Window light is soft, diffused, and even. Use white cardboards for backgrounds and for reflectors if needed.

Exposure and Sharpness Considerations

Exposure meters in modern cameras are quite reliable over a range of lighting conditions and scene properties. When using color negative film for prints, serious misexposures are uncommon when there is not enough light. One-time-use cameras and point-and-shoot cameras without exposure control should generally be used in daylight for best results. Cameras with exposure control can be used at lower light levels, particularly if a tripod or surface is used to stabilize the camera during the longer exposures needed in dimmer light. Even at higher light levels, images taken with tripods or other support are usually sharper, and a tripod makes it much easier to compose a pleasing and effective image, because it permits the viewfinder image to be studied carefully and adjusted precisely. Use of a cable release or timer also can improve stability. For close shots, if possible, manually focus carefully on the primary subject. If you are using a point-and-shoot camera with autofocus, do not get closer to the subject than the minimum focusing distance (see previous section); with fixed focus and one-time-use cameras, assume this distance to be 4 feet.

If your camera has an ISO speed control, be sure it is set to the film speed you are using. ISO 400 color negative film is a good all around choice for most science fair photography, when prints will be made for display or analysis. To produce a slide program, ISO 200 slide film is a good choice. Slide film has less exposure flexibility than color negative film, and should be used in a camera with exposure control. With slide film, it is a good idea in unfamiliar circumstances to "bracket" your exposures, that is, make three different exposures of each scene. The middle exposure should be that indicated by the camera light meter, and the other exposures should be one stop to either side. In a manual metering mode, to change the exposure by one stop, move the shutter speed or aperture to an adjacent value. For example, if the middle exposure is at 1/60 second and f/8, the bracketed exposures would be at 1/30 second (increased exposure) and 1/125 (decreased) at f/8, or at f/5.6 (increased) and f/11 (decreased). With automatic metering, you can change the film speed by a factor of two in each direction (higher exposure is a lower film speed and vice versa) or, if your camera has one, the compensation to +1 (higher) or -1 (lower).

If your subject does not fill much of the frame, and is very different in brightness from the background, it is worth adjusting your exposure from that indicated by the camera meter. This may be done in several ways. First, you can move closer to your subject, so it mostly fills the frame, and take a new meter reading. Second, you can meter off a midtone gray surface (such as a Kodak gray card, available at most camera stores) that is in the same light as the main subject, and is tipped slightly toward the main light source (see instructions with the Kodak gray card). Third, you can make an adjustment based on whether the background is dark (decreased exposure one stop), light (increase exposure one stop), or truly bright (as in a back-lit scene; increase exposure 2 stops). Some cameras have spotmeters that can be aimed at the main subject, activated to "freeze' the exposure and focus, and then re-aimed to compose the picture.

SPECIAL PHOTOGRAPHIC TECHNIQUES

Close-Up Techniques

Many science fair projects require close-up pictures necessitating a camera-subject distance closer than the normal camera lens will focus. This is known as photomacrography. Few cameras can focus closer than 2 feet, and many point-and-shoot and one-time-use cameras cannot be used at distances less than 4 feet (check your owner's manual to find the minimum focusing distance). However, for many small subjects—insects, a single plant leaf or blossom, a detail of an electronic circuit—some sort of an accessory lens attachment will have to be used to render the subject sharply (see below).

Using such an accessory will result in a far better quality photograph than taking the picture with a standard lens and then making an enlargement in a darkroom.

When taking close-up photographs with cameras having built-in flash, place two thicknesses of tissue paper or a handkerchief over the flash so it does not overpower the ambient light, but still provides some fill light to the shadowed areas

Close-Up Hardware. Various optical accessories are available at camera stores to accomplish close-up photography; the advantages and disadvantages of each type are itemized as follows:

- *Close-up lenses* (sometimes known as portrait attachments) are the least expensive accessories for taking close-up pictures. These lenses are available in screw-in mounts to fit various diameter camera lenses. The automatic camera exposure mechanism is not affected, and accurate through-the-lens exposures can be obtained.

These supplementary lenses come in three common magnifying powers: +1, +2, and +*4*. The higher the lens number, the closer you can focus on the subject. They can be used either singly or in any combination of two of them. Combining three is not recommended because of probable loss of image quality. A +10 is available if you need to reproduce a very small object in 1:1 (actual) size. However, note that a +10 close-up attachment will necessitate a very short working distance so that you may crowd your subject with not enough room to arrange the lighting.

- A *macroreverse ring* fits between the lens and the camera body and allows you to *reverse* the lens for improved optical quality at extremely close working distances. There are two notable disadvantages to a reversing ring: You lose the advantage of meter-coupled exposures; and you have only one fixed camera-to-subject distance with no focusing adjustment. To focus, you must observe the subject through the viewfinder and move back and forth until the subject becomes critically sharp. The reproduction ratio will be in the neighborhood of 1:2; that is, the subject will be imaged at 1/2 its actual size.

- *Extension tubes* are available for most popular interchangeable-lens 35 mm cameras. Different length tubes can be used for a variety of working distances. Excellent image quality is possible because you are not adding any glass to your camera optical system (as with close-up lens attachments). However, the added distance between lens and film requires additional exposure. Nonautomatic tubes are available, but the automatic variety is far more desirable because it incorporates the advantage of automatic, meter-coupled exposures. Extension tubes also have the feature of accommodating different focal length lenses. Thus, it is possible to use a short telephoto lens, such as a 100 mm lens, on an extension tube to provide a large image when you can't operate too close to the subject.

- *Bellows* are expensive and generally are used extensively for photomacrography. Fitted between the lens and the camera and mounted on a track to permit precise focusing, bellows have the advantages of accepting different focal-length lenses and allowing a completely variable camera-to-subject distance. They are available with and without automatic exposure coupling; this saves a lot of exposure calculations and exposure guesswork.

- *Macro lenses* offer probably the best, most convenient way to do close-up photography— though probably the most expensive. This is a special lens designed to produce very sharp images at very close subject distances. The usual focal lengths are 55 mm and 100 mm, with the latter being preferred by the experts since it prevents being right on top of the subject. Most macro lenses will focus to a 1:2 range and with an extension tube to 1:1.

- *Zoom lenses with macro capability* are zoom lenses that can be shifted into close-up capability. They are not true macro lenses, but some of them will focus to a 1:4 ratio—1/4 normal size. In other words, they are not really suitable for photographing extremely small subjects. However, if you are on location with a zoom lens-equipped camera, it is handy to be able to shift the lens to the macro setting since the camera-to-subject distance is reduced to about 11 inches.

Small nest of eumenid wasp lit with two reflector photoflood lamps—sources too broad for such a small specimen.

Lit with a bare, clear glass projection lamp having a 1 centimetre filament. Lighting angle and all other technical factors were the same for both photos. Note how much better the small source has rendered the specimen.

Operating Techniques. As the camera-to-subject distance diminishes—as you get closer to tiny subjects to obtain a frame-filling image—the zone of sharpness (depth of field) also becomes shorter (see page 8). If you are photographing an object at 1:1 ratio, the total depth of field at f/16 is only about 1/4 inch! Consequently, for extreme close-up photography, two interrelated camera techniques become very important: First, you must focus the subject critically. The camera should be focused on a plane 1/3 to 1/2 of the way into the depth range.

Second, you should use the smallest feasible lens opening (highest f-number) to preserve as much subject sharpness as possible. The small lens opening will necessitate a comparatively slow shutter speed to obtain the correct exposure. This necessitates that the camera be on a firm support that will keep it motionless during exposure. Use a tripod, copying stand, or set the camera onto the edge of a table, but keep it steady!

A cable release will help prevent jarring the camera. If you don't have one, use the camera self-timer to make the exposure.

Lighting for Close-Ups. There's more to making good close-ups than getting close enough to the subject, stopping the lens down, and keeping the camera steady. Lighting is also an important factor.

Avoid flash mounted on the camera. You can't observe the lighting effects until it's too late. The single frontal-light source obliterates much of the detailed texture of the subject.

The best lighting results in photomacrography are accomplished by using very small light sources and patiently manipulating them to enhance the subject's form and details. The result of the lighting should be observed through the camera viewfinder *before* the picture is taken.

Specifically, it's best to use light sources of a size comparable to that of the subject. For example, suppose you want to photograph the small nest of a eumenid wasp. The nest, shown in the accompanying illustrations, is about 1/3 inch in diameter with details of shape and texture that demanded careful lighting.

When such a small subject is photographed with the use of reflector photoflood lamps, much of the form and texture is lost because the beams of the lamps are too broad. These lamps are not suitable for subjects of less than 3-inch size. To produce a crisp, magnified record, undiffused illumination from a small source is needed.

The light source used for the nest was 1-centimetre square. It was a clear-glass, bare, 500-watt, 3200 K, with a projection bulb located 1 foot from the nest. A lighting direction was chosen that cast an informative shadow on the neck. Fill-in illumination was reflected from the main source by a piece of matte metallic foil. The accent on the lip was obtained from a small mirror that was covered with black paper containing a 1/8-inch hole. The tiny spot of light reflected from the main light by this 1/8-inch "mirror" has the effect of bringing the neck and lip forward, enhancing the three-dimensional modeling of the nest.

Except for the use of small light sources, lighting a photomacrographic specimen is not much different from lighting a larger one. For subjects 5 mm or smaller, a bare microscope-lamp bulb having a filament about 1 mm in diameter is useful. For subjects in the 1 to 2-inch range, a miniature desk or inspection light with a high- and low-voltage switch will work. For living specimens, with which some subject motion might be encountered, electronic flash units (two firing synchronously) on extension cords can be used. You may want to use one fairly close to the subject from one side, and the other about twice the distance from the opposite side. A piece of white reflector cardboard could be substituted for this second light to provide shadow-filling illumination. You also may want to consider masking the flash reflector (or reflectors) with a piece of black paper containing a hole cut in it about the size of the subject.

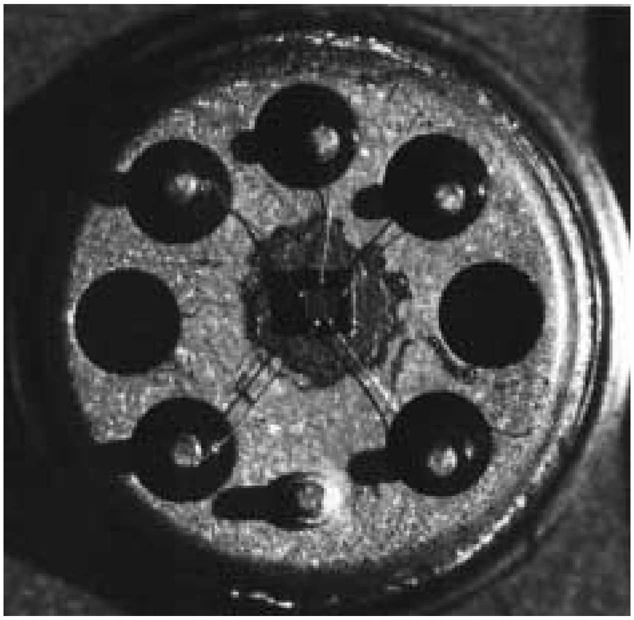
There are times when undiffused lighting is too contrasty, especially with smooth, shiny subjects. These are better rendered with diffuse lighting because they are lustrous and have no significant texture, and no relief. Small, white, translucent paper cylinders placed around a specimen will diffuse the illumination. The photomacrographic light source is then placed outside the cylinder. The effects of cylinder height and lighting angle can be observed visually from the camera viewpoint.

Copying Flat Subjects

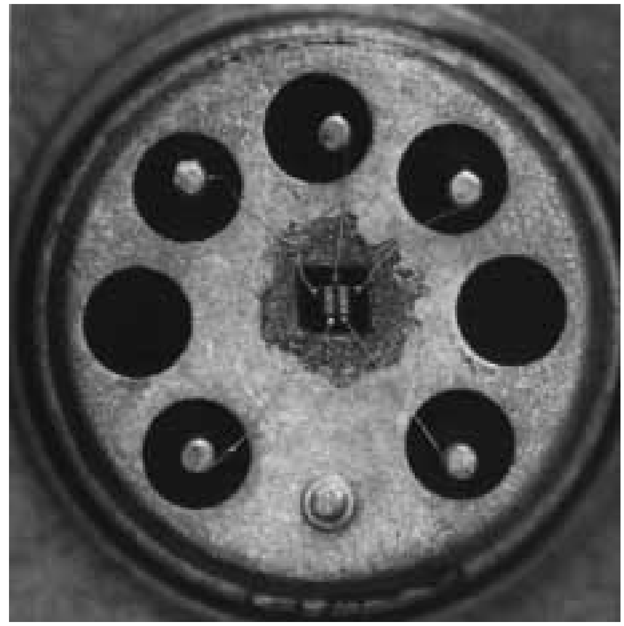
Sooner or later you may be faced with photographing a piece of flat copy. This could be a page from a reference book, a chart, a graph, a title, or other artwork.

Making a good copy is easy if you keep these suggestions in mind:

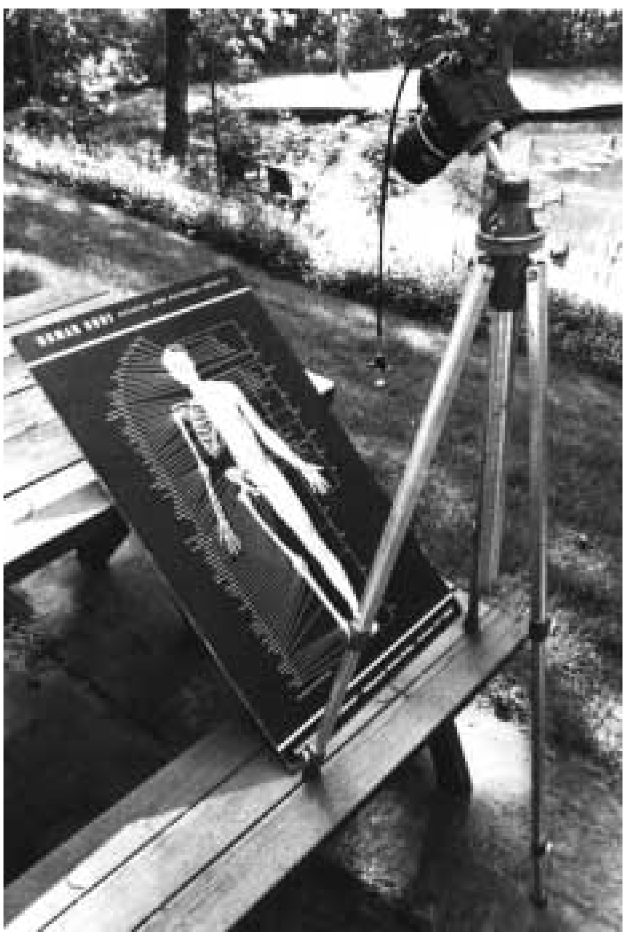
- Outdoor lighting of any kind—shade, overcast, or full sun—is very suitable.
- If your artwork is on floppy construction paper, lay it down flat for copying; if it's on stiff cardboard, prop it up against a tree or a chair at a convenient angle to photograph it. Don't let it sag—keep it flat.
- Be sure to align your camera so that the lens axis is perpendicular to the center of the object to be copied. Angle shots will cause parallel chart lines and columns of type to diverge and, in addition, may cause differential sharpness across the plane of the object.
- Fill the viewfinder with the chart image—no more and no less—don't let any background show at the edges. The extraneous material could be cropped out when making a print enlargement, but there is no convenient way to eliminate this mistake in a slide. Plan ahead, and use artwork cardboard that has a 2:3 ratio (e.g., 10 x 15 inches, 12 x 18 inches, etc.), and your title or graph will fit in a 35 mm camera viewfinder. Don't trap yourself by making your original artwork too small or you'll have to use some sort of supplementary close-up lens attachment to get close enough to fill the frame.

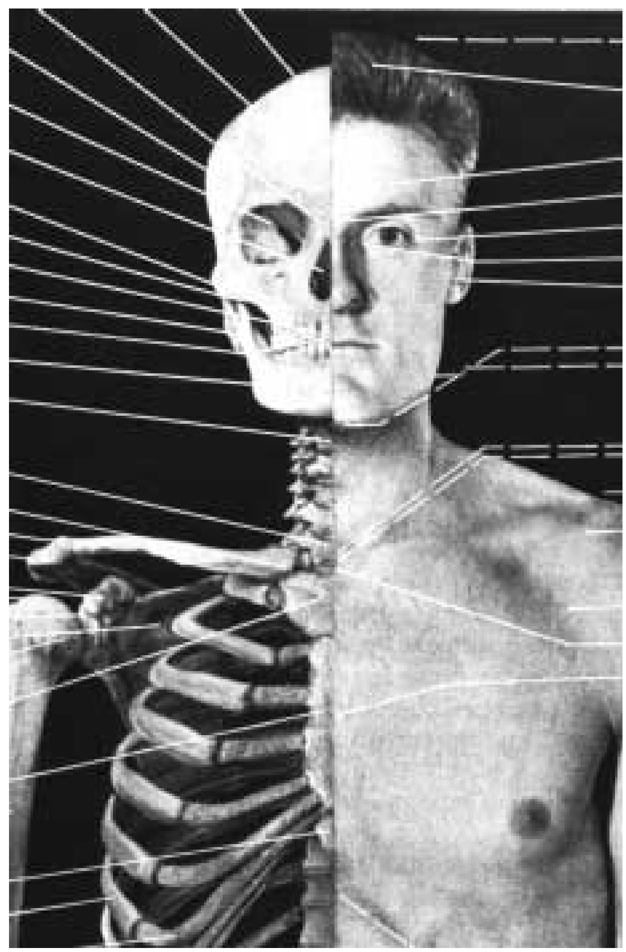


This detailed integrated circuit was too complex for raw lighting. Shadows and highlights are quite confusing, and the broken lead wire is difficult to see.



Made with diffused illumination.



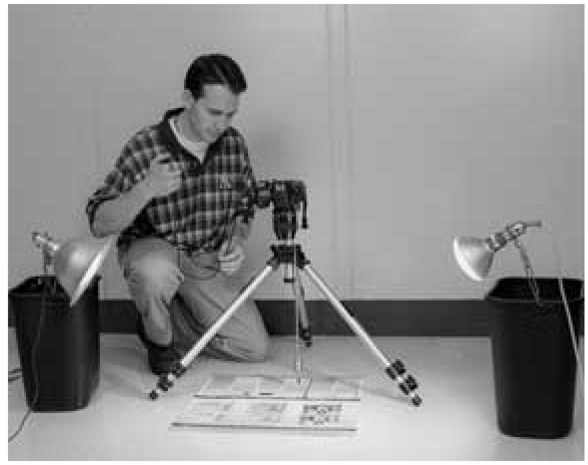


Outdoors makes a fine copy studio. Use a tripod to help line up the image precisely and a cable release for “jarless” exposures. Check for reflections before shooting. If you’ve done everything correctly, your chart will result in a clean, clear copy.

- Use a tripod for precise framing and for an absolutely steady camera. If you are taking the picture in sunlight, be sure that neither you nor the tripod legs cast a shadow across the subject.
- Resist the temptation of shooting flat art with a handheld camera, even if there is enough light. You won't align things precisely and you may also lose image sharpness through camera movement.
- Use slow-speed, fine-grain films if utmost resolution of details is important.
- Stop down the lens to help compensate for slight errors in focusing and depth of field
- Check the image in the viewfinder before you shoot to make absolutely sure the artwork isn't picking up surface reflections from the sun or the bright sky, which will degrade the image. This could happen especially with glossy subjects. Tip the subject forward and then backward a bit while watching *critically from the lens position.* If there are reflections, a slightly different angle should eliminate them.

If it isn't feasible to do your copy work outdoors, you can do it indoors with artificial light. *Do not use flash on the camera.* If your camera has a built-in flash that cannot be turned off, tape a piece of aluminum foil over the flash to block the light. Direct flash will cause reflections, even from matte subjects, that will probably ruin the picture. Instead, use two inexpensive clamp-on reflectors equipped with photoflood lamps. These are readily available from photo dealers or electrical supply stores. Here's one way to make the arrangement:

Set two same-size, nonmetallic wastepaper baskets on a flat, stable surface—a lab bench or a table or even the floor. Attach one of the clip-on reflectors to the rim of each basket. Place the material to be copied between the baskets. Adjust the position of the lights so that they are the same height as the center of your subject and are at a 45-degree angle from each side. Don't use the lights too close—about 4 feet from most subjects should be about right. Check for evenness of illumination on the subject by holding a pencil 2 inches from the subject and parallel to its surface. The two-light arrangement should cast identical twin shadows—same angle, same density—on the subject. If necessary, make the illumination even by *repositioning the wastebaskets,* not the metal reflectors, which can become very hot.



An improvised setup for making an occasional copy. If you do not have light stands, try the wastebasket described here.

Exposure Determination. If the subject you are copying is comprised mostly of middle gray tones, you can rely on your through-the-lens camera-metering system to give you the correct exposure. However, if your artwork consists of a few lines on a white background, your meter will cause you to underexpose it. You must give a very light-toned subject like this 1 stop more exposure than the meter indicates. Conversely, if you make your title art, for instance, on a dark or black sheet of paper, decrease the calculated exposure by 1 stop (using 18% gray card).

Infrared Photography

Infrared photography involves the production of photographs by means of near-infrared radiation. This radiation that lies in a range roughly between 700 and 900 nanometers can be recorded on specially sensitized photographic emulsions. Infrared radiation actually comprises a much greater part of the electromagnetic spectrum, most of which cannot be recorded directly by photographic means. Elaborate electronic equipment is required to record heat waves. Various techniques in infrared photography and thermal photography are discussed in detail in KODAK Publications No. P-570, *Thermal Recording and Infrared Photography of Hot Objects.*

Technical Applications. Near-infrared radiation has the ability to penetrate aerial haze, which makes it possible for you to photograph distant terrain, a valuable factor in aerial photography. Even more important is the way in which foliage is recorded on infrared-sensitive emulsions. The internal structure of leaves reflect infrared strongly, so that they appear lighter in tone in the photograph than they do when viewed directly. The usefulness of infrared photography lies in the unique tonal differentiation that it produces. Conifers, for example, appear darker than the leaves on deciduous trees; diseased fruit and vegetable crops or those suffering climatic or nutritional stress can be detected before trouble becomes apparent visually. These features of infrared photography become especially valuable in pictures taken from the air.

Infrared color photography is a technique that provides even greater differentiation than black-and-white infrared photography does. It is accomplished with an infrared film such as KODAK EKTACHROME Professional Infrared EIR Film. This modified color (false-color) emulsion has layers that are sensitized to green, red, and infrared, instead of blue, green, and red as in regular color films. With it, healthy leaves record red, whereas stressed leaves vary in color from purple to yellow. Many dramatic pictorial effects, as well as numerous informative scientific and technological records, can be obtained with infrared color film.

Panchromatic (left) and infrared (right) renditions of magnolia leaves covered with a sooty mold. Note how the leaf structures have reflected the infrared radiation, allowing the infrared-absorbing mold to stand out.

In infrared color photography, the visible component is, of course, added to the infrared record. As a result, this film produces the correct colors in photographs of many animal and botanical substances. It is the infrared component, however, that produces the modified color renditions. This translation of the color of objects is the basis of infrared color photography and is a valuable asset in the study of phenomena revealed in the infrared.

Other outdoor applications are possible in the natural sciences. The technique of infrared photography is extremely valuable in ecology for differentiating plants and soils; in hydrology for studying pollution and water conditions; and in archaeology, to some extent, for revealing ancient sites. Zoological infrared photography is quite similar to medical infrared photography.

Infrared photography is used in the examination of obliterated and questioned documents and is part of the routine examination of paintings. Fossils and coals lend themselves to infrared study. Human and animal behavior in the dark can be recorded with invisible infrared radiation, when such radiation is supplied by an external source.

Recording Infrared Radiation. You can use conventional cameras and specially sensitized films to record infrared radiation. The camera lens should be fitted with a filter that excludes the near ultraviolet and all or part of the visible spectrum.

By using conventional techniques, you can image reflected and transmitted infrared radiation directly on the film. Similarly, it is possible to record infrared luminescence from certain materials that respond to excitation by green, blue, or ultraviolet radiation. The same procedures can be used to record the self-radiance of objects that have been heated to at least 50°C (approximately 480°F). Objects that have been heated to more than 500°C (approximately 930°F) emit visible radiation and, therefore, can be photographed with films having panchromatic or extended-red panchromatic sensitivity. However, such heated objects also emit strongly in the infrared, so there may be special situations in which it would be appropriate to record heat patterns of marginally incandescent objects with infrared films.

Lighting for Infrared Photography. The light commonly used for ordinary photography can supply or excite the infrared radiation in indoor reflection, transmission, or emission techniques. However, artificial lighting for infrared photography must be symmetrical and flat because the characteristics of infrared emulsions are inherently contrasty. Two lamps at equal distances from the subject and at 45-degree angles to the camera axis usually suffice.

A single flash unit on the camera does not give acceptable results because the lighting is neither flat nor even. Neither are fluorescent tubes acceptable because they do not emit much infrared radiation.

Whenever possible, use electronic flash for living subjects. This is especially recommended for infrared color photography because the film is balanced for illumination of daylight quality. The illumination must be uniform. Lighting for small objects can be adequately provided with two lamps.

Outdoors, sunlight furnishes adequate infrared radiation for photography in this energy band. However, the intensity varies with the amount of haze present and the extent of cloud cover. If you can't wait for a sunny day, it may be necessary to make a range of exposures to obtain the desired rendition of the subject.

Filters in Infrared Photography. Infrared emulsions are sensitive to visible radiation as well as infrared energy. A filter must be used over the camera lens or over the light source to block the unwanted visible wavelengths. Filters are chosen by the amount of sky darkening and haze penetration that they achieve, by subject considerations, and by the infrared effects desired.

KODAK WRATTEN Gelatin Filter No. 25 (red) or equivalent is recommended for general black-and-white infrared photography because it limits the film to exposure by the red and infrared region of the spectrum, yet allows visual focusing. If only infrared is to be recorded, WRATTEN Filters No. 87, No. 87C, No. 89B, or equivalent should be used. However, because these are visually opaque, the camera cannot be focused through them.

For infrared color photography, a KODAK WRATTEN Gelatin Filter No. 12 (yellow) or Wratten 15 is used on the camera to block the blue light to which the three emulsion layers are also sensitive.

Focusing for Infrared Photography. Because infrared radiation is longer in wavelength than visible radiation, it will come to a focus farther from the film plane. Thus the visible focus must be adjusted for critical exposures.

Some cameras carry an infrared focusing mark on the lens focusing ring. They may be focused visually and then be reset to the infrared focus mark. If your camera has no mark, you can focus through a red filter (WRATTEN Filter No. 25 or equivalent) and photograph the subject through a small aperture such as f/16 or f/22. The depth of field usually offsets the slight difference between the visual and infrared focus.

Exposure. Exact film speeds for setting exposure meters cannot be given for infrared films because the ratio of infrared to visible energy is variable and meters do not respond to infrared radiation. Film speeds can be offered only as suggested starting points for trial exposures. The instructions packaged with Kodak infrared films suggest meter settings that can be used to determine exposures under average conditions when using meters marked for ISO (ASA) speeds or exposure indexes.

Infrared Luminescence. Just as some substances fluoresce and emit light when excited by ultraviolet radiation, so do other substances emit infrared radiation when excited by blue-green light. The infrared emission cannot be seen, of course, but it can be photographed. Photographs of this invisible luminescence often reveal characteristics of a specimen or document that are not readily apparent through other methods of examination. For example, chlorophyll does not reflect infrared, but it does luminesce. This provides a means for studying certain plant diseases.

To remove reflected infrared from a luminescing specimen, you can hold back infrared radiation from the light source with a blue-green, infrared-absorbing filter. Then any infrared radiation coming from the subject can be due only to luminescence. It is also necessary to place an infrared filter, such as a KODAK WRATTEN Gelatin Filter No. 87, over the camera lens to bar blue-green light reflected from the light source.

Infrared luminescence studies are usually carried out with enclosed tungsten lamps. Corning glass color filter 9780, C.S. No. 4076 (8 mm, molded) provides an efficient excitation filter over the lamps. This filter is available from Corning Glass Works, Corning, New York through special order.

The exposure, using two suitably filtered 500-watt spotlights at 3 feet, will be roughly 6 minutes at f/5.6 for high-speed Kodak infrared films. With two 500-watt reflector photofloods at 16 inches, it will be about 3 minutes at f/5.6..

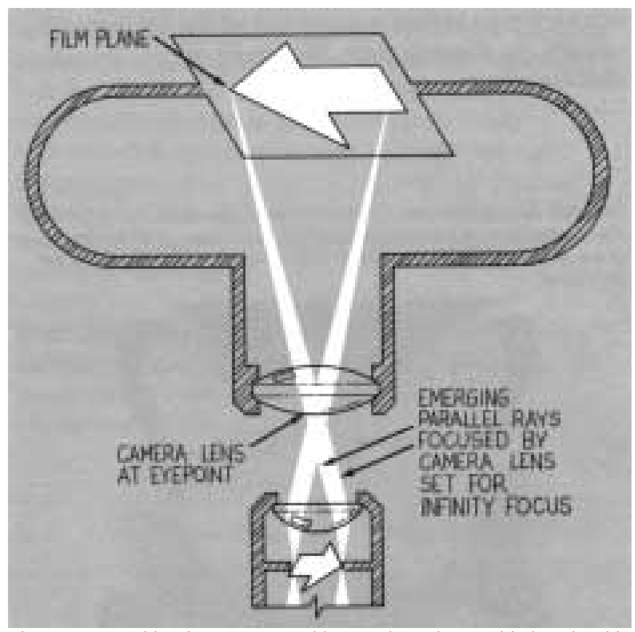
Photomicrography

Two main problems you must solve if you are going to obtain good pictures through a microscope are mounting the camera and establishing proper illumination. Mounting the camera on the microscope and making photographs can be a simple and routine operation. Neither the microscope nor the camera needs to be excessively expensive. Your major concern will be to achieve correct focus at the film plane.

Mounting a Camera with Noninterchangeable Lenses. The simplest way to make a photomicrograph is to use a conventional camera over the microscope viewing tube.

It might be an inexpensive fixed-focus camera or an expensive 35 mm camera, but it is usually one designed for regular photography of people and places. The lens that is an integral part of the camera often cannot be removed. A fixed-focus camera is the simplest, having only one shutter speed and usually only one lens aperture. The more expensive camera offers a range of shutter speeds, various distance settings, and a variety of aperture settings. This type offers more versatility, particularly in exposure control.

When you focus a microscope visually with a normal, relaxed eye, the image may be considered to be at infinity. Therefore, if there is a distance scale on the camera, it should be set at infinity. If the camera is placed over the microscope viewing tube in the correct position, the image will be in focus on the film plane. The correct position of the camera lens is with the front surface of the lens at the eyepoint.



The correct position for a camera with a noninterchangeable lens is with the camera lens at the eye point of the eyepiece.

The position of the eyepoint can be determined by holding a piece of white paper right on top of the eyepiece with the microscope focused and the stage illuminated, then slowly raising the paper. A bright circle will appear on the paper. This circle becomes smaller and then larger. The position above the eyepiece at which the circle is the smallest is the eyepoint. The distance of the eyepoint above the eyepiece will vary with different eyepieces. If the eyepiece is changed, therefore, the eyepoint may appear in a different position. The distance may be only a few millimeters or it may be almost 20 millimeters.

The camera can be held in place over the microscope by any available means. You can construct a vertical stand out of wood or metal, use a laboratory ring stand, attach the camera to the upright member of a small enlarger (with the enlarger head removed), or use a camera tripod. You should still be able to move the camera up out of the way or swing it to one side to look into the microscope and adjust image focus. The rule is: Focus the microscope; do not change the distance setting on the camera.

A piece of black cloth or tape or front-to-front matting (different size) sun shades can be used to exclude light between the eyepiece and camera lens. Place one shade on the camera and the other on the microscope.

When the image appears sharp, the camera can be replaced in position to make an exposure. The camera stand should have some kind of positioning stop or other arrangement to bring the camera back to the correct position.

Mounting a Camera with Interchangeable Lenses. A single-lens-reflex (SLR) camera can be adapted for use over a microscope. Many firms that manufacture reflex cameras also offer microscope adapters. Normally, when a reflex camera is to be used over a microscope, the lens is removed from the camera and one or more extension tubes are placed on the camera in the lens position. A microscope adapter ring, into which the microscope eyepiece fits, is then fastened in the front extension tube. The whole assembly of camera, tubes, and adapter can be placed onto the microscope, fitting the microscope eyepiece and the adapter ring directly into the drawtube of the microscope. This assembly, in some designs, can be attached to a rigid stand that is supported independently of the microscope.

The microimage is usually focused by adjusting the focus knob on the microscope while viewing the image in the camera viewfinder. A better way is by adjusting the eye lens of a photographic eyepiece, if your equipment allows it. An accessory side telescope that includes a beam splitter allows accurate focusing on the film plane. Focusing on a ground glass within the viewfinder is all right for lower magnification. Beyond about 80X, critical focus cannot be obtained on the ground screen.

Illumination. Although good illumination is important in visual work, it *is absolutely vital in photomicrography*. For visual observation, a diffuse illumination often is adequate, but it is not suitable for photography. Therefore, you should learn the basics of good illumination.

When a microscope does not have built-in illumination, an external illuminator must be used. Separate illuminators are available from microscope manufacturers or dealers.

The light source should provide sufficient intensity to allow reasonably short photographic exposure times. The lamp housing should allow easy access to the light source and should contain those elements necessary for proper adjustment of the illumination furnished to the microscope. It also should dissipate heat efficiently.

For color film exposure, the light source should have the proper color temperature or allow suitable filtration to meet the requirements of the film. A source with a continuous visible spectrum is necessary. Most common light sources like daylight or tungsten light meet this requirement.

Kohler illumination is the most common system of illuminating a microscope specimen in photomicrography. It is applicable in visual work, too, for best image quality and highest resolution. However, because it requires meticulous adjustment, it is used less often in visual microscopy.

Basically, this type of illumination consists of using the field (lamp) condenser to focus an image of the light source at the substage condenser, which, in turn, focuses an image of the lamp condenser in the plane of the specimen. Thus the lamp condenser becomes the source of illumination and provides a uniformly illuminated field.

Microscope illumination, including the Kohler method, is described in detail in *Photography Through the Microscope*, which is available through Silver Pixel Press, Publication No. P-10, Catalog number 1528371.

Exposure. The lens-aperture settings (f-numbers) on the camera do not control exposure as they do in regular photography. They have no effect on image brightness. Use the largest aperture setting. A small aperture cuts into the image field and reduces field size, so only a small, circular image is recorded on the film.

Exposure time can be determined either by making an exposure test series or by using a sensitive exposure meter. Because image brightness in photomicrography can be quite low, particularly at high magnification, an exposure meter should be sensitive to very low-light levels.

Some exposure meters are made specifically for photomicrography and are sensitive enough to respond to light through a wide range, from very low to very high brightness. Other meters that are very sensitive to light have readings in terms of units of illuminance, such as foot-candles. In this case, the manufacturer often provides a simple calculator, table, or graph so that brightness readings can be converted to exposure times.

If you don't have a suitable meter, you can make an exposure test series. A convenient series includes all of the exposure times available with the camera shutter. These may range from 1 second to 1/125 second or 1/250 second. If the shutter has a time (T) setting, you can make a few long exposures also (2, 4, and 8 seconds, for example). Out of this wide range of exposure times, one should be correct for the particular film and the existing image brightness.

When the film is processed, keep a detailed record of specimens, light source, filters, exposures, etc. This will permit duplication of a setup for future use with the same specimens or similar specimens.

Exposure becomes a problem with simple, fixed-focus cameras because the exposure time or shutter speed is usually very short—no longer than 1/40 or 1/60 second. This means that you must have a very bright image in the microscope and, of course, a very bright light source.

Astrophotography

All you need to start taking astrophotographs is a camera (that can make time exposures), a cable release, a rigid tripod, and film. A long focal length lens can be used in place of a telescope in some situations.

Stationary Camera. Since many of your pictures will be time exposures, one of the most important requirements for astrophotography is a steady camera support. Therefore, place your camera onto a rigid tripod before taking pictures. Also, use a cable release. This will help you get sharp pictures by keeping camera vibration to a minimum when you open and close the shutter.

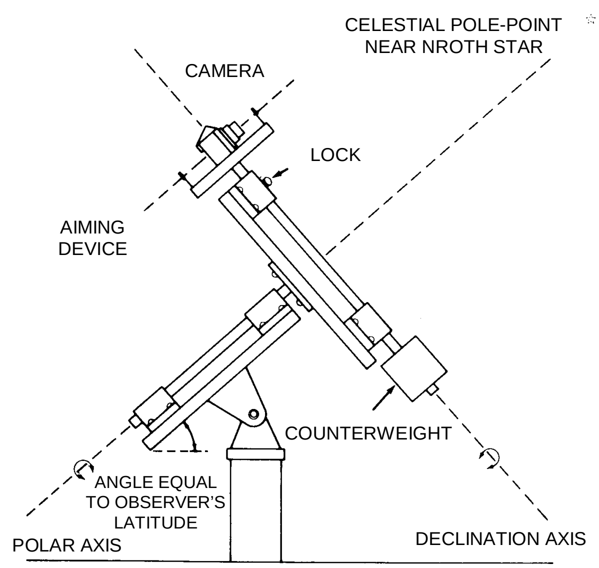
To determine the best exposure for your equipment, make test pictures. Load your camera with a fast film. Set the camera lens at its maximum opening and the focus at infinity. With your camera on a tripod, aim it toward a group of stars and open the shutter for several minutes. At the end of the exposure, close the shutter.

After your film has been processed, you will find that the stars have been recorded as a series of streaks or star trails. From these star trails you can determine the next exposure. If the trails are needle-sharp, you know that your lens is in sharp focus at the infinity setting. If the trails are straight and not jagged, you know that your camera support is sufficiently rigid.

Using similar techniques, but different exposures, you can also photograph comets, meteors, auroral displays, and the moon.

Guided Camera. You can improve your astrophotographs by using your camera on an equatorial mount to compensate for the rotation of the earth and keep the images stationary on your film during the long exposures that may be necessary for pictures of faint objects. An equatorial mount provides a heavy, firm support and orients your camera for convenient tracking of celestial objects. You can purchase an equatorial mount without motorized drive. Motorized drive, however, works better.

Equatorial mount for guided cameras.



You can take pictures of brighter objects without using a drive system, but a drive system is almost a necessity for photographing faint objects requiring long exposures. This equipment will permit the recording of planets, nebulae, galaxies, and star clusters. Reasonably priced Equatorial mounts with clock drives are available from scientific-supply firms. For best viewing and photography results, choose a site away from urban lights.

Telescope and Camera. To photograph astronomical subjects in greater detail, you will need a telescope. The four basic telescope-camera systems are (1) eyepiece-camera lens, (2) eyepiece projection, (3) prime focus, and (4) negative-lens projection. The system you use depends primarily on your equipment and on the desired image size.

The *eyepiece-camera lens system* does not require a special camera or a camera with a removable lens. You can take astrophotographs with an ordinary camera positioned close to the eyepiece of your telescope. However, when using this system, you may find it difficult to check alignment and focus. Image contrast may be reduced by reflections from the many lenses in the light path.

There are several kinds of optical instruments that you can use for the telescope part of your eyepiece camera system. These include binoculars and spotting scopes as well as astronomical telescopes with eyepieces. To take pictures with your camera and telescope, you'll need a simple mounting device to attach the two units. The mounting device should provide both precise alignment of your camera lens with your telescope eyepiece and a rigid, vibration free support for your camera. Although the mount should furnish a lighttight guard between the two units, this guard is not absolutely necessary. A black, lint-free cloth will do. You can purchase mounting devices inexpensively from optical-supply firms.

With the other three telescope-camera systems, you do not use your camera lens. Therefore, you'll need a camera with a removable lens and a shutter that's built into the camera body.

An excellent camera for astrophotography with a telescope is the single-lens-reflex camera with a removable lens. You can use this type of camera with all four telescope-camera systems by using the camera with or without its lens, depending on the system you employ.

You can purchase specially built astrocameras from telescope manufacturers.

With the *eyepiece-projection system*, you attach your camera, with its lens removed, to the telescope eyepiece. The eyepiece projects the image directly onto the camera film plane. Because you don't use the camera lens, there are fewer lenses for the light to pass through. As a result, less light is absorbed and there are fewer lens aberrations to affect the image.

Also, with the eyepiece-projection system, you can increase magnification by moving the film plane farther from the eyepiece. However, as you do this, the image-forming light is spread over a larger area. This fainter image requires a longer exposure.

To focus the image on the film plane, it's necessary to move the eyepiece outward slightly from the setting for visual use.

In the *prime-focus system*, the objective of the telescope focuses the image directly on the camera film plane, thus eliminating extra lenses. Consequently, this system yields small images of maximum contrast, sharpness, and brightness.

The *negative-lens projection system* is similar to the prime-focus method, but a negative achromatic lens, usually referred to as a Barlow lens, is placed inside the focus of the objective. This lens magnifies the image without greatly increasing the length of the telescope. This principle is used in telephoto lenses.

Exposure. General exposure recommendations are given in the table below. Because there are so many variables in taking astrophotographs, such as equipment, speed of the film, and atmospheric conditions, the table gives exposure ranges to serve as a basis for your own pictures.

For more information on astrophotography, see *Astrophotography Basics*, KODAK Publication No. P-150.

Exposure Guide for Basic Astrophotography

Subject	Instrument	Mount	Objective	*f*-Number	Films	Exposure
Star Trails and Comets	Camera with time exposure	Rigid support	Any lens	Wide open	Fast,* B/W and color	Up to 30 min or more
Meteors	Camera with time exposure	Rigid support	Good wide-field lens	*f*/6.3 or wider	Fast,* B/W and color	10 to 30 min
Aurorae	Camera with time exposure and fast lens	Rigid support	Fast lens	*f*/4.5 or wider	Fast,* B/W and color	1 s to 2 min
Man-Made Satellites	Camera with time exposure and fast lens	Rigid support	Fast lens	*f*/4.5 or wider	Fast,* B/W and color	Hold shutter open for duration of pass
Moon	Camera or camera with telescope	Rigid or equatorial with or without device	1" diameter or larger	*f*/4.5 or slower	Medium-speed,** B/W and color	1/125 s to 10 s
Stars and Comets	Camera or camera with telescope	Equatorial with guiding sights	1" diameter or larger	*f*/6.3 or wider	Fast,* B/W and color	1 min to 1 h
Star Clusters, Nebulae, and Galaxies	Camera or camera with telescope	Equatorial with sights and drive	1" diameter or larger	About *f*/6.3	Fast,* B/W and color	10 min to 1 h
Planets	Camera with telescope	Equatorial preferably with drive	1" diameter or larger; for detail, 6" and up	Use *f*-number determined by your system.	Fast,* B/W and color	½ to 15 s

* ISO 200-800
** ISO 64-200

DISPLAYING YOUR PICTURES

Graphics—charts, graphs, and photographs—can support and enhance your science fair project. Photographs, especially, can supplement your written work and bring to the judges scenes and events that cannot be recreated, or allowed (e.g., plant material and chemicals) in a display. Very small objects can be presented in a large scale. Colors, textures, numbers, positions, or time sequences can be communicated by photographs. They can thus serve as a dramatic focus for a static display.

Science Fair Exhibit

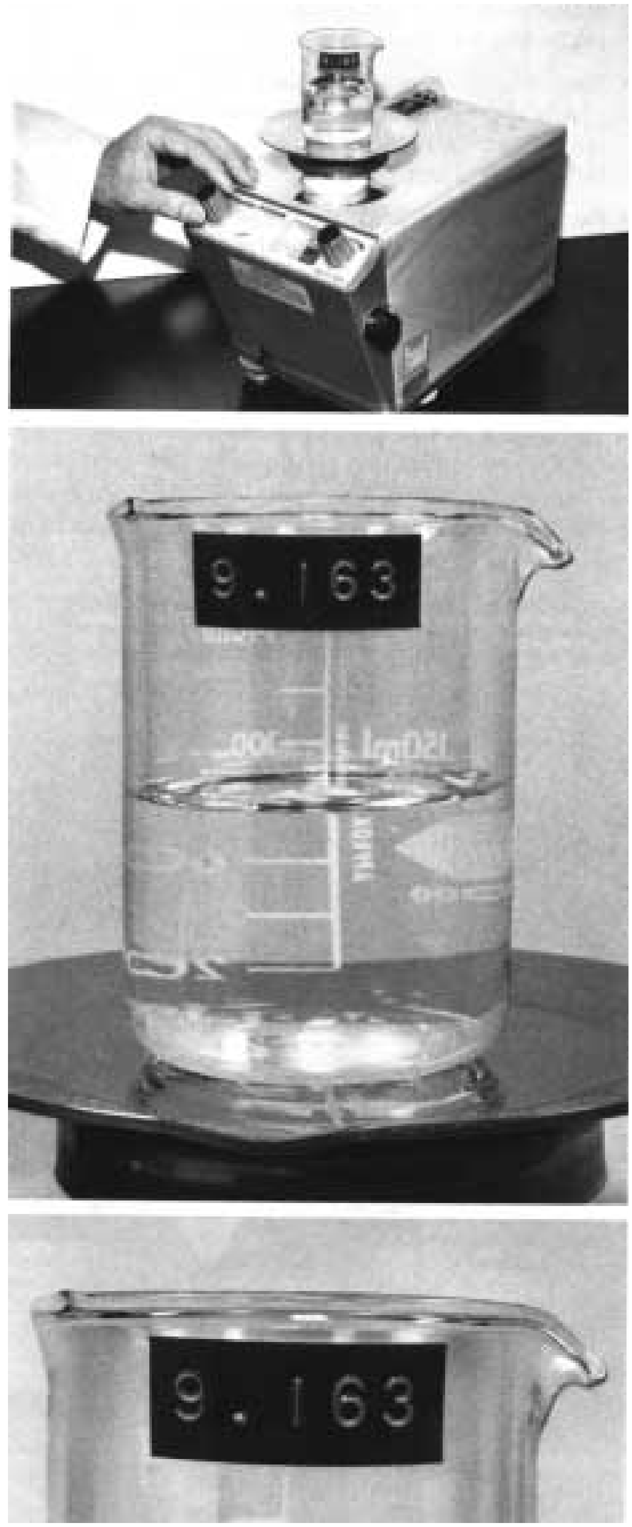
Effective Pictures. To be effective, photographs in the form of a display media, prints, slides, videos, or video displays, must be of good technical and artistic quality. The exposure must be right, the contrast normal, and the composition simple. Making good photographs does not require expensive equipment, but does require reasonable care, prior planning, and attention to detail.

The first and simplest photograph that you may use in your display is an overall pictorial scene. This photograph can be the first in a series of prints or slides, or it can be the establishing scene in a video about your project. You might show the site of your field work—a meadow or stream, a building construction site, or a laboratory.

When composing an overall picture, you should consider how you will relate it to close-ups of specific details that you want to show in other photographs. Do you show the color and density of your test plot or hybrid wheat? Are the structural members of a new building outlined and not obscured by equipment? Does the overall laboratory picture convey the scale of your original test setup?

Once the overall scene or site is established, move close to record the details of your experimental work. Pictures tell the story best when they make one very obvious point. Concentrate on that point.

Close, closer, closest—use the camera as near to the subject as needed to fill the frame with the important detail. The closest picture was taken with a macro lens.



Mounting the Exhibit Prints. Two recommendations: Prints should be *securely* mounted on an underlay of dark cardboard that will help keep them absolutely flat and distinctly separate the print borders from the display panel itself. There have been some instances in which an exhibition hall happened to have high humidity, so that inadequately mounted prints became detached, presenting a sorry-looking display.

It's also advisable that all photographs have a matte (not glossy) surface. Some exhibit panels have a built-in light at the top that could cause annoying reflections on the higher prints to the point that they simply would be ignored. If you already have glossy prints, they can be dulled with an inexpensive matting spray available from most photographic dealers.

Color vs Black-and-White Graphics. An experienced science fair winner, Jack Lobatin had this to say:

> *"I think one of the biggest things I've learned from my experience in science fairs, just by looking around at the different projects, is that the ones that really catch my eye are the ones that are the most colorful. So that's what I've tried to do with my photographs and my graphics. A really important thing is to use clear lettering. I also obtained very colorful construction paper and tried to use as many colors as I could in the graphs and in the actual displays. As for the photographs, I think they are so important because they actually bring the laboratory to your exhibit. It also brings in the color element, too, very much."*

Using Slides. Some science fair exhibits utilize projected slides as a supplement to their photographic display. You should consider these advantages:

- Many pictures can be projected in a relatively short time.
- Pictures are viewed one at a time, concentrating the observer's attention on each (rather than distracting the viewer's attention with a multiple-print display).

Particularly impressive exhibits utilize photography as a measuring or recording device instead of merely to decorate the display. Note the use of a selected few mounted enlargements presented sequentially.

- The brightness range of a projected color slide is far greater than that of a color print. Thus, the photograph is more realistic and impressive.
- Slides can be cycled automatically or, with equipment such as the KODAK EKTAGRAPHIC AudioViewer/Projector, a tape sound track can be synchronized with the projected images.
- The size of the projected slide images can be varied. For example, some models of the KODAK EKTAGRAPHIC III Projectors feature a small built-in screen. This can be pulled from the projector and snapped into place for slide viewing in restricted space such as a science fair exhibit. A larger projected image can be obtained in the same space by bouncing the projector beam from a mirror onto a white surface or onto a sheet of ground glass from behind. If this folded-beam technique is used, be sure to reverse the slides in the tray so that the images will be laterally correct.

  If your projector doesn't have a built-in darkscreen shutter, don't make the mistake of having a glaring white screen at the beginning and end of your show. This can easily be prevented by placing a 2 x 2-inch piece of cardboard in the projector gate before you show the first slide and a second piece of cardboard in the tray following your last slide.
- A disadvantage to using slides versus photographs is that a judge may not have time to observe them all, so keep the selections to a few critical ones.

The "folded beam" method of slide projection. The projector image is reflected from a mirror (beneath the screen) onto a small rear projection screen. This technique produces fairly large, brilliant color images.

Lecture-Demonstration

Slide Presentation. In some science fairs, especially local and regional, your project may be presented to a panel of judges in a lecture-demonstration procedure. The usual format is a 10-minute presentation followed by 5 to 10 minutes of questioning. In this type of presentation, slides are an effective way of communicating the project objectives, procedures, and conclusions.

Editing Your Slides. To view your slides while you're arranging them into an effective presentation, you need a light box or illuminator. Although one can be purchased at a photo-supply store, it also can be made quite easily from household materials. Perhaps one of the easiest approaches is to take a storm window and lay it flat so that it bridges two chairs (two small tables, two sawhorses, or any two sturdy supports that are the same height). Tape plain white tissue paper to the underside of the glass and put a lamp, with its shade removed, on the floor underneath the paper-covered glass. Your storm-window light box should provide you with plenty of room to lay out and arrange your slides. One word of caution: Whether you're using a homemade or commercially made light box, do not leave your slides on a lighted surface for an extended period. Turn the light out whenever you're not working with the slides. Editing may be one of the hardest steps in making a slide show. This is the moment when you must part with some of your slides because—

- They're not good enough. Take out any slide that's too light, too dark, out of focus, not close enough, not posed right.
- They're not the best for the job. Take out all the second-best shots, the near misses, the competent-but-dull slides, the duplicates, or those that just don't contribute anything to your story.

Leave only slides that speak for themselves on your light box.

Titling Tips. Limit yourself to as few words as possible per slide. One or two work best. Make the letters big and bold. Then there will be no question as to whether or not the people in the back row of your audience will be able to read them.

Avoid black letters on a white background. (They'll not only be boring but could also fool your exposure meter.) Choose dark, rich colors for your backgrounds. Consider using textured paper or fabric—burlap, lace, canvas—to convey a special atmosphere. Use a blackboard, memo board, or sand table—any surface you can write on. Try other surfaces like windows, walls, and rugs that can be temporarily lettered. Be original in your choice of materials. Match them to the mood of the show. But always remember to keep it simple.

Adding Words. Like the light box you used to arrange your finished slides, a script should help you organize many different elements—slides, words, and sound effects, if you need them—by bringing them together in one place.

Write what you want to say when various slides appear on the screen. Informal remarks are usually best. Refer to any planning cards and notes for ideas, and keep these tips in mind.

- Make your comments short and snappy. Remember, you don't have to, nor should you even want to, talk over every slide. Let slides or slide sequences speak for themselves whenever they can.
- Build word bridges from one section to the next. You may find whole slide sequences that say plenty with just a brief introduction from you. Knowing when to be quiet and when to speak is the mark of a pro.
- Work toward an interplay between slides and words. Try not to explain what's obvious from looking at the screen. If you have trouble being objective here, ask for an outside opinion.
- Be bright. Be conversational. Be brief.

If at all possible, your presentation should be made without referring to or (even worse) reading a script. An outline may be useful to keep your presentation orderly and logical while you're talking extemporaneously. After all, you're the expert on your research and you should know enough about it to look your judges in the eye and tell them about it. Sound authoritative. Be enthusiastic. Smile.

Before the Presentation. Perfect your final presentation by practicing with the script and slides alone at first. Then try the program on a test audience of family, friends, and science instructors. Try to scout the room in which you'll present your show. Locate the light switch and enlist an assistant to operate it for your show. Good slides should be visible without darkened rooms—where the audience can doze.

Locate the electrical outlets. Check the distances between the outlets and the places you'll put the projector and other electrical equipment. You may need to bring one or more extension cords of the proper current capacity.

Be sure there's a podium, a microphone, a pointer, a table tall enough to hold your projection equipment—all the little things you need to put on a top-flight show.

Unless you're the kind of person who thinks of everything, the best way to find out what is missing or what isn't quite right is to rehearse on location. If your podium prevents you from seeing the screen, or if you can't see your script with the lights out, it's a lot easier to make adjustments without an audience. Move the podium during rehearsal. If necessary, bring a high-intensity lamp and an extension cord from home to light your podium.

On the Day of the Presentation. Arrive early enough to set everything up before your audience begins to arrive. Be sure you have a spare projection lamp.

Adjust the screen so that its bottom edge is at least 4 feet above the floor. Place your projector above the heads of the audience and on a sturdy projection stand. The projection lens should be level with the center of the screen, and the projected image (or its longer dimension) should fill the screen. Position your loudspeaker, tape recorder, or other sound source high and near the screen.

Provide your assistants with well-marked copies of the script. Place any controls you'll be handling close enough to the podium so that you can work them easily without taking your eyes off the script. If you handle slide changes from the podium, you'll avoid the "Wait!" and "Next slide, please!" syndrome.

Make sure the podium light doesn't spill onto the screen or into the audience. Often, a piece of cardboard taped to the side of the podium will shield the screen.

Warm-up and cue the projector and sound equipment before showtime. If you have time, it's a good idea to run through a quick rehearsal at this point to be sure nothing has gone wrong during your setup.

USEFUL FILMS FOR SCIENCE FAIR PROJECTS

To help you select the film type best suited for your science fair project please go to Kodak's **Guide to Films** web page at:
http://www.kodak.com/global/en/consumer/film/index.shtml
There you will find:

- Kodak Film Finder: This will quickly help you find the right film for any situation
- A complete overview of Kodak consumer films
- Information on new Kodak film products

MORE INFORMATION

The books listed below can help you in your science fair project. Other helpful Kodak books on a variety of photographic topics are available through your photo dealer. For a current list of photography books and prices visit http://www.saundersphoto.com/html/books.htm or call Silver Pixel Press at 1-800-368-6257

KODAK Guide to 35 mm Photography (AC-95)
KODAK Pocket Photoguide (AR-21)
KODAK Pocket Guide to 35 mm Photography (AR-22)
KODAK Filters for Scientific and Technical Uses (B-3)
Close-Up Photography (KW-22)
Photography Through the Microscope (P-2)

The following Kodak pamphlets may be of help to you. Single copies are available free from Department 841, Eastman Kodak Company, Rochester, New York 14650.

Thermal Recording and Infrared Photography of Hot Objects (P-570)
Astrophotography Basics (P-150)
Close-Up Photography with 35 mm Cameras (AB-20)
KODAK Technical Pan Film 2415/6415 (P-255)

For other helpful publications, check your community and school libraries, book stores, and scientific supply houses.

Photographic Products Group
EASTMAN KODAK COMPANY · ROCHESTER, NY 14650

Photography in Your Science Fair Project
KODAK Publication No. **AT-20**

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