Behavior of Undisturbed 1- to 10-day-old Chicks in Different Rearing Conditions

D. M. BROOM

Department of Zoology
University of Reading
Reading, England

BROOM, D. M. (1969). Behavior of Undisturbed 1- to 10-day-old Chicks in Different Rearing Conditions. Developmental Psychology, 1(4): 287-295. Most of 11 measures of the behavior of undisturbed chicks showed a gradual increase in frequency of occurrence between the 1st or 2nd and the 10th day. A group of 4 measures, associated with feeding, showed a peak at 6 days among isolated birds. These changes are related to studies of food reserve utilization and improvement in motor ability during this period. Group-reared birds showed patterns of behavior change with increasing age similar to isolated, but showed them earlier.

Chicks were reared in conditions of different visual complexity and their behavior watched while they were undisturbed at 6 days. Where a moving object had been visible to the chicks during rearing, their behavior was much affected. Such birds spent much time as near to that object as a perspex partition would allow. If the object had been moving continuously, the birds were active for more of the observation period than were birds in grey-walled pens, but conditions that were identical except for the lack of movement had no such effects on behavior.

Behavior development is changed and perhaps accelerated by certain increases in the complexity of a chick's environment.

chick behavior environment complexity social rearing early learning development preferred activities imprinting maturation

NEWLY HATCHED CHICKS (Gallus gallus) are able to perform most of the activities that 10-day-old chicks can perform (Spalding, 1873; Krujit, 1964). They can see well (e.g., Fishman & Tallarico, 1961; Tallarico, 1961) and during brain development most of the reported changes in anatomy (Rogers 1960), enzyme activity (Lindeman, 1947; Rogers, de Vries, Kepler, Speidel, 1960), and electroencephalogram (EEG) (Garcia Austt, 1954; Key & Marley, 1962) are complete by hatching. After hatching, certain motor abilities improve so that running (Krujit, 1964), pecking (Breed, 1911; Padilla, 1935), and even copulatory movements (Andrew, 1966) are efficiently performed by the 4th day.

In most studies of behavior changes during chick development, the chick is subjected to an environmental change of some sort. This change is usually complicated by the presence of the observer during testing, so it is difficult to compare the results of such experiments with other concurrent changes in the animal. The absence of the experimenter from rearing and testing conditions reduces the number of variables affecting behavior and makes it more likely that deliberately engineered differences between groups of birds will be limiting in determining behavior.

In the experiments here described, the aim was to relate behavioral changes to other changes during development so the birds were completely undisturbed. Three experiments are here reported. In experiment 1, the behavior of undisturbed chicks reared in visual isolation or in groups of 3 was watched on one of 8 days during the 10 days after hatching. The results of this experiment are reported in 2 sections; firstly, the differences between isolated birds at different ages, and secondly, the differences between isolated and group-reared birds. Experiment 2 was a comparison of birds reared in different conditions of illumination and watched when 2, 6, or 10 days old. The visual

Received for publication 17 February, 1969.

Developmental Psychology, 1(4): 287-295 (1968)
complexity of the rearing conditions was varied in experiment 3, in which the chicks were 6 days old when watched. The rearing conditions were chosen with regard to the many studies of what objects chicks will approach preferentially (reviewed by Sluckin, 1965). The statistical tests used were 2-tailed Mann-Whitney U Tests unless otherwise stated.

METHOD

EXPERIMENT 1

Eggs of a breed ('Chunkies') of domestic fowl were transported from a commercial hatchery to Glevum Superior incubators 3 to 4 days prior to hatching. They were placed in the incubator so that each egg was touching at least one other egg in order that any mechanisms for synchronization of hatching might be maximally effective (Vince, 1964). Seventy-five percent of the eggs hatched during a period of 6 hr and the chicks were transferred to rearing pens when 9 to 15 hr old. The incubator was darkened and transfer was affected using an opaque box with a lid so that chicks did not see one another or the experimenter for more than 30 sec.

The chicks were kept in either visual isolation or groups of 3 in pens with a floor area of 700 cm² and with 23-cm-high hardboard walls. The pen, which was identical to that shown in Fig. 1 except that all walls were painted matt grey, was roofed with wire netting and was empty except as shown.

All birds had ample food and water at all times. A standard measure of chick crumbs was put on the floor of each pen prior to transferring the chicks to the pens and at 5, 7, and 9 days. The water dishes were filled on days 2 to 10. The mean temperature in each pen was maintained at 29 to 34° C and the room was continuously illuminated by strip lights, the only form of lighting.

During the feeding operations and the provision of water, one arm and the head of the experimenter were visible to each chick for 5 to 10 sec. Apart from this the chicks did not see the experimenter during rearing or observation, since their pens were shielded by hardboard and black cloth partitions from the part of the room that the experimenter entered. The behavior of the chicks could be watched from darkness through vertical, one-way plastic film windows which were 1.5 m above the pens, so that the chicks could never see themselves or the observer. This was checked by looking at the observation points from the position normally occupied by the chicks. Chicks never fixated an observation point. All the experimenter's movements were kept as quiet as possible and, after the observation position was reached, a 5-min interval was always allowed before recording began. This was started at least 30 min after feeding or water provision and occurred between 0900 and 1300 hr G.M.T.

Several batches of eggs were necessary for the experiment. There appeared to be few differences between batches in any respect, but within each batch the numbers of isolated and of group-reared birds and the

![Fig. 1. Rearing pen used in experiment 3 conditions (2), (3), (5) and (6). The wire netting roof and central infrared heater have been removed.](image-url)
number of birds watched at each age were kept equal as far as was possible. Each bird, or group of 3 birds, was watched once but remained in the pen until 10 days old. The experiments were designed so that for each combination of age and rearing condition, \( N = 12 \). Since a few birds died, \( N \) varied from 9 to 12. The behavior of the undisturbed chicks was watched for 15 min at one of the following ages: \( 1\frac{1}{2}, 2\frac{1}{2}, 3\frac{1}{2}, 4\frac{1}{2}, 5\frac{1}{2}, 6\frac{1}{2}, 8\frac{1}{2}, \) or \( 10\frac{1}{2} \) days.

Birds’ activities were recorded by means of an Edgcumbe moving paper event recorder whose 12 pens could be deflected by using a switchboard on the lap of the observer. The switches were selected for quietness and modified so that they made less noise than a chick’s footfall. The event recorder was kept in a different room from the chicks since it made some noise when a pen was deflected.

The behavior observed was coded on to the 12 channels of the event recorder using the “period occurrence” technique. At the end of successive 10-sec periods, each of 11 measures of behavior was recorded by a pen deflection (or 2) if they had occurred in that period. Using this method, 3 animals could be observed at once but every activity seen during the watch was shown on the final record. The disadvantage that no differentiation is made between activities that occur continuously and those that occur once during each period was minimized by making the period as short as possible. The 10-sec intervals were indicated by means of a tape-recorder, in an adjacent room, connected to an earphone 1 to 2 cm from the ear. This noise could not be heard by the chicks.

Twelve isolated, undisturbed chicks were also watched at 8-hr intervals up to 48 hr to determine the ages at which various activities first appeared.

**Experiment 2**

The same methods were used as in experiment 1, except that the chicks (all visually isolated) were transferred to pens at 2 to 8 hr, the pen design was different, and the birds were watched at 2, 6, or 10 days of age. The pens had the same floor areas as those used in experiment 1 but, since the overhead illumination was controlled, the roof of the pen was 4.8 mm thick, translucent “opal” perspex with a tubular, filament bulb above it and one wall was made of wire netting. Water was supplied by a pipe with a 5-cm diameter hole on the upper surface in each pen. Chicks could drink easily from these holes and the pipe could be filled without disturbing the birds.

Three rearing conditions were compared: (1) high diffuse overhead illumination, (2) low diffuse overhead illumination, (3) low diffuse overhead illumination but with a 6.3-v torch bulb illuminated on the wall. The overhead illumination levels were adjusted so that the average of 6 readings, from a Weston Master 5 light meter, taken at 90° to one another in the center of the pen was 4.1 to 4.2 in conditions (1) and (3), but 2.6 in condition (2). The 2.6 value was chosen because it was the mean level in the pens in experiment 1 and the increase due to torch-bulb illumination was from 2.6 to 4.1 or 4.2. There were no detectable differences among the mean temperatures in the pens.

**Experiment 3**

The same methods were used as in experiment 1 except that the rearing conditions were of 6 types, differing in visual complexity, and the chicks (all visually isolated) were watched at 6 days. Rearing conditions:

1. Grey—G. Plain grey pens as used in experiment 1 (\( N = 32 \)).
2. Stationary objects—S. One of the walls of each pen was made of transparent perspex, which allowed the chick to see into the adjacent pen. This was the same size as its own pen, but filled with objects of varied colors and shapes. The perspex wall was always on the right-hand side of the rearing pen (Fig. 1). The illumination was such that it was not possible for the chick to see its own reflection in the perspex. The objects were: (a) an approximately spherical ball of white cotton wool 5 cm in diameter, mounted as shown on the spindle of a motor in front of a grey board 15\( \times \)10 cm; (b) a piece of white card 15 cm square; (c) 4 small pieces of coke whose mean diameter was 3 cm; (d) a red rubber tube 15 cm long; (e) a wooden cube, of side 4.5 cm, painted red, (\( N = 30 \)).
3. Moving object—O. Exactly the same as S except that the motor was continuously working so that the cotton wool ball traced a circle once every 2 sec. The motors were selected for their silence, but they did make some noise (\( N = 24 \)).
4. Mirror—M. The same as G except that a mirror (18\( \times \)15 cm) was glued centrally, but touching the ground, to the right-hand wall of the pen (30\( \times \)23 cm) (\( N = 14 \)).
5. Stationary objects after alternation—(s). A time clock with 6 switches was connected via a relay to the motor so that the motor was moving for 4 hr and stationary for 4 hr. The birds were tested between 0930 and 1230 hr during a period when the motor was stationary. No observations were made during the 30 min after the motor stopped or the 30 min before it started again (\( N = 12 \)).
6. Moving object after alternation—(o). The same
as (s), but watched while the motor was moving (N = 12).

All statistical comparisons are restricted to birds from the same batches of eggs. The numbers in such comparisons were as follows: G 24 vs S 21; G 12 vs O 18; G vs M and S vs O, both 14 × 14; (s) 12 vs (o) 12; S vs (s), S vs (o), O vs (s), O vs (o), all 6 vs 12; S 6 vs M 6.

For each batch of birds, pens with birds reared in different ways were alternated around the room. The sound levels in the pens were measured and some overlap was found between the quietest pens from which a moving object could be seen O, and the other rearing conditions. The noise of the striplights and thermostatically controlled blower heater was greater than that of the motors. Apart from this small sound difference, the only differences between rearing conditions were visual.

Experiment 1 (a). CHANGES IN BEHAVIOR OF ISOLATED BIRDS WITH INCREASING AGE

RESULTS AND DISCUSSION

Most of the activities whose occurrence was recorded were observed at 10 hr. More than 75% of the chicks walked, pecked the ground and twittered, while some of them preened, moved near the torch bulb, pecked the wall, and gave loud calls. The first defecation was observed at 18 hr and the first drinking and jumping at 36 hrs. These observations are similar to those of Krujt (1964), who watched junglefowl. As Krujt pointed out, there is an increase in strength with age. The legs and feet of a recently hatched chick are much softer and more fleshy than those of birds a few days older, and at 3 days birds appear to be better balanced on their legs and able to run faster than on the 1st day. I found that chicks forced to jump off a 5-cm-high brick were unable to land on their legs alone on the 1st or 2nd day but could do so on the 3rd day or after.

The changes in behavior with increasing age from 1½ to 10½ days are plotted for 4 of the measures in Fig. 2. Chicks not recorded as moving were asleep and vocalizations were divided into "twitters" and "loud calls" (see Broom, in press). As shown in Fig. 4 (solid line), the other three more frequently occurring measures, "walking," "drinking," and "moving near bulb" showed a steady increase as the birds got older. The fact that all measures except vocalization showed an increase in frequency between 1½ and 10½ days may be due in part to the improvement in motor abilities during the 1st week after hatching, but there are other concurrent bodily changes. Randall (1943) and Moreng and Shaffner (1951), for example, found that there is a gradual improvement in the ability of young chicks to control their body temperature, while Sisken, Roberts, and Baxter (1960) found that an

![Graph showing changes with age of undisturbed isolated birds. Each point is the median of 11 or 12 chicks. Mann-Whitney U-test values (2-tailed) are for comparison between the points marked with an asterisk.](image-url)
increase in glutamic acid decarboxylase activity continued until as late as the 12th day after hatching in various parts of the chick brain.

The increase in the frequency of moving, pecking the ground, preening, and twittering from a comparatively low level during the first 2 to 3 days to a peak at 5½ to 6½ days (Fig. 2) is clearly related to the increased necessity for feeding. The yolk sac makes up about 10% of the chick's weight at hatching, but this drops to 1% by 5 days (Schilling & Bleecker, 1928; Parker, 1929). Some of this reduction is compensated by an increase in liver weight, but blood lipid levels drop rapidly over this period (Entenman, Lorenz, & Chaikoff, 1940). Since the food reserves are being used for general metabolic purposes and are rapidly reduced over the first 3 days, it is necessary for the chick to feed more at this age. The evidence for this supposition, that the chick subsists largely upon its food reserves for the first 2 days but then starts to feed, is also derived from measurements of total body weight, which show a minimum of 2 to 3 days (Latimer, 1924).

Since pecking the ground does not occur among birds that are almost asleep, it would be expected that the measure "moving" would increase when "pecking the ground" increases. A Spearman rank correlation has been carried out to determine the extent to which the birds that moved most were those that pecked the ground most. A 1-tailed test can be used here, for the result is logically predictable from previous observations and gives a probability value of less than .05 at all ages from 1½ to 8½ days. Since birds often twitter when pecking the ground, the similarity in changes with age in these 2 measures is expected. They are also correlated (p < .05) at 1½, 2½, 4½, 6½, and 8½ days. Undisturbed birds preen for a fairly constant proportion of the time that they are active, so this measure follows the same pattern of change with age as "moving."

The decrease in the 4 measures from 6½ to 8½ and 10½ days is less easily explained. However, since the chick's pecking accuracy does not improve after 5 to 6 days (Cruze, 1935; Padilla, 1935) but weight gain accelerates smoothly over this period (Latimer, 1924), it seems likely that during the first week, the chick's motor systems mature and it learns how best to utilize its abilities to acquire food. Thus, at 8½ or 10½ days it is able to eat all that it requires without spending much time doing so. The decrease in pecking the ground is followed by decreases in the other 3 measures.

A similar result was obtained by Pulliainen (1965), who watched pheasant chicks at successive ages and recorded that feeding and drinking behavior rose to a peak at 10 days and then decreased, while resting behavior was the reverse.

Since food is spread all over the floor of the pen, it is not necessary for the chick to walk in order to feed, so there is no reason why walking should change in the same way as moving and pecking the ground. The other measures that show a general increase in frequency from 1½ to 10½ days, but no peak at 5½ and 6½ days, are dependent to some extent upon walking.

Figures 2 and 3 show that, contrary to the general trend, there were decreases in twittering from 1½ to 3½ days (p = .02), and in pecking the wall (p = .012), loud calling and jumping from 1½ to 2½ days. The number of activities performed by each bird was less on day 2½ than on day 1½ (p = .008) despite the fact that the proportion of time spent moving and sleeping remained the same. Young chicks explore their abilities and their environment on the first day, but some of these activities are more beneficial to the birds than others and are retained in the repertoire, while others are later performed less frequently. Pecking is more random initially, but that directed against the ground may be followed by food ingestion while that directed against the wall of the pen has no such consequence. Such selection of activities is possible only because the sense organs and integration mechanisms in the brain of the young chick are well developed at hatching.

Since this experiment is restricted to one breed of chicks, any explanation of the results and correlation with other work on chicks of the same ages must be somewhat tentative for there is evidence for divers differences between breeds (e.g., Lamoreux & Hutt, 1939; Phillips & Siegel 1966). These results have previously been summarized in abstract (Broom, 1966).
Experiment 1 (b). COMPARISON OF VISUALLY ISOLATED AND GROUP-REAURED CHICKS

RESULTS AND DISCUSSION

Figure 4 shows for isolated and group-reared birds the changes with age in the median per cent of 10 sec periods during which each activity was performed. Every activity measured that occurred frequently enough for the median to be greater than zero is shown. The patterns of change in behavior of group-reared birds were remarkably similar to those shown by isolated birds, but occurred earlier. Both increases and decreases occurred earlier among group-reared birds, while they showed a final increase in some measures at 8½ to 10½ days that the isolated birds had not shown by this age, but might perhaps have shown later.

For each of the measures of behavior, the speed of behavior development was measured by calculating (a) the first age at which \( p < .05 \) for a comparison with the 1½- or 2½-day value using a 2-tailed Mann-Whitney U test; (b) the age at which the first peck occurred; and (c) the age of the lowest median after the first peck. Group-reared birds reached each of these criteria earlier than isolated birds by almost every measure of behavior, particularly those associated with feeding.

It is not possible to determine from this experiment whether it was the long-term rearing condition or the sensory input during and immediately prior to the observation period that caused the differences recorded. This could be decided by following the development of the behavior of individual birds and recording the times that various stages are reached, but in this experiment each bird was watched only once, so such analysis is not possible. It seems reasonable to suggest, however, that the changed and increased sensory input received as a consequence of the presence of other birds, speeded the developmental processes of the group-reared birds.

Work such as that of Bayer (1929) and Tolman (1964) on social facilitation effects, allows the predic-

![Graphs showing activity levels of isolated and group-reared birds](image)

**FIG. 4.** Group-reared birds develop faster than isolated birds. The median value for the % of 10-sec periods during which each activity was performed at ages 1½ to 10½ days is plotted for isolated birds (continuous line) and group-reared birds (dotted line).
tion that birds in a group will start to peck the ground at an earlier age than those in isolation. It was noticeable during this experiment that 3 birds, watched in the same pen, were much more likely to be pursuing the same activity than were 3 isolated birds. The rate of development of behavior is likely to be close to that of the fastest bird in the group for each activity, although still limited by physical maturation rates.

Ratner (1965) watched birds in their home pens, but was visible to them. He reported on the development of a certain number of activities that appear principally during interaction between individuals and noted that these appeared earlier among group-reared than among isolated birds. This is predictable from the nature of the measures and corresponds with the results of the experiments here described. Findings such as those of Guiton (1958) and Sluckin and Salzen (1961) that the age at which naive group-reared birds cease to follow a moving object is earlier than that at which isolated birds do so, may also be evidence of faster maturation among birds reared in groups.

Experiment 2. COMPARISON OF BIRDS REARED UNDER DIFFERENT ILLUMINATION CONDITIONS

RESULTS AND DISCUSSION

Birds reared with a torch bulb illuminated in their pen fixed that bulb much more often than did birds reared with the same mean illumination level supplied wholly by diffuse overhead illumination (at 2, 6, and 10 days; p < .05). This expected result was the only difference between birds reared in the 3 conditions except for a very small tendency for birds in the brighter pens to be more active. The differences between conditions in this experiment were much smaller than those used by Shreck, Sterritt, Smith, and Stilson (1963), who found greater mortality among birds reared in dim light.

Experiment 3. COMPARISON OF BIRDS REARED IN CONDITIONS OF DIFFERENT VISUAL COMPLEXITY

RESULTS AND DISCUSSION

The principal conclusion that can be made as a result of this experiment is that the presence of a moving object that can be seen but not touched during rearing has a considerable effect on the behavior of undisturbed chicks at 6 days. The presence of stationary objects, however, has much less of an effect. The comparison of birds reared identically with alternating 4-hr periods of movement and no movement in the adjacent pen, but watched while the object was moving in one group and stationary in the other, shows no major differences at all between these conditions. This fact supports the hypothesis that it is the complexity of the rearing condition that has the most effect on behavior, as measured in these experiments.

The presence of a mirror in the pen has a similar effect on behavior to that of a moving object, but the effect is not as pronounced.

When the chicks were first put into the pens there was an immediately apparent difference in behavior between birds that could see a moving object and birds that could not. No quantitative observations were made, but within about 3 min almost every bird that could see the moving cotton-wool ball was seen to be sitting as close as possible to it, as in Fig. 1. Birds in all other conditions were most likely to be sitting in the warmest part of the pen under the infra-red lamp. Some of the birds with a mirror on the wall sat in front of the mirror, but most sat under the lamp.

The measures of behavior for which large differences were apparent at 6 days were (a) sleeping—entirely motionless for whole 10-sec period, (b) "moving only"—moving but not walking, preening, pecking, drinking, jumping, or defecating, and (c) moving near the partition (head within 5 cm) quoted as a percentage of the total time each bird was moving. Tables 1 and 2 show for each rearing condition the median percentage of periods during which these measures were recorded in the 15-min watch and Mann-Whitney U test values for all inter-condition comparisons listed in the Methods section if p < .1, 2-tailed.

The group O chicks (moving object continuously visible) slept much less than the others and spent much more time "moving only" near the partition. Since all these observations were made during the morning, it seems possible that the rearing condition may affect the diurnal rhythm of the birds. The presence of stationary objects behind the partition led to only a slight

<table>
<thead>
<tr>
<th>Rearing Condition</th>
<th>G</th>
<th>S</th>
<th>(s)</th>
<th>(o)</th>
<th>M</th>
<th>O</th>
<th>GvO</th>
<th>SvO</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>34</td>
<td>28</td>
<td>22</td>
<td>39</td>
<td>18</td>
<td>3</td>
<td>p &lt; .002</td>
<td>p &lt; .05</td>
</tr>
<tr>
<td></td>
<td>20</td>
<td>20</td>
<td>20</td>
<td>26</td>
<td>20</td>
<td>41</td>
<td>p = .02</td>
<td>p &lt; .02</td>
</tr>
</tbody>
</table>

TABLE 1. Sleeping and "Moving Only" at 6 Days (Undisturbed)
TABLE 2. Moving near Partition at 6 Days (Undisturbed)

<table>
<thead>
<tr>
<th>Rearing Condition</th>
<th>Mdn % of Periods near Partition</th>
<th>Mdn % of Periods Moving that Chicks near Partition</th>
</tr>
</thead>
<tbody>
<tr>
<td>G</td>
<td>5</td>
<td>7</td>
</tr>
<tr>
<td>S</td>
<td>8</td>
<td>15</td>
</tr>
<tr>
<td>(s)</td>
<td>26</td>
<td>51</td>
</tr>
<tr>
<td>(o)</td>
<td>27</td>
<td>51</td>
</tr>
<tr>
<td>M</td>
<td>19</td>
<td>42</td>
</tr>
<tr>
<td>O</td>
<td>36</td>
<td>50</td>
</tr>
<tr>
<td>GvO</td>
<td></td>
<td>$p = 10^{-4}$</td>
</tr>
<tr>
<td>SvO</td>
<td></td>
<td>$p &lt; .002$</td>
</tr>
<tr>
<td>GvM</td>
<td></td>
<td>$p &lt; .002$</td>
</tr>
<tr>
<td>(s)vS</td>
<td></td>
<td>$p = .1$</td>
</tr>
<tr>
<td>(o)vS</td>
<td></td>
<td>$p &lt; .1$</td>
</tr>
</tbody>
</table>

The results of experiment 3 are in accord with studies of following and of preference in choice tests. A considerable variety of objects has been observed to elicit approach and following by various young precocial birds. The factor that the objects had in common was that they moved, usually at approximately walking speed, away from the bird. Since James (1959) showed that chicks would approach a flashing light, experiments have been carried out to determine the optimum size, intensity, rate of flashing, etc., for eliciting such approach (Smith, 1962; Sluckin, 1965). Moltz (1963) has pointed out that the retinal input from a regular flash may be very similar to that from a moving object. He has suggested that the pecten might play a part in detecting or magnifying such input, while Sackett (1963) proposed that the retinal system for detecting the particular movement that is approached might mature earlier than other systems.

The presence of stationary objects that are brightly coloured and varied in shape appears to the human observer to alter the complexity of the chick’s environment considerably. It does not have much effect on the preferred activities of the chicks at 6 days, although other behavioral tests (e.g., Bateson, 1964a) might demonstrate some effect of this rearing condition variation. The present study emphasizes that the presence of a moving object during rearing, even if not moving at the time of observation, has a marked effect on chicks’ activities.

NOTES

I thank Professor W. H. Thorpe, F.R.S., and Professor R. A. Hinde for their advice and encouragement, and Dr. G. K. Wallace for discussion of the manuscript.

This work was carried out at the Sub-department of Animal Behaviour, University of Cambridge, and was supported by a grant from the Science Research Council.

Mailing address: D. M. Broom, Department of Zoology, The University, Reading, England.

REFERENCES

Entenman, C., Lorenz, F. W., and Chaitoff, I. L. (1940). The lipid content of blood, liver and yolk sac of the newly hatched
chick and the changes that occur in these tissues during the first month of life. *J. Biol. Chem.*, 133: 231–241.


Lindeman, V. F. (1947). The cholinesterase and acetylcholine content of the chick retina, with especial reference to functional activity as indicated by the pupillary constrictor reflex. *Amer. J. Physiol.*, 148: 40–44.


Conceived and compiled by the Animal Behavior Society, this collection of laboratory exercises introduces the student to salient behavioral concepts with illustrations employing animal subjects from invertebrates through mammals. Suitable for courses in comparative psychology, invertebrate zoology, genetics, evolution, and ecology.


Course content for the student of introductory biology. Presented in a “levels of organization” format, from molecules, through cells, organisms, populations, communities, to ecosystems. Stresses the interplay of systems and individuals at each level.


Twenty-six contributors present a multidisciplined treatment of invertebrate research, particularly on the planarian, that is designed to convey the “state of the art” of investigating memory mechanisms in lower organisms from both behavioral and molecular standpoints. Useful discussion sections follow each major topic in this proceedings volume.


Fifteen chapters with discussion sections on topics including the search for a common language with the chimpanzee, teaching the deaf child to speak, and attempts to perfect mechanical devices capable of monitoring and acting on acoustic patterns of speech. Now in its third printing (1966), this paperback is the fascinating outcome of a conference on “Language Development in Children” sponsored by the National Institute of Child Health and Human Development, U.S.P.H.S.


This important volume takes an interactional approach to behavioral variability, where neither genetic nor environmental parameters alone are held to exert an exclusive, deterministic influence. Included are papers discussing the relationship between genetics and intelligence, the role of social competition in natural selection, and biogenetic theories of social structure and process.


An aid to advancement from the descriptive to the quantitative level of investigation in the field of neuropathology...nothing like it exists in the western world today.” (From the Foreword by Donald B. Lindsley.) Includes 167 pages of tabular material.


An interesting study of how electrified particles present in the air influence animal and human behavior. The author is particularly concerned with human allergic sensitivity and its control through alteration of the electrical conductivity of various substances in the patient’s immediate environment.


A one-semester survey of microorganisms including protozoa, algae, fungi, bacteria, and viruses. This revised edition is thoroughly updated and contains a chapter on the history of microbiology as well as much new material on microbial genetics.


An exciting discussion of recently secured data, much of it hitherto unpublished, dealing with the behavioral effects of brain lesions and of steroid hormones introduced early in development. Proceedings of a symposium held at the University of Michigan, 1967.


A radiantlly speculative treatise abundantly couched in matters of fact. The author writes with a style that easily communicates a sense of excitement and suggests his personal success as a classroom instructor. A worthwhile investment of reading time for the developmental researcher.