where all these stars came from because in the city only about 25 stars are visible in the sky even on clear nights. As they continued to stare, tiny flashes of light appeared and were gone before students could utter a word. Shooting stars, the Perseid meteor shower, put on quite a display for them that night. The Giant Sequoia groves also held a special fascination for many students. "The trees were like kings on thrones watching us. The forest was so quiet (that) it made a noise," observed one girl.

A large proportion of the success of this experience was due to Frank Baele, our instructor from the Yosemite Institute. Frank was more than an instructor; he also served as tour guide, trail guide, chauffeur, medical advisor, camping authority, search party director, and bear chaser. We genuinely regretted saying goodbye to him at the airport. Through an inimitable combination of first-hand knowledge, earnestness, and humor, he won the enthusiastic admiration of our entire group.

A Change in Attitude

Perhaps the most impressive lesson the students learned from our trip was that the Park is a trust belonging to everyone. I observed a complete shift in attitudes by the final day of our trip when we discussed park management. At the beginning of their two-week stay, they could not understand why there was "nowhere to go" and "nothing to do" at night or during their free time at Yosemite. During our visit to Yosemite, we spent two nights in the tourist area of Yosemite Valley where there was plenty to see and more places to go with more people than they would see in the other twelve days combined. After leaving the Valley, they learned to provide their own amusements—games and quiet activities. By the end of our stay, students wished the Park could be returned to its former unspoiled state; they wanted to reduce the number of automobiles and recreational vehicles, discontinue "artificial" amusements, such as the ice skating rink, swimming pools, and stables offering horseback riding. They wanted to take the tourists from the Valley and put them on the hiking trails so that the tourists could learn some of the many lessons the students themselves were absorbing so eagerly.

And from the Teacher's Perspective . . .

If you have ever considered offering your students an extended outdoor learning experience and then decided against doing so for whatever reason, why not take those plans out and dust them off? I experienced problems and disappointments, too. And it is not necessary to travel quite as far as our group did. Perhaps our school's next trip will be closer to home. The curriculum for "Natural Science" can be modified to fit any natural area. However, I can say with certainty that none of my eighteen students nor my husband and myself will ever forget the extraordinary summer adventure we all shared in Yosemite National Park.

The Bacteriophage: A Functional Model for Demonstrating a Viral Life Cycle

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Viruses play an important role in our everyday lives. They affect our well-being. Students, throughout their school careers—from kindergarten through college—miss classes due to viral diseases such as measles, mumps, chicken pox, influenza, as well as the "common cold."

The field of virology is a young, developing area. Although most high school and college students can explain the basic life cycle of a cell, few can describe the function of a virus particle. The sequence of events in a one-step growth curve remains equally unclear.

In recent years, students have become aware of the role viruses play in their lives. Many colleges have included sections on viral agents in their biology courses or have added courses in general virology. The virology research projects many students are doing for regional and state science fairs require a great deal of preparation (Speece 1975).

Virions can only be visualized with an electron microscope, so equipment and supplies for demonstrating their shapes and life cycles are not available in many schools. Viral particle sizes range from the large pox virus, about 300 nm, to the small polio virus of 17 nm. Because most available viral models were either too expensive or nonfunctional, we recognized the need to develop models demonstrating the life cycle and unique assembly procedures of viruses. The development of models for classroom use is not unique. Walter (1968) explained how to make bacterial models useful for teaching.

We were interested in developing a practical model that was both inexpensive and useful. We, therefore, created a functional model that is easily made and has been successfully used by students. We have used this model in a variety of classes and feel that it can have wide application for studies in both college and high school biology courses.

TABLE 1. Materials Required for the Bacteriophage Model.

Material	*Use*
1 10-12 cm cardboard core, 2.5-cm diameter	Core Protein
1 25-30 cm cardboard core, 3.5-cm diameter	Sheath
1 30-cm by 30-cm cardboard sheet, 3-cm diameter center hole	Tail Plate
1 1-m by 1-m cardboard sheet	Head Protein
3 Wire clothes hangers	
12 7.5-cm cardboard circles, 3-cm diameter center hole	Sheath Protein
2 10-cm cardboard pieces, 3-cm diameter center hole	Neck Protein
1 1-m double-stranded rope, 1.7 cm diameter	Nucleic Acid
1 1-m thin wire	Holding Model

Materials and Methods

The materials needed for the model and their use are given in table 1.

Most of the cardboard core materials can be obtained from empty paper towel rollers. The cardboard sheets can be obtained from old boxes, and cut with a knife or scissors. The "head protein" can be drawn on the large cardboard sheet using 12-cm hexagonal shapes leaving small tabs for stapling the pieces together. Figure 1 shows a picture of all the pieces used in producing the model.

Procedure

Before assembling this model, place all pieces in a box labeled "bacterial cell." Then put the model together as if the virus were being assembled by the bacterial cell. The double-stranded rope is color coded. It represents a double-stranded DNA molecule hooked together to make a circle-like bacteriophage DNA. Attach the wire to the rope. Slit the "head protein" cardboard so the hexagon head can be bent and shaped. Staple or tape the pieces into place. Leave the bottom of the head open so the "sheath" protein core can be attached to the head. Pull one end of the wire previously attached to the rope through the top of the "head protein" and make a loop so that it does not slip out. The loop can be used to hang the model when it is stored.

Next, place the sheath protein in the "head." Stuff the "DNA" rope into the "sheath" core and the "head protein." Place the neck pieces over the sheath pieces. Add the "sheath protein" circles. These circles represent the distal sheath proteins that can contract. Attach the rope to the small cardboard core and tape one end of the core closed. This will serve as the "core protein." Place it inside the "sheath core." Glue the "tail plate" in place. Cut each coat hanger into two pieces. Bend each half and attach it to the tail place.

You now have a complete bacteriophage. You may want to paint the model to make it more durable. We have used our model for five years, and it is still functional.

Uses of the Model

We have used this model to demonstrate the bacteriophage life cycle. By producing two sets of model parts for students to assemble, we have provided an educational activity. We are also able to demonstrate the complete life cycle of the bacteriophage (fig. 2).

The completed model can also be used to demonstrate the relationship

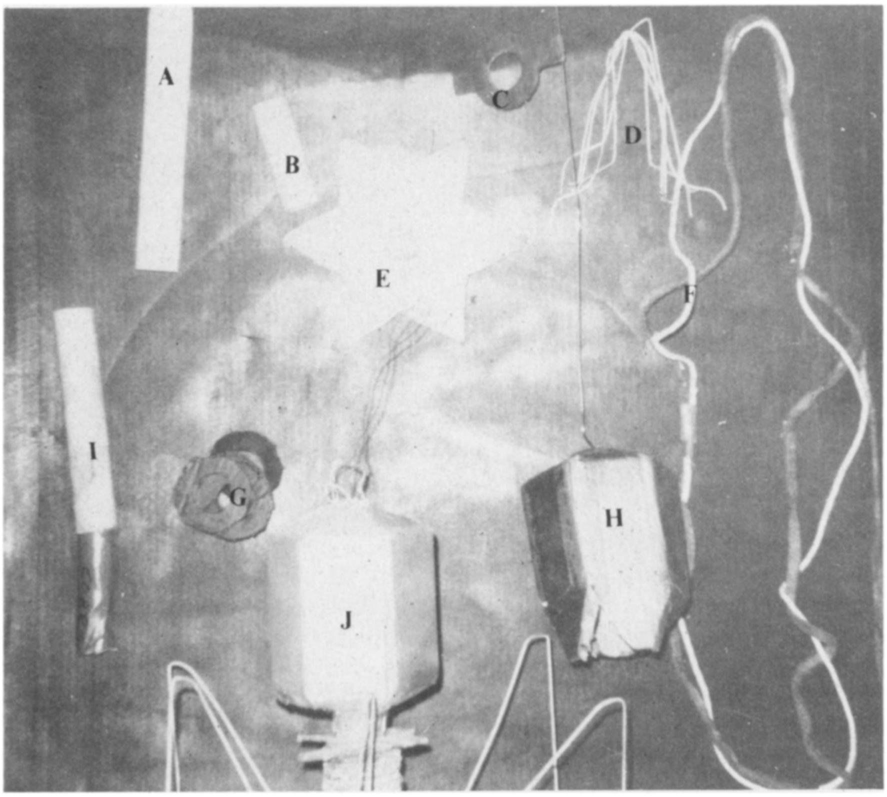

FIGURE 1. Photograph of the pieces used for assembling the Model. Pieces labeled as follows: A-Sheath, B-Core, C-Neck Piece, D-Tail Fibers, E-Tail Plate, F-DNA, G-Sheath Protein Rings, H-Head with Wire, I-Sheath with Core, and J-Finished Model.

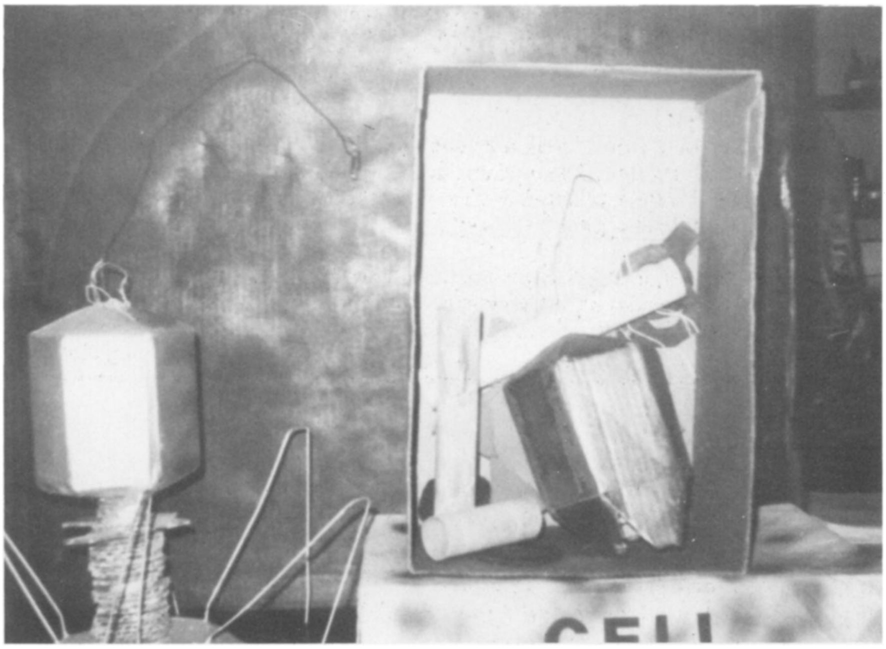

FIGURE 2. Photograph of completed model with parts inside cell model.

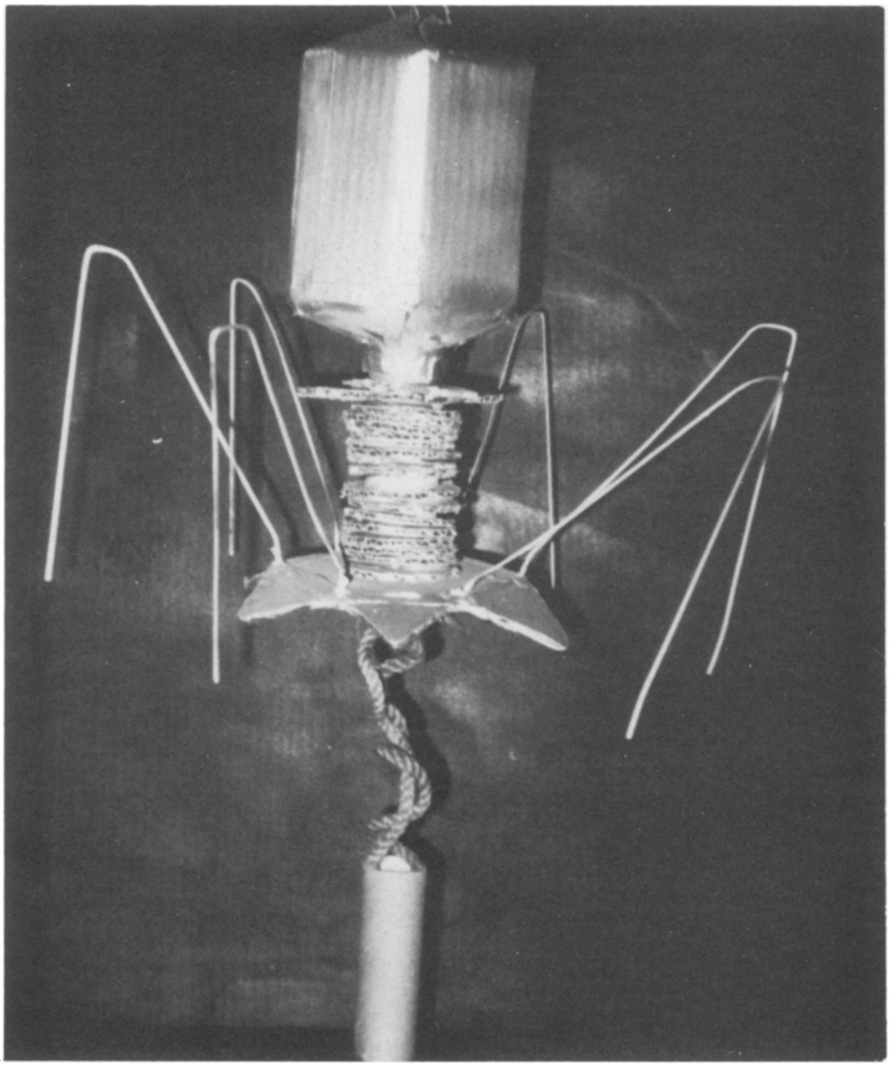

FIGURE 3. Photograph of Core Protein with Nucleic Acid out of the Sheath.

of complex viral components to the whole particle. Using the box to represent a bacterial cell, the phage attaches to the top of the box using its "tail plate" and "tail fibers" (step 1—adsorption). This can be facilitated by making correctly aligned holes in the box so the tail fibers and tail plate will fit into them. Second, the "core protein" can be pulled out of the sheath and the "sheath protein" contracted (step 2—penetration). This will cause the "DNA" to come out of the sheath, demonstrating that only the DNA and core protein go into the cell (fig. 3). Additional steps can also be demonstrated, including step 3—replication of the DNA molecule; step 4—replication of protein head, sheath, core, tail fibers, and plate; step 5—assembly of mature virus; and step 6—lysis of cell, release of viruses. Viral replication can be completed by removing the top of the box and returning to the mature virus model to repeat the cycle. We have found that this model and procedure have been helpful in presenting general information on viruses as presented by Pelczar, Reid, and Chan (1976). The model also works well with laboratory exercises presented by Cunningham (1973) and Benson (1973).

Discussion

We have found that our model, in addition to showing the virus assembly process, is functional for demonstrating the life cycles of a virus. By making their own models, students develop the concept of assembly. This differs from the binary division of other microorganisms. While working with this hands-on project, students observe the intimacy of the virus and the host cell.

The model described integrates virology instruction with general biology education. It has facilitated both student recollection and comprehension of virology principles and their relationship to viral life cycles. These concepts can then help to explain viral infections that affect humans.

(Concluded on p. 283)

Chili Hot Pot

"The way to a man's heart is through his stomach." "An army travels on its stomach." And less-than-eager students are motivated to learn by the lure of food!

Thirteen students participated in the investigation "Chili Hot Pot," a unit on nutrition. We chose to feature chili because it is a tasty, economical entree. Considerable research on the nutritional composition of chili preceded the actual "hands-on" dicing, slicing, frying, and mixing.

Students performed chemical analyses (presence of fat, protein, starch, glucose, chloride, water, and percentage composition of water) for each ingredient. Math emerged as an important tool of science. Because our facilities are limited, students wearing a white lab coat took turns performing the different analyses at a desk in front of the class. The shy gained a security blanket; the extroverts assumed roles as "mad" scientists! Everyone eagerly participated. We shared results so that tests only needed to be performed once. Excitement and expectation filled the room.

When the time arrived to prepare the ingredients, all the students pitched in to play chef, diener, and diner. A friendly competition developed to prove who was the greatest food-chopper in the group, and many eager cooks stirred and seasoned the base. We refrigerated the chili base, and students left the class eagerly anticipating the next day's activities.

A day later, the students met me at the door, most anxious to begin. A salad and garlic bread were chosen to accompany the chili feast and activity escalated as students tossed the salad and heated the bread. Like the Pied-Piper's tune, the aroma of freshly heated bread carried from cooking area to science room, and guests appeared for the festivities. To the chili base, we added cans of kidney beans. Flasks of lemonade appeared. Good cameraderie as well as good food were enjoyed by all.

In the days that followed, we computed nutritional value and cost. Students prepared nutritional data booklets by using mimeographed material from a current magazine. They analyzed cost using the daily newspapers. After they determined the cost per serving, I challenged students to come up with another meal of equal nutritional value at the same or a lesser cost. Biology, chemistry, and math had blended together, as had the ingredients of the chili, to create a most palatable product.

"A Worm is to Wriggle"

Directions for this activity follow. Devise and complete an investigation on innate behavior and learning potential of members of a species. Bring to school six members of a species (ants, earthworms, sowbugs, crickets, grubs, etc.) in a "livable-container." Identify each member as to weight and size. Try to get a variety in the members as to size and agility. Prepare a chart for your data indicating each member's response to a given stimulus. Some suggested areas of study are: temperature changes, changes in light intensities, touch, water, odors, gravity, sound, color, and shape. A shoe-box maze may be constructed for gathering data on trial-and-error learning as well as on conditioning. Draw conclusions based on your data. Indicate modifications for procedures that would enable further research.

Let the fun begin. Move back. Learning needs room to flourish.

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References

HOFFER, A. 1974. *Supernutrition*. Regina, Saskatchewan, Canada: Canadian Schizophrenia Foundation.

HURDLE, J.F. 1970. *Low blood sugar: A doctor's guide to its effective control.* New York: Parker Publishers.

LEHNINGER, A.L. 1973. *Short course in biochemistry*. New York: Worth.

MACY, I.G. 1942. *Nutrition and chemical growth in childhood*. Springfield, Illinois: Charles C. Thomas.

PHLEGAR, F.L., and PHLEGAR, B. 1969. Diet and school children. *Phi Delta Kappan* 61(1):53.

RICHMOND, J.B. 1979. *Healthy people*. (Report from the Surgeon General, Assistant Secretary for Health of the Department of Health, Education, and Walfare.) Washington, D.C.: Superintendent of Documents, U.S. Government Printing Office.

SCHROEDER, H.A. 1977. Micronutrient deficiencies in major sources of calories. *In* Williams, R.J., and Kalita, D.K., *A physician's handbook on orthomolecular medicine*. Elmsford, New York: Pergamon.

SMITH, L.H. 1976. *Improving your child's behavior chemistry*. New York: Pocket books.

STRONCK, D.R. 1976. The need for nutrition education. *The American Biology Teacher* 38(1):19.

______. 1980. Blame diet for learning problems. *The American Biology Teacher* 42(5):306.

TAUB, H.J. 1976. Introduction. *In* Passwater, R.A., *Supernutrition*. New York: Pocket Books.

ULLRICH, H.D. 1973. Needed: A definition, legislation, action. *Journal of Nutrition Education* 5(4):224.

WILLIAMS, R.J. 1959. *Alcoholism: The nutritional approach*. Austin: University of Texas Press.

______. 1977. *The wonderful world within you*. New York: Bantam Books.

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References

BENSON, H.J. 1973. *Microbiological applications*. 2nd ed. Dubuque, Iowa: William C. Brown. (Chapter on "Bacteriophage: Isolation and Culture," 83-87.)

CUNNINGHAM, C.H. 1973. *A laboratory guide in virology*. 7th ed. Minneapolis, Minnesota: Burgess Publishing Company.

PELCZAR, M.J., REID, R.D., and CHAN, E.C.S. 1976. *Microbiology*. 4th ed. New York: McGraw-Hill Book Company. (Chapter 20 on "Viruses: Bacteriophages and Phages of other Protists," 397-412).

PETERSON, P. 1973. Microbiology as a high school elective. *The American Biology Teacher* 34(7):396.

SPEECE, S.P. 1975. Science fair—an endangered species. *The Hoosier Science Teacher* 1(2):54.

WALTER, W. 1968. Mobiles for the biology classroom. *The American Biology Teacher* 30(6):540.