necessary material can usually be found in any laboratory, or can be purchased for a few cents, and the time and skill required to perform the demonstration is negligible.

The giant chromosome is really nothing more than a few inches of ordinary electric lamp cord, namely, the kind in which the two strands of wire are encased in a single rubber coat. The role of the spindle fibers is played by two pieces of very thin wire or stout thread, each about a foot long. With a scalpel, or preferably a pocket knife, a small slit is cut lengthwise in the rubber casing between the two parts of the electric wire, at the midpoint of the artificial chromosome. Through this slit the two pieces of thin wire or thread are passed, and one of them is securely fastened to each of the separated rubber coated wires. The giant chromosome should then be bent to form the characteristic V shape. Then by pulling on the two thin wires or threads, which act as spindle fibers, the rubber casing of the electric wire will easily tear in a manner very similar to the traditional splitting of a chromosome. The accompanying illustrations show four stages in the splitting of this giant chromosome.

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The Aquarium as a Teaching Device

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(*Continued from January*)

9. Locomotion

The pupil can spend a good deal of time watching the locomotion of animals in an aquarium; after he has observed the leech, compared the snail with planaria, noted such various insects as the water strider, back-swimmer, water boatman, whirligig beetle, diving beetle and mosquito wiggler, seen the way in which the rainbow darter uses its fins to climb over rocks and watched the swimming movements of the water snake, frog and turtle he cannot help but see the correlation of body form and type of movement. He will realize that different animals bring about the same type of movement with different body parts and that the same animal may have two or more distinct types of locomotion making use of different body parts.

10. Protection

By careful placing of rocks, sand and vegetation the aquarium can be so arranged as to bring out the protective coloration of the tadpole and the hiding behavior of the crayfish. The closing of the shell of the clam and turtle and the trapdoor of the snail can be observed at close range. And the student may himself give the stimulus that induces the protective response. Such weapons as the spines of many of the fishes, the jaws of the hellgramite and the claws of the crayfish can be seen in action. The use of speed to escape a predator can be observed in a large aquarium.

11. Learning

Fishes of some types can be taught to appear for feeding in a certain corner of the aquarium and in response to a certain signal. It is easy to observe that some species adjust themselves rather quickly to such a change in environment as a glass partition across the middle of the aquarium and that others merely continue to bump their noses against the glass. The change in general behavior after a period of captivity varies tremendously with different kinds of animals. Some fishes that are normally bottom feeders will learn to come to the surface for food; others will starve to death without learning. If a considerable number of specimens of the same species are taught to come for feeding on a certain signal, it will be observed that some individuals learn more quickly than others. Animals vary not only in making adjustments to artificial conditions, but also in forgetting them after the artificial conditions are removed. If the feeding signal is omitted for a week or ten days some fishes have to learn all over again.

12. Physical Factors of the Environment

There is no limit to the number and variety of experiments that may be devised to test the effects of light, temperature, chemicals and other non-living influences on the organisms in the aquarium. Temperature stratification may be produced by means of a partially submerged light bulb at the surface and an anchored piece of ice on the bottom. Many of the smaller organisms will orient themselves rather sharply in respect to such stratification. The effect of evaporation may be shown by covering one aquarium with a glass plate and leaving another uncovered. The former will usually be several degrees warmer. The oxygen content of the two can then be measured and thus several ecological factors studied in relation to each other. A stirring motor can be set up to produce a constant current through the aquarium, to illustrate responses of animals to running water. There is of course no limit to the chemical changes that can be made in the water. These can be correlated with studies of pollution and conservation.

13. Hydrogen-ion Concentration

Measurements of the hydrogen-ion concentration made at various times of day reveal many interesting relationships. The accumulation of carbonic acid during the night and the shortage of the acid after a day of photosynthesis can thus be checked. If a running water aquarium is available it is instructive to take frequent readings of the pH of the water as it comes out of the tap and compare it with that of the aquarium. Readings made in the field may be compared with those in the aquarium. Sometimes these differ widely. Some aquatic animals cannot stand a very abrupt change in hydrogen-ion concentration and may show various signs of distress when transferred from their habitat to the aquarium. Checking changes in pH resulting from addition of dilute acids and alkalis, salts, limestone and other substances offers opportunities for correlation with physical science.

14. Temperature Effects

We have used the aquarium for physiology experiments to study the effect of temperature changes on general activity, rate of respiratory movements, carbon dioxide production and feeding habits of fishes, locomotion rate of snails and planaria, growth of mosquito larvae, rate

of development of snail eggs, feeding activities of crayfishes, oxygen production of elodea and several other physiological activities. In some cases the responses are delicate enough so that the rate changes can be measured with considerable accuracy and the effect of temperature on rate compared with the corresponding effect in ordinary chemical reactions. The speed of locomotion of planaria is such a case. The construction of heating and cooling devices suggests correlation with physical science and industrial arts.

15. Balance and Unbalance

A balanced aquarium may be established in a gallon bottle. A few good oxygenating plants such as elodea and several small animals such as snails will live successfully, even with the bottle sealed, provided sudden temperature changes are avoided. In any aquarium that is approximately in balance, unbalance may be produced directly by the addition of new forms of animals in considerable numbers or of excessive numbers of forms already present. It may be produced indirectly by an abrupt change in temperature, the addition of chemicals, reduction in the amount of light or other changes in conditions favorable to some of the species present and unfavorable to others. Then the establishment of a new balance may be noted if the changes are not too drastic. Long time successions may also be noted. We have a ten gallon carboy aquarium which has not been disturbed, except for the addition of water to replace that lost by evaporation, since September, 1933. Since then there have occurred many cycles of scarcity and abundance of both plants and animals, as well as the building of more than an inch of "soil" above the bottom sand originally placed there.

16. Sanitation

A dead animal may be put into the aquarium, or one that dies left there, to illustrate the activity of molds, bacteria and other microorganisms or the action of scavengers, or both. Sometimes the scavengers will not be able to keep ahead of the microorganisms and decay results. Excess food will ferment and decay. Here are opportunities to correlate microscopic studies with ecological. If facilities are available pure cultures may be made of some of the organisms. Bacteriological tests are practical in some schools. There are many applications to the problems of water supply and sewage disposal.

17. Parasitism

We had at one time in the same aquarium a sunfish infested with "water mold" or white fungus, several minnows heavily infested with "fish lice," a small snapping turtle with about a dozen leeches on it and a number of fishes of various species carrying clam glochidia. We have observed several other examples of parasitism in the aquarium. The glochidia also illustrate the shift from the parasitic habit to the free-living state. If heavily infested fishes or crayfishes are kept in separate jars with uninfested specimens of the same species it is sometimes possible to observe some of the details of transfer and life history of the parasites.

18. The Marine Aquarium

It has in recent years become practical to ship the necessary materials for a marine aquarium to almost any point in the country. It is a rather expensive procedure for the extremely small schools, but even there in terms of total experience gained, on a per-pupil basis, it may be money well spent. It often

offers the only opportunity for pupils to see live starfish, sea urchins, sea anemones, hermit crabs, king crabs, sandworms, corals and the like. To the inlander the feeding of marine animals presents a whole new set of problems. The observation of a starfish feeding on a barnacle is worth considerable reading of printed material. Some comparison with related fresh water forms is of interest. Transfer from fresh to salt water and vice versa offers possibilities for experiments for those so inclined. The adaptability of different animals to mixtures of various percentages of fresh and salt water can be tested.

Biological Briefs

KAISER, ALBERT D. *Significance of the Tonsils in the Development of the Child.* Journal of the American Medical Association 115: 1151–1156. October 5, 1940.

The author of this article argues for a reduction in the numbers of unnecessary tonsillectomies performed on children. Where markedly hypertrophied tonsils persist after the age of four years, their removal is indicated, since repeated attacks of tonsillitis and adenitis impair physical development. Such a condition exists in no more than 20% of all children. Although it has been argued that tonsillectomies prevent frequent colds, sinusitis, and laryngitis, these statements have never been satisfactorily proved. Similarly, the tonsils do not appear to play any important role in the incidence of bronchitis, pneumonia, tuberculosis, rheumatic disease, or nephritis.

SHOUGH, W. WREN. *The Feeding of Ground Beetles.* The American Midland Naturalist 24: 336–344. September. 1940.

The ground beetles are largely predaceous in habit, but a few will eat other types of food. An abundant source for them is under freshly mown clover or alfalfa, where the insects feeding on the living plants are still present to serve as prey for the beetles. They may be kept in small containers with damp sand or moistened filter paper. A great variety of living forms were given to the beetles, and in most cases any insect which could be penetrated was quickly eaten. Some jumping insects were able to resist attack, while larval forms were the most helpless. Small beetles attack the larvae of insects bigger than themselves, if the prey is slow-moving. The slime of earthworms and slugs is unpleasant to them, but proves no deterrent if the beetles become extremely hungry. A few are plant feeders to some extent, and some in captivity accepted raw beef or cheese for food.

GRIGGS, ROBERT F. *Timberline on Mount Washington.* The New England Naturalist, No. 8: 11–16. September, 1940.

The reasons for the occurrence of scrub forests and of timberline on the heights of mountains are difficult to analyze. Temperature does not seem to play the strongest role, since the disappearance of trees cannot be clearly correlated with decreased temperature levels. Wind apparently is the most important factor, both directly by mechanical injury to the struggling plant, and indirectly by controlling the depth and deposition of snowdrifts. The marked increase of fogginess at higher levels must also play a part, since fog droplets clog the stomata and thus interfere with carbon dioxide intake.