THE DESIGN AND EVALUATION OF A TELEVISION PACKAGE ON THE CHICK EMBRYO

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ABSTRACT

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The purpose of this thesis-equivalent was to prepare and evaluate an inexpensive television package at the high school leaving examination level for biology students. If students exhibited a notable change in knowledge and comprehension levels that were significant at $p < .01$, then this package would be termed effective.

Based on criteria stated by Herman (1965), Gagné (1969), Gordon (1970) and others, an inexpensive television package was created. A thirty-eight item measuring device which was used as a pre- and post-test was created according to Hedges (1968).

Sixty-eight students took part in the study. The students received a pre-test on day one of the study. On day two they participated in the program package, and on day three they took the post-test.

A t-test for the significance between the means for correlated samples was calculated on the pre- and post-test results. The test results indicated that there was a notable increase in knowledge and comprehension capabilities that was significant at $p < .01$. The students' knowledge and comprehension increased from 26.245 to 73.487 per cent.

A feasibility study indicated that this package could be produced within a school board cheaper than the purchase of a similar 16mm. film. The students reacted favourably towards the package and were able to offer constructive modifications.

PREFACE

The original concept of this study was the development and evaluation of an instructional television program on chick embryology. It was thought that the resultant program would be at least as effective as the conventional face-to-face lecture format that is widespread in our schools. Due to administrative limitations, this comparison could not be done. However, the instructional television program developed into a learning package that had some educational benefits.

What is discussed in the following pages is a thesis-equivalent consisting of two parts of equal importance—a media presentation on video tape, and an evaluation of a television package including the video tape and a student guide booklet.

Without the assistance of the following biology teachers, Al Armitage, Leslie Benzormeny and Linda Fowler, the evaluation of the television package would have been impossible. Acknowledgments must include the many fellow graduate students who participated in the production of the television program. Special thanks go to Steve Bloomer, who gave life to my written words.

I am indebted to Professors Roger Buckland, Gary Coldevin and George Huntley, who acted as thesis advisors.

This study has been held together by the encouragement, so thoughtfully given, by Kathy and my mother. They not only made the study possible, but they also made it worthwhile.

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CHAPTER I

INTRODUCTION

1. Context of the Problem

Educational planners are faced with the problems that gave planners of yesteryear continuous headaches. Today's educators are not really troubled by the flood of new pupils, since the baby boom is subsiding. However, they are plagued with problems that have existed for years. These include lack of money, a shortage of suitably qualified and competent teachers, and new emphasis on different content and higher quality. The educators are now faced with designing a curriculum whereby students can follow individualized studies, and, at the same time, the students can receive an education of equal high quality. Further, teachers request more time so that they can give their students the necessary person-to-person feedback. In other words, the teachers want to better fill their advisory roles in school. In conventional school systems, there is little time for teachers to give individual attention since they spend a great deal of their working hours preparing for each lesson.

In the early fifties, educational planners felt that their problems would be solved with the use of technology. Television, child of the new communications technology, was going to sweep their problems away. It did not happen. Other methods, including the use of television, had to be devised.

Television became accepted as an efficient means of instruction by some, inefficient by others, and expensive by all.

Like many other products of technology, television was quickly absorbed into education without due consideration of its value.

Since 1958, extensive research has been accumulated on the use of television for instruction. This thesis-equivalent will consist of the design and production of a television package based upon the findings of various studies on the use of television for instruction. The use of such packages may aid teachers in their endeavour to give individualized instruction at a reasonable cost. The National Association of Educational Broadcasters stated that "Teachers desperately need more time to conduct suitable, adaptive and reinforcement activities for their many students including activities of the directed self-study category."[1] The packages as described above could enable the teachers to have the time for ". . . shaping and reinforcing the learning of the students."[2]

2. The Problem

The purpose of this thesis-equivalent was to prepare and evaluate an inexpensive television package at the high school leaving examination level for students in the English Protestant schools of Quebec.

This study was an attempt to produce a television package

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[1] National Association of Educational Broadcasters, Television in Instruction: What Is Possible (Washington, D.C.: NAEB, 1970), p. 15.

[2] Ibid.

that would result in a notable change in knowledge and comprehension levels of the students who participated. This change would be significant at $p < .01$.

3. Literature Review: Why Television

Television instruction is only twenty years old. During this time, much has been collected on factors affecting its use and effectiveness.[1]

Extensive research has been compiled on the comparison of the relative effectiveness of instructional television versus face-to-face lecture instruction.

In 1958, C. F. Haban stated that

> There is every reason to expect that there should be less learning in a television class. There is an absence of intellectual give and take believed to characterize some of the most effective teaching. There is little opportunity to adjust to individual differences, rates and needs. The student wouldn't so readily feed back his responses, or signal his lack of understanding, or clear things up with a question. There is indeed good reason to expect that conditions would make for a less favourable outcome and a less well-informed student. However, there is as much learning taking place in a television class as in a non-television class.[2]

Summaries of comparison studies of television versus face-to-face instruction have been performed by Kumata,[3] Holmes,[4] MacLennan

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[1] L. B. Griffith and D. MacLennan, eds., Improvement of Teaching by Television (Columbia, Missouri: University of Missouri Press, 1964), p. 17.

[2] C. F. Haban, "Hope and Fulfilment in Educational Television Research," Audio-Visual Communication Review, 6 (1958), pp. 165-171.

[3] H. Kumata, An Inventory of Instructional Television Research (Michigan: Educational Television and Radio Center, 1956).

[4] D. Holmes, Jr., Television Research in the Teaching-Learner Process (Detroit, Michigan: Wayne State Division of Broadcasting, 1959).

and Reid,[1] and Schramm.[2] Since more recent summaries have indicated the same results as Schramm, I will review the latter in some detail.

W. Schramm took a detailed and impartial look at 393 studies which involved a comparison of learning via television and via "live" teacher. He found that ". . . in 65 per cent of the studies, there was no significant difference. In 21 per cent students learned significantly more [by television], in 14 per cent, they learned significantly less from television."[3]

One would expect that if there was really no significant difference (NSD) between the two methods of teaching, then at least 95 per cent of the time, NSD would be the result. However, it is possible that one method of teaching may be favoured by the subject matter, grade level, or research design.

Examining the data compiled by Schramm more closely, it was revealed that ". . . improvement over conventional teaching by televised instruction appeared most frequently in the high school groups, and least frequently in college and university groups.[4] This statement was based on the information derived from Table 1.[5]

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[1]D. W. MacLennan and S. C. Reid, A Survey of the Literature of Learning and Attitude Research in Instructional Television (Columbia, Missouri: Department of Speech, University of Missouri, 1963).

[2]W. Schramm, Educational Television; The Next Ten Years (Stanford, California: The Institute for Communication Research, Stanford University Press, 1962).

[3]Schramm, Educational Television, pp. 84-86.

[4]Ibid., p. 85.

[5]Ibid.

TABLE 1

RESULTS OF COMPARISON STUDY COMPILED BY W. SCHRAMM

	Primary	High	College
	(Per Cent)		
Students who learned significantly more by TV	33	13	3
No significant difference	56	63	84
Students who learned significantly less by TV	11	24	13

Seventy-six per cent of the high school groups tested showed that televised instruction was a good as or better than conventional instruction.

The conclusions drawn by testers, school administrators, teachers and students has been that the average student can most likely learn about as much from a television class as from an ordinary classroom method.[1] Schramm stated that no kind of student profits more than any other kind from the use of instructional television.[2]

Variation in the effectiveness of television teaching according to subject matter was also revealed by Schramm. Those subject matters which had outstanding success for the groups tested were mathematics, sciences, including biology and social studies. Humanities and literature have had the least success.[3]

[1] Ibid., p. 52.

[2] Ibid., p. 61.

[3] Ibid., pp. 52-54.

A further clarification of Schramm's findings was made by Stickell in 1963.[1] He believed that many research studies were invalidated by inadequate control of variables. Thus he set stringent requirements for such comparison studies and then carefully examined 250 studies. Of these, 217 were classified as "uninterpretable," 23 as "partially interpretable" and 10 as "interpretable." Of the remaining 10, all showed NSD in learning at the .05 level between face-to-face and televised instruction.

It was apparent that in general, there was no significant difference between those taught by television and those by conventional methods. However, the assumption which was implicit but never questioned in these types of studies, according to Schramm, was that the "present conventional teaching methods produced the optimum possible in the teaching situation and therefore provided an adequate base for comparison."[2] This was the standard that was used throughout the literature and it was also the one that was used in this thesis.

It should also be noted that results obtained in studies involving retention testing were the same for immediate information gain tests: no significant differences when compared with conventional lecture formats. This result was obtained whether the retention test lasted for 30 to 45 days, a year, or three years.[3]

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[1] D. W. Stickell, "A Critical Review of the Methodology and Results of Research Comparing Televised and Face-to-Face Instruction," unpublished Ed.D. Thesis (State College, Pennsylvania: Pennsylvania State University, 1963).

[2] W. Schramm, ed., The Impact of Educational Television (Urbana, Illinois: University of Illinois Press, 1960), p. 178.

[3] Ibid., p. 181.

If it can be accepted that there was no significant difference between those taught by television and those taught in the conventional educational manner, why did schools spend money on educational television? There were a number of distinct advantages in using instructional television.

From the outset, it must be clearly stated that children were able to learn from instructional television (ITV). According to Gordon and Cassirer, ITV can be successfully employed in teaching any subject material involving one-way communication.[1,2]

ITV stood out, not only because it was used for enrichment, co-operative, team and total teaching, but because of numerous practical reasons.

Experience has shown that there was no single teaching method or technique which had appeared to be markedly better than others.[3] There was no essentially correct or proven method of producing instructional video lessons.[4] Thus, anyone who was producing an ITV production was not limited to the means by which he achieved his goals. The suggestions or limitations for what makes a good or poor television production will be discussed more fully in the following chapter.

Costello and Gordon stated that television was a medium which had the potential to bring together all of the audio visual artifacts,

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[1]G. N. Gordon, Classroom Television (New York, N.Y.: Hastings House, 1970), p. 90.

[2]H. N. Cassirer, Television Teaching Today (Paris: UNESCO, 1960), p. 56.

[3]Gordon, Classroom Television, p. 67.

[4]Ibid. p. 125.

such as films, filmstrips, slides, records and other prepared audio visual aids.[1] The audio and visual elements of these sources could be combined to increase the amount of meaning to be communicated. The sound may have complemented the video or the video the sound. In education, according to Gordon, sound was accepted as having the overriding intellectual stimulation.[2] However, in science, especially biology, the visual was essential. The less audio and visual gadgetry that was within the production, the more profitable was the result.[3] It was obvious that complex processes such as the development of the chick could be made simple and digestible for an intended audience by the use of graphics, selective narration, and time lapse photography.

Television was a means by which the same quality and content could be viewed by numerous students and teachers. Gordon, Haney and Ullmer stated the "The screen size made little difference in ITV's contribution to learning, and the specific advantage of colour television had yet to be determined."[4,5]

Since television cameras could take close-ups of objects and people, according to Costello and Gordon, the intimacy that was

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[1]L. Costello and G. Gordon, Teach with Television, 2nd ed. (New York, N.Y.: Hastings House, 1965), p. 34.

[2]Gordon, Classroom Television, p. 132.

[3]Ibid., p. 112.

[4]Ibid., p. 90.

[5]J. Haney and E. Ullmer, Educational Media and the Teacher (Dubuque, Iowa: W. C. Brown Co. Publishers, 1970), pp. 15, 19.

frequently missing in the real lecture hall could be transmitted.[1] Close-ups permitted each member of the television audience to have a front row seat. The television camera was able to clarify, to enlarge and to isolate biological specimens, charts and graphs from their surrounding field.[2] In reality (and psychologically) the view given to the student may have been better than "front row"—contingent upon the skill of the lecturer and the attention of the viewer. If the former possessed the talent to evoke and stimulate interest, TV would not dampen it.[3]

Since television could accommodate film, it was possible to use film techniques such as time lapse photography in any ITV production. This technique would enable time to be contracted, and promote the suppression of details. The normal development of a chick, which takes 21 days, could be illustrated in 34 minutes or less.

Obviously, television was not the only medium that could have been used for this thesis-equivalent. Film was another possibility. Film and television have minor differences which have not been found to affect the final product. Glaser stated that the differences between television and film "lie more in the philosophy and practice of production than in any inherent differences characteristic of the media. Aside from minor differences in grain or resolution, the television lesson, kinescope recording [a process of recording

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[1] Costello and Gordon, Teaching with Television, p. 31.

[2] Ibid.

[3] Ibid.

television images on film] or videotape recording differ primarily from the sound picture in terms of screen size."[1]

Although the videotape had a rougher image texture than film, the roughness was virtually unnoticeable if both videotape and film were shown with the same size image and the observer was a few feet in front of it.[2] The screen size of television was found to have no consequence on learning as long as the students could clearly see the screen.[3]

Television was used in this thesis-equivalent instead of film because of availability, lower production and duplication costs, non-existent development procedures (i.e. instantaneous reproduction) and no pedagogical advantage or disadvantage over other forms of media.

Most important for this study, all schools in the testing area had access to monitoring equipment.

According to W. Schramm,

> There can no longer be any doubt that students learn efficiently from instructional television. The fact has been demonstrated now in hundreds of schools, by thousands of students, in every part of the United States and in several other countries. . . .
>
> Instructional television is at least as effective as ordinary classroom instruction, when the results are measured by the usual final examination or by standardized test. . . [And] employing the usual tests that schools use to measure progress of their students, we can say with considerable confidence that in 65 per cent of a very large number of comparisons between televised and classroom teaching, there

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[1] R. Glaser, Training and Research in Education (New York, N.Y.: John Wiley and Sons, Inc., 1962), p, 253.

[2] Gordon, Classroom Television, p. 57.

[3] G. Chu and W. Schramm, Learning from Television: What the Research Says (Stanford, California: Institute for Communications Research, 1967), pp, 23, 33-35.

> is no significant difference. In 21 per cent, students learned significantly more, in 14 per cent, they learned significantly less, from television.[1]

Thus, this study was not concerned with whether instructional television could be as effective as face-to-face or conventional instruction. This has been clearly proven. Students do learn from television quickly and efficiently.[2] The concern of this study was whether the program on chick embryology designed according to information revealed in past research, was an effective program in that it would cause a notable change in knowledge and comprehension levels of the students who participated.

4. Hypothesis

After participating in a television package on the chick embryo, students would exhibit a notable change in knowledge and comprehension levels which was significant at $p < .01$ as measured by a paper and pencil test.

5. Rationale for the Hypothesis

It has already been noted that any subject may be taught on television[3] particularly science topics.[4] It has also been stated that there was a notable change in capabilities of the students after watching educational television programs. This change was similar to that of students who had received a conventional lecture

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[1] Schramm, Educational Television, p. 49.

[2] Ibid., p. 66.

[3] Cassirer, Television Teaching Today, p. 56.

[4] Schramm, Educational Television, pp. 52-54.

presentation.[1] Thus, there was a strong indication that the television package as used in this study would result in a notable change in knowledge and comprehension on the part of the viewers. This could be measured by a paper and pencil test designed specifically for the television program.

R. Gagné stated that a change in knowledge and comprehension levels of the students indicated that learning had occurred.[2] This change was and is one of the many purposes of instruction. Therefore, if the television package caused these changes, then it was possible to state that the package was an effective means of instruction since learning had occurred.

The procedure of this study is based upon Schramm's definition of learning:

> Learning [or information gain] is defined as the difference between a subject's actual response or performance on an information test following receipt of a communication and his response or performance on an equivalent test before receipt of the communication.[3]

6. Significance of the Study

All items used in our system of education should be examined for their educational benefits before they are accepted as having educational value.

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[1] Ibid., p. 49.

[2] R. Gagné, "Learning Communication," in Educational Media: Theory and Practice, edited by Raymond V. Wimon and Wesley C. Meierheney (Columbus, Ohio: Charles Merril Publishing Co., 1969), pp. 95-96.

[3] Schramm, The Impact of Educational Television, p. 230.

It was hoped that this study could be used for the evaluation of knowledge and comprehension changes on the part of its student viewers. Further, the findings of this study could be used as a guideline for the redesigning, construction, and evaluation of subsequent programs which deal with biology at a high school level.

CHAPTER II

DESIGNING AND PRODUCING THE MEDIA PRESENTATION

1. Intended Audience

The television package was designed for grade 10 and 11 English-speaking Quebec students, specifically those who were registered in the Biological Sciences Curriculum Study (BSCS) blue version program, as opposed to the standard biology program. The students were familiar with the approach and content of the following textbook: Biological Science, Molecules to Man (Blue Version).[1]

Students in either the BSCS program or the standard biology program could have been used in the study. However, most schools in the Province of Quebec were eliminating the standard biology program and adopting the BSCS version. The Quebec Department of Education decreed that the study of the chick embryo was a definite part of the BSCS program, whereas the chick embryo may have been used as an example in the standard modern biology program.

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[1] Biological Sciences Curriculum Study, Biological Science, Molecules to Man, Blue Version (Boston, Mass.: Houghton Mifflin Co., 1968).

2. Educational Objectives of the Media Presentation

The media presentation was an attempt to achieve objectives on the first two levels of Bloom's[1] taxonomy scale of educational objectives. The two levels were knowledge and comprehension.

If the proposed television program was an effective teaching tool, students would have been able to do the following after viewing the television program:

a) Identify conditions of embryonic development.

b) Indicate knowledge of the terminology used to describe structure and function of

   1) a fertile egg

   2) a developing chick embryo.

c) Identify various stages of chick embryonic development.

d) Identify relationships among various terminology indicated on objective number 2 above.

e) Recognize terms and concepts that have been translated into different phraseology.

3. Rationale for the Production Design

It was decided that a program on chick embryology that logically fitted into the existing curricula and school timetables should be prepared. Further, it was essential that the television program did not appear as an enrichment feature of the biology course, but an integral part of it. Finally, the program had to bring about the greatest change in learner capability as possible.

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[1] B. Bloom, ed., Taxonomy of Educational Objectives, the Classification of Educational Goals, Handbook I: Cognitive Domain (New York, N.Y.: David McKay Co. Inc., 1969), pp. 62-118.

With these criteria in mind, the television program included questions and pauses during which students worked in their booklets. The use of a booklet to guide the students through the learning situation was suggested by Costello and Gordon.[1] To do this, the television program included beeps to warn the students of upcoming questions and to permit time for the students to answer. The guide booklets in which the students worked contained a series of questions. These could be answered in the spaces provided in the booklet. In order to enable the students to answer quickly, the guidebook included blanks and line drawings.

Since it has been found that the length of a lesson that could be successfully utilized in high school runs between twenty and forty minutes,[2] it was decided that the television program must be clear and succinct to include all pertinent information within a forty minute time period.

According to Gagné the purpose of the process of education was and is to bring about a change in the capabilities of the human learner.[3]

The change that takes place as a result of instruction was referred to as learning.[4] Thus, the educational television package used in this study was designed to bring about a change, specifically a change in knowledge and comprehension in the students who

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[1] Costello and Gordon, Teaching with Television, p. 85.

[2] Ibid., p. 73.

[3] Gagné, Educational Media, p. 95.

[4] Ibid.

participated in it. To bring about this change, Gagné states that the instructional event, in this case the television package, must have the seven components as follows:

1. Gaining and controlling attention
2. Presenting the stimuli for learning
3. Informing the learner of the required performance
4. Recalling previously learned capabilities
5. Guidance of learning
6. Providing feedback
7. Promoting transfer of learning.[1]

Not only must the whole program have these components, but the learning of each concept or principle must involve these components.

To facilitate the application of Gagné's ideas on the instructional event, the television program was considered to be concerned with one concept—embryology: the process of development of an offspring from a single cell to a multicellular organism. Embryology was a concept consisting of several components—the formation and description of the gametes, the conditions for development, mitosis, cleavage, formation of germ layers, and structure and functions of various parts of the developing embryo. The chicken embryo was used to exemplify this concept.

Gagné's ideas could be applied to the program as a whole since it was believed that the program consisted of one concept.

According to Gagné[2] the first component of instruction was the gaining and controlling of the learner's attention. It was important for the learner to mediate the neural events necessary for learning. To accomplish this, an initial registration effect had to

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[1] Ibid., p. 93.

[2] Ibid., p. 101.

occur. This stimulus may have been provided in a visual and/or auditory manner. The program on chick embryology opened with an 8mm. film which showed the actual hatching of a chick from its egg. Music was added to heighten the stimulus presented to the learner. The music was carefully selected to elicit a feeling of growth and the existence of life. Further, it was essential that the music be unfamiliar to the audience so that the audience would note the existence of the music. These stimuli, visual and auditory, were used to create an initial registration effect on the learner, thereby focussing his attention on the chick embryo and not on the construction of an igloo or the political situation in China. Gagné stated that the attention in older students could be aroused by brief verbal directions.[1] Thus, in order to gain and control the learners' attention, words such as "notice," "look at," and "follow" were used by the host.

The second component of instruction involved the presentation of the stimuli for learning. A learner had to be exposed to the class or symbols of the objects to which this learning was directed. It was essential that the program contain live chicks and numerous slides and films of items that were discussed by the host. The visual stimuli were supported with verbal representations of the stimuli. Since high school students were considered to be experienced learners who were aware that words were merely representations of reality, verbal stimuli were presented. When important items were to be presented, the learners were given visual stimuli, as well as an

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[1] Ibid., p. 102.

auditory stimulus. For example, when cell division was described in sentence form by the host, slides appeared to reinforce his words.

The next component of instruction was the informing of the learners of what they were expected to do once they had learned. At the beginning, and throughout the program, and on the second page of the student guide booklet, the learners were given a list of objectives. The learners were expected to read these objectives before the program commenced and to listen to the host who reviewed the objectives and stated the performance level at the beginning and during the television program.

In order for new learning to occur, a recall of previously learned knowledge, upon which the new knowledge was built, was to be included. The recalling of previously learned capabilities was another component of instruction. This recall was performed verbally by the use of such expressions as "In your previous studies . . . Remember . . . Let's review it" and "Do you remember . . ."

The instructional sequence had to direct the learners' attention to the information being presented to them. Verbal statements and questions were presented which would determine the direction of the learners' internal intellectual processes. Instead of giving students the opportunity to consider possible alternatives, the host used such phrases as "Did you see what I have just done?" in order to direct the attention of the students. The amount of this type of guidance in this particular package was minimal. The learners were experienced. They had spent several years in a high school system that was based on a 45 minute study period per subject.

The learners had to receive some kind of communication that

indicated they had been successful in dealing with the information presented. In order to provide for feedback, the sixth component of instruction, each section of the program contained built-in review questions and tasks which the learners were directed to do in the student guide booklet. As the host gave the answers, the learners could check their work and thus determine how well they were progressing. In addition, the host gave encouragement by using phrases such as "Okay, you're doing well."

The primary function of learning was to promote the immediate transfer of learning from the immediate learning situation to those external to it. Information learned by the viewer was related both visually and verbally to realms of biology that lay outside the aim and content of the program. The host used verbal cues such as "The process of development in all animals varies"; and "No matter what vertebrate embryo you're studying, whether it's a chicken or a human embryo . . . " The latter words were further emphasized by the presence of a drawing of a human embryo beside that of a chicken embryo.

The above discussion considered the television program as one concept divided into several components. However, if each program component was considered as a concept, then it was necessary to note how Gagné's ideas applied. Table 2 below lists Gagné's components on the left; on the right are quotations from the section of the script dealing with the extraembryonic membranes which fulfill Gagné's component requirements.

TABLE 2

GAGNE'S SEVEN COMPONENTS AS APPLIED TO THE PRESENTATION OF EXTRA-EMBRYONIC MEMBRANES

Components	Quotation
Gaining and controlling attention	"Let's take a closer look at a fertilized egg."
Presenting the stimuli for learning	"As I draw each part, you should do the same on the prepared outline in the booklet."
Informing the learner of the required performance	"... you should be able to ... identify and draw ... the developing fertile egg and its associated membranes."
Recalling previously learned capabilities	"This is the part of the egg that contains the genes that I mentioned earlier."
Guidance of learning	"This should give you a clue as to its function."
Providing feedback	Review questions and answers were given. For example, "Can you list the egg membranes that are secreted one after another as the egg passes down the hen's oviduct?" "There are five of them ... vitelline, egg white ..."
Promoting transfer of learning	"No matter what avian egg you see, whether it is a duck or an ostrich, these extraembryonic membranes are present...."

After observing the above table, one can see that Gagné's ideas may be applied to the program as a whole or in sections.

Other than those already mentioned, there were numerous other design principles that were included in the program.

According to Lewis Herman,[1] there are five basic criteria that must be followed if a media presentation is to teach. These are relevance, accuracy, organization, comprehensibility and interest.

The television package dealt with a subject matter that was part of the high school biology curriculum. Since the learners involved were all grade 10 and 11 high school biology students, and the chick embryo topic was part of their curriculum, one could assume that the television package was relevant for its viewing audience. Further, the video portion of the package was hosted by an individual who had experience in communicating biological information to the students' age group, and the script was written by one who had similar experience. Thus the narration was presented at a level that was appropriate to the learning intelligence of the viewers.

Relevancy was to appear hand in hand with accuracy and authenticity in both picture and narration. In order to achieve this, the program script was reviewed by six grade 10 and 11 biology teachers who were asked to make any corrections in the script for accuracy and relevancy to the intended audience. These teachers did not participate in the study. All slides and films used in the program were made of actual embryos.

A program may be relevant, accurate and authentic, but if it is not organized to form a comprehensible whole, then the audience may be confused and orderly learning would not be likely to occur. Thus, the television package was created so that it followed a logical sequence—from fertilization to hatching. The narrator

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[1] L. Herman, Educational Films: Writing, Directing and Producing for Classroom, Television and Industry (New York, N.Y.: Crown Publishers, 1965), p. 4.

assisted in making the program more understandable by omitting details which were unnecessary for grade 10 and 11 students, and by keeping the words used in narration to the verbal level of the audience.

An educational program should be able to seize and hold the attention of the audience. An individual who could attract attention by presenting himself as a "human being," who was interested and involved with his topic, could seize the attention of the viewer. The host treated each viewer as an individual by using such phrases as "You can see . . ." Numerous illustrations were used in order to make the audience ask themsleves, "What's next?" If questions were posed and answered in the program, then viewer participation would be likely to occur.

It was previously established that no single teaching method or technique for television has appeared to be markedly better than others.[1] Thus, a simply prepared program should have the same success as a visually contrived program.[2] This conclusion was verified by the fact that humour and complicated animation techniques were found to be irrelevant to learning from instructional television.[3,4] However, simple animation cues or subtitles and repetition of examples in an

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[1] G. Gordon, Educational Television (New York, N.Y.: The Center for Applied Research in Education, 1965), p. 67.

[2] Ibid., p. 112.

[3] Ibid., p. 91.

[4] Chu and Schramm, Learning from Television, p. 28.

instructional program increase learning.[1,2] Thus, simplicity and directness became the guiding factors in the design of this educational program.

Clarity and continuity of the verbal and visual materials appeared to have some relevance to learning according to Gordon.[3] Things which could be illustrated and emphasized were said to make the most interesting of televised lessons.[4] Since the process of explanation was found to demand continual illustration of every kind,[5] great attention was paid to the sequencing of words and illustrations. Thus it became necessary to include visuals that would enhance and illuminate the verbal soundtrack. In doing so one became aware of the capacity of the small television screen to direct and hold attention by showing what was pertinent and excluding the extraneous.[6] The magnification and visual display function that television could perform was used to its fullest potential.[7]

It was also decided to include an on-camera host, who could be portrayed as looking directly at each member of the audience. This

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[1]Gordon, Classroom Television, p. 91.

[2]A. Lumsdaine, R. Sulzer, and F. Kopstein, "The Effect of Animation Cues and Repetition of Examples on Learning from an Instructional Film" in Current Research on Instruction, ed. by R. Anderson, G. Faust, M. Roderick, D. Cunningham and T. André (Englewood Cliffs, N.J.: Prentice-Hall Inc., 1969), pp. 95-102.

[3]Gordon, Classroom Television, p. 91.

[4]Gordon, Educational Television, p. 75.

[5]Gordon, Classroom Television, p. 88.

[6]Costello and Gordon, Teach with Television, p. 75.

[7]National Association of Educational Broadcasters, Television in Instruction: What is Possible (Washington, D.C., 1970), p. 5.

relationship was further enhanced by the host using the word, "You" when referring to the audience. The host also conveyed a human quality through his attire, drawing ability, verbal and facial expression. It was hoped that some kind of rapport could be established between the television host and the learners. The host attempted to fill the gap between impersonalized television and personalized live teacher-student interaction. The inability of television to offer two-way communication to the learners has not been overcome, but by presenting the host as humanly as possible, it was hoped that this gap could be reduced.

Variety and pace of the program was altered since it was found that they would improve learning, particularly when the program was relatively long.[1,2]

The end product of the production design was a well thought out television program involving a simple and direct method of teaching, utilizing one instructor or host. Each word and image was considered for its impact upon the audience.

4. Summary of Production Events

Before discussing the production events in detail, here is a brief summary of the events leading to the production.

A written script based on the rationale for the production design was produced. This script had to meet the educational objectives as outlined previously.

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[1]Chu and Schramm, Learning from Television, pp. 31-32.

[2]Gordon, Classroom Television, p. 88.

Guides for both students and teachers were then made to accompany the television script.

To ensure that the above-mentioned items did not have technical errors, the items were reviewed by six biology teachers. Once these items had been approved, a studio recording date was arranged. All remaining production events were geared to that date.

While visuals, such as slides and graphics were prepared, a host was selected and began rehearsing for his part in the final production.

A one-man dry run of the production was performed to ensure that the execution of the script was practical. This dry run enabled the producer to determine the exact number needed to form the television production crew. The crew was subsequently selected and their various functions were outlined.

The television program was taped in one afternoon session.

5. Creating the Script

In the formation of the script, student guide booklets and test, attempts were made to involve the teachers in their creation and revision.

Using the criteria described in Section 3 entitled "Rationale for the Production Design," a list of program objectives, a vocabulary list, as well as a program outline were sent to six grade 10 and 11 biology teachers. The cover letter included with these items requested the teachers to make comments on the attached items. The contents of these teacher packages may be found in Appendix A.

The teachers agreed with the contents of the packages except for certain words in the vocabulary list. These words—somite, cranial ganglia, feather follicles, umbilicus, pipped, and gill pouches—were thought to be unnecessary for the level of the students, and so were eliminated from future work on the script. All the teachers thought that the content was most appropriate and presented in a logical order. All felt that the items discussed were necessary, but they queried whether some part of the program would have to be eliminated due to lack of time.

Due to program time considerations, techniques on opening the egg were omitted from the script.

Detailed scripts, student guide booklets and tests were distributed to the above-mentioned teachers. An expert from the Poultry Department of Macdonald College reviewed the script. The teachers were again asked to make comments, this time on content, pacing, presentation and accuracy. Only minor changes were made to script wording, everything else was left intact. The student guide booklets and tests were accepted as originally written.

Using the criteria explained in the previous section entitled "Rational for Production Design" as a guide, the researcher and two biology teachers checked the script to insure that the script fit the design requirements. These design requirements could be summed up in these words: clarity, simplicity and directness.

6. The Final Television Script

An outline of the final television script is given in Table 3 below. A complete detailed script of the television program may be found in Appendix B.

Each stage of the script appears below in order of presentation. There is a brief description of the events in each stage, followed by mention of the primary visual source and the approximate duration of each stage.

TABLE 3

OUTLINE OF THE TELEVISION SCRIPT

	Description	Visual	Approximate Time in Minutes
1.	Outline of educational objectives.	Live	1.33
2.	Introduction of the topic by the host. In this section there was a definition of vertebrate embryology and reasons were given for the selection of a chick embryo for study	Live and slides	0.84
3.	Formation of gamete and differences between fertile and infertile egg.	Live, 3-D model	1.33
4.	Description of the major parts of the fertile chicken egg and their relationships.	Live, graphics	5.00
5.	Conditions for embryonic development.	Live, 3-D model	1.75
6.	Cleavage in the fertile hen's egg including the stages of mitosis	Live, graphics, slides	4.75
7.	The first thirty hours of microscopic development, illustrated via time lapse photography.	Slides, film	7.84
8.	Differentiation and the formation of the germ layers.	Live, graphics, slides	4.00
9.	Review of the program contents.	Live, character generator	6.50

7. Teacher's and Student's Guides

a) Teacher's Guide

The teacher's guide was created using the outline given in the books entitled Classroom Television[1] and Teach with Television.[2] These books stated that the teacher's guide should be clearly and succinctly written. They should contain enough information to permit the teacher to study it well, and long enough to cover all important points, such as objectives, vocabulary, the background the students should have, the materials required by the students, a brief description of the program content, suggestions for follow-up activities, additional reading, as well as tests. These were all included in the teacher's guide which appears in the Appendix D.

b) Student Guide

According to Costello and Gordon,[3] the student guide was to be organized in a workbook fashion. This guide included instructions to the student, educational objectives of the lesson, fill-in-the-blank statements arranged in the order appearing in the television program, necessary diagrams, review questions, bibliography and additional information for those who wanted to pursue embryonic studies.

The actual content of the student guide booklet can be found in Appendix E.

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[1] Gordon, Classroom Television, p. 186.

[2] Costello and Gordon, Teach with Television, p. 83.

[3] Ibid., p. 85.

8. Production of the Media Presentation

Once the script was written and revised, one could start assembling the program. The first task was to establish a time for studio recording. In this way, all events could be geared to that day.

Next, a host was selected who had experienced the eye of a television camera, who was familiar with the material to be presented, and had instructed the age group of the intended audience. An individual who had hosted several CBC youth programs including the nature series entitled "Steve's Corner" was chosen. The content of the program and its production rationale were given to the host in order that he could become familiar with the program.

Meanwhile, the visual materials were collected. The most important of these was a series of slides which showed the development of a chick embryo from day one to the twenty-first day. Arrangements were made with a professor at the Poultry Department of Macdonald College of McGill University to obtain 200 fertile chicken eggs, and the use of a commercial incubator.

Each day for a three week period, the eggs were opened and photographed in order to record each day's developments. Three methods were used to open the eggs, depending on what was to be photographed. In order to show the embryo in relation to its surrounding environment, the eggs were candled, marked at the spot where a dark mass appeared through the shell and then opened at this mark, using tweezers and a pair of sharp scissors. It was found to be easier to gently break the shell at the mark with a blunt object,

such as the handle of the scalpel, and then to remove the broken pieces with tweezers.

For close-up detailed views of the embryo, it was necessary to remove much of the material surrounding it. Textbooks[1] recommend the use of micropipettes to remove the surrounding liquid. However, this method was slow and time-consuming, especially when tissues adhered to the pore of the pipette. Another method was to remove the embryo by carefully cutting around the embryo using a pair of small surgical scissors. The embryo could thus be released from its environment and transferred to filter paper for closer inspection.

The above methods were tried and found unsatisfactory. The following method was used. The egg was candled, and the location of the embryo within the egg was marked. Opposite the mark, on the other side of the egg, a small hole was made. The contents of the egg were quickly drained, using a scalpel to assist the exit of the contents. The membranes that were still attached to the embryo were cut with scissors as they hung from the hole in the shell. Care was taken to ensure that the embryo did not fall through the hole. The embryo was transferred to a spoon, which was then placed under gently running, warm water. The remaining tissues external to the embryo were removed, thereby giving an uninhibited view of the embryo. If the above procedure was performed quickly, the heart of the embryo would still be functioning.

The chick embryos were photographed using an Ashai Pentax

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[1]Biological Sciences Curriculum Study, Biological Science, p. 349.

Spotmatic II with a 50mm. lens and extension tubes, and a Nikon F with a Micro Nikkor lens.

When photographing, care was taken to prevent the embryo from drying out. To accomplish this, distilled water was dropped from an eye dropper on to the embryo. Of course the water had an unwelcomed side effect in that it caused multiple reflections. Diffusers were used on the lights and a polarized filter was used on the camera lenses in an attempt to reduce heat and reflection. Unfortunately, this also reduced the amount of necessary light, and thereby limited the depth of field of the resulting photographs.

A few of the incubated eggs were transferred from the commercial incubator to a small wooden incubator on the eighteenth day of their incubation. As these eggs hatched, they were filmed by a Nizo 580 super 8mm. movie camera which had a built-in intravolmeter. This latter instrument enabled time lapse photography to be accomplished.

It was hoped that filming of the early stages of development could be recorded on super 8mm. or 16mm. film. However, as there were no telophoto lenses that could be added to the super 8 camera, and since 16mm. film equipment had to be rented at high commercial rates, no filming of the developing embryo was done. Trials made with the super 8 camera produced small images with less contrast than in a 16mm. commercial film which was eventually used for this segment of the program. Further information concerning this can be found in Appendix M.

The words that were to appear on the television screen during the production had to be typed on a television monitor using a

character generator, after which the monitor was photographed. This procedure was necessary because the character generator did not have the capacity to store items. No one could possibly type one phrase and have the next phrase appear immediately.

Prepared graphics were used to illustrate the oral communication of the host. These were prepared by making dark blue markings on light blue non-glare bristol board. These colours were used in order to reduce severe contrast on the screen. This contrast would cause burn-in on the video tube cameras that were to be used. Burn-in refers to the latent image that occurs on a television screen after the actual image has disappeared. It occurs due to very bright images affecting the camera more than dark images.

All graphics were prepared in the aspect ratio which was standard for television—4:3.[1] This meant four units of measurement across and three units vertically.

It was decided that other graphics could be drawn by the host as he spoke. This would insure that only essential information, when required, would be presented on the screen. Thus the host became an integral part of the program. He did not exist solely as a voice in the background.

Once the slides, films and graphics were prepared and sorted, music was selected to add variety and emphasis to the program. The opening music had to be unrecognizable to the audience in order to attract attention. Further, it had to create an image of developing, growing, coming to life. "La Pavanne," played by the flutist, Hubert

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[1]Gordon, Classroom Television, pp. 129, 235.

Laws, fulfilled these criteria. The high pitch of the flute would cause the audience to take note.

The music played during the time lapse sequence which showed the development of the chick was selected for its up tempo and drive to a crescendo. It was used to convey rapid development of the chick. This music was entitled "Olé" by John Coltrane.

At the end of the program a series of hatching slides appeared. These were accompanied by the music of Coltrane.

The music used in the program served three purposes: to attract the attention of the audience, to help convey the events on the television screen, and to give variety to the program by offering a change from the host's voice. Refer to Appendix L for the sources of recorded music.

The next step was the combining of all items in order to determine their feasibility and "look" on the television screen. A dry run of the program was made which involved only the producer of the program. This dry run was performed to ensure that the scripted camera and stage directions could be followed. This one-man dry run enabled the producer to finalize his decision on how many members of a television crew would be necessary. Fourteen people were required to make the production run smoothly. Fewer individuals could have been used. The list of personnel utilized can be found in Appendix K.

Each member of the television crew was briefed on the roles they were going to play. They also received a copy of the television script.

The host received a copy of the final script several weeks

before the actual taping of the program. A dry run with the host was completed during this period.

The evening before the actual taping, the television set was constructed, and the lighting of the set was completed.

On the morning of the final taping, all equipment was checked for malfunctions. Those which could be corrected were, such as dirty video tape heads. Since the special effects mixer and the sub-switcher in the television control room were inoperative, it was fortunate that the script did not require any production trickery.

Following this equipment check, all graphics and slides were put into place. Shot lists for each camera man and brief job descriptions were taped to the locations of each member of the technical crew.

The host was scheduled to arrive before the technical crew. This permitted the host to go through a dry run without undue distractions.

When all members of the production and technical crew were present, they were re-informed of their duties and the difficulties that could be incurred.

The program on chick embryology was completed in one continuous shooting on the second taping following a dry run, with all necessary personnel being present.

A third taping might have eliminated a few of the rough spots in the recording of the production. However, due to lack of time, studio booking restrictions, and personal commitments on the part of the production crew, this third taping could not be done.

CHAPTER III

METHOD OF EVALUATION

1. Introduction

The design of the evaluation procedure for the television package was based on that suggested by George Gordon.[1] Briefly, the evaluation procedures followed a pattern similar to the one below:

a) A grade level and subject area would be defined as exactly as possible.

b) A list of objectives would be enumerated.

c) An outline for the classroom program would be drawn up.

d) The outline would be discussed and criticized by teachers, especially those who would use it.

e) The final script would be submitted to consultants on the subject matter and teachers at the appropriate subject and grade level.

f) A pretest would be administered to the classes using the television package.

g) The television package would be presented.

h) Following participation in the package, the students would receive a post-test, thereby hopefully indicating the successes and failures of the package.

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[1] Ibid., p. 219.

Gordon[1] suggested that fifty to seventy per cent correct response pattern should be enough to validate a lesson on a high school level. He also stated that those lessons that had been validated should be left alone. Those which were not validated should be rewritten and retaped when necessary.

The procedure outlined by Gordon was followed with one exception. A pilot study was included. This study was to be as similar to the main study as possible. The pilot study was performed to determine whether the television program was so ineffective as to require extensive overhaul, and thereby make a large evaluation of it unnecessary.

2. The Pilot Study

a) Subjects

In the school selected for [redacted] tudy, the only available class of grade 10 and 11 students [redacted] the BSCS blue version, Biological Science, Molecules to Man[2] was utilized. The nineteen students were all part of an English-speaking Protestant Quebec school board, located west of Montreal. The Board was situated in what the district education officer described as a middle to upper middle class district. He also stated that most graduates of the school system proceed to college or university. This gives some indication of the drive or motivations present in the students of the school system and of that particular school.

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[1] Ibid.

[2] Biological Sciences Curriculum Study, Biological Science.

The subjects attended a comprehensive school. This school offered courses in the arts, sciences, and vocational training. The population of the school was approximately 2,000 students.

The teacher volunteered the use of the class. She was interested in using teaching methods, television included, that could increase the effectiveness of her teaching. She had made extensive use of the well equipped school board media-resource centre, and thus her students were accustomed to being taught via media presentations.

The students, aged 15 to 17, had all been participating in the biology course since the beginning of the school term.

Although permission was requested from the school board, it was not possible to obtain the intelligence quotients so a range, mean, and standard deviation could be determined for the group. However, the students all took the Lorge-Thorndike Intelligence Test in grade 8. This test was given to all the grade 8 students within the school board. The test consisted of verbal and non-verbal parts. The total intelligence quotient (I.Q.) was the average of the above-mentioned parts. Unofficially, of the nineteen students, I.Q. scores of eleven of them indicated a range of 93 to 133. The remaining scores could not be obtained.

b) The Measuring Devices

i) Paper and pencil test

The instrument used to indicate what students already knew, and how much they had learned from the television program, was a paper and pencil test.[1] This measuring device was used both as a pre- and post-test. At the time of the study it was difficult, if not impossible, to determine the above information in any other way.

Forty questions were selected from a list of sixty questions specially designed for this purpose. The questions and the resulting test were created according to the book Testing and Evaluation for the Sciences by W. Hedges.[2]

This test was designed to evaluate the achievement made by students on the educational objectives listed previously. To reiterate, the students, on the completion of the television package should have been able to identify and indicate knowledge of conditions and development patterns of chick embryonic growth.

Test instructions were included on the first page of the test. The test was divided into four sections. The first section consisted of eighteen matching questions. These questions were concerned with the structure and function of various parts of the developing embryo and its environment.

Part two of the test consisted of twelve multiple choice questions with four possible answers. This section asked questions

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[1] Costello and Gordon, Teach with Television, p. 164.

[2] W. D. Hedges, Testing and Evaluation for the Sciences in the Secondary Schools (Belmont, California: Wadsworth Publishing Co. Inc., 1968).

concerning the make-up of a fertile egg, cleavage, food, conditions necessary for growth and mitosis.

The third part of the measuring device contained four fill-in-the-blank questions on mitosis.

Part four included a cross-sectional diagram of a fertile hen's egg. Parts of the egg were to be identified and labelled.

A copy of the actual measuring device used in the pilot study can be found in Appendix H.

ii) Questionnaire

In order to determine what students thought about the program, a questionnaire was developed. The structure of this questionnaire was based in part upon those used by the Ontario Educational Communications Authority to evaluate their programs, and part on suggestions made by Gordon.[1] The questionnaire asked the viewers what they thought of the program and what suggestions they would make for improvements.

Likert-scaled, fill-in-the-blank, and open-ended questions were used to elicit this information.

The actual format of this questionnaire is included in Appendix J.

iii) Observer

Since all the possible reactions to a television program could not be obtained scientifically, or categorized, it was decided that an observer would be placed at the back of the classroom to

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[1]Gordon, Classroom Television, p. 215.

determine any problems that should be overcome, and to determine the overall general reaction to the program.

c) The Procedure

i) Introduction

Due to administrative limitations a one group pre- post-test design was used for this study. This design enabled the researcher to determine some information concerning the level of each student before participating in the television package. The pre-test showed the degree of accomplishment up to the time the course of study began.[1] The differences between pre-test and post-test results would indicate changes in knowledge or comprehension levels made by the students. Therefore, it was necessary to determine whether there was a significant difference of $p < .01$ in a one-tailed test between pre-test and post-test scores, i.e. there would only be one chance in 100 that no differences would occur between pre- and post-test scores. Not only should there be a difference 99 out of 100 times, but the post-test scores should be greater than the pre-test scores.

Unfortunately, the above design did not adequately control for history, maturation, testing or statistical regression. The influence of these factors on the results will be reviewed in the discussion section of this paper.

Identical tests were used for the pre- and post-tests. This was done to ensure that the tests were measuring the same knowledge and comprehension levels of the students.

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[1]Costello and Gordon, Teach with Television, p. 166.

The study within the school involved three consecutive school days.

ii) Day 1

On the first day of the study, the teacher was given the teacher's instructions and nineteen 40-item pre-tests, enough for each member of the class. The teacher's instructions can be found in Appendix G. The teachers used these instructions for carrying out the activities of the first day.

The tests were distributed to all students. The teachers were instructed to ask the students if they all received a complete readable test, if they all had writing utensils, and if they all understood the test instructions. When all students gave a positive reply to these queries, the students were given thirty minutes to complete the test.

The remaining fifteen minutes of each class period involved the distribution and collection of the tests, the taking of attendance, and the making of daily class announcements.

At the end of the first day, the teacher received the teacher's guide book and the student guide booklets. Thus, the teacher could be prepared for the activities to be performed on the second day.

iii) Day 2

On the second day of the study, the necessary equipment was set up by the researcher and brought in by teachers and students. This equipment included a half-inch video tape-deck, a television

monitor, auxiliary speakers and the necessary connecting cables. The half-inch video tape of the television program was threaded on the video player.

Since the visibility of the picture on the monitor was a function of picture reception from the video player, contrast and external lighting conditions,[1] the equipment had been previously tested in the school room.

Using the conditions listed by Gordon,[2] the television monitor was placed four feet above the floor in a location that permitted a maximum of a thirty degree viewing angle for the closest member of the class. The minimum viewing distance for the twenty-four inch monitor for the closest viewer was five feet, and the maximum viewing distance for the furthest viewer was twenty-two feet from the screen. Since all students indicated that they could clearly see the screen with their unaided and aided eyes (contact and glass wearers), no viewer had to be moved from their normal classroom seating position.

The television monitor was operated in a room that was lighted, but slightly dimmed. The lights immediately over the television set, and the sunlight coming at a ninety degree angle to the set were turned off or blocked by drapery. These procedures were used to eliminate glare from the glass of the television tube.

While the equipment was being placed in the classroom, the student guide booklets were distributed. The students were instructed to read them before viewing the program. Using the itemized teacher's

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[1] Gordon, Classroom television, p. 190.

[2] Ibid.

instructions, which can be found in Appendix D, as a guide, the teacher asked the students if they all had complete booklets, if they understood what was expected of them, if they had writing utensils, and if they could see the monitor clearly. Once affirmative answers from all the students in the room were obtained, the video tape was played. At the beginning of the program, students were asked if they could hear and see the program clearly.

Each time the students heard the sound of a beep as the program was played, they filled answers in the spaces provided in the student guide booklet. At the end of the program, the equipment was removed and the class dismissed.

The students were not informed as to whether they would receive a test on the following day.

During the showing of the television program, the viewers were observed from the back of the classroom by the researcher.

iv) Day 3

On the third day of the study, the teachers received the post-tests and instructions, both of which were identical to those used in the pre-test. The teachers became aware that the post-test and instructions were identical to the pre-test after the students had commenced work on the tests.

The instructions given to the teachers were followed. Each student received thirty minutes in which to complete the post-test. The test papers were then collected.

A questionnaire was distributed to the students in order to

determine what they thought about the program. The questionnaires were filled out and collected.

The class was then dismissed.

d) Data Analysis

Since I.Q. scores could not be obtained for the sample used in this pilot study, there was no way of actually checking for selection bias within the socio-economic group tested. However, it should be noted that the students in the sample were not placed in the class due to their academic ability. During the previous spring term, students were permitted to select their own timetable, i.e. their courses and when they wanted to take them. Therefore, one had to assume that the class contained a random distribution of academic background and ability.

Further, it must be assumed that the errors of measurement would be randomly distributed around the mean scores of the tested group, and hence it was possible to consider the mean of the pre-test as a true estimate of their beginning knowledge and the mean of the post-test as a true estimate of their beginning knowledge plus knowledge gained while participating in the television package.

The tests were scored, their averages and ranges and standard deviations were recorded.

The data analysis was performed on the results of the tests in order to determine whether there was a significant difference measurable at $p < .01$ between pre- and post-test scores, and to determine the reliability and validity of the measuring device.

The pre- and post-tests were examined for:

i) content validity

ii) item difficulty

iii) item discriminability

iv) split-half reliability

v) test reliability according to the Kuder-Richardson Formula 20.

Since the split-half reliability could only be used scientifically to evaluate those tests which involved at least two odd and even numbered questions that measured the same item, it was decided to use the Kuder-Richardson Formula 20[1] for more accurate results. However, it should be noted that the split-half method could have been used on questions 19 to 40 on the test. Only the first 18 items of the test were not paired correctly.

The t-test for the significance between two means for correlated samples was calculated on the pre- and post-test results. The t-test as well as other data analysis was performed according to G. A. Ferguson's book entitled Statistical Analysis in Psychology and Education[2] and B. Tuckman's book Conducting Educational Research.[3]

The results of the questionnaire were tabulated. The opinions from the questionnaire and those of the observer which could not be tabulated were listed.

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[1]B. Tuckman, Conducting Educational Research (New York, N.Y.: Harcourt Brace Jovanovich, Inc., 1972), p. 139.

[2]G. Ferguson, Statistical Analysis in Psychology and Education (Toronto, Ont.: McGraw-Hill, 1971).

[3]Tuckman, Conducting Educational Research.

e) The Results

i) Paper and pencil test

The forty-item measuring device which was used as a pre- and post-test was found to have content validity since all questions were based on information provided by the television package material. Six teachers verified that the answers to each question on the test could be found in the information included in the television package.

The split-half reliability for the pre-test was .905 and for the post-test, .809. The estimated reliability for the whole test was .950 on the pre-test and .894 on the post-test. As was previously stated, the test for split-half reliability could not yield accurate results since the first eighteen questions were not paired in a manner in which each member of the pair measured the same item. Therefore, the Kuder-Richardson Formula 20 was employed. This formula yielded a reliability coefficient of .72 for the pre-test and .72 for the post-test. Thus, this measuring device was found to be reliable.

Item difficulty and item discriminability were calculated for each item on the forty-item test. These calculations were made using the highest 26.32 per cent (or five students) of the total number of students and the lowest 26.32 per cent. The formulas used for these calculations are written below:

$$\text{Index of Difficulty} = \frac{\text{number who fail an item}}{\text{total number in both groups}}$$

$$\text{Discriminability} = \frac{\text{number in high group who pass item}}{\text{number in both groups who pass item}}$$

The results of the above calculations are written in Tables 4 and 5 on the following pages.

TABLE 4

INDICES OF ITEM DIFFICULTY AND DISCRIMINATION FOR PILOT PRE-TEST

Test Item Number	Number in High Group Who Passed Item	Number in Low Group Who Passed Item	Difficulty of Item	Discrimination of Item
1	0	0	1.0	0.00
2	0	0	1.0	0.00
3	1	0	0.9	1.00
4	1	0	0.9	1.00
5	2	0	0.8	1.00
6	0	0	1.0	0.00
7	1	0	0.9	1.00
8	0	0	1.0	0.00
9	1	0	0.9	1.00
10	5	2	0.3	0.72
11	1	1	0.8	0.50
12	3	0	0.7	1.00
13	0	1	0.9	0.00
14	0	0	1.0	0.00
15	0	0	1.0	0.00
16	0	0	1.0	0.00
17	0	0	1.0	0.00
18	0	0	1.0	0.00
19	3	2	0.5	0.60
20	5	4	0.1	0.56
21	3	1	0.6	0.75
22	3	0	0.7	1.00
23	5	3	0.2	0.63
24	3	1	0.6	0.75
25	3	2	0.5	0.60
26	2	0	0.8	1.00
27	1	1	0.8	0.50
28	5	2	0.3	0.71
29	1	0	0.9	1.00
30	4	1	0.5	0.80
31	2	1	0.7	0.67
32	3	0	0.7	1.00
33	4	0	0.6	1.00
34	2	1	0.7	0.67
35	5	2	0.3	0.72
36	4	3	0.3	0.57
37	3	1	0.6	0.75
38	2	0	0.8	1.00
39	2	0	0.8	1.00
40	1	1	0.8	0.50

TABLE 5

INDICES OF ITEM DIFFICULTY AND DISCRIMINATION FOR PILOT POST-TEST

Test Item Number	Number in High Group Who Passed Item	Number in Low Group Who Passed Item	Difficulty of Item	Discrimination of Item
1	1	1	0.8	0.50
2	3	1	0.6	0.75
3	5	0	0.5	1.00
4	4	3	0.3	0.57
5	4	1	0.5	0.80
6	1	0	0.9	1.00
7	3	1	0.6	0.75
8	5	1	0.4	0.83
9	3	4	0.3	0.43
10	4	4	0.2	0.50
11	3	0	0.7	1.00
12	4	4	0.2	0.50
13	1	1	0.8	0.50
14	5	1	0.4	0.83
15	4	2	0.4	0.67
16	2	1	0.7	0.67
17	4	1	0.5	0.80
18	5	2	0.3	0.72
19	5	5	0.0	0.50
20	5	4	0.1	0.56
21	4	4	0.2	0.50
22	3	1	0.6	0.75
23	5	5	0.0	0.50
24	2	2	0.6	0.50
25	4	3	0.3	0.57
26	5	4	0.1	0.56
27	1	2	0.7	0.33
28	5	2	0.3	0.71
29	1	2	0.7	0.33
30	4	2	0.4	0.67
31	3	1	0.6	0.75
32	1	3	0.6	0.25
33	5	3	0.2	0.63
34	4	1	0.5	0.80
35	3	2	0.5	0.60
36	4	3	0.3	0.57
37	4	3	0.3	0.57
38	2	0	0.8	1.00
39	3	1	0.6	0.75
40	3	3	0.4	0.50

On the pre-test the researcher was seeking questions which had a combination of 0.5 to 1.0 index of difficulty and a discrimination index of 0.6 to 1.0. Questions twenty and twenty-three were substantially below the above-stated index of difficulty and borderline in their index of discrimination. All other questions either met the researcher's minimum requirements or were strong in one of the two indices.

On the post-test, the researcher was seeking low levels of difficulty for this would indicate what portions of the program were presented in a successful manner to enable most students to respond correctly. One would also expect low levels of discrimination if there were small levels of variability in post-test scores.

The mean score obtained on the pre-test was 10.600 or 26.500 per cent of the total possible score, and on the post-test, 21.200 or 53.000 per cent of the total possible score. The range of the pre-test scores was 2 to 19, and for the post-test, 16 to 33. There was an overlap of four students or 21 per cent of the total students in this pilot study. The standard deviation for the pre-test was 3.813 and for the post-test 4.475. Table 6 below shows this information in a more concise form.

TABLE 6

RESULTS OF PILOT STUDY

	Pre-test	Post-test
Mean score	26.500%	53.000%
Range of scores	2 to 19	16 to 33
Standard deviation	3.813	4.475

It appears that the students knew twice as much information after they participated in the television program than before they started.

The results of the study were submitted to a t-test for correlated samples. This test was justified since the same students who took the pre-test also observed the program and took the post-test. Thus, the data was composed of pairs of measurements. The result of the t-test was found to be significant at better than $p < .01$. One may thus conclude that there was a significant difference between the means of the pre-test and the post-test. Further, it can be stated that this difference was due to the participation of the students in this television package.

As was previously mentioned, Gordon stated that a 50 to 75 per cent correct response pattern would be enough to validate a lesson on a high school level,[1] and since the students in the pilot study received a mean score of 53.000 per cent, it may be stated that the television program was validated.

ii) The questionnaire

The questionnaire determined the opinions of the students regarding the television package, and any improvements they would make. Most answers were favourable and consistent.

Out of a possible score of 10, the students found the program to have the ratings as listed in Table 7.

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[1]Gordon, Classroom Television, p. 219.

TABLE 7

PILOT STUDENTS' RATING OF THE TELEVISION PACKAGE

Category	Score	Standard Deviation
High educational value	10.000	0.000
Worthwhile watching	8.075	1.823
Effective	8.555	2.125
Mature	8.031	3.334
Entertaining	6.667	4.420

For the question "What did you like about the program?" the students replied that they liked the easy-going format of the host. They found that the program was full of information that was directly related to their biology course. They felt that they learned information that they did not know before. They found the section on mitosis to be a repeat of what they had previously learned, but they felt the review was helpful. Others were intrigued with the photography. Three of those who responded to the question mentioned that the concept of watching a television program while filling out a booklet was new to them, but useful.

The third question on the questionnaire asked the students "What did you dislike about the program?" Out of the sixteen questionnaires that were returned, fourteen maintained that the program went too fast for them. They were constantly missing scenes on the screen which they would like to have seen, but were too busy filling in blanks. One student wrote, "In some parts, I saw the

booklet more than I saw the television. But I found it interesting. My friends said it was great." Another student wrote that he found the host "corny." Apart from this latter comment, no student referred to any other part of the television package except to remark on its fast pace.

In response to the fourth question "What would you like to see changed?" all students except two requested that the program be slowed down. The other two had no comments.

When the students were asked whether they thought the amount of information conveyed was too much for one class period, three felt there was too much information, thirteen indicated that the information was about right for one class period.

All students stated that they would like to see more television programs similar to the one they saw on chick embryology.

All students confirmed that the student guide booklet helped them to learn the content of the program.

Fifteen of the sixteen students who replied indicated that they could not have learned the same amount of information without the booklet.

The students were asked if they would like to receive a course in which a program similar to the chick embryology program was shown at the beginning of the week. For the remainder of the week they would work on what they did not know. All students replied in the affirmative—they would like to have a course design as just described.

The last question on the questionnaire was of the open-ended type. It was designed to solicit comments which were not included

in other parts of the questionnaire. However, no comments were made.

iii) The observer

The observer found that the attention of all students was riveted to the television set or the booklets. At no time were the students restless or disinterested in the proceedings of the television lesson.

All students appeared to watch the program intently. When they missed a blank or were confused by the rapidity of the beeps, they asked their neighbors for assistance. When questioned, about twelve students, or two-thirds of the class completed the student guide booklet without asking their classmates for help.

Students were confused during the section of the program which involved the drawing and labelling of the fertile hen's egg.

f) Discussion

Since the findings of the main study and the pilot study were similar, a detailed discussion of the findings will be given in the discussion section of the main study.

It was clearly evident that the television package had a fast pace which students found difficult to keep up with. Yet all students were able to cope with it. Despite the fact that during the actual taping of the television program a booklet was filled out by a student in order to determine the pace of the program, it was too fast for the real audience. The only solution to this problem would have been a retaping of the program. This solution was impractical since a retaping could not be done quickly enough so that it could be

used in time for the main study. Perhaps if a retaping had been done, the differences between pre-test and post-test scores would have been greater.

However, other modifications to the television package could be done and were. First, the student guide booklet needed to be revised to enable students to complete it quickly. Questions in the booklet were not changed. The answers for the fill-in-the-blank queries were changed so that they could be filled out more quickly. Larger spaces were provided for the answers. The changes made to the questioning section of the booklet are included in Appendix F.

After examining the item difficulty and discrimination performed on the results of the paper and pencil measuring device, it was decided that questions twenty and twenty-three had to be eliminated because ninety per cent of those who did the pre-test knew the answer. These questions also had low levels of discrimination.

Questions four, seven, and ten were modified to make the meanings clearer to the students.

In question twenty-nine, the word "similar" was changed to "reverse" for clearer meaning.

Since the events written in question thirty-one and thirty-two were borderline events of mitosis which could be classified as being at the end of one stage or the beginning of another stage, these questions were changed. However, the answers remained the same. The confusion that existed in the students' minds was evident when one looked at the answers they gave to these questions. They considered mitosis as a continuous process and thus found it difficult

to draw a demarkation point. This confusion was reflected in their answers, and so modifications were made to eliminate this confusion.

It was felt that students may have required more time to survey the questions in the test, so a minute of time was reallocated from Part II in the test to the survey-of-question time allocation.

The above minor changes were incorporated into the final test that was used in the main study. Thus the final test contained thirty-eight items and not forty as was the case in the pilot study. A copy of the final test is contained in Appendix I.

On examining the indices of difficulty for the post-test, it was noted that only questions one, six, thirteen and thirty-eight had a difficulty level of .8 or higher. These questions were concerned with the vitelline membrane, chalazae and the germinal disc. To determine what difficulties may have been encountered by the students with these questions, the television program was viewed along with the student guide booklet. It was found that the host did not give as clear an explanation as he could have. Further, the student guide book needed additional information on the chalazae.

The explanations given by the host on the above three items could not be changed in time for inclusion in the main study as it would involve retaping. However, the student guide booklet could be modified and was.

g) Conclusion

It was concluded that the television package was effective in causing a change in the capabilities of the learner, thus the package was capable of instructing. It was also decided that a slightly

modified student guide booklet and measuring device would improve the effectiveness of the television package. If these modifications were made, the television package could be successfully employed in the main study. These changes were made before the start of the main study.

3. The Main Study

a) Subjects

The subjects used in the main study were similar to those utilized in the pilot study.

Four classes of English-speaking Protestant students who were registered in the Biological Sciences Curriculum Study (BSCS) Blue Version, biology course participated in this study. These four classes composed the total population of students who were enrolled in the BSCS Blue Version course in two schools located within the same school board as the pilot study. Two classes were used from each of the two schools. The description of the socio-economic status of the communities from which the students were drawn was described by the district education officer as middle to upper middle class. Most graduates proceded to college or university. It should be noted that all three schools used in the pilot and main study were within two to five miles of each other as the crow flies or three miles by road.

All subjects were registered in a comprehensive high school which offered courses that could be divided into arts, science, and technical-vocational. The approximate population of one school was 1,500, the other was 1,900.

The teachers in the two schools volunteered the use of their classes as they were interested in any methods that would increase the effectiveness of their teaching. All teachers involved had utilized the in-school media centre and the well-equipped school board media centre. The students were accustomed to seeing media presentations and therefore would not react to the presence of a television monitor as a novelty.

The students, aged 15 to 17, had participated in the biology course since the beginning of the school term.

Although the school board was requested to supply intelligence quotients (I.Q.) for all students involved in the study, permission had not been granted at the time of the writing of this report. Therefore, it had to be assumed that there was a random distribution of I.Q. scores within the sample utilized. This assumption has some validity since students were not required to take this or any particular biology course. In the spring prior to taking the course, the students were permitted to make up their own timetable, i.e. choose their courses and when they wanted to take them. Thus the students were not in the BSCS biology course because of their academic ability, but because after they succeeded in passing the required number of credits in grade nine, they were permitted to choose the courses of their liking.

Only those students who took the pre- and post-test and participated in the television package were used in the results and analysis of this study. Sixty-eight students registered in the grade 10 and 11 BSCS Blue Version biology course were used.

b) The Measuring Devices

All measuring devices used in the main study were identical to those used in the pilot study.

i) Paper and pencil test

The paper and pencil test was used to determine whether there was any change in the knowledge and comprehension capabilities of the student.

The test used in the main study was changed slightly from that used in the pilot study. A copy of the final test given to the four classes of students can be found in Appendix I. The changes that were made to the original test were required to make some questions clearer and more specific so that there could only be one correct answer. Two questions were eliminated from the original test so that the final test contained thirty-eight items. For a detailed discussion of the changes, please refer to the discussion section of the pilot study.

At the conclusion of the pilot study, it was established that the paper and pencil measuring device had content validity and a Kuder Richardson reliability coefficient of .72 when used as a pre-test, and .72 when used as a post-test. Further item difficulty and item discrimination analysis indicated that only two items had to be eliminated. Thus it was concluded that a slightly modified paper and pencil test used in the pilot study could be used in the main study.

The final test consisted of a cover sheet which provided space for student and school identification, and the test instructions included a time schedule which the students could use as they completed the measuring device.

The remaining three pages consisted of thirty-eight questions divided among four sections. The first section consisted of eighteen matching questions which determined the students' knowledge of the structure and function of the embryo chick and its environment.

Ten multiple-choice questions dealing with the physical features of the fertile egg, cleavage, the yolk, the germinal disc, incubation conditions and mitosis were included in the second section.

Part three of the test consisted of four multiple-choice questions on mitosis.

The last section contained six questions which asked the students to identify parts of a fertile hen's egg.

After the students read the test instructions, they were given thirty minutes to complete the test.

ii) Questionnaire

In order to determine what students thought about the program, the identical questionnaire that was used in the pilot study was utilized in the main study. A copy of this questionnaire was included and discussed in the measuring-devices section of the pilot study.

iii) Observer

An observer recorded reactions of the students to the television package. This observer was located at the back of the classroom The observations that were recorded by the observer were used in deciding what modifications to the television package should be made.

c) The Procedure

The procedure followed in the main study was in all ways identical to that used in the pilot study. Thus, only a summary of the procedure is necessary here.

The study required three consecutive school days. On the first day, students took the pre-test; on the second day they participated in the television package while writing answers in their student guide booklets; and on the third day they took a post-test that was identical to the pre-test. Also, on the third day, they completed the questionnaire.

A multigroup pre- and post-test design was used. This design can be illustrated as:

O_{1-1} X O_{1-2}

O_{2-1} X O_{2-2}

O_{3-1} X O_{3-2}

O_{4-1} X O_{4-2}

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where: ---- indicated intact groups

O_{1-1} was the pre-test of the first group

O_{1-2} was the post-test of the first group

O_{2-1} was the pre-test of the second group

O_{2-2} was the post-test of the second group

O_{3-1} was the pre-test of the third group

O_{3-2} was the post-test of the third group

O_{4-1} was the pre-test of the fourth group

O_{4-2} was the post-test of the fourth group

X was the treatment or television package.

It should be noted that groups one and two, which were located at one school, took part in the study on the same day. In another school, groups three and four participated in the study several weeks later, but on the same day. This was because groups three and four did not reach the same point in the curriculum as groups one and two until several weeks later.

The pre-, post-test design that was utilized did not adequately control for history, maturation, testing or statistical regression. However, due to administrative limitations, this intact group design, as suggested by Gordon,[1] had to be used. The factors that affected this design will be discussed in more detail in the discussion section of this paper.

d) The Data Analysis

Since all students enrolled in the BSCS Blue Version course within the two schools were utilized in this study, and since all the students volunteered to take the course in the previous spring, it can be assumed that selection bias within the socio-economic group was minimal, for the group contained a random distribution of academic background and ability. Thus it was also assumed that the errors of measurement were randomly distributed around the mean scores of each tested group. Therefore, it was possible to consider the mean of the pre-test as a true estimate of the students' beginning knowledge and comprehension capabilities, and the mean of the post-test as the true estimate of the sum of their beginning capabilities and those gained while participating in the television package.

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[1]Gordon, Classroom Television, p. 219.

Since no I.Q. scores could be obtained for the groups tested, and all groups were taken from the same socio-economic group as defined by the district education officer from which the groups were selected, one can only assume that all four groups were homogeneous and thus could be added together to form one sample population. The pre-test scores as recorded in Table 8 of the results section of this paper, indicate that the pre-test groups were similar. The four groups obtained mean scores varying from 9.263 to 11.346. This supported the assumption that the four groups were taken from the same sample population. It was on this latter population that the analysis of the data was made.

Based upon the data obtained in the pilot study, the paper and pencil measuring device was found to be valid and reliable and thus a suitable instrument for measuring knowledge and comprehension capabilities of the students.

With the above assumption and facts in mind, it was possible to state that the function of the data analysis was to determine whether there was a significant difference measurable at $p < .01$ between pre- and post-test scores.

To analyze the data, the tests were scored, their averages, ranges and standard deviations were recorded. The researcher scored the tests twice and a student was hired to recheck the scores a third time.

A t-test for the significance between two means for correlation samples was calculated on the total sample population. This test was justified since the same students who took the pre-test also observed the program and took the post-test. Thus, the data were

actually composed of sixty-eight pairs of measurements. The t-test was performed according to G. A. Ferguson's book, Statistical Analysis in Psychology and Education.[1]

The results of the questionnaire were tabulated. The results of the questionnaire and the opinions of the observer which could not be tabulated, were listed.

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[1]Ferguson, Statistical Analysis, p. 153.

CHAPTER IV

THE RESULTS OF THE EVALUATION

1. Paper and Pencil Test

The means, ranges and standard deviations for each group were tabulated as shown in Tables 8 and 9 below.

TABLE 8

PRE-TEST RESULTS

Group	N	Range	Standard Deviation (S.D.)	Mean	Per Cent
1	26	2-18	4.009	11.346	29.858
2	12	4-14	3.147	9.917	26.097
3	11	4-15	3.264	9.364	24.642
4	19	4-14	2.690	9.263	24.376
Overall			3.278	9.973	26.245

TABLE 9

POST-TEST RESULTS

Group	N	Range	Standard Deviation (S.D.)	Mean	Per Cent
1	26	17-37	5.953	28.192	74.189
2	12	23-37	4.207	29.667	78.071
3	11	18-36	5.292	27.000	71.053
4	19	18-38	5.757	26.842	70.637
Overall			5.302	27.925	73.487

Graph 1 shows the frequency distribution of the raw scores for the total pre- and post-test population.

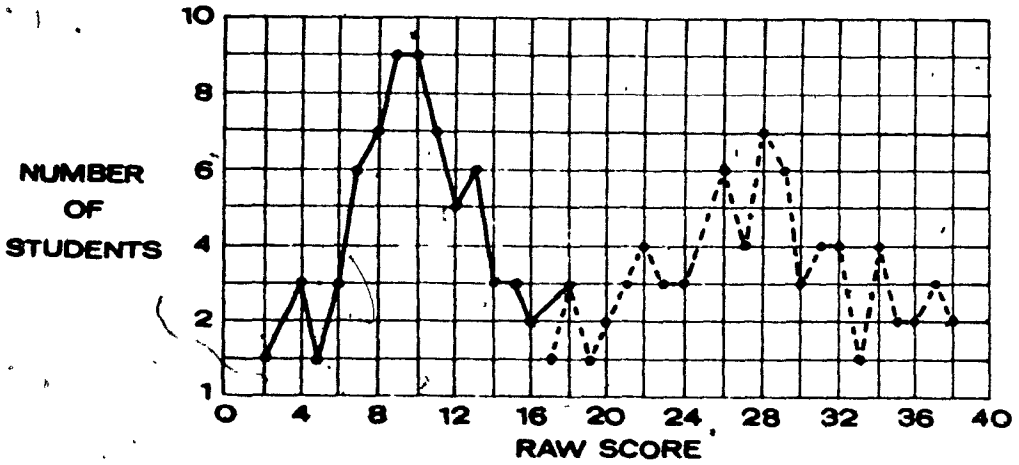
It was noted that the mean for the total sample population on the pre-test was 9.973 and on the post-test was 27.925. From knowing 26.245 per cent of the total content of the program, the students completed the television package knowing 73.487 per cent of it. This information is represented graphically for each group and the total population in Graph 2.

The means of the pre- and post-tests were submitted to a t-test for correlated samples. This test yielded a t ratio that was significant at $p < .01$.

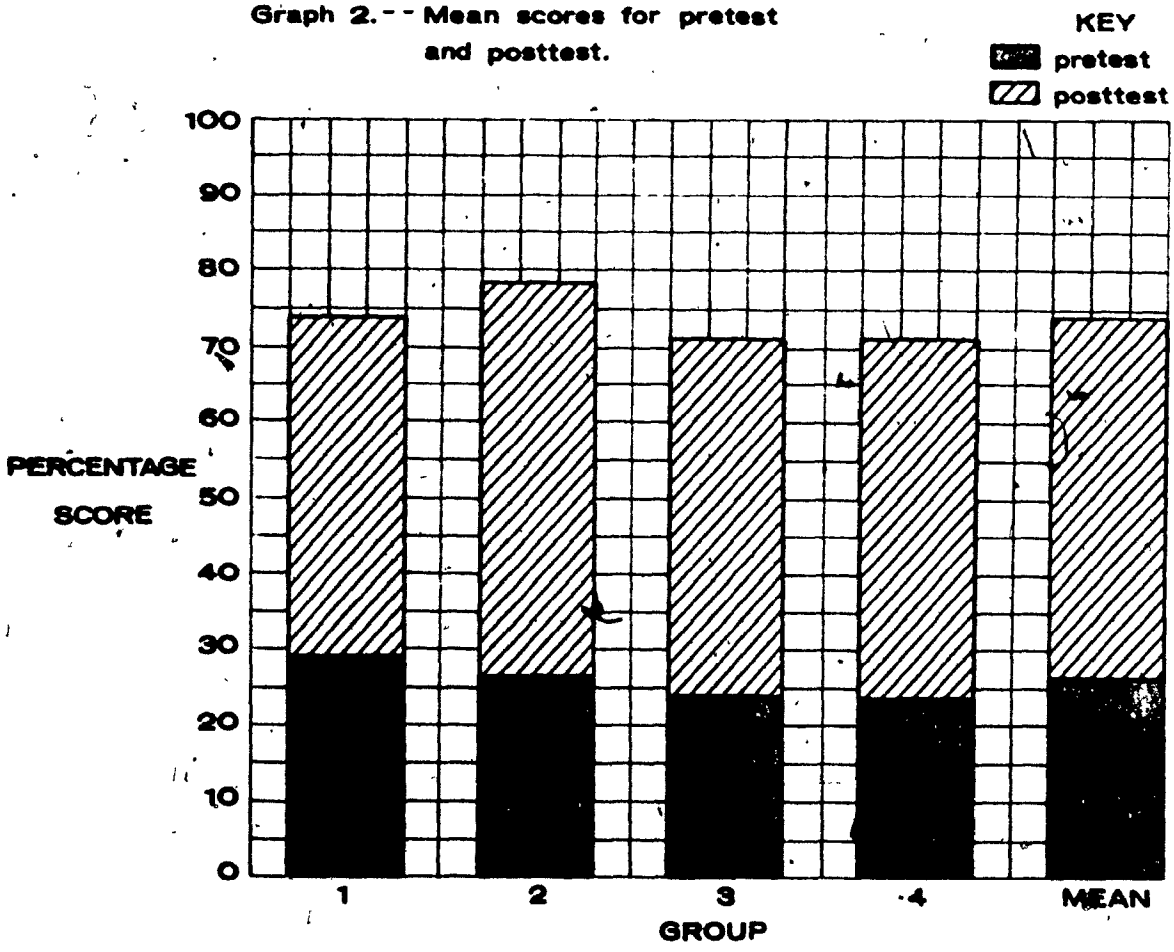
2. Questionnaire

Sixty completed questionnaires were returned for examination. The results of each question on the questionnaire are recorded below.

Graph 1. - - Distribution of raw scores for pretest and posttest.



Graph 2. - - Mean scores for pretest and posttest.



Question 1

The students were asked to determine a rating for the program in five categories. The rating scale varied from one to ten, with ten being the highest, most favorable rating.

The results of this rating are shown below in Table 10.

TABLE 10

STUDENTS' RATING OF THE TELEVISION PROGRAM

Category	Rating	Standard Deviation
Educational value	10.000	0.000
Worthwhile watching	8.536	1.565
Effective	8.027	1.475
Mature	7.555	3.168
Entertaining	6.015	5.346

Question 2

The students were requested to list what they liked about the program. The number of students who listed a particular feature were recorded. Generally the students were not specific about what they liked. They found the program interesting and informative. Table 11 lists the features favoured by the students.

TABLE 11

FEATURES FAVOURED BY THE STUDENTS

Feature	Number Who Liked It
"I don't know what I liked, I found the program excellent and very interesting."	32
"...advantage of it being fast, one really paid attention."	4
"...illustrations were good and effective..."	8
"...the time-lapse photography was good."	4
"...the easy-going attitude of the host, I really liked."	3
"The host gave good, clear explanations."	7
"...important words were put on the screen."	5
"I liked the review sections. They made the program effective."	6
"It's nice to see things rather than to read them in the textbook."	3
"I did learn many things which I didn't know before."	7
"The program was good because you can see things that you wouldn't normally see."	5
"...well made since it was easy to understand."	6

Question 3

Most students found that the program progressed at a fast pace. This was their major complaint. Only a few students disliked it for other reasons. Table 12 below lists the answers given to question three, plus a numerical value expressing the number of times the comment occurred in all the questionnaires.

TABLE 12

FEATURES DISLIKED BY STUDENTS

Feature	Number Who Disliked It
"The program went too fast."	46
"There were too many blanks to fill."	8
"The host stumbled a lot."	1
"...more space for answer to question 22."	1
"...filmed in black and white."	1

Question 4

The students gave constructive criticism on how the program could be changed. Since they felt its primary fault was its rapid pace, three suggestions were made to correct this. The program had to be lengthened, or the questions reduced, or the program had to be seen twice.

The comments made by the students are categorized in Table 13. Some students made more than one suggestion.

TABLE 13

IMPROVEMENTS SUGGESTED BY STUDENTS

Suggestion	Number Who Support Suggestion
"... should be a longer pause of a few seconds after the beep so you wouldn't miss anything."	45
"...fewer questions."	12
"We should see the program twice. First for looking at it. The second time we should answer questions."	10
"The program should be in colour."	2
"...a female hostess instead of a male."	1
"Steve should be more precise."	1

Question 5

Students were asked if the amount of information conveyed for one class period was too much, about right, or too little. The majority, ninety per cent, felt that there was the right amount of information, ten per cent felt there was too much and no one stated that there was not enough information to be covered in one class period.

Question 6

This question asked students if they would prefer to see similar television productions. Ninety-five per cent of the students were in favour of similar programs. Five per cent expressed no desire to see them.

Question 7

The students were unanimous in stating that the student guide booklet was helpful in learning the content of the program.

Question 8

This question was included in the questionnaire in order to determine whether the student guide booklets were useful. Only thirty per cent of the students felt that they could have learned the same amount of information without the booklet. Seventy per cent of the students definitely needed the booklet in order to accomplish the objectives of the lesson.

Question 9

Students were asked to consider a course design which included a television package containing the week's information followed by four days of individualized work. All students (one hundred per cent) expressed a desire to participate in such a course design.

Question 10

This question permitted students to express an opinion on topics not covered by the previous nine questions. Forty-six students took advantage of this space to make comments, but few were specific and constructive. Table 14 includes the statements made by the students and the number in agreement with the statement.

TABLE 14

STUDENT COMMENTS IN GENERAL

Statement	Number in Agreement
"I enjoyed the program."	30
"It was interesting."	14
"I learnt a lot."	5
"We could watch and make notes because the lights were on."	3
"...a very good way to learn and study about not only chick embryology, but other topics too."	16
"Once the booklet was filled in, it was a valuable addition to my notes."	6
"The booklet was a good idea, especially the review work and references."	7

Four students wrote lengthier comments than others. The four comments are given in entirety below.

Student 1

> I think that the program was good—it was interesting, informative and effective, but it had one fault. A slightly slower pace would have made it a better program. I think that other students would agree with me.

Student 2

> I think it would be very good if most of our biology course was this way so that we could learn quicker with more coordination. I find it quite hard to study from notes. A booklet like this is easier to study from, it gives you what to study, the bare facts; supplementary work and a review with answers to go over and correct yourself later. Also it isn't all the teacher's work, we have to go dig up the answers.

Student 3

The program was well made and easy to understand, but there was not enough time to grasp in everything said—completely that is. The points were put across in a good fashion. Also, it was easier than reading the book.

Student 4

I thought that this method was very effective. I especially liked the way in which each and every fact was firstly introduced, and repeated several times throughout the program. Although it was rather swift-moving, I think this was good because it maintains the student's interest and attention, and discourages any wandering thoughts.

I personally feel that I gained some very valuable knowledge of the chick embryo which will not be readily forgotten.

I wish that this method could be used throughout the entire B.S.C.S. course. I'm sure it would improve my understanding, and aid me greatly in biological sciences.

3. The Observer

The observer at the back of each classroom noted that all students either watched the screen or were working in the booklets. At no time did he note disinterest or idle conversation. Occasionally, he noted that students asked each other questions that appeared to be related to the learning situation. These occurrences appeared more frequently during the part of the televised program that discussed various parts and functions of the fertile egg of the hen. These occurrences took place less frequently than during the pilot-test.

CHAPTER V

DISCUSSION OF THE PROGRAM AND ITS EVALUATION

I. Effectiveness and Limitations

The aim of this study was to produce and to evaluate a biological television package at the grade eleven level, that would lead to a notable change in the knowledge and comprehension levels of the students as measured by a thirty-eight item paper and pencil test. This change was found to be significant at $p < .01$.

A discussion of possible threats to validity follows.

As was stated in the preface, no comparison between face-to-face instruction and the television instruction could be arranged, nor could several post-tests be given during a time interval involving weeks and/or months. If these procedures had been followed, there would have been a more effective evaluation of the television package. However, based on the studies performed by Kumata,[1] Holmes,[2] Schramm,[3] and Gordon[4] in the literature review, one would expect that there would be no significant difference between lecture and television package.

One had to be content with the use of a multiple group

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[1]Kumata, An Inventory of Instructional Television Research.

[2]Holmes, Television Research in the Teaching-Learner Process.

[3]Schramm, Educational Television.

[4]Gordon, Classroom Television.

pre- and post-test design which, according to Tuckman,[1] would fail to control completely for such factors as history, maturation, testing and statistical regression. These factors affect internal validity. A study has internal validity if the outcome of the study can be stated as being due to the experimental treatment designed by the researcher. Factors which may have affected the internal validity of this study are discussed below.

The term history was used to refer to events occurring in the environment at the same time the television package was being tested. It was not possible to control for history since methods of removal or counterbalancing could not be used.

Historical facts did affect the study. Classes within each school were subjected to the same stress immediately prior to and during the testing period. In each school at the time of testing, several high school events were in progress. These included winter carnival, field trips, and variety shows. These events not only were sources of stress, but also caused a reduction in class size during the period of the study. Without the stress, the scores on pre-test and post-test might have been higher. The stress occurred before and during the whole testing period, involving all students who participated. Therefore, it can be said that all students participated in the television package under the same historical conditions. The results of the study were obtained under the conditions specified above.

Maturation refers to the general processes of change that

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[1]Tuckman, Conducting Educational Research, p. 105.

took place within the students. Since the testing period occurred during three consecutive days, it should be acceptable to state that the amount of maturation that occurred which could have affected the study was negligible.

The term testing referred to the effects of taking a pre-test on the following post-test of the individuals involved. Since no standardized information concerning the capabilities of the students could be obtained, the testing factor could not be eliminated. The pre-test was taken to measure the initial state of the subjects before the television package was used. It would be expected that under this condition, the post-test scores would be higher than if a pre-test was omitted.[1] This was only a hypothesis which could not be tested since there were no other classes available in the schools tested that could be used for verification of the hypothesis. To insure that the measuring devices, the pre- and post-tests, were measuring the same item, the pre- and post-tests were identical.

To refer to the selection of subjects on the basis of some extreme variable, the term statistical regression was used. Statistical regression played a minor role in this study as long as one keeps in mind that all classes of BSCS biology, blue version students in a particular school board and specific geographical location were utilized in this study. It was assumed that there was a random distribution of capabilities within the groups selected. The students were not selected on an individual basis but as a group from a certain socio-economic, geographical location.

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[1] Ibid., p. 76.

The above factors had some minor unknown effect on the internal validity and test results of the study.

There were other factors which may have modified the effectiveness of the televised instruction.[1] The more important ones were the learning rate of the students, the class size, the attitudes of students towards teachers, the attitudes of teachers towards televised instruction, and the student motivation. It was not within the scope of this study to deal with these factors, but they were considered.

The learning rate of students was found to determine how much information a student could acquire within a given period of time. The fast learner would learn more, the slow learner, less. It was not in the interests of the researcher to determine whether a fast learner or a slow learner achieves more or less after seeing this televised program. The researcher was more interested in determining the general or average effect of a televised instructional package on a mixed population of students—male, female, slow learner, fast learner—from a specific socio-economic background within a given school board and location. Obviously, it would have been preferable that the data collected were based on a verified normal distribution of characteristics, but since this was not administratively possible, the data must be accepted within the conditions outlined previously.

No evidence has yet been given to support the notion that class size affects student learning. As long as the students can

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[1] Gordon, Classroom Television, pp. 86-96.

clearly hear and see the image on the television screen, class size had no bearing on learning from television.[1]

It can only be assumed that the attitudes of students towards their classroom teachers were consistent over the short testing period of three days. The students were taught by their teachers for the five months prior to the study. Therefore, they should have been familiar with the teacher's personality.

The observer at the back of each classroom detected a friendly student-teacher relationship within the classroom. No simmering or open hostility was felt or observed.

There may have been a considerable latitude in the students' attitude towards the television package, but according to the results of the questionnaire, all students favoured it. W. Schramm and the Stanford Institute for Communication Research[2] found that students were more favourable to programs that had demonstrations than those that did not. Perhaps this finding might partly have accounted for the students liking the chick program.

It should be noted also that the use of television and other modern technologies was not new to the students since they had been frequently exposed to them during their school year. Perhaps the students had formed a low or high opinion of television before the study, but the teachers of the classes stated that the students use the modern technologies as they would use a book in their search for information and the formation of capabilities.

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[1]Chu and Schramm, Learning from Television, p. 23.

[2]Schramm, Educational Television, p. 58.

Students' attitudes may not be a major factor in the effectiveness of a program. Cassirer[1] stated that favourable attitudes towards a program were not always necessary for effective learning to occur from it.

Teacher attitude towards television instruction may have affected the outcome of the study, but if it did, and to what extent it may have, was unknown. However, the teachers were all favourably inclined towards anything that would help them to improve the effectiveness of their teaching, whether it was film, slides, graphics, guest speakers, field trips, or television which they were familiar with. It should be noted that all the teachers were present during the study and they found the program interesting and effective. Their positive attitude towards media may have been conveyed to the students, who, in turn, were more attentive to the program than they might otherwise have been. As a result, the students obtained high scores on the measuring devices.

One could expect that a highly motivated student would do well and a low motivated student would perform poorly on the measuring device. To what extent the students in the study were motivated was a big unanswerable question. It would not have been feasible or valid to interview all the students regarding their reasons for taking biology, to assign a value to the reasons, to calculate a factor and to work it in with the test scores. Since the students were not forced to select biology and did it by choice, one may say that the students were motivated towards biology.

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[1]H. Cassirer, Television Teaching Today (Paris: UNESCO, 1960), p. 67.

The Hawthorne, or novelty effect on the student scores could not be ruled out in the analysis of the results.[1] However, it was stated previously that the students were familiar with the use of media in the classroom, thus the novelty effect should have been minimal.

All the factors that have been discussed above were considered during the analysis of the data. None were felt to be capable, singly or combined, to affect the conclusion that a notable difference between pre- and post-test capabilities of the students was noted. The factors may have affected the amount of this difference, so that students received high scores on the post-test. Instead of students increasing their knowledge and comprehension levels on chick embryos from 26.245 to 73.487 per cent, as measured by the thirty-eight item paper and pencil test, students might only have increased to sixty or seventy per cent of the possible capabilities.

The television package was termed "effective." The term effective, as was used in the study, referred to an increase in student capabilities with respect to knowledge and comprehension of chick embryology.

In addition to being effective, the program received a generally favourable reaction from the audience. On a ten point scale from one to ten (low to high opinion) students rated the program at eight. Whether attitudes or motivations of the students changed towards biology were not tested since they were not the concern of this study.

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[1] Schramm, Educational Television, p. 61.

As was stated previously in the discussion section of the pilot study, the television program instructed all items effectively except for vitelline membrane, chalazae, and germinal disc. This conclusion was based on the analysis of the pilot post-test indices of difficulty.

2. Feasibility of Using Program

Although program efficiency and financial considerations were not of primary concern in this study, they were important practical considerations.

To make a judgment concerning the efficiency of the television package, one would have to compare the television package to other methods of instruction, such as the conventional lecture format. One would attempt to determine which method of instruction could enable a student to achieve the most objectives in a given period of time. This comparison was not done, though it could be performed in future studies. However, the study indicated that students could achieve 73.487 per cent of the program objectives in thirty-four minutes as determined by a thirty-eight item paper and pencil test of knowledge and comprehension. If the program was extended to forty minutes, as would be done in a future version, one would expect that higher scores could be achieved by the students.

In response to the question as to whether this instructional package could be feasibly employed in schools, the answer would be in the affirmative. This study gives adequate proof.

The major problem is whether the cost of preparing such packages can be handled by schools. On a professional level, such as

the Canadian Broadcasting Corporation, a television program such as the one used for this study would be extremely expensive. On an amateur scale, using television equipment present in some schools, colleges and universities in the Province of Quebec, this program could be created with a minimum amount of expenditure.

The producer of the television program used in this study, used the facilities that were available at Sir George Williams University. His total expenses for the production were $230.00 (a detailed breakdown of the actual production cost can be found in Appendix K). This total could have been reduced if graphs were used instead of slides, and if duplication of scripts were performed by ditto machines. A saving of at least fifty dollars could be realized if these measures were employed.

A minimum of $170.00 would be necessary to produce this forty-minute video tape program. If one compares this cost to the purchase of a 16mm. film of the same length, one would realize a saving of approximately $390.00 if the film was colour, or $110.00 if the film was black and white. These figures were obtained from the media consultant of the school board in this study. She stated that an educational science film in colour costs $14 per minute and black and white film $7 to $8 per minute. She also stated that very few science films in recent years have been made in black and white. Only about ten per cent of the films available at present are in black and white. These latter films are usually copies of films made before 1960.

The above discussion would indicate that a recent educational science film which may not suit the exact needs of a specific school

board may be more than twice as expensive as a video production produced by and tailored to the board's needs.

Further, if the video program is shown more than once, and used by several schools in the board, the cost per showing would be reduced substantially.

3. Suggestions for Program Modifications

Following the analysis of data obtained from the questionnaire, only a few modifications to the program appear to be necessary.

a) Program Pace

During the original taping of the television package, a student responded to questions in the student guide booklet. The working speed of the student determined the intervals between beeps. In the beginning of the program, the location of the beeps and the intervals between them were not ideal. Students had difficulty in completing notes or answers in the time provided.

According to the results of the questionnaire, the students suggested several solutions. They were:

"There should be a pause of a few seconds after each beep so that you wouldn't miss anything."

"Either the program should be lengthened or the number of questions reduced."

"We should see the tape twice. The first time we should look at it, the second time we could answer the questions."

If the number of questions were reduced, the television package would lose its effectiveness for teaching its objectives. If the program was to be seen twice, the benefits of using such a

capsulized package would have been lost since there would be a reduction in efficiency. Here, the term efficiency refers to the number of bits of information that could be presented and learned by a student in the shortest possible time. The fact that the package could teach all the information it contained in thirty-four minutes was one of its good points.

If the pauses of a few seconds were placed after each beep, during which time the student could ready himself for the information, the television program would only be lengthened by two to three minutes. Thus, one could retain all questions without extending the presentation of the information for more than one forty-five minute class period.

If longer pauses were placed in the program, the program would appear to proceed at an extremely slow pace by those persons who do not use the student guide booklet. Thus, unintentionally, the possible versatility of the television program would be reduced. The program could no longer be effectively used by those who do not use a booklet as they would quickly become bored.

It should be noted that a minority of students liked the fast pace. According to them:

"Although it was rather swift-moving, I think this was good because it maintains the student's interest and attention, and discourages any wandering thoughts."

"Because it was fast, we really paid attention."

Obviously there can not be a pace for the presentation of information that pleases all who participate. A compromise must be achieved between a slow, plodding production and a rapid-fire program.

The compromise should lean towards a fast pace. Slow rates make students bored, and once that occurs, it would be difficult to re-attract them to the program.

b) The Host

The host should have felt more comfortable with the script. If this were done, it is felt that his stumbles and errors in voicing as evident in the transcript of the television program (Appendix C) would be minimized. This would present a more authoritative image of the host. But his human quality might be lost. It was interesting to note that only one student commented on the fumbles of the host, so perhaps this alteration is unnecessary.

As stated in the discussion of the pilot study, in a revised program the host would have to slow his pace and give clear explanations of the vitelline membrane, chalazae, and germinal disc as was written in the script.

c) Student Guide Booklet

To eliminate the confusion that some students faced while completing the student guide booklet, page 3 in the booklet should be reorganized so that it accurately follows the flow of the televised program. This page would be reorganized as shown in the appendix. More complete answers could be printed in the booklet to facilitate quicker answers. Longer pauses combined with quick answering questions would enable all students to complete answers before the host proceeded with more information.

d) Technical Quality

Technical quality of the production could be improved only if some of the production crew were more experienced with the equipment, if studio equipment was functioning correctly, and if low-priced educational equipment could attain the high quality of professional equipment costing much more. However, technical blemishes were annoying only to the producer and not to the students, for they made no comment on the program's technical quality.

e) Addition of Slides

It would have been easy to add many more slides to the production, but this idea was rejected. It was thought that only a few slides which succinctly provided useful information should be used in order to limit the visual bombardment of the audience.

The essence of the televised program was simplicity and effectiveness. This was achieved. Therefore, only a slower pace in the program would be absolutely essential for the modification of the program.

4. Recommendations for the Production of Similar Programs

If one wished to produce similar television packages, several recommendations based on the experience of this study are passed on to the reader.

a) There should be a time schedule made for the completion of each step of creating the packages.

b) A great deal of detailed planning must be completed in order for the program to be successful. Adequate time must be allowed for the planning and completion of the details.

c) Teachers who will use the package should be involved in the planning stages. They will be able to outline what they want and how they will use it. This information will greatly help the producer in preparing his script.

c) Adequate time must be given for students to complete answers in their booklets. However, care must be taken that the pauses are not too long or viewer bordom will result. It is better to have a fast pace, thereby keeping the students' undivided attention.

e) For experienced learners, such as high school students, simplicity and directness should describe the final production.

5. Recommendations on Future Studies

Future research based on this study should aim for rigid controls of factors that may have affected the internal validity of this study.

It would also be of interest to determine the effect of varying lengths of pauses after each beep sound was heard in the television program. One would try to determine the most effective length.

The last question on the questionnaire suggested a curriculum which included one day of television and four days of individualized study. Students unanimously favoured such a curriculum. This curriculum should be tried and tested in comparison with other curriculums.

CHAPTER VI

CONCLUSIONS

This study has validated a program package on chick embryology designed for grade ten and eleven English-speaking students who were enrolled in the Biological Sciences Curriculum Study (blue version) biology course. The television package proved to be effective since a notable increase in knowledge and comprehension capabilities of the students was noted. This increase was significant at $p < .01$.

The observations made in the study suggest that similar programs could be produced, utilized and accepted by teachers and students. Further, the study points the way to a curriculum which involves a television package which capsulizes all the information a student would require in one week of conventional teaching. This package would be given at the beginning of the week. A test would be given to determine the strengths and weaknesses of each student. When the tests are corrected the students would be directed to learning packages which would help them to overcome their difficulties. These learning packages could be similar to those described by Kapfer and Ovard.[1] They stated that individualized learning packages (ILPs) could be created to serve the individual needs of the students. To do this, each ILP would contain:

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[1]P. Kapfer and G. Ovard, Preparing and Using Individualized Learning Packages for Ungraded, Continuous Progress Education (Englewood Cliffs, N. J.: Educational Technology Publications, 1971).

1) concept, skill, or value statements
2) specific learning objectives
3) alternative learning activities, including media and methods of all types, selected according to the content and strategy of instruction and learning
4) assessment, evaluation, or testing, including pre-, self-, and post-assessment methods, and
5) quest in breadth and in depth.

If students used such packages, by the end of the week the student should be able to successfully complete all objectives that were outlined at the beginning of the television package. A separate test, or one included in the learning package could be used to assess the progress of the students.

According to students, such a curriculum would enable them to "learn quicker with more co-ordination" and would "improve [their] understanding and aid [them] greatly" in learning the course content. At the same time, the students would have "a lot more fun to learn this way and thus [they would] enjoy learning the subject."

If such a curriculum were followed, the teachers would be relieved of routine duties involved in the preparation of lessons. Television would provide

> . . . a means of bringing a complementary, well organized presentation into the classroom, while giving the classroom teacher more time for the creative teaching aspects of stimulating, motivating and developing the learning activities that involve the student, with the information that was presented.[1]

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[1] R. Burke, Instructional Television: Bold New Venture (Bloomington, Indiana: Indiana University Press, 1971), p. 5.

At the same time students would not have to labour over things they already knew, nor would they have to progress at the rate of the slowest learner. As a result, there would be a saving of time on the part of students and teachers. Greater efficiency and more personalized attention would be the product of such a curriculum.

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APPENDIX A

CONTENTS OF TEACHER PACKAGES

The following are the contents of the teacher packages that were sent for preliminary evaluation. This evaluation preceded the formation of the final script.

December 1972

Fellow Teachers,

I am endeavouring to determine the content and effectiveness of a proposed video tape program on chick embryology, which will hopefully be shown to grade 10 and 11 biology students.

I would appreciate any comments that you may have concerning the objectives, vocabulary, content and sequencing of events. A blank sheet of paper is enclosed for this purpose.

The following information is provided on the attached sheets: educational objectives of the media presentation, outline of content and form of presentation, and vocabulary to be used.

Thank you for your kind cooperation.

Yours very truly,

Clayton R. Wright

P.S. Please return your comments by December 13, 1972.

THE MEDIA PRESENTATION

Educational Objectives of the Media Presentation

The media presentation will attempt to achieve objectives on the first two levels of Bloom's[1] taxonomy scale of educational objectives. These are knowledge and comprehension.

If the proposed television program is an effective teaching tool, students should be able to do the following after viewing the television program:

1. Identify conditions of embryonic development.
2. Indicate knowledge of the terminology used to describe structure and function of
   a) a fertile egg
   b) a developing chick embryo.
3. Identify various stages of chick embryonic development.
4. Identify relationships among various terminology indicated in objective number 2 above.
5. Recognize terms and concepts that have been translated into different phraseology.

It is also hoped that students will be motivated towards practical embryonic studies. A separate evaluation will be performed on this latter objective.

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[1]Benjamin S. Bloom (ed.), Taxonomy of Educational Objectives, The Classification of Educational Goals, Handbook I: Cognitive Domain (New York: David McKay Co., Inc., 1969).

Outline of Content and Form of Presentation

The program will be a video tape television production of approximately twenty-five to thirty minutes in length. It will involve the following elements: host, three-dimensional models, graphics, slides, super 8 and 16mm. film.

The proposed program is outlined below. Each stage appears in order of presentation.

Description	Visual	Approx. length of time in minutes
1. Introduction of the topic by the host. In this section there will be a definition of vertebrate embryology and the reasons for the selection of a chick embryo for study.	Live	1.0
2. Construction of a wooden incubator, including explanation of how incubator provides optimum conditions of growth.	Live, 3-D Model, Graphics	3.0
3. Start of incubation. The incubator will be set up complete with eggs, thermostat, thermometer, light bulb and water dish.	Live, 3-D Models	1.5

	Description	Visual	Approx. length of time in minutes
4.	Description of major parts of fertile eggs and their relationships will be reviewed.	Live, Graphics	2.5
5.	Cleavage of a fertile hen's egg will be discussed.	Live, Graphics	3.0
6.	The first 30 hours of microscopic embryonic development will be shown with the use of a four-minute time lapse segment of a National Film Board film. The film will be run silently, with the host describing the events shown in the film.	NFB Film	4.0
7.	The technique of opening an incubated egg will be explained and demonstrated. During post activities, this technique will enable the student to follow the development on his own.	Live, 3-D Models	3.0
8.	Eggs that have been opened on various days of development will be shown and discussed.	Slides, Graphics	5.5

	Description	Visual	Approx. length of time in minutes
9.	The hatching of a chick will be shown. The host will narrate the film	Super 8 film	1.5
10.	The host will review the conditions of growth, cleavage, development and hatching of the chicken egg.	Live, Graphics, Slides	3.0
11.	The conclusion of the program will include the importance of the study of embryos. Live chicks will be present.	Live	1.0
	Total time in minutes		29.0

Vocabulary

The following words will be used and explained in the program:

egg	amnion	endoderm
cleavage	yolk sac	feather follicles
mitosis	allantois	beak
yolk	somite	umbilicus
cytoplasm	neural ectoderm	fertile eggs
shell	limb buds	pipped
membranes	cranial ganglia	gill pouches
incubator	germ layers	amniotic cavity
germinal disc	ectoderm	chorion
primitive streak	mesoderm	

APPENDIX B

THE ACTUAL TELEVISION SCRIPT

AN INTRODUCTION TO CHICK EMBRYOLOGY

Note: Beeps are indicated by an asterisk.

CAMERA SHOTS	VIDEO	AUDIO
(1) T/C	Film: Super 8 of hatching chick	Theme on Tape Cut 1.
(2) CHAR. GEN.	Dissolve to Char. Gen. An Introduction to Chick Embryology	
(3) #2 CU	of incubator, then pan left, zoom out to MS of Steve	Theme out.
	Steve and booklet	Hi, I'm going to be your host for this introductory show on the embryology of the chicken.
		At the end of this program, you should be able not only to identify and draw a fertilized egg, but you should be able to explain the function of each part in your own words. This also applies to the developing fertile egg and its associated membranes.
		Without hesitation, you should be able to state the ideal conditions for chick embryonic growth.
		Next, you should be able to draw and write about the changes that occur during the four phases of mitosis.

			Mitosis is part of another process called cleavage. Therefore, I expect you to be able to draw and explain the basic cleavage pattern of the chick.
			All parts of the adult chicken are derived from primary germ layers. Thus you should be able to list the parts of the chicken that come from these germ layers.
(4)	#3 CU	Steve	This sounds like a tall order, but it is not. Just answer the questions as we go along, and by the time the program is over, you will have achieved the program goals.
(5)	T/C	Slide: Chicken embryo out of shell 1	So, let's get started shall we? (PAUSE)
(6)	T/C	Slide: Chicken embryo out of shell 2	The chicken embryo is often used to study embryology because it yields knowledge which can be applied to the understanding of the relationships of the extraembryonic membranes in eggs, circulation and primary germ layers in mammals, such as man for instance.
(7)	#2 CU	Steve	Today we shall use chicken eggs and embryos in our study of
(8)	T/C	Slide: Embryology	<u>embryology</u>, the science that deals with the study of embryos. (PAUSE)
(9)	T/C	Slide: Embryo in shell	Embryos are unborn offspring in an egg or maternal body. (PAUSE)
(10)	#2 CU	Steve	The process of development in all animals varies, but in some ways it is more or less the same.
(11)	#2 CU + CHAR. GEN.	Super Char. Gen. "fertilized egg"	For instance, it begins with a single cell—the fertilized egg.
		Lose super	* This cell is produced when a male and female mate—as is the case when a rooster and hen produce a <u>fertile egg</u>.
(12)	#1 CU	Graphic: Hen and rooster providing genes	In your previous studies of animal reproduction, you learned that a fertile egg contains genes—the units of heredity. (PAUSE) A female

contributes one half the number of genes in a fertilized egg, and the male contributes the remainder.

(13) #2 MS Steve

A certain combination of genes will result in the production of a chicken. Another combination will produce a man or a whale.

Not all eggs are fertile eggs. On the outside, a fertile and an infertile egg may look the same, but one can develop into an embryo, the other cannot.

(14) #3 CU Two eggs in an egg carton

Can you tell me which of these two eggs is fertile and which is not? (PAUSE) *

You can't tell can you? This one marked with an "F" is fertile. This other egg which is normally sold in grocery stores is infertile.

(15) #2 MS Steve

Let's take a closer look at a fertilized hen's egg. We will examine its structure with the use of a side-view cross-sectional diagram.

(16) #1 CU Graphic: Outline of hen's egg

As I draw each part, you should do the same on the prepared outline in the booklet. * (PAUSE)

Steve and graphic

The hen's egg is a single cell plus membranes to support it during development. It is quite large because it contains enough

(STEVE DRAWS ITEMS ON PREPARED OUTLINE NO LABELLING)

yellow yolk to feed the developing chick embryo until it hatches. * A clear cytoplasm which contains the egg nucleus is located on top of the yolk. This is located up on the top. It is usually referred to as the germinal disc. This is the part of the egg that contains the genes that I mentioned earlier.

(17) #2 MS Steve

Then there is the "white" of the hen's egg, the shell, and some membranes lining the shell are not part of the egg cell, but are secreted by the hen as the egg passes through her oviduct. These membranes are called extraembryonic membranes. * Their functions are nutrition, respiration, excretion and protection.

(18) #2 MS Super Char. Gen. + CHAR. GEN. "Extraembryonic membranes"

Lose super

The membranes lining the shell and the shell itself protect the cell from the outside environment and also help maintain the egg's internal equilibrium.

(19) #1 MS Steve and graphic of hen's egg

Now right around the yolk is a thin vitelline membrane which covers the surface of the egg yolk. Next to it is the white of the egg. Eighty-five per cent of the egg white is water, * the rest is a mixture of proteins, mostly albumen. This should give you a clue as to its function. (PAUSE)

The egg white serves as an additional source of nourishment and is gradually used up like the yolk in the course of the development of the embryo.

* The denser part of the egg white forms strands like this known as chalazae. They help to keep the egg cell in the center of the egg white.

(20) Graphic

Next to the egg white come two layers of "shell membranes" of keratin fibers. Over most of the surface of the egg they are in contact with each other, but at the blunt end they are separated. The inner membrane adheres to the egg white, the outer membrane adheres to the shell. In between there is an air space.

(21) T/C Slide: Egg shell

The outer most membrane is a calcium carbonate * shell. The shell contains about 7,000 fine pores, through which the embryo obtains oxygen and releases carbon dioxide.

(22) #2 CU Steve

Can you list the egg membranes that are secreted one after another as the egg passes down the hen's oviduct? (PAUSE)

(23) T/C Slide: Hen's egg unlabelled

There are five of them. (PAUSE)

(24) T/C Slide: Egg membranes

No matter what avian egg you see, whether it is a duck or an ostrich, these extraembryonic membranes are present: vitelline, egg white, two shell membranes, and the egg shell. That makes five.

(25) #2 CU Steve

* In your booklet on the diagram provided, indicate where you can find the yolk, the vitelline membrane and the egg white. (PAUSE)

(26) #1 CU Graphic: Hen's egg unlabelled

(STEVE POINTS)
This is the yolk, this is the vitelline membrane, and this is the egg white.

* Now can you tell me which of these provide food for the developing embryo? (PAUSE)

(27) #2 MS Steve

Two do—the yolk and the egg white.

Good, you're doing fine.

(28) T/C Graphic: Adult chicken

A hen or rooster consists of millions of cells, yet they began as a single cell. Somewhere along the line, the fertilized cell must divide rapidly to produce the many cells that form the adult body.

(29) #2 MS Steve

For the development of the fertilized egg to occur, there are certain environmental conditions that must be met.

The ancient Egyptians hatched eggs in large "walk-in" ovens, the Chinese used to pack eggs in rotting manure. Why? Because as manure decomposes,

heat is produced. The manure is wet, and therefore maintained the necessary high humidity.

* Now, from what I have said, can you list three conditions of chick embryonic growth? (PAUSE)

The eggs must be fertile, heat must be provided and so must a high humidity.

(30) #3 CU Incubator

This wooden incubator provides the optimum conditions for embryonic growth. * The eggs will develop as long as the eggs are fertile, a constant temperature of between 101-103°F is maintained, the humidity is high, about 60 per cent as determined by a wet thermometer, and the eggs are turned at least three times daily.

(31) T/C Slide: Conditions of embryonic growth

(32) #2 MS Steve

If you intend to study embryology of other egg-laying animals, similar considerations must be kept in mind.

(33) #3 CU Incubator

When incubation conditions are as described above, the embryo develops normally. What was once an interesting mass of yolk and albumen soon begins to attain form and function. The first event that occurs is

(34) T/C Slide: cleavage

* cleavage—a series of mitotic cell divisions.

(35) #2 CU Steve

Providing that the male sperm has penetrated the tiny white circular spot on the egg yolk called the germinal disc, and the conditions are favorable, the disc will undergo a process called mitosis. You studied this process earlier in your school term.

(36) T/C Slide: Mitosis

* Mitosis is a cell division which produces two identical daughter cells.

(37) T/C Slide: Mitosis 1

(USE POINTER)
The disc contains a nucleus containing chromosomes, a nucleolus, a nuclear membrane, cytoplasm, and a cell membrane.

(38) T/C Slide: Mitosis 2

* During the first stage of mitosis called the prophase, the chromosomes thicken and divide to form pairs. The nuclear membrane disappears as well as the nucleolus.

(39) T/C Slide: Mitosis 3

* Metaphase begins. The disappearance of the nuclear membrane coincides with the appearance of a new structure in the cytoplasm called spindle which radiates from the centrosomes.

(40) T/C Slide: Mitosis 4

The chromosomes then move to attach themselves to the spindle fibers.

(41) T/C Slide: Mitosis 5

* The next stage is anaphase. The chromosomes which duplicated themselves to form two chromatids joined at the centromere, split and move apart. Termination of the anaphase occurs when the chromosomes form a densely packed group at opposite ends of the cell.

(42) T/C Slide: Mitosis 6

(43) T/C Slide: Mitosis 7

* The telophase begins. The events are essentially the reverse of those occurring in prophase: the nuclear membrane forms, the chromosomes uncoil to become slender threads again, and the nucleolus reappears. The cell is then cleaved into two parts.

(44) #2-CU Steve (Optional shot)

(45) #1 CU Graphic: Mitosis

This process is repeated many times over in the developing embryo.

* In your booklet list the main stages of mitosis in order of occurrence. (PAUSE) You should have written

(46) T/C Slide: Phases of mitosis

the phases of mitosis in this order, prophase, metaphase, anaphase and telophase.

(47) #2 CU Steve

* Now list the main events that occurred in each phase.

(48) T/C Slide: Phases of mitosis

(PAUSE)

(49) #1 CU Graphic: Phases of mitosis

A prophase occurs during which chromosomes are duplicated. During

		metaphase, the chromosomes attach to spindle fibers. The chromosomes migrate to opposite ends of the cell during anaphase.
(50) #2 CU	Steve	
		Telophase is completed when the original cell cleaves in two.
(51) T/C	Slide: Mitosis	
		Mitosis has yielded two daughter cells which are half the size of the original cell but are similar in other qualities.
(52) #2 CU	Steve	
		The germinal disc of the embryo chick undergoes a series of mitotic divisions known as cleavage. (PAUSE)
(53) T/C	Slide: Side-view of cleavage	
		Since the cleavage in the chicken embryo is limited to the small disc of protoplasm on top of the yolk * it is called
(54) T/C	Slide: Discoid cleavage	* <u>discoid</u> or <u>incomplete</u> cleavage. (PAUSE)
(55) #1 CU	Graphic: Top view of cleavage	* These top views of a hen's egg show that cleavage divides the protoplasm into progressively smaller units that eventually give rise to the milticellular embryo and all its extraembryonic structures.
(56) #2 MS	Steve	
		I want to show you the early development of a chick embryo first with slides, and then by a time lapse film. * Make brief notes on the following words which are listed in the booklet: primitive streak, vitelline, blood system, allantois, chorion, amnion.
(57) T/C	Slide: Development 1	
		The germinal disc, which is attached to the yolk by a membrane, starts to enlarge immediately after the start of incubation.
(58) T/C	Slide: Development 2	
		The circle widens as the cells at the edge of the disc cleave and thereby multiply.
(59) T/C	Slide: Development 3	
		As development proceeds, one edge of the disc grows faster than the rest, this represents the front or head of the embryo.

(60) T/C Slide: Development 4

* We can see a thickening of the developing tissue along the middle line, this is the primitive streak—it is the chief area of further growth.

(61) VTR Film: 16mm.

(Fade in music cut 2 on tape) During the second day, a tubular heart is formed. (PAUSE) With further growth and the turning over of the embryo on the left side, the heart becomes twisted and pushed out to the right. The heart will become a valved, four-chambered organ. Eyes, ears and nasal openings are present in rudimentary form. (PAUSE)

Meanwhile, the germinal disc has grown out and has covered a large area of the upper surface of the yolk. It has developed a network of blood vessels containing blood. This complex system lies outside the developing embryo. (PAUSE)

* The vitelline blood system carries food from the reservoir of yolk to sustain the growth of the developing chick. Pumped through the system by the embryo heart. (PAUSE)

In this microscopic scene, we can see the blood travelling through the vessels covering the yolk. There is a backflow of the blood since no valves are present. (PAUSE)

The flow of blood is stronger and more positive as the valves develop and the heart becomes stronger. (PAUSE)

The blood flow also varies with the temperature of the egg. The cooler it is the faster the heart beat, the hotter it is the slower the heart beat.

A circulatory system formed from the mesoderm is also laid down in the embryo itself. (PAUSE)

At a later stage, the vitelline blood system completely encloses the yolk. It forms a part of the extra-embryonic membrane called the yolk sac.

A second of these membranes appears at the end of the third day of incubation, as a small sac protruding from the underside of the tail end of the embryo. It is called the allantois. (PAUSE)

Here is a scene in microsection. Like the yolk sac, it is made up of two parts. A layer of endoderm, and a layer of mesoderm. (PAUSE) In this time lapse scene, we can see it grow.

The violent movement of the embryo is due to muscular action; also, the time lapse photography exaggerates the movement.

* The function of the allantois is to absorb oxygen through the porous shell and to remove carbon dioxide. Also, the allantois brings nutrients from the albumin and calcium from the shell for bone structure. To do this efficiently, the allantois grows until it completely lines the egg by nine days.

* The chorion, or serosa, separates the embryo and yolk sac from the egg white. (PAUSE)

The chorion must be removed in order to see the amnion. * (PAUSE) The amnion is a transparent bladder of fluid surrounding the embryo proper. It provides a comfortable shock-proof environment for the growing embryo. (PAUSE)

At six days, the embryo is birdlike, with a long neck, well developed head, with a brain, eyes and ears, a tail and limbs, and an efficient heart and blood system, the beginning of a beak and many other avion characteristics. These will be developed over

		the next 15 days until hatching. (PAUSE)
		Let's quickly watch the development from day one to day six with this section of time lapse film.
		The first, and most obvious item is the vitelline blood system. (PAUSE)
		The embryo now turns on its side. (PAUSE)
		The brain grows rapidly. (PAUSE)
		The allantois starts to swell. It grows until it covers everything.
(62)	#2 MS Steve	Let's check over your notes.
(63)	CHAR. GEN. Char. Gen. Primitive Streak—chief area of embryonic growth	The primitive streak is a thickening of cells that will be the chief area of embryonic growth.
(64)	T/C Slide: Day 5 embryo in shell	The vitelline blood system which surrounds the yolk carries food from the yolk to the developing embryo.
(65)	T/C Slide: Allantois	The allantois primarily absorbs oxygen and removes carbon dioxide.
(66)	#2 CU Steve	As well, the allantois brings nutrients from the albumen and calcium from the shell for bone structure.
(67)	T/C Slide: Chorion	The chorion separates the embryo and yolk sac from the egg white.
(68)	T/C Slide: Amnion	The amnion protects the embryo from jarring and sudden temperature changes.
(69)	#2 MS Steve	If you have at least those notes you will have little trouble reaching the program objectives.
		As you may recall, mitosis produces two identical daughter cells. Obviously a chick or man himself is not made of just one type of cell;

there are nerve cells, muscle cells, digestive cells and so on. So, where did I go wrong?

What causes each cell to change slightly from the previously existing cell is not known clearly. But it is known that the genes in each cell cause the individual cell to change slightly from its original cell.

(70) CHAR. GEN. Char. Gen: Differentiation: process of change in cell resulting in variety of structure and function

This process is known as <u>differentiation</u>. (PAUSE)

(71) #1 MS Steve draws graphic

* (STEVE DRAWS GRAPHIC OF GERM LAYERS) As the cells on the yolk cleave and thereby multiply, * some move inward to form what is known as the <u>endoderm</u>. The cells that are left on the outside are called the <u>ectoderm</u>. The cells continue to multiply forcing cells between the two existing layers. This middle layer is termed the <u>mesoderm</u>. These layers are called germ layers. (PAUSE)

(72) T/C Slide: Germ Layers

* They contain the germ, or the beginning of all tissues of the adult body. As the chick develops, these germ layers form definite patterns within the embryo.

(73) T/C Close up: Steve

(74) #1 CU Graphic: Germ layers

This cross-sectional diagram of a chick shows the relationships of each layer to the others. (STEVE POINTS TO EACH LAYER)

* On the outside of the embryo is the ectoderm. One part of the ectoderm forms

(75) T/C Slide: Claw

the skin, claws,

(76) T/C Slide: Head

beak, hair and feathers.

(77) #1 CU Graphic

* The other part, called the neural ectoderm gives rise to the nervous system

(78) T/C Slide: Embryo on its side

which begins outside the body, but moves inside very early in development.

(79) #1 CU Graphic

* The layer of cells inside the embryo is called the endoderm.

(80) T/C Slide: Embryo out of shell

This tissue will line the digestive system from the mouth to anus, as well as other internal organs.

(81) #1 CU Graphic

* Between the ectoderm and endoderm a third layer of cells develops called the mesoderm.

(82) T/C Slide: Wing

The mesoderm will develop into muscles such as those found in the wings and legs,

(83) T/C Slide: Young embryo in shell

the circulatory system, bones, kidneys and ducts of the reproductive system are also formed by the mesoderm.

No matter what vertebrate embryo you are studying,

(84) #1 CU Graphic: Comparison chick and foetus

whether it is the chick on the left or the human foetus on the right, all have three germ layers—ectoderm, mesoderm and endoderm.

(85) #2 MS Steve

We shall now review what you have learned so far. Use your booklet to help you with this review.

If you are going to do a project on chick development, you should know something about it. So let's review shall we?

(86) T/C Slide: Conditions of growth

First, a fertile chick egg needs three conditions for optimum growth: (PAUSE) * a temperature range of not more than 101-103°F, high humidity, and daily rotation of the eggs.

(87) #3 CU Incubator

A small home-made incubator like this one will provide the three necessary functions.

(88) T/C Slide: Cytoplasm

The hen's egg is a single cell. * It contains the fertilized cytoplasm in the form of a germinal disc, plus necessary food.

(89) #2 CU Steve

Do you remember the names of the egg membranes? * (PAUSE) There are five of them.

(90) T/C Slide: Hen's egg

(91) T/C Slide: Egg membranes

They are vitelline, egg white, two shell membranes and the egg shell.

(92) T/C Slide: Yolk

As the embryo develops, * the yolk sac which provides food is used up.

(93) T/C Slide: Amnion

* An amnion grows around the embryo. The amnion and its amniotic fluid protect the embryo from sudden temperature changes and jarring.

(94) T/C Slide: Allantois

* The allantois provides the developing embryo with oxygen and removes carbon dioxide until the twentieth day.

(95) T/C Slide: Shell

* Calcium for embryonic bones comes from the egg shell.

(96) T/C Slide: Egg white

* Albumen, a protein, comes from the egg white.

(97) T/C Slide: Chorion

* The chorion is the membrane which separates the embryo from the albumen.

(98) #2 CU Steve

As the embryo develops, * three primary germ layers are formed—do you remember them? (PAUSE)

(99) T/C Slide: Germ layers

The ectoderm, the mesoderm and the endoderm.

(100) T/C Slide: Epidermal ectoderm

* The epidermal ectoderm produces skin, hair, feathers and claws.

(101) T/C Slide: Neural ectoderm

* The brain and spinal cord are formed from the neural ectoderm.

(102) T/C	Slide: Mesoderm	* From the mesoderm, circulatory and reproductive systems, muscles, bones and kidneys are formed.
(103) T/C	Slide: Endoderm	* The endoderm forms the lining of the digestive tract and the bladder.
(104) #2 CU	Steve	What can you recall about cleavage? We talked about it, remember. * (PAUSE)
(105) T/C	Slide: Cleavage	The developing embryo undergoes a series of mitotic divisions called cleavage.
(106) T/C	Slide: Mitosis	* Mitotic divisions yield two identical daughter cells.
(107) T/C	Slide: Mitosis	The four phases of mitosis are: prophase, metaphase, anaphase, and telophase.
(108) T/C	Slide: Discoid cleavage	* The chicken egg undergoes discoid or incomplete cleavage of the germinal disc.
(109) #2 MS	Steve	The following series of slides show the chick embryonic development from primitive streak to the twentieth day.
(110) T/C	Slide: Series of Embryonic Development Slides	Fade up theme.
		Fade down theme to background.
(111) #2 MS	Steve	For those of you who want to go beyond this program and do your own embryonic studies, ask your teacher for help.
		Good luck.
(112) T/C	Dissolve to slides of hatching and credits which are mixed	Fade up theme.
	Dissolve to black	Fade out theme.

APPENDIX C

TRANSCRIPT OF AN INTRODUCTION TO CHICK EMBRYOLOGY

CAMERA SHOTS	VIDEO	AUDIO
(1) T/C	Super 8 film of hatching chick	Theme on Tape Cut 1.
(2) CHAR. GEN.	Dissolve to Char. Gen. "An Introduction to Chick Embryology"	
(3) #2	CU of Incubator, pan left, zoom out to MS of Steve	Theme fade to background then out.
		Hi, how are you. I'm going to be your host for this program on chick embryonic development. And after this program you should be able to identify and differentiate among the various parts and functions of a fertile chicken egg and a developing chick embryo. That's one, and the conditions of chick embryonic development and characteristics of the germ layers should be easy to remember, once you've heard them. And even though maybe you're not an artist, well, I'm going to expect you to be able to draw and label a fertile egg.
		Now if that sounds like a tall order, it really isn't. All you have to do is to be able to follow along in your booklet with me and by the time the program is over, you'll be able to achieve the program goals.
(4) T/C	Slide: Chick embryo out of shell 1	So, let's get started shall we?

		The chick embryo is often used to study embryology because it yields knowledge that can be applied to the understanding of the relationship of the extraembryonic membranes in eggs, circulation and primary germ layers in mammals, such as man for instance.
(5)	T/C	Slide: Chick embryo out of shell 2
(6)	#2	CU of Steve
		So, today, we'll use chicken eggs and embryos in our study of <u>embryology</u> which of course means the science that deals with the study of embryos.
(7)	T/C	Slide: Embryology
(8)	T/C	Slide: Embryo in shell
		Now embryos are unborn offspring in an egg or maternal body.
(9)	#2	CU of Steve
		The process of development in all animals varies, but in some respects it is very much the same. For instance, it begins with a single cell—the fertilized egg.
		Super - Char. Gen. Fertilized Egg
		Lose super
		Now this cell is produced when a male and a female mate, such is the case when a rooster and a hen produce a <u>fertile egg</u>.
(10)	#1	CU of graphic: Hen and rooster providing genes
		In your previous studies of animal reproduction, you learned that a fertile egg contains genes, the units of heredity. A female contributes one half of the genes in a fertile egg, and the male contributes the remainder.
(11)	#2	MS of Steve
		So a certain combination of genes will result in the production of a chicken, or another combination might produce a man or a whale.
		Now, not all eggs are fertile eggs. On the outside a fertile and an infertile egg may look very much the same, but one can develop into an embryo and the other cannot.
(12)	#3	CU of 2 eggs in egg carton
		For instance, look at these two eggs I have here. Can you tell me which of these two eggs is fertile and which is not?

		You can't tell can you. Well, I marked that one with an "F" so I know that's the fertile one. This other is the kind you normally get in grocery stores and of course it's infertile.
(13) #2	MS of Steve	Let's take a closer look at a fertile hen's egg. Let's examine it by the use of a cross-sectional drawing, a side view cross-sectional drawing of an egg.
(14) #1	CU of graphic outline of hen's egg	Now, as I draw each part, you should do the same on the prepared outline in your booklet. Now the hen's egg is a single cell plus membranes to support it during development.
		It's quite large because it contains enough (STEVE DRAWS) yellow yolk to support and feed the developing chick embryo until it hatches.
		Then there's a clear cytoplasm which contains the egg nucleus, it's generally up on top like that. This is generally up on top and it's referred to as the germinal disc. This is the part of the egg that contains the genes that I was talking about before.
		Then there's the white of the hen's egg. Well, the white of the hen's egg, the shell and some membranes lining the shell, they're not really part of the egg itself, they're not part of the egg cell, but are secreted by the hen as the egg passes down the oviduct.
	Super: Extraembryonic membranes	These membranes are called extra-embryonic membranes. And their functions are nutrition, respiration, excretion and protection.
	Lose super	The membranes lining the shell and the shell itself protect the cell from the outside environment, and they also help maintain the egg's internal equilibrium.

Now right around the yolk is a very thin thing called the vitelline membrane.

That's one, the next is the white, and this includes these funny looking things called chalazae, and these are actually there to help stabilize the egg. So we have then the vitelline, the egg white and then there's a membrane here which is called the shell membrane. Now did you notice what I just did, that gives you an airspace between that shell membrane and this shell membrane which stays close to the shell itself, the very shell itself.

(15) T/C Slide: CU of egg shell

Now, that outer shell contains the calcium carbonate, that's the part that has the calcium in it that forms the bones and things in the chicken. And this part of the shell contains about 7,000 tiny pores all over it.

And it's through those that the embryo obtains oxygen from outside and gets rid of, or releases its carbon dioxide.

(16) #2 CU of Steve

Now, can you list the egg membranes that are deposited on the egg as it passes down the hen's oviduct? Remember what I just said, there are five of them.

(17) T/C Slide: Diagram of unlabelled hen's egg

No matter what avian egg you see, whether it's a duck, a hummingbird or an ostrich, these extraembryonic membranes are present.

(18) T/C Slide: Char. Gen. listing membranes

Here they are, vitelline, egg white, two shell membranes and the shell itself. There's your five.

(19) #2 MS of Steve

Now, in your booklet on that diagram that's provided for it, you indicate where you'll find the yolk. The yolk, the vitelline membrane and the egg white.

(20) #1 CU of graphic showing cross-section of egg unlabelled

Right in the middle of the egg there, that's the yolk, and the vitelline membrane is the part that goes right around it like that and of course this out here is called the white or the albumen, and these are part of the white actually, those little things that help to maintain the egg in the middle in the big egg shell.

(21) #2 CU of Steve

Now, can you tell me which of these provide food for the developing embryo, which provide food? Well, actually two of them do. The yolk, the one in the middle, the yellow yolk and the egg white.

Okay, you're doing pretty good.

(22) #1 CU of graphic of hen and chicks

Now, a hen, or a rooster, consists of millions and millions of cells, and yet they began as a single cell. Somewhere along the line the fertilized cell must divide very rapidly to produce the many cells that form the adult body.

(23) #2 MS of Steve

Now, for the development of a fertilized egg to occur, there are certain environmental conditions that must be met. Now, the ancient Egyptians used to have great big walk-in ovens that they incubated the eggs in, and it is said that the Chinese used to incubate eggs in rotting manure. Now your question is why.

Well, because rotting manure, decomposing manure actually gives you heat, and it gives you a high humidity, which are two of the things necessary to incubate eggs successfully.

Now, from what I've said, can you list the three conditions of chick embryonic growth, that are necessary for chick embryonic growth?

Remember, the eggs must be fertile, that's one, heat must be provided, that's two, and they must have a high - humidity.

(24) #3 CU of wooden incubator

Now, there's a wooden incubator here, and this provides optimum conditions for embryonic growth.

(25) T/C Slide: Char. Gen. Conditions of growth

The eggs will develop as long as the eggs are fertile, as long as a constant temperature of between 101 and 103 degrees Fahrenheit is maintained, and then, of course, you have to have that high humidity I spoke of which is about 60 per cent as determined by a wet thermometer, and then last, the eggs are to be turned over at least three times daily, that is, rotated daily.

(26) #2 CU of Steve

Now, if you intend to study embryology, to go on with this study of embryology of other egg-laying animals, similar conditions must be kept in mind. These are the things that are necessary.

(27) #3 CU of incubator

When incubation conditions are right, the embryo develops normally. What was once an interesting mass of yolk and albumen soon begins to attain form and function.

(28) T/C Slide: Cleavage

The first event that occurs is cleavage.

(29) #2 CU of Steve

Now, providing that the male sperm has penetrated the germinal disc, that circular spot on the yolk that we talked about, and the conditions are favorable, the conditions we talked about, that disc will undergo a process called mitosis. I'm sure you studied this process. Now let's review it.

(30) T/C Slide: Char. Gen. on mitosis

Mitosis, cell division producing two identical daughter cells, right?

(31) T/C Slide: Mitosis

Now the disc, that disc we talked about, contains the nucleus, the

chromosomes, a nucleolus, a nuclear membrane, cytoplasm, and a cell membrane. So during the first stage of mitosis called the

(32) T/C Slide: Mitosis

prophase the chromosomes thicken and divide to form pairs. The nuclear membrane disappears as well as the nucleolus.

(33) T/C Slide: Mitosis

Then metaphase begins. The disappearance of the nuclear membrane coincides with the appearance of a new structure in the cytoplasm called spindle, which radiates from the centrosomes.

(34) T/C Slide: Mitosis

The chromosomes then move to attach themselves to spindle fibers.

(35) T/C Slide: Mitosis

Now, the next stage is anaphase. The chromosomes which duplicated themselves to form two chromatids joined at the centromere split and move apart.

(36) T/C Slide: Mitosis

Termination of the anaphase occurs when the chromosomes form a densely packed group at opposite ends of the cell like that.

(37) T/C Slide: Mitosis

Now the telophase begins. The events are essentially the reverse of those occurring in prophase. The nuclear membrane forms, the chromosomes uncoil to become slender threads and the nucleolus reappears. You can see it there. The cell is then cleaved into two parts.

(38) #1 CU graphic showing all stages of mitosis

Now this process is repeated many times over in the developing embryo.

Now, in your booklet, list the main stages of mitosis in order of their occurrence.

(39) T/C Slide: Phases of mitosis

Now, you should have written the phases of mitosis in this order, ready? Prophase, metaphase, anaphase, and telophase.

(40)	#2	CU of Steve	Now, can you list the main events which happened in each stage?
(41)	T/C	Slide: Phases of mitosis	
(42)	#1	CU of graphic showing all phases	A prophase occurs during which chromosomes are duplicated.
			During metaphase, the chromosomes attach to spindle fibers.
			The chromosomes then migrate; they migrate to opposite ends of the cell during anaphase.
(43)	#2	CU of Steve	Last, telophase, that's completed when the original cell cleaves into two parts.
(44)	T/C	Slide: Mitosis	So mitosis has yielded two daughter cells which are about half the size of the original cell, but they are very similar in other qualities.
(45)	#2	CU of Steve	Now the germinal disc of an embryo chick undergoes a series of mitotic changes or divisions known as cleavage.
(46)	T/C	Slide: Side view of cleavage	So, since the cleavage in a chicken embryo is limited to the small disc of protoplasm on top of the yolk,
(47)	T/C	Slide: Discoid cleavage	it's called <u>discoid</u> or incomplete cleavage.
(48)	#1	CU of graphic: Top view of cleavage	So these top views of the hen's egg here show that cleavage divides the protoplasm into progressively smaller units that eventually give rise to the multicellular embryo and all its extraembryonic structures.
(49)	T/C	Slide: Development 1	The germinal disc, which is attached to the yolk by a membrane, starts to enlarge immediately after the start of incubation.
(50)	T/C	Slide: Development 2	

(51) T/C Slide: Development 3

(52) T/C Slide: Development 4

(53) VTR 16mm. film

The circle widens as the cells at the edge of the disc cleave and thereby multiply.

As development proceeds, one edge of the disc grows faster than the rest, this represents the front, or head end of the embryo.

We can see a thickening of the developing tissue along the middle line, this is the primitive streak—it is the chief area of further growth.

During the second day, a tubular heart is formed. (PAUSE) With further growth and the turning over of the embryo on the left side, the heart becomes twisted and pushed out to the right. The heart will become a valved four-chambered organ. Eyes, ears and nasal openings are present in rudimentary form. (PAUSE)

Meanwhile, the germinal disc has grown out and has covered a large area of the upper surface of the yolk. It has developed a network of blood vessels containing blood. This complex system lies outside the developing embryo.

The vitelline blood system carries food from the reservoir of yolk to sustain the growth of the developing chick, pumped through the system by the embryo heart. (PAUSE)

In this microscopic scene, we can see the blood travelling through the vessels covering the yolk. There is a backflow of the blood since no valves are present. (PAUSE)

The flow of blood is stronger and more positive as the valves develop and the heart becomes stronger. (PAUSE)

The blood flow also varies with the temperature of the egg. The cooler it is the faster the heart beat, the hotter it is, the slower the heart beat.

A circulatory system formed from the mesoderm is also laid down in the embryo itself. (PAUSE)

At a later stage, the vitelline blood system completely encloses the yolk. It forms a part of the extraembryonic membrane called the yolk sac.

A second of these membranes appears at the end of the third day of incubation as a small sac protruding from the underside of the tail end of the embryo. It is called the allantois. (PAUSE)

Here is a scene in microsection. Like the yolk sac, it is made up of two parts. A layer of endoderm and a layer of mesoderm. (PAUSE) In this time-lapse scene, we can see it grow.

The violent movement of the embryo is due to muscular action; also, the time-lapse photography exaggerates the movement.

The function of the allantois is to absorb oxygen through the porous shell and to remove carbon dioxide. Also, the allantois brings nutrients from the albumin and calcium from the shell for bone structure. To do this efficiently, the allantois grows until it completely lines the egg by nine days.

The chorion, or serosa, separates the embryo and yolk sac from the egg white. (PAUSE)

The chorion must be removed in order to see the amnion. (PAUSE) The amnion is a transparent bladder of fluid surrounding the embryo proper. It provides a comfortable shockproof environment for the growing embryo. (PAUSE)

At six days, the embryo is birdlike, with a long neck, well developed head, with a brain, eyes and ears, a tail and limbs, and an efficient

heart and blood system, the beginning of a beak and many other avian characteristics. These will be developed over the next 15 days until hatching. (PAUSE)

(54) #2 CU to Steve

Let's quickly watch the development from day one to day six with this section of time-lapse film.

(55) VTR Film: 16mm.

The first, and most obvious item, is the vitelline blood system. (PAUSE)

The embryo now turns on its side. (PAUSE)

Muscular movements are in evidence. (PAUSE)

The brain grows rapidly. (PAUSE)

The allantois starts to swell. It grows until it covers everything.

Fade out music.

(56) #2 MS of Steve

Now, let's check over your notes.

(57) CHAR. GEN. Primitive Streak: Chief area of embryonic growth

First is the primitive streak. It's a thickening of cells that will be the chief area of embryonic development. Embryonic growth I should say.

(58) T/C Slide: Day 5 embryo in shell

Then there's the vitelline blood system, which surrounds the yolk and carries food from the yolk for the developing embryo.

(59) T/C Slide: Allantois

The allantois primarily absorbs oxygen and removes carbon dioxide. Now as well, the allantois brings nutrients from the albumen, from the white and calcium, from out of the shell, for the bone structure of the animal.

(60) T/C Slide: Chorion

The chorion separates the embryo and the yolk sac from the egg white.

(61) T/C Slide: Amnion

The amnion protects the embryo from jarring and sudden temperature changes and things like that.

(62) #2 MS of Steve

Now, if you have at least these notes, you really shouldn't have any trouble in reaching the program objectives.

As you may recall, mitosis produces identical daughter cells, so obviously a chick or a man or a whale is not made out of just one type of cell.

There are nerve cells, muscle cells, brain cells, digestive cells, and so on. I'm all nerve cells myself.

Now what causes each cell to change slightly from the other, from the previously existing cell? We don't really know clearly, we don't know exactly, but it is known that the genes in each cell cause the individual cell to change slightly from the original cell. All right.

(63) CHAR. GEN. Char. Gen.: Differentiation

Now this process is called differentiation. Differentiation.

(64) #1 Drawing of yolk and germinal disc

As the cells on the yolk cleave, and thereby multiply, there on the top, some move inwards to form what is known as the endoderm. Like this. Up there at the germinal layer, they start to cleave.

Now the cells that are left on the outside are called the ectoderm. The cells continue to multiply forcing cells between the two existing layers here. Now this middle layer is called the mesoderm.

(65) T/C Slide: List of germ layers

And these layers are called the germ layers. They contain the germ or the beginning of all tissues of the adult body.

As the chick develops, these germ layers form definite patterns within the embryo.

(66) #1 Graphic: Cross-section of embryo

Now this cross-sectional diagram of a chick shows the relationship of each layer to the others.

Let's start with the outside one, okay? On the outside of the embryo is the ectoderm, that's the one that goes all the way around. That's the epidermal ectoderm. But there's a neural ectoderm too.

(67) T/C Slide: Head

This outside one gives you the skin, the claws, beak, hair and feathers.

This other part right here, that is the neural ectoderm and it gives rise to the beginnings of the nervous system. Which begins outside the body but moves inside at a very early part in the development.

Now the layer of cells inside the embryo is called the endoderm. That here, that's the endoderm. This tissue will line the digestive system all the way from the mouth to the anus, as well as other internal organs.

Between the ectoderm and the endoderm, there's another layer which we call the mesoderm and that's here.

(68) T/C Slide: Wing

The mesoderm will develop into muscles such as those found in wings, legs, etc.

(69) T/C Slide: Young embryo and blood vessels

The circulatory system, bones, kidneys, and ducts of the reproductive system are also formed by the mesoderm.

(70) #2 CU to Steve

No matter what vertebrate embryo you're studying, whether it's a chick or a human embryo,

(71) #1 Graphic: Comparison of chick and foetus

they're all going to have these three germ layers, the ectoderm, the mesoderm and the endoderm. There's a human embryo on the right and a chick embryo on the left. Look at the difference in the size of the eyes.

(72) #2 CU of Steve

Now let's review what you've learned so far. Let's use your booklet to help you with the review.

(73) T/C Slide: Conditions of growth

First of all, a fertile chick egg needs three conditions for optimum growth. Do you remember them? First the egg has to be fertile. Then you have to have a temperature range of not more than 101, I should say not less than 101 and not more than 103 degrees Fahrenheit, a very high humidity, lots of moisture, and it should be rotated at least three times daily.

(74) #3 CU of incubator

Now a small homemade incubator like this one will provide the three necessary functions, temperature, humidity and rotation of course.

(75) T/C Slide: Cytoplasm

Now the hen's egg is a single cell and it contains the fertilized protoplasm in the form of a germinal disc, plus necessary food.

(76) #2 CU of Steve

Do you remember the names of the egg membranes? There are five of them.

(77) T/C Slide: Diagram of egg

The vitelline membrane right around the yolk, the egg white, two shell membranes, that's four, and the egg shell itself, that's five.

(78) T/C Slide: Def. of yolk

As the embryo develops, the yolk sac which is really providing the food for the embryo is used up.

(79) T/C Slide: Def. of amnion

And the amnion, this grows around the embryo. The amnion and its amniotic fluid protect the embryo from sudden temperature changes and jarring.

(80) T/C Slide: Def. of allantois

Then there was the allantois which provides the developing embryo with oxygen and removes the carbon dioxide until the twentieth day.

(81) T/C Slide: Shell

The shell, well, calcium for embryonic bones comes from the egg shell.

(82) T/C Slide: Egg white

The egg white; albumen, a protein, comes from the egg white.

(83) T/C Slide: Chorion

The chorion is the membrane which separates the embryo from the albumen.

(84) #2	CU of Steve	Now as the embryo develops, three primary germ layers are formed, do you remember them?
(85) T/C	Slide: List of germ layers	They are the ectoderm like ecto, extra, means outside of, the mesoderm like middle, meso and the endoderm which means inside, in. Ecto, Meso, and Endo.
(86) T/C	Slide: Epidermal ectoderm	The epidermal ectoderm produces skin, hair, feathers and claws.
(87) T/C	Slide: Neural ectoderm	The brain and the spinal cord are formed by the neural, the neural ectoderm.
(88) T/C	Slide: Mesoderm	From the mesoderm, circulatory and reproductive systems, muscles, bones and kidneys.
(89) T/C	Slide: Endoderm	The endoderm forms the lining of the digestive tract, the bladder.
(90) #2	CU of Steve	What can you recall about cleavage? We talked about it remember.
(91) T/C	Slide: Cleavage	The developing embryo undergoes a series of mitotic divisions. We call this cleavage.
(92) T/C	Slide: Mitosis	Mitotic divisions yield two identical daughter cells, and these stages of mitosis
(93) T/C	Slide: Phases of mitosis	are prophase, metaphase, anaphase and telophase.
(94) T/C	Slide: Discoid cleavage	The chicken egg undergoes discoid or incomplete cleavage of the germinal disc.
(95) #2	MS of Steve	Now the following series of slides show chick embryonic development from the primitive streak up to the twentieth day.
(96) T/C	Series of hatching and credit slides	Fade up tape cut 3. Fade to background for Steve.

(97) #2 MS of Steve

So for those of you who want to go beyond what you've seen here today and go into embryology a little bit on your own, well ask your teacher for help. Okay, you can do it, and good luck to you.

Fade up music to end.

APPENDIX D

TEACHER'S GUIDE FOR AN INTRODUCTION TO CHICK EMBRYOLOGY

Program Title: An Introduction to Chick Embryology

Host: Steve Bloomer

Producer: Clayton R. Wright

Program Length: 34 minutes

Grade Level: Senior high school, first year college

Subject Area: Biology

Reproduction: Black and white

Objectives:

At the end of the video program, students should be able to:

1. Distinguish between a fertile and an infertile hen's egg.
2. Identify the functions of a fertile hen's egg.
3. Identify which parts of the hen's egg are secreted by the hen as the egg passes through the oviduct.
4. Label a cross-section of a fertile hen's egg.
5. Define cleavage and its results.
6. Identify the events of each stage of mitosis.
7. Identify the ideal incubation conditions for chick embryonic development.
8. Identify the functions of the extraembryonic membranes of a developing chick embryo.
9. Identify the derivations of the primary germ layers.

Program Summary:

The television program proceeds in a simple, logical, step-by-step manner to describe the main events of the development of the chick embryo from sperm and egg to the twenty-first day.

Vocabulary Presented:

egg	germinal disc	neural ectoderm
cleavage	primitive streak	epidermal ectoderm
discoid cleavage	amnion	mesoderm
mitosis	yolk sac	endoderm
yolk	allantois	beak
cytoplasm	somite	fertile eggs
shell	limb bu	amniotic cavity
egg membranes	germ la	chorion
incubator	ectoder	egg white

Utilization:

It is recommended that students study the cell, multicellular organisms in general, heredity, mitosis and meiosis before they see this program.

This instructional package consists of a television program and student guide booklets. A booklet should be handed to each student before the program begins. At each beep heard in the program, the students should proceed to the next statement in the booklet and fill in the appropriate answer in the spaces provided.

The following is a list of instructions that should be followed by those who intend to use the television program package.

1. Take class attendance.
2. Make any general class or school announcements.
3. Inform the students that they are to see a television program on chick embryology. The program runs for about 34 minutes.
4. The students should be told that a booklet will be handed to them. the booklet will help them to understand the program.
5. Ask each student whether they have a workable writing utensil. Provide them with a pen or pencil if they don't.
6. Hand out the booklets. Instruct the students to check that they have 12 pages in their booklets. You will be provided with more booklets than you need.
7. Review the instruction on the first sheet of the student guide booklet in the following manner:
   a) Read the instructions aloud, and insist that the students read along with you, silently.
   b) After they have read the instructions, tell the students that they have five minutes to look over the booklet.
   c) Ask the students if they have any questions. Answer any instructional questions. Then proceed with the program.
8. All the equipment will have been set up and prepared to run by me. When you have ascertained that the students are ready, put the video player into the "play" mode.
9. When the program has ended, stop the video player.
10. Remind the students that there are review questions in the back of the booklet.
11. Dismiss the students.

At the conclusion of the program, a short follow-up lesson should be held in order to clarify any points the instructor or students felt were hazy in the program.

The attached test should be given to determine how well the students achieved the program objectives. A test answer sheet is included. Next, the instructor should decide what areas of study individual students need more work in if they are to achieve the program objectives. The test scores will be helpful in making this decision.

For follow-up work, students could be assigned research assignments in the books listed in the bibliography. However, it is recommended that students incubate eggs on their own and study the developing embryos at various stages. The details for such a study are included at the back of each student guide booklet.

APPENDIX E

STUDENT GUIDE TO AN INTRODUCTION TO CHICK EMBRYOLOGY

NAME:_____

This instructional booklet is designed so that you may get the most out of the television program you are about to see. So read the brief instructions below.

Instructions:

First, look at the booklet so that you will be aware of what is expected.

The questions in this booklet follow the content of the program, so every time you hear a beep, answer the next question in your booklet.

Write answers and make notes in an abbreviated form that is understandable to you. For example, instead of writing the word calcium, write "Ca", and for each phase of mitosis write pro, meta, ana, and telo, instead of "prophase," "metaphase," "anaphase," and "telophase."

After the program, for homework, there are some review questions that you should do on your own. For those of you who are interested in chick embryological studies, there is information on how you can start your own program, and a bibliography which lists several useful sources of information. The booklet is yours, You should keep it for future reference.

This is not a test, but only an exercise, so use it. It will help you to master the program objectives listed on the following page.

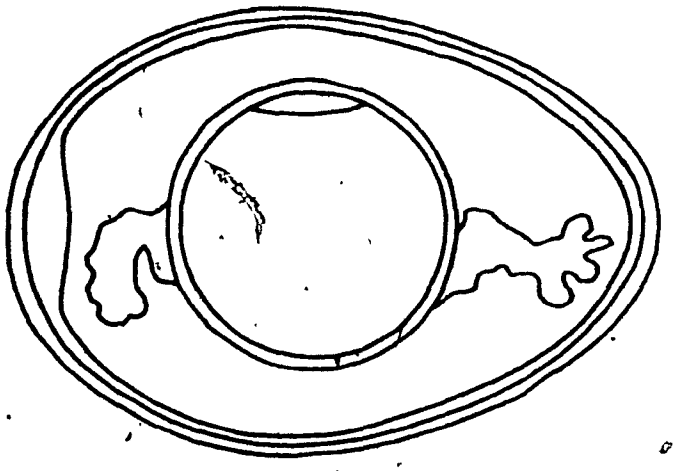
EDUCATIONAL OBJECTIVES OF VIDEO PROGRAM

AN INTRODUCTION TO CHICK EMBRYOLOGY

At the end of the video program, students should be able to:

1. Distinguish between a fertile and an infertile hen's egg.
2. Identify the functions of a fertile hen's egg.
3. Identify which parts of the hen's egg are secreted by the hen as the egg passes through the oviduct.
4. Label a cross-section of a fertile hen's egg.
5. Define cleavage and its results.
6. Identify the events of each stage of mitosis.
7. Identify the ideal incubation conditions for chick embryonic development.
8. Identify the functions of the extraembryonic membranes of a developing chick embryo.
9. Identify the derivations of the primary germ layers.

1. Embryology is the science that deals with the study of embryos.
2. Embryos are unborn offspring in an egg or maternal body.
3. The mating of a hen and a rooster produces a _____ egg.
4. Externally, fertile and infertile eggs _____.
   If you want to find out how to determine whether an egg is fertile or not, look at the back of this booklet.
5. Connect the names on the right with the parts of a fertile hen's egg on the left as the host draws.



Shell
Shell membranes
Germinal disc
Vitelline membrane
Chalazae
Yolk
Egg white
Air space

6. A clear cytoplasm contains _____.
7. The four functions of the extraembryonic membranes are: (One word answers)
   a) nut_____ b) res_____
   c) exc_____ d) pro_____
8. The chalazae are part of the e_____ w_____.
9a. The chalazae helps to _____ the yolk of the egg; i.e. to keep the yolk in the center of the egg white.
9b. Eighty-five per cent of the egg white is water, the rest is a mixture of proteins, mostly albumen. The egg white serves as an

additional source of food and is gradually used up like the yolk in the course of the development of the embryo.

9c. Calcium carbonate is found in the _____ of the egg.

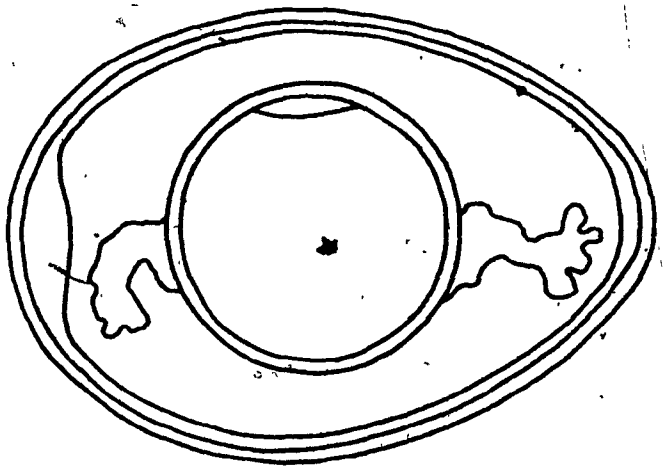
10. List the five egg membranes:

a) d)

b) e)

c)

11. Label the yolk (y), vitelline membrane (v.m.) and egg white (e.w.). Use abbreviations: y, v.m. and e.w.



12. Which of the above provides food for the developing embryo?

13. List briefly three conditions of chick embryonic growth.

a)

b)

c)

14. Specific conditions of embryonic growth are:

a) temperature range of _____

b) humidity of _____

c) rotated _____

15. Cleavage is _____ cell divisions.

16. Mitosis is _____

which produces _____.

17. Write in the main events of mitosis for each phase.

a) prophase

b) metaphase

c) anaphase

d) telophase

18. List the stages of mitosis in order of occurrence.

a)

b)

c)

d)

19. List the main events that occur in each stage.

a)

b)

c)

d)

20. Discoid cleavage is also known as _____.

21. Only the _____ cleaves.

22. As you watch the slides and film, write down the significance or function of the:

Primitive streak - is a _____ of the developing _____ along the middle line. It is the chief area of _____.

Vitelline blood system - carries food from _____ to _____.

Allantois - absorbs _____ through the porous shell and removes _____. It also brings _____ from the _____.

Chorion - separates the _____ from the _____ in the developing egg.

Amnion - surrounds the embryo. It provides _____ _____.

23. Differentiation is the process of change in a cell resulting in a variety of structures and functions.

24. List the three germ layers.

a) _____derm

b) _____derm

c) _____derm

25. They contain the beginning of all _____ of the adult body.

26. List the tissues or organs that are derived from each germ layer.

a) ectoderm

b) endoderm

c) mesoderm

27. To review most of the things you have learned, write a concise definition of each word listed below:

Cytoplasm

Egg membranes

Yolk

Amnion

Allantois

Shell

Egg white

Chorion

Germ layers

Epidermal ectoderm

Neural ectoderm

Mesoderm

Endoderm

Cleavage

Mitosis

Discoid cleavage

A homemade incubator that will satisfy the conditions listed in this program is described at the end of this booklet.

It is suggested that you do the review questions on the next page for homework.

REVIEW QUESTIONS

To help you in your review of the program, answer the questions below. It should not take you more than 10 minutes to complete them. Check your answers with the answers you wrote previously.

PART I. Indicate whether the statements are true or false.

1. Embryos are unborn offspring in an egg or maternal body. T F
2. Externally, a fertile egg is different from an infertile egg. T F
3. A female provides all the genes in a fertilized egg. T F
4. An infertile egg can develop into an embryo. T F
5. The yellow yolk and the egg white provide food for the developing embryo. T F
6. The vitelline membrane separates the egg white from the shell. T F
7. The egg white is a mixture of protein and water. T F
8. Albumen is a protein. T F
9. Genes are present in the egg yolk. T F
10. The shell and the chick bones contain calcium. T F
11. The chalazae are thickenings of the yolk. T F
12. An air space appears between two membranes lining the egg shell. T F
13. The shell membranes consist of keratin fibers. T F
14. The egg white, shell membranes and egg shell are secreted as the egg passes down the oviduct. T F
15. A fertile hen's egg needs a temperature of 102° F. in order to develop. T F

16. Incubated hen's eggs need a humidity of 40 per cent. T F

17. Cleavage is a series of mieotic cell divisions. T F

18. Mitosis is a cell division. T F

19. Cleavage is a series of multiple cell divisions. T F

20. Telophase and metaphase are similar. T F

21. Telophase and prophase are similar. T F

22. Spindle fibers are formed in anaphase. T F

23. When the chromosomes form a densely packed group at opposite ends of the cell, telophase is completed. T F

24. The nucleus contains chromosomes. T F

25. The phases of mitosis occur in this order: prophase, metaphase, telophase, anaphase. T F

26. Mitosis yields two identical daughter cells. T F

27. Cleavage of a chicken egg is limited to the bottom of the yolk. T F

28. Discoid cleavage is incomplete cleavage. T F

29. The primitive streak is a thickening of cells. T F

30. Future growth of a chick embryo occurs at the primitive streak. T F

31. The vitelline blood system provides the developing embryo with oxygen. T F

32. The allantois provides the embryo with water. T F

33. The chorion separates the embryo and the yolk sac. T F

34. The amnion is a solid sac that surrounds the embryo. T F

35. The amnion has a similar function as the allantois. T F

36. The allantois brings calcium and albumen to the embryo. T F

37. Germ layers are formed by the process of differentiation. T F

38. The innermost germ layer is called the mesoderm. T F

39. Bones are formed by the mesoderm. T F

40. The ectoderm forms the skin and nervous system. T F

41. The linings of the internal organs are formed by the mesoderm. T F

The answers for the above true and false questions are as follows:

1. T	11. F	21. T	31. F
2. F	12. T	22. F	32. F
3. F	13. T	23. F	33. T
4. F	14. T	24. T	34. F
5. T	15. T	25. F	35. F
6. F	16. F	26. T	36. T
7. T	17. F	27. F	37. T
8. T	18. T	28. T	38. F
9. F	19. T	29. T	39. T
10. T	20. F	30. T	40. T
			41. F

PART II. Use your school text and any other reference book to help you find the answers to these questions.

1. If you intend to incubate duck eggs, what conditions must be considered?

2. Will all the characteristics of an animal be determined by one parent?

3. Does mitosis occur in all living mammals? Does mitosis occur in any other living organism?

4. Does man have similar extraembryonic membranes to birds?
5. If differentiation did not occur, could complex animals like mammals be formed?
6. What determines whether cleavage will be complete or incomplete?
7. Is blood a major transport system in all animals?
8. Are germ layers found in all animals? What type of animals do not have three germ layers?
9. What functions must an organism perform in order to be classed as living?

ARTIFICIAL INCUBATION OF CHICKEN EGGS

Construction of an Incubator

With a small amount of money, a medium amount of luck, and lots of patience, anyone can hatch chicks or watch the progress of the developing embryo.

For a project of this type, you will need fertile eggs. These eggs are produced from hens that have been allowed to mate with roosters. Fertile eggs may be obtained from a local hatchery. Most eggs sold in grocery stores are infertile, that is, the females have not been allowed to mate with the males.

Next you will need an apparatus called an incubator in order to provide a temperature of between 101-103° F. and a high humidity—60 per cent. The incubator must also allow you to rotate the eggs on a daily basis.

You can make an incubator from a cardboard box, or you can purchase a small commercial incubator. However, I would suggest that you build one out of plywood for just a few dollars.

You will need less than 1/4 of a sheet of 1/2" plywood. This will be used to form the sides, back and bottom. Five running feet of one by two board will be required in order to make a tray. Hardware cloth or metal screening can be used to form the bottom of the tray. Tray runners can be made from 1/2" wood.

In order to keep in the heat provided by a 60 watt light bulb, glass should be purchased to cover the top and one side of the incubator. If grooves are placed in the plywood sides, the glass may be moved back and forth in order to control the amount of heat.

A better method of heat control would be the installation of a thermostat between the electrical outlet and the light bulb socket. The thermostat may be borrowed from you school biology or physics laboratories, as well as a wet and a dry thermometer. These may also be purchased for a nominal cost.

A small bowl can be used to provide moisture and thus maintain a high humidity level. The bowl of water should be placed at the bottom of the incubator.

Of course you will need nails and screws, and when you put it all together, you'll have an incubator that will be ideal for your project.

Candling the Eggs

From the first day of incubation, if the egg is held up to a strong light in a darkened room, embryo development can be easily seen. This process is called "candling." Infertile eggs will be quite clear. If the embryo is developing, you will see a red blotch or a net-like pattern of veins, and if the egg is rotated and then held still, you can usually see the embryo moving about in later days of incubation.

Studying the Embryo in the Shell

To study the embryo within the shell, select a fertile egg and leave it in the blunt-end-up position in the incubator for about four hours. Remove the egg from the incubator and puncture the shell in the centre of the blunt end with a pair of small shears. With the shears, cut out a small circle of the shell, the embryo can then be seen floating on top of the yolk. After you have located the embryo,

the egg opening may be enlarged, being careful to avoid the embryo and the blood vessels. A magnifying glass or binocular microscope is useful in identifying the various body parts. The embryo can be replaced in the incubator and will live several hours in this condition. The technique of studying embryos in the shell is useful only up to six days. After that time, the developing membranes cover the embryo and it should be broken into a small dish for study.

Preserving Embryos

If you break open eggs at various stages for study, it is possible to preserve them in order to later display the sequence of development. Break the egg gently into a flat dish. Separate the embryo from all extra-embryonic membranes with blunt tweezers and sever the umbilical cord near the body wall. Wash the embryo very gently and thoroughly in warm tap water to remove all yolk and albumen material. To preserve the embryo, place it in a 10 per cent formalin solution in a small jar with a screw cap. Small baby food jars are excellent for this purpose. Never leave your formalin solution where young children can reach it and never inhale the fumes yourself. It can cause burns. Label each jar with age of embryo, etc.

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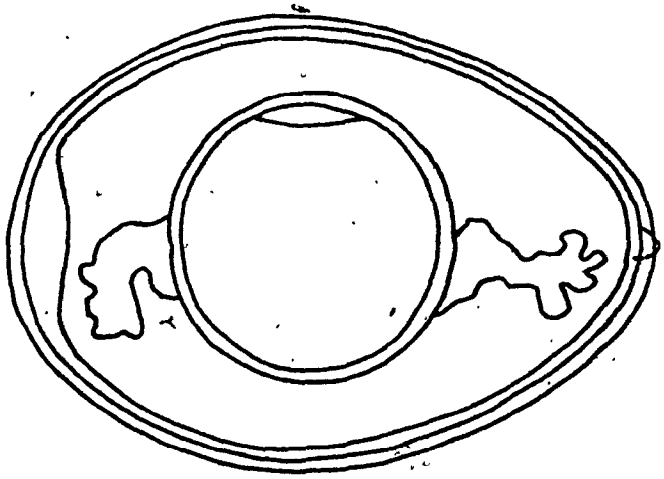
APPENDIX F

MODIFIED SECTION OF STUDENT GUIDE

1. Embryology is the science that deals with the study of embryos.
2. Embryos are unborn offspring in an egg or maternal body.
3. The mating of a hen and a rooster produces a _____ egg.
4. Externally, fertile and infertile eggs _____.

   If you want to find out how to determine whether an egg is fertile or not, look at the back of this booklet.
5. The hen's egg is a single cell.
6. Connect the names on the right with the parts of a fertile hen's egg on the left as the host draws.



yellow yolk

clear cytoplasm or germinal disc

egg white

vitelline membrane

chalazae

shell membrane

air space

shell

7. A clear cytoplasm contains the egg nucleus.
8. The four functions of the extraembryonic membranes are:

a) nutrit_____ b) respir_____

c) excret_____ d) protec_____

9a. The chalazae are part of the egg white.

9b. The chalazae helps to _____ the yolk of the egg; i.e. to keep the yolk in the center of the egg white.

10. Eighty-five per cent of the egg white is water, the rest is a mixture of proteins, mostly albumen. The egg white serves as an additional source of food and is gradually used up like the yolk in the course of the development of the embryo.

11. Calcium carbonate is found in the _____ of the egg.

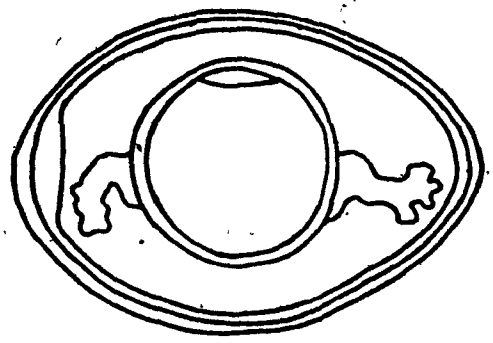
12. List the five egg membranes which are deposited as the egg passes down the oviduct. Use abbreviations.

a) d)

b) e)

c)

13. Draw lines to the yolk, vitelline membrane, and egg white.



yolk

vitelline membrane

egg white or albumen

14. Which of the above provides food for the developing embryo?

a) b)

15. List briefly three conditions of chick embryonic growth.

a)

b)

c)

16. Specific conditions of embryonic growth are:

a) temperature range of _____ F.

b) humidity of _____ per cent

c) rotated _____

17. Cleavage is a series of _____ cell divisions.

18. Mitosis is _____

which produces _____

19. Write in the main events of mitosis for each phase. Be brief.

a) prophase

- chromosomes _____ and _____ to form pairs
- nuclear membrane and nucleolus _____

b) metaphase

- appearance of _____
- chromosomes move to attach themselves to _____

c) anaphase

- chromatids joined at centromere
- chromatids _____ and _____ apart
- termination of anaphase occurs when chromosomes form a _____

d) telophase

- nuclear membrane _____
- chromosomes _____
- nucleolus _____
- the cell is cleaved into _____ parts

20. List the stages of mitosis in order of occurrence.

a) _____phase

b) _____phase

c) _____phase

d) _____phase

21. List the main events that occur in each stage.

a)

b)

c)

c)

22. Discoid cleavage is also known as _____

23. Only the _____ cleaves.

24. As you watch the slides and film, write down the significance or function of the following:

Primitive streak - is a _____ of the developing _____ _____ along the middle line. It is the chief area of _____ _____

Vitelline blood system - carries food from _____ to _____

Allantois - absorbs _____ through the porous shell and removes _____. It also brings _____ from the _____

Chorion - separates the _____ from the _____ in the developing egg.

Amnion - surrounds the embryo. It provides a comfortable _____ environment, thereby protecting the embryo from its surroundings.

Check over your notes with the host.

25. Differentiation is the process of change in a cell resulting in a variety of structures and functions.

26. List the three germ layers.

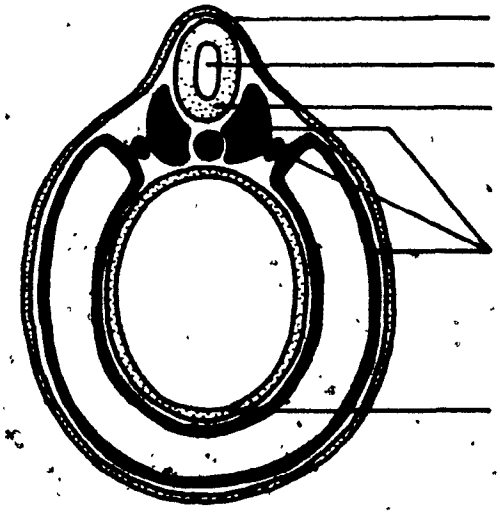
a) _____derm - inside

b) _____derm - outside

c) _____derm - in the middle.

27. The germ layers contain the beginning of all _____ of the adult body.

28. As the chick develops, these layers form definite patterns within the embryo.



29. List the tissues or organs that are derived from each germ layer.

a) ectoderm - epidermal

- neural

b) endoderm

c) mesoderm

APPENDIX G

PROGRAM INSTRUCTIONS FOR TEACHERS

THE CHICK EMBRYO

PLEASE FOLLOW THESE STANDARDIZED INSTRUCTIONS

1. Take class attendance.
2. Make any general class or school announcements.
3. Inform the students that they are to see a television program on chick embryology. The program runs for about 34 minutes.
4. The students should be told that a booklet will be handed to them. The booklet will help them to understand the program.
5. Ask each student whether they have a workable writing utensil. Provide them with a pen or pencil if they don't.
6. Hand out the booklets. Instruct the students to check that they have 12 pages in their booklets. You will be provided with more booklets than you need.
7. Review the instructions on the first sheet of the student guide booklet in the following manner:
   a) Read the instructions aloud, and insist that the students read along with you, silently.
   b) After they have read the instructions, tell the students that they have five minutes to look over the booklet.
   c) Ask the students if they have any questions. Answer any instructional questions. Then proceed with the program.

8. All the equipment will have been set up and prepared to run by me. When you have ascertained that the students are ready, put the video player into the "play" mode.
9. When the program has ended, stop the video player.
10. Remind the students that there are review questions in the back of the booklet.
11. Dismiss the students.
12. I will remove all the equipment between class periods.

APPENDIX H

PILOT PRE- AND POST-TEST

THE CHICK EMBRYO

NAME: SCHOOL:

CLASS: DATE:

NUMBER OF TEST PAGES - 4

INSTRUCTIONS

1. Read all questions carefully.
2. Make a quick survey of all questions.
3. Plan a rough time schedule and try to stick to it.
   Suggested time schedule:

Survey of questions	- 4 min.
Part I	- 10 min.
Part II	- 6 min.
Part III	- 2 min.
Part IV	- 3 min.
Review answers	- 5 min.

4. Read the directions several times. Ask the teacher to explain any directions which are unclear.
5. Answer the easier questions first.
6. Write answers first with pencil so that you can change them easily. When you review your answers, you may then write the correct answers with a pen.
7. Make sure that all answers are printed clearly.
8. Answer all questions in the space provided on the right.
9. Each question has a value of one, "1".
10. No penalty will be given for guessing.

THE CHICK EMBRYO

PART I DIRECTIONS: Match the terms on the left with the definitions on the right, using letter answers.

A. Egg white	1. Primarily a food transport system.	___ 1
B. Mesoderm	2. A membrane which separates two parts of a hen's egg.	___ 2
C. Amnion	3. A protein used by the embryo.	___ 3
D. Shell membranes	4. Has many pores through which oxygen passes.	___ 4
E. Yolk	5. Are concerned with nutrition, respiration, and protection of the embryo.	___ 5
F. Vitelline membrane	6. Holds the egg yolk in place.	___ 6
G. Ectoderm	7. A thickening of cells.	___ 7
H. Germinal disc	8. Forms muscles and bones.	___ 8
I. Chorion	9. A mixture of water and protein.	___ 9
J. Allantois	10. Will not develop to form an embryo.	___10
K. Endoderm	11. Origin of all adult tissue.	___11
L. Primitive streak	12. The primary source of food for the developing embryo.	___12
M. Shell	13. A clear cytoplasm containing the egg nucleus.	___13
N. Germ layers	14. Lines the digestive tract.	___14
O. Extraembryonic membranes	15. Absorbs oxygen for a developing embryo	___15
P. Infertile egg	16. Line the air space of the hen's egg.	___16
Q. Chalazae	17. Has two divisions - epidermal and neural.	___17
R. Albumen	18. Protects the embryo from sudden jarring.	___18

PART II DIRECTIONS: Select the best choice to complete the following statements. Write its letter in the space at the right.

19. Externally, a fertile hen's egg is:
    a) larger than an infertile egg
    b) whiter than an infertile egg
    c) rounder than an infertile egg
    d) the same as an infertile egg ___ 19

20. A fertile egg receives
    a) all the genes from the rooster
    b) all the genes from the hen
    c) equal amounts from the rooster and the hen
    d) equal amounts from the germinal disc and the hen ___ 20

21. Cleavage is a series of
    a) mitotic cell divisions
    b) incomplete cell divisions
    c) meiotic cell divisions
    d) unequal cell divisions ___ 21

22. Cleavage in a chicken egg is referred to as
    a) equal cleavage
    b) primitive cleavage
    c) multicellular cleavage
    d) incomplete cleavage ___ 22

23. Mitosis yields
    a) two dissimilar daughter cells
    b) two identical daughter cells
    c) four dissimilar daughter cells
    d) four identical daughter cells ___ 23

24. Which of the following is <u>not</u> secreted by the hen as the egg passes down the hen's oviduct?
    a) egg white
    b) egg shell
    c) shell membranes
    d) yolk ___ 24

25. Which of the following is not used as a source of food in the developing chick egg?
    a) germinal disc
    b) egg white
    c) yolk
    d) chalazae ___ 25

26. Which combination of conditions listed below are necessary for a fertile egg to develop?
    a) low humidity, temperature of 102° F., daily rotation
    b) high humidity, temperature of 98° F., daily rotation
    c) high humidity, temperature of 102° F., daily rotation
    d) low humidity, temperature of 98° F., daily rotation ___ 26

27. If you were going to incubate chicken eggs, which collection of equipment and materials would best provide your needs?
    a) a wet thermometer, snow, sunshine
    b) a dry thermometer, a thermostat, an electric fry pan
    c) a thermostat, a wooden box, sunshine
    d) a dry thermometer, water, light bulb ___ 27

28. Which are the stages of mitosis in order of occurrence?
    a) prophase, anaphase, metaphase, telophase
    b) prophase, metaphase, anaphase, telophase
    c) prophase, anaphase, telophase, metaphase
    d) metaphase, prophase, anaphase, telophase ___ 28

29. Which stage of mitosis is similar to telophase?
    a) anaphase
    b) metaphase
    c) prophase
    d) none of these ___ 29

30. Which part of the fertile chicken egg cleaves during development?
    a) yolk
    b) chalazae

c) germinal disc

d) egg white ___ 30

PART III DIRECTIONS: Print your answer in the space provided on the right.

During what stages of mitosis do the following events occur?

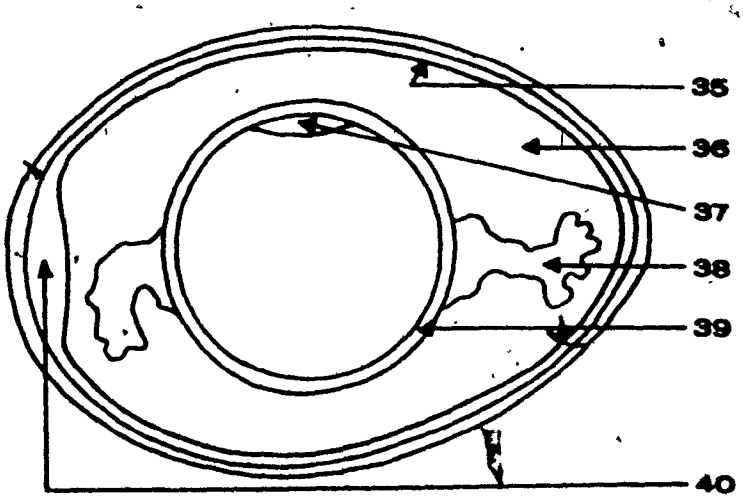
31. The chromosomes clump together at either end of the cell. _____ 31

32. The nuclear membrane has completely disappeared. _____ 32

33. The chromosomes thicken. _____ 33

34. The chromosomes attach to spindle fibers. _____ 34

PART IV DIRECTIONS: On the outline of a cross-section of a fertile hen's egg given below, identify the parts labelled with the numbers attached. Write your answers in the space provided on the right.



35 _____

36 _____

37 _____

38 _____

39 _____

40 _____

APPENDIX I

FINAL PRE- AND POST-TEST

THE CHICK EMBRYO

NAME: SCHOOL:

CLASS: DATE:

NUMBER OF TEST PAGES - 4

INSTRUCTIONS

1. Read all questions carefully.
2. Make a quick survey of all questions.
3. Plan a rough time schedule and try to stick to it.
   Suggested time schedule:

Survey of questions	- 5 min.
Part I	- 10 min.
Part II	- 5 min.
Part III	- 2 min.
Part IV	- 3 min.
Review answers	- 5 min.

4. Read the directions several times at the start of the test period. Ask the teacher to explain any directions which are unclear.
5. Answer the easier questions first.
6. Write answers first with pencil so that you can change them easily. When you review your answers, you may then write the correct answers with a pen.
7. Make sure that all answers are printed clearly.
8. Answer all questions in the space provided on the right.
9. Each question has a value of one, "1".
10. No penalty will be given for guessing.

THE CHICK EMBRYO

PART I DIRECTIONS: Match the terms on the left with the statements on the right, using letter answers. Select the best answer.

A. Egg white	1. Primarily a food transport system.	___ 1
B. Mesoderm	2. A membrane which separates the yolk sac from the egg white in a developing hen's egg.	___ 2
C. Amnion	3. A protein used by the embryo.	___ 3
D. Shell membranes	4. Has a calcium carbonate structure through which oxygen passes.	___ 4
E. Yolk	5. Are concerned with nutrition, respiration, and protection of the embryo.	___ 5
F. Vitelline membrane	6. Holds the egg yolk in place.	___ 6
G. Ectoderm	7. A narrow thickening of cells formed by cleavage.	___ 7
H. Germinal disc	8. Forms muscles and bones.	___ 8
I. Chorion	9. A mixture of water and protein.	___ 9
J. Allantois	10. Produced by the hen, but will not develop to form an embryo.	___10
K. Endoderm	11. Origin of all adult tissues.	___11
L. Primitive streak	12. The primary source of food for the developing embryo.	___12
M. Shell	13. A clear cytoplasm containing the egg nucleus.	___13
N. Germ layers	14. Lines the digestive tract.	___14
O. Extraembryonic membranes	15. Absorbs oxygen for the developing embryo.	___15
P. Infertile egg	16. Line the air space of a hen's egg.	___16
Q. Chalazae	17. Has two division - epidermal and neural.	___17
R. Albumen	18. Protects the embryo from sudden jarring.	___18

PART II DIRECTIONS: Select the best choice to complete the following statements. Write its letter in the space at the right.

19. Externally, a fertile hen's egg is:
    a) larger than an infertile egg
    b) whiter than an infertile egg
    c) rounder than an infertile egg
    d) the same as an infertile egg ___ 19

20. Cleavage is a series of
    a) mitotic cell divisions
    b) incomplete cell divisions
    c) meiotic cell divisions
    d) unequal cell division ___ 20

21. Cleavage in a chicken egg is referred to as
    a) equal cleavage
    b) primitive cleavage
    c) multicellular cleavage
    d) incomplete cleavage ___ 21

22. Which of the following is <u>not</u> secreted by the hen as the egg passes down the hen's oviduct?
    a) egg white
    b) egg shell
    c) shell membranes
    d) yolk ___ 22

23. Which of the following is <u>not</u> used as a source of food in the developing chick egg?
    a) germinal disc
    b) egg white
    c) yolk
    d) chalazae ___ 23

24. Which combination of conditions listed below are necessary for a fertile egg to develop?
    a) low humidity, temperature of 102° F., daily rotation
    b) high humidity, temperature of 98° F., daily rotation
    c) high humidity, temperature of 102° F., daily rotation
    d) low humidity, temperature of 98° F., daily rotation ___ 24

25. If you were going to incubate chicken eggs, which collection of equipment and materials would best suit your needs?
    a) a wet thermometer, snow, sunshine
    b) a dry thermometer, a thermostat, an electric fry pan
    c) a thermostat, a wooden box, sunshine
    d) a dry thermometer, water, light bulb ___ 25

26. Which are the stages of mitosis in order of occurrence?
    a) prophase, anaphase, metaphase, telophase
    b) prophase, metaphase, anaphase, telophase
    c) prophase, anaphase, telophase, metaphase
    d) metaphase, prophase, anaphase, telophase ___ 26

27. Which stage of mitosis is the reverse of telophase?
    a) anaphase
    b) metaphase
    c) prophase
    d) none of these ___ 27

28. Which part of the fertile chicken egg cleaves during development?
    a) yolk
    b) chalazae
    c) germinal disc
    d) egg white ___ 28

PART III DIRECTIONS: Print your answer in the space provided on the right.

During which stage of mitosis do the following events occur?

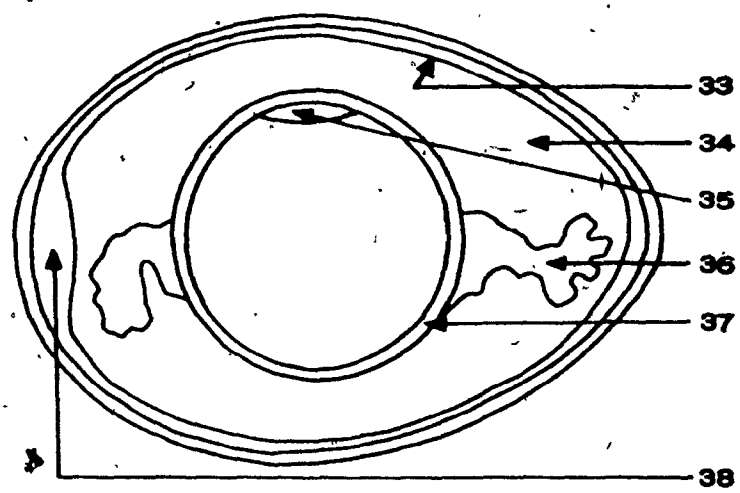
29. The chromatids split and move apart. _____ 29

30. The chromosomes uncoil and become less distinct. _____ 30

31. The chromosomes thicken. _____ 31

32. The chromosomes attach to spindle fibers. _____ 32

PART IV DIRECTIONS: On the outline of a cross-section of a fertile hen's egg given below, identify the parts labelled with the numbers attached. Write the most specific answer. Write your answers in the spaces provided on the right.



_____ 33

_____ 34

_____ 35

_____ 36

_____ 37

_____ 38

FINAL PRE- AND POST-TEST ANSWER SHEET

1. F
2. I
3. R
4. M
5. O
6. Q
7. L
8. B
9. A
10. P
11. N
12. E
13. H
14. K
15. J
16. D
17. G
18. C
19. D
20. A
21. D
22. D
23. A
24. C
25. D
26. B
27. C
28. C
29. ANA
30. TELO
31. PRO
32. META
33. SHELL MEMBRANES
34. GERMINAL DISC
35. YOLK
36. CHALAZAE
37. VITELLINE MEMBRANE
38. AIR SPACE

APPENDIX J

QUESTIONNAIRE USED FOR PROGRAM EVALUATION

1. Indicate how you felt about the program by placing a circle around the appropriate number between the word pairs that corresponds with your impressions of the program:

a) high educational value	10 9 8 7 6 5 4 3 2 1	low educational value
b) worthwhile watching	10 9 8 7 6 5 4 3 2 1	not worthwhile
c) effective	10 9 8 7 6 5 4 3 2 1	ineffective
d) mature	10 9 8 7 6 5 4 3 2 1	childish
e) entertaining	10 9 8 7 6 5 4 3 2 1	not entertaining

2. What did you like about the program?

3. What did you dislike about the program?

4. What would you like to see changed? How could this program be improved?

5. Is the amount of information conveyed for one class period

   too much_____ about right_____ too little _____

6. Would you like to see more television programs like this one?

   yes_____ no _____

7. Did the student guide booklet help you to learn the content of the program?

   yes _____ no _____

8. Do you think that you could have learned the same amount of information without the booklet?

   yes _____ no _____

9. Consider this course design: At the beginning of each week, students watch a program like the chick embryo program you have seen. This program would be a capsule of some segment of your biology course. The rest of the week the students would work on what they didn't know, laboratory work and other individualized studies. Would you like this kind of course design?

   yes _____ no _____

10. If you have any further comments, please write them in the space below.

APPENDIX K

ACTUAL PRODUCTION BUDGET

DESCRIPTION	UNIT		
Production Personnel:			
Producer	1	N/C	
Script Assistant	1	N/C	
Video Switcher	1	N/C	
Audio Mixer	1	N/C	
Camera Control	1	N/C	
Telecine Operator	1	N/C	
Videotape Operator	1	N/C	
Camera Control Operator	1	N/C	
Cameramen/Women	3	N/C	
Stagehands	2	N/C	
Floor Director	1	N/C	N/C
Performers:			
Host	1	N/C	N/C
Studio Facilities:			
Studio Rental	1	N/C	
Studio Equipment Rental		N/C	N/C
Equipment Rental:			
Bolex Super 8mm. Camera	1	N/C	
Braun Nizo Super 8mm. Camera	1	N/C	
Nikon F 35mm. Camera	1	N/C	
Ashai Pentax 35mm. Camera	1	N/C	
Photolights	3	N/C	
Animation Stand	1	N/C	
Photographic Filters	4	N/C	

DESCRIPTION	UNIT		
Equipment Rental (Continued):			
Camera Tripod	1	N/C	
Commercial Incubator	1	N/C	N/C
Videotape:			
One Inch Master	1	$40.00	
Half Inch Distribution Copy	1	20.00	$ 60.00
Film and Processing:			
35mm. Colour Slide Film	14	63.00	
Super 8mm. Colour Film	9	47.25	110.25
Artwork:			
Graphics	14	32.50	32.50
Costumes and Props:			
Stool	1	N/C	
Tables	2	N/C	
Art Easels	2	N/C	
Wooden Incubator	1	8.00	8.00
Music:			
Records	2	N/C	N/C
Commercial Film Rental:			
Rental of Film Insert	1	5.00	5.00
Broadcasting Rights:			
Record Rights	2	N/C	
Film Rights	1	N/C	N/C
Duplication of Scripts:			
Duplication of Scripts for Production Crew and Host	13	14.30	14.30
TOTAL			$230.05

APPENDIX L

SOURCES OF RECORDED MUSIC

Coltrane, John. "Olé," from the album Olé Coltrane. New York: Atlantic Record Corporation, Record No. SD1373.

Laws, Hubert. "La Pavanne," from the album The Rite of Spring. New York: CTI Records, Record No. CTI6012.

APPENDIX M

SOURCE OF 16mm. FILM FOOTAGE

National Film Board of Canada. The Embryonic Development of the Chick, produced by J. V. Durden, 1953.