Readability of biology textbooks

June Dorak

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THE READABILITY OF BIOLOGY TEXTBOOKS

by

Mrs. June Dorak

SUBMITTED IN PARTIAL FULFILLMENT
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CHAPTER I

NATURE OF THE PROBLEM

Introduction

Much has been written on the readability of basal readers in the elementary school, but readability of texts in content areas at secondary level has been given relatively little emphasis. The purpose of this paper was to examine biology books for readability.

The difference in readability of biology books was brought to the writer's attention by a son. The boy attends a city high school and the writer teaches in a rural high school. Preference for the rural textbook by the student was evident when homework was attempted. Hildreth has this to say about the usability of books.

When reading materials are too far over the heads of the children, they are likely to lose interest and become discouraged. On the other hand, if the assigned books are too easy, the children become bored and lose interest. Ill-fitting books can be as useless as ill-fitting shoes. If we want a child to love reading and to use reading as a tool for study, we must make sure that the materials supplied them are written within reasonable range of their readership. ¹

Statement of the Problem

It was the purpose of this paper to determine the readability of six current sophomore biology textbooks according to Fry's graph for estimating readability.\(^1\) Pages dealing with heredity, botany, zoology, and ecology were selected for readability evaluation. Important physical characteristics of these six books were also compared.

Scope of the Problem

This paper deals with six biology textbooks. Three of these books are from the BSCS series. The other three books are individual texts that are not related to each other or to a series. All of these books have a copyright of 1968 except one with a copyright of 1969.

Limitations

Three biology texts from a series and three independent biology books were analyzed. Many other current biology texts were excluded from this study. Since these six books are currently being used in the northeastern Wisconsin teaching area, the writer has selected them for this reason.

Fry's readability graph was chosen because of its reasonable accuracy and simplicity. The easy formula saves time and the simple graph saves space. It is concerned with the important mechanical aspects of average number of syllables and average number of sentences.

Significance

Biology teachers worry about the difficulty of their textbooks. A certain book might be well-received by some students and ignored by others. This problem became very obvious to the writer at many biology teachers' meetings. It is hoped through this readability study to help these teachers select biology texts in the future that will better fit the needs of their individual pupils.

Summary

Today's biology teachers have many textbooks of varying degrees of readability or difficulty to examine. With the help of Fry's readability graph, the writer has ranked six of these books according to grade level. Hopefully, this study will benefit interested biology teachers.

Buckingham and Dolch make the following statement about textbooks.

One of the major problems of the school is that of adapting teaching materials to the learner. A large part of this problem is the choosing for school books of a vocabulary which is within the word knowledge of the children who are to study those books. This cannot be done until we have found out the words of which the children in the various grades know the meanings.¹

CHAPTER II

REVIEW OF RELATED LITERATURE

Definition of Terms

Readability: An objective measure of the difficulty of a book usually in terms of average sentence length and vocabulary load.¹

Readability Formula: A method of estimating the difficulty or readability of printed material usually based on vocabulary difficulty, sentence length, and other factors.²

Since the readability of a book refers to its difficulty, the readability formula acts as a tool to measure the relative difficulty of the printed page. Klare refers to the readability formula as "a predictive device that will provide quantitative estimates of the style difficulty of writing."³

History of Readability Formulas

Readability is definitely not a new concept in the reading field. Talmudist scholars made word counts in


²Ibid., p. 37.

vocabulary to improve comprehension in books as far back as 900 A.D.¹

Rubaken, a Russian, made an analysis of reading material in Russia because the sentences were too long and the vocabulary was too difficult.²

Yen, a Chinese, made a list of a thousand basic characters for the illiterate Chinese coolies.³

Thorndike published a book with 10,000 most frequently used words in 1921. This affected later research on readability.⁴

At the same time, Kitson showed the relationship between sentence length and word length in syllables to show difficulty in newspaper and magazine writing. Lively and Pressey also wrote a paper on vocabulary burden in 1923.⁵

Vogel and Washburn were the first to study the influence of sentence structure on reading difficulty. In 1928 they used Lively and Pressey's plan to analyze reading materials for children. Before this, vocabulary was the

¹Edward Lay, "How Readable are Your Textbooks?" Ohio Schools, XLV (March, 1967), p. 32.
²Klare and Buck, Know Your Reader, p. 32.
³Ibid., p. 37.
only criterion used. It was important for at least 75\% of a group sharing a book to be able to comprehend the material.\footnote{Jeanne S. Chall, "This Business of Readability," Educational Research Bulletin, XXVI (January, 1947), pp. 4-11.}

Lewerenz, in 1929, worked on word difficulty with the belief that beginning letters had something to do with difficulty. The element of polysyllabic words was added in 1939.\footnote{Klare, Measurement of Readability, p. 40}

The Johnson readability formula, based on the percentage of polysyllabic words in thirty 100-word samples, was developed in 1930.\footnote{Shubert and Torgerson, Dictionary in Reading, p. 99.}

Patty and Painter used a special readability technique at Indiana University in 1931 on all texts except language. They concluded that since difficult words were bound to be repeated in longer books, it was necessary to find a better method to evaluate other features that affected readability.\footnote{W. W. Patty and W. I. Painter, "A Technique for Measuring the Vocabulary Burden of Textbooks," Journal of Educational Research, XXIV (September, 1931), pp. 128-34.}

Gray and Leary prepared a checklist of possible factors of readability in 1934. They were concerned with the reading habits of adults of limited reading ability.\footnote{William S. Gray and Bernice E. Leary, What Makes a Book Readable? (Chicago: University of Chicago Press, 1935), p. 90.}
Ojemann also worked on difficulty of materials for adults during the same year.\footnote{Irving Lorge, "Readability Formulae—An Evaluation," \textit{Elementary English}, XXXVI (February, 1949), p. 90.}

In 1935, the Gray-Leary readability formula based on the number of words not found in the Dale list of 766 words, number of personal pronouns, average sentence length in words, percentage of different words and the number of prepositional phrases, was introduced.\footnote{Shubert and Torgerson, \textit{Dictionary in Reading}, p. 99.}

Dale and Tyler were also working on factors that influenced the difficulty of reading materials for adults of limited reading ability at the same time as Gray and Leary. Comprehension tests on health paragraphs given to adults pointed out that technical words and difficult non-technical words were the two main factors that caused trouble.\footnote{Edgar Dale and Ralph Tyler, "A Study of the Factors Influencing the Difficulty of Reading Materials for Adults of Limited Reading Ability," \textit{Library Quarterly} IV (July, 1934), pp. 393–98.}

Yoakam, in 1940, used the vocabulary count alone in the Yoakam readability formula. Some of the words appeared in Thorndike's 10,000 most frequently used word list.\footnote{Shubert and Torgerson, \textit{Dictionary in Reading}, p. 99.}

Flesch, because of a concern with the inadequacy of the 1945 Flesch formula, worked with average sentence and word length to produce the "reading ease score" in 1948. A
"human interest score" for the reader was also developed.\(^1\) Flesch warned people to be aware of books with large numbers of prepositions, connectives, and conjunctions in 1949.\(^2\)

The Dolch Readability formula was introduced at the same time as the famous 1948 Flesch formula. It was used on primary materials and based on the average sentence length in words, "long sentence" length (upper tenth), and the percentage of words not in Dolch's first 1,000 words.\(^3\)

The introduction of the important Dale-Chall readability formula in 1948 highlighted all the readability measurement of the era. It was based on the average sentence length in words and on the number of words not found on the Dale 3,000 word list. At least 80% of the children in fourth grade are familiar with the words in the Dale 3,000 word list.\(^4\) Chall also stated in 1958 that "the term readability has no standard meaning."\(^5\)

The Science Research Associates produced the relatively simple SRA formula in 1950. A plastic gadget which


\(^3\)Shubert and Torgerson, Dictionary in Reading, p. 99.


\(^5\)Jeanne S. Chall, Readability--An Appraisal of Research and Application (Columbus, Ohio: Bureau of Educational Research, Ohio State University, 1948), p. 4.
costs several dollars is needed and it designates only four areas of difficulty.\(^1\)

The Farr, Jenkins and Patterson readability formula in 1952 used the average sentence length in words and the number of one syllable words per 100 words to determine reading difficulty.\(^2\)

The Spache readability formula for primary grades was introduced in 1953. Sentence length and vocabulary difficulty were the two important factors used to calculate readability. Spache concentrated his efforts on grades one through four. Above the primary grades sentence length is less controlled and is less significant in reading difficulty. He used the Dale list of 769 words as a criterion for difficult words for the primary students.\(^3\) Spache, in 1958, referred to readability formulas as good tools in finding books for the reader whose ability is not known.\(^4\)

Taylor, in 1953, did the first work on the cloze readability procedure. The original deletion method was changed, but it can still be used on any verbal instructional material. The passage used for instructional purposes

\(^1\)Fry, "Readability Formula", p. 513.

\(^2\)Shubert and Torgerson, Dictionary in Reading, p. 513.


had every fifth word deleted. Students were expected to fill in the blanks with the exact word from the passage. Bormuth and Rankin checked to see if it was valid and reliable in 1968. It provides a valid measure of student's reading comprehension ability and also a valid method of measuring comprehension difficulties.

The Botel predicting readability formula appeared in 1961 and proved to be more useful as a technique for measuring general story materials than for subject matter materials. Some of the main factors used in predicting levels included vocabulary style, topic sentence length, and size of type. It completely ignores structure complexity.

The McLeod technique was also introduced at this time. A graph was plotted on the proportion of children successfully reading a given book.

Mills and Richardson stated some important information on publishers and the meaning of grade level as a 1963 readability study. Publishers and educators don't

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1 John R. Bormuth, "New Data on Readability" paper presented at the International Reading Association meeting, Anaheim, California, May 5, 1970.


concern themselves over level of difficulty because they are unable to control the variables. A common formula is needed in the grading of textbooks by a single publishing company and among various companies. At this time one-half of the publishers used no standard formula. They depended on authors or educational consultants instead. Some companies didn't even answer several letters requesting the readability level and method used to obtain it.¹

Bormuth made a new approach to readability in 1966. The two main goals of this study were readability prediction and control. Factor analysis techniques on the linguistic variables are being used at the present time for both goals.²

Coleman and Miller reported on a new measure of readability in 1968. It measured the efficiency with which a passage transmitted new information. Information gained during prose learning by different cloze techniques was used to measure readability.³

The Aquino investigation in 1969 was intended to validate the Miller-Coleman Readability Scale. Linguistic variables in thirty-six 150-word passages were checked. Transformational depth was found to be one of the most


promising indicators of syntactic difficulty. It can also be used to measure information gained. The experiment also showed that the cloze test is an economical technique for determining passage difficulty.  

Fry's readability formula and readability graph were first printed in April, 1968. "The formula revolves principally around two factors of average sentence length and aggregate number of words of three or more syllables in the sample."  

Other formulas are tedious and impractical, but Fry's graph according to the latest copy found in the April, 1970 Grade Teacher is simple and practical. "A new approach to checking out the reading level of written material will save you time and trouble while helping you match the book to the child."  

McLaughlin's SMOG or simple method of grading appeared in May, 1969. It is a linguistic measure of word and sentence length to have most productive power.  

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According to Pauk, SMOG revolves around one factor, "the aggregate number of words of three or more syllables in a sample."  

McLaughlin states that it is not only based on word length, but it also takes full account of sentence length.  

In conclusion, it is most fitting that Bormuth's readability paper presented at the May 5, 1970 meeting of the International Reading Association be mentioned. The purpose of the paper was to inform educators about the work that has been done in readability research studies. Allied disciplines such as psychology, linguistics, and mathematics provide powerful new tools to measure instructional material.  

**Fry's Contributions to Readability**  
At the present time, "Fry is a Professor of Education and Director of the Reading Center in the Graduate School of Education at Rutgers, the State University, New Brunswick, New Jersey." Fry, a dedicated man in education, has given much time and talent to the reading field.  

Fry's Instant Word List, a basic vocabulary that is graded on the basis of frequency, was introduced in 1957.  

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3. Bormuth, "New Data on Readability".  
The word list has been used frequently by remedial reading teachers in classroom and clinic situations.

During the academic year 1961-62, Fry was sent by Loyola as a scholar to Makereie College at Kampala, Uganda. The original readability graph was first developed when Fry was in Africa. It was geared to a set of African readers and was read mostly by British readers.¹

The new Fry readability graph published in 1968 was aimed at United States' education and yields 1-13 grade levels. Fry's comment was, "the simplicity is a need I find universal."²

Fry's formula correlates substantially with Dale-Chall, Flesch, and Spache formulas. However, it can rank books in grades 1-13, while the Dale-Chall and Flesch formulas can't rank books below fourth grade and the Spache formula can't rank books above fourth grade.³

Fry's graph definitely illustrated the suggested curvilinearity pointed out by Bormuth's 1966 analysis of a number of readability factors. "The curve is drawn so that in the lower levels sentence length plays a major role in readability while at the upper levels word length accounts for most of the variability."⁴

¹ Fry, "Readability Formula," p. 513.
² Ibid., p. 513.
³ Edward Fry, "Readability Graph Validated at Primary Levels," Reading Teacher XXIII (March, 1969), p. 537.
⁴ Ibid., p. 535.
Maginnis used Fry's graph in March, 1969 on informal reading inventory passages because they are often less than 100 words. He used it downward through the primer and pre-primer levels. He drew the following conclusion concerning Fry's graph.

Hence, in plotting a particular passage on this graph, one would be comparing the passages to all the books plotted by Fry. The comparison would be in terms of sentences per 100 words and syllables per 100 words.¹

The Fry Readability formula and graph are new readability tools that can be used to determine the reading level of texts from the preprimer through the freshman year in college. Fry's hopes for the time and space saving readability device is that teachers, librarians and publishers use it as an objective method to determine readability in the future.²

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²Fry, "Readability Formula," p. 577.

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developed "Essential", "Accessory", and "Not Necessary" vocabularies for each of the six branches of science.¹

At the same time, Stiles made a study of the pictures found in ten biology textbooks. The age of the text was told by the types of figures. The older texts had few small evolutionary figures, and the newest texts had many large health pictures accompanied by graphs, tables, and charts. The newer, more attractive texts were easier to understand.²

In 1925, Powers used Thorndike's *Teachers' Word Book* to test biology, general science, and chemistry texts for uncommon words. If the words were not on Thorndike's List, they were uncommon. Biology texts had the most technical vocabulary and general science texts had the least. Words most frequently used were the easiest and those with the least usage were most difficult.³

No important investigations of readability of science textbooks were conducted during the next decade. Curtis, in 1938, completed an important study on the development of scientific vocabularies. He discovered that both technical and non-technical vocabularies of general science, biology,


chemistry, and physics texts were too difficult for the pupils who read them. Too many difficult non-technical words were found in the books and only a very small percentage of the technical terms were defined.¹

Neal, in 1940, reported that 23.6% of the total space in biology textbooks was given to illustrations. The trend of the time was to have larger pictures for greater understanding.²

Cole's famous Handbook of Technical Vocabulary was published at this time. It included subject matter vocabularies. All branches of science had a special vocabulary that had to be learned.³

Not until the appearance of two evaluation scales for the selection of high school science textbooks in 1949 and 1951, was the topic of science textbook readability mentioned in the literature on reading. Burr's proposed scale in 1949 had eight general headings⁴ while Vogel's in 1951 had ten general headings.⁵

Mallinson, in 1950, stated that scientific terminology should be simplified in biology texts. The earlier passages were not any easier than the later ones.¹

Mallinson also made an important readability statement in 1951, "the levels of reading difficulty of many textbooks in all areas of science are too advanced for the student for whom they are written."²

In 1951 Crombie stressed the vocabulary difficulty as an important factor in evaluating all science tests³ and St. Lawrence pointed out the importance of vocabularies as teacher aids in biology texts.⁴

Mallinson, in 1954, stated that scientific terminology should also be simplified in physical science and earth science textbooks.⁵ "In order to be effective the


⁴Francis St. Lawrence, "The Use of Teaching Aids in Biology Textbooks," Science Education XXXV (March, 1951), p. 78.

reading difficulty of books must be at least one grade level below that of students for whom it is designed.\(^1\)

Culver, in 1954, explained that an adjustment in reading rate must be made when science materials are being read. "Of all content fields, science requires the most accurate reading."\(^2\)

Herrington and Mallinson, in 1958, told science teachers that readability formulas were far better to use than teacher estimates in measuring reading difficulty of elementary science materials.\(^3\)

Mallinson and Bryce, in 1958, suggested four points to be considered in the selection of science textbooks. The number of technical terms used should increase with regard to the normal vocabulary, technical terms should explain scientific meanings, many technical terms used are

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non-essential and should be eliminated, and readability formulas should be used.¹

Blough, in 1958, pointed out the importance of word recognition followed by an understanding of ideas that is found in grade school science texts. As the grade level increases, the textbook authors worry less about these concepts.²

Shores, in 1960, showed the importance of purpose for mature efficient reading of science content. Adults and sixth graders were used in the study. Most adults not only looked back to reread, but also paused, slowed down, and even finger pointed and vocalized. He reminded science textbook authors to remember that teen-agers need to learn to vary reading procedures in science. Various adjustments must be learned. He also reported that main ideas are stronger factors for science reading purposes than meanings with ideas in sequence. Rereading science materials helps a reader to become better at sequence reading.³


²Glen Blough, "Developing Competence in the Interpretation of Scientific Materials," Reading in the Content Areas, ed. by Don L. Cleland (Report of the Fifteenth Annual Conference on Reading, University of Pittsburgh, 1959), p. 102.

³J. Harlan Shores, "Reading of Science for Two Separate Purposes as Perceived by Sixth-Grade Students and Able Adult Readers," Elementary English XXXVII (November-December, 1960), pp. 467-68, 552.
Belden and Lee conducted two important science textbook studies during the early 1960's. Five biology textbooks were checked with the Dale-Chall formula in 1961. The reading achievements of 357 tenth grade biology students according to the Nelson Denny Reading Test were also compiled. The conclusions drawn from the study stressed the importance of the textbook as a study aid. It needs editing to make it readable for students. Biology texts should be readable by biology students. Decoding is not enough. Comprehension must also be included.¹ A similar study was done in 1962 with five chemistry and five physics books. One point was made very clear. It is necessary to include the readability of texts and the reading ability of the students among the criteria for selecting textbooks.²

Podendorf agreed with Lee and Belden at this time. More books that can be comprehended by the reader were needed, but all science reading materials should be used to establish good habits of thinking.³

Science educators felt the importance of using reading skills in science teaching. In 1963, Parker ex-


plained why good reading programs were necessary in science teaching. Children develop general reading skills which should be individualized according to each child's capacity and rate. The multi-level approach must be used when children are reading in science texts. Key-concept science word lists and the development of word-analysis skills should be stressed at all times.¹

Severson's study of readability skills in biology teaching was made during the same year. It showed that the integration of subject matter content with basic reading skills led to higher subject achievement and higher student morale. Constant stress of word analysis skills in the study of biology word lists proved to be of essential importance.²

Bamman, in 1964, reminded teachers of a few important facts.

Words are the tools of all knowledge.

The major difficulty in developing vocabulary for science and math in the secondary school class is that so many terms must be mastered and applied at once.³

¹Don H. Parker, "Reading in Science Training or Education," *Science Teacher* XXX (February, 1963), pp. 43,45.


Ediger, in 1965, discussed reading for a purpose in science, not just for reading's sake. Children must be motivated to read with rich experiences. Questions and problems must be discussed and vocabulary studies stressed.¹

O'Toole and Bedford, in 1966, did a special study on science word lists. They developed a 36-word supplementary science list. It was used with the Dale List and the Dale-Chall formula on a seventh and eight grade science book. The use of the science list lowered the level to fifth and sixth grade. They warned teachers to be aware of the definite lack of science terms appearing in the readability word lists.²

Ekwall, in 1967, explained that one of the important duties of a science teacher is to help students become familiar with science vocabularies. Students should always preview chapters before vocabulary studies are attempted.³

Beard, in 1967, used the cloze procedure with 250 high school sophomores on a biology, chemistry, government,


and history text. The comprehensibility of the four texts was found to be about the same.¹

Mallinson summarized the results of nine years of research in 1967 on the problems connected with the reading of science texts. The problems have been studied more extensively for science than for any other subject. As science fields explode, the vocabularies expand and an overlap of science topics at different grade levels is apparent. Scientific ideas get complex and polysyllabic words are needed, but authors and publishers disagree on the level of reading difficulty with which science textbooks should be written. Some develop sequential reading skills with science concepts and others use science materials only to learn science and not develop reading skills.²

Generally, publishers seek to establish the level of reading difficulty on the basis of Gestalt, about one-grade level below the students for whom the book is designed . . . Many publishers have not been able to resolve the problem of increasing the level of sophistication of science materials without increasing reading difficulty of these materials.³

Williams, in 1968, did a study for the benefit of elementary science textbook selection committees. They


³ Ibid., p. 333.
should consider the factor of readability before adopting the texts. He used the Yoakam readability formula on science materials and discovered a non-technical vocabulary of fourth to sixth grade level and the same vocabulary with the addition of the technical vocabulary of 7.5 grade level. After these materials were rewritten with the help of Cole's handbook of technical words, the simplified non-technical vocabulary was on the third grade level and the same vocabulary with the addition of the original amplified technical vocabulary, was between the third and fourth grade level. All students using the adapted materials did better comprehensive work.¹ "Too frequently all children in a given classroom are expected to read with understanding from the same textbook regardless of individual pupil readiness for reading at the readability level of the textbook in use."²

Several publishing companies are beginning to publish more adapted science textbooks on the secondary as well as the elementary level.

Shepherd, in 1969, stressed the importance of fusing reading skills and scientific content. The expository writing of most science books is different than the narrative


²Ibid., p. 204.
material found in basal readers. Since science is called one of the technical subjects, the words have general meaning in content and specific scientific meaning.¹

Cramer and Dorsey, in 1969, investigated the readability of six series of elementary science texts. They used the Spache formula which counts each unfamiliar word once and Dale-Chall formula which counts each unfamiliar word each time it appears. The two formulas also differ in the weight assigned to sentence length. Spache gives a direct grade level including months while Dale-Chall gives a raw score which is converted to a grade level. The study found that for primary grades vocabulary and sentence length have been controlled to grade levels, but there is a wide variation at the intermediate level. The readability formulas also give higher grade levels than do the publishers.²

As a concluding thought, Hudgins and Reed advise science teachers to take time to teach reading skills now in 1969-70. It is important to stress the decoding of words,


phrases, sentences, and sentence combinations. Materials must be organized into meaningful thought units. Textbooks that clearly show concepts on the concrete, representative and abstract levels are valuable aids to science teachers.  

Explanation and History of BSCS

BSCS (Biological Sciences Curriculum Study) was established by AIBS (American Institute of Biological Science) in January, 1958 at the University of Colorado under the direction of Mayer to improve biology education at all levels. It was a discrete science discipline with the major emphasis in the tenth grade.  

BSCS was finally organized in January, 1959 as a principal educational program of AIBS. At first a series of investigations were prepared for fifty high school students. This series was eventually altered and became a book for second year biology students.  

A group of seventy high school biology teachers and university research biologists prepared preliminary trial investigations.

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materials for three experimental textbooks in the summer of 1960. The individual chapters of each of the texts were written by a team made up of a university biologist and a high school teacher. The books were tested in 100 schools. The green version was ecological, the yellow version was cellular, and the blue version was molecular.

The materials were revised in the summer of 1961 and used in 500 schools in the 1961-1962 academic year. The first edition was published in 1963.

Each version is a full one-year course intended for use at the tenth-grade level with average and above average students. BSCS is laboratory and discussion-oriented with a de-emphasis on lecture and rote learning.

The BSCS is concerned not only with improving the biological subject matter being presented, but also with the manner of presentation, the emphasis, and the focus.

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4 Ibid., p. xi.


The three components of the BSCS biology program included the study of phenomena at three levels, organization of concepts and the use of the enquiry process.\(^1\)

The committee authorship claimed that the three versions are of equal difficulty even if the materials and approaches seem to make the blue version the hardest and the green version the easiest.\(^2\)

BSCS revised the teaching of biology from a traditional non-scientific method to a scientific one. It was necessary to have greater discrimination in the choice of subject matter and students should be allowed to translate the nature of scientific truths.\(^3\) "One has to read well between the lines of these newsletters to realize that the very creation of the BSCS Special Materials Course was an admission that the standard versions were too difficult for a great many pupils."\(^4\)

The ecological green version, the cellular yellow version, and the molecular blue versions show sharp contrasts


\(^2\)Grobman, Biology Implementation in the Schools, pp. 90-94.


to the conventional text with the traditional studies of organs and tissues, individual organisms and population problems.¹ The BSCS approach is strictly analytical and experimental while the traditional approach is naturalistic and descriptive with emphasis on taxonomy and physiology.²

The laboratory approach has been referred to as a chemical analysis for the purpose of obtaining quantitative data. Experiments with living tissues in the laboratory are very different from the descriptive traditional approach based on rote memory.³

... The three BSCS versions differ in point of view and degree of emphasis on level of organization. All three however, bring out the essential character of scientific activity of the great biological theme.

... The green version with an ecological and evolutionary approach accents the population and community levels.⁴

... The BSCS under the direction of Dr. Arnold Grobman has brought together for this project research biologists who know the frontiers of science best and good high school biology teachers who know the student best.⁵


The blue version stresses inquiry as the problem of diversity is introduced and transport systems and modern problems are studied. Inquiry is more important than knowledge.1

On the balance, therefore, except for the Green Version, the BSCS textbooks do not in my opinion constitute much of an improvement over the better conventional texts in terms of either conceptual contents or congruence with contemporary thinking in an approach to biology; in some substantive and most pedagogic respects they fall below the standard of the typical conventional text.2

A high school science department in Brookfield, Wisconsin, after using BSCS for the 1963-1964 academic school year expressed this opinion.

... the lowest 20% of the students were probably lost in the course ... some teachers are of the opinion that the text material, at least in part, is too difficult even for a large percentage of the students in the average tenth grade class.3

A study in Phoenix, Arizona reported no significant differences between results on the Nelson Biology Tests given to the BSCS students and the non-BSCS students. The BSCS program stresses self-discipline and direct experience. The three texts were written with these two ideas as important factors.4


2Ausubel, Evaluation of BSCS Approach, p. 177.


In 1965, a BSCS committee identified a series of questions that needed much research to make BSCS work. The questions must be investigated in order to improve the next textbook edition.¹

After the BSCS blue version had been taught for a year at a Potomac Maryland High School, a survey of the reactions from students, teachers, and parents was taken. The students realized that they must adjust their thinking to develop an inquiring attitude. Many students also complained that the evolution of biological organism is taught as a theory rather than a fact. Older teachers preferred traditional biology because BSCS has unfamiliar current material in the texts. The material must be mastered first and this takes time. Many teachers also stated that they feel it is too difficult for the average tenth grader. Parents want to be kept informed of the BSCS progress. They were also concerned about the effect of BSCS on future biology work.²

A questionnaire was filled out by 65 Ohio teachers who were using any of the three BSCS versions in 1966. There was no great preference for any one version of BSCS, but all


agreed that BSCS teaching took more time and effort on the part of the teacher.¹

A readability study using the Dale-Chall formula was done in 1967 with the three regular 1963 BSCS texts, the 1963 BSCS second year text, the 1966 BSCS text for slow learners, and two of the general biology books used in Lee and Belden's 1961 readability study. It is surprising to note that the blue version had a grade level of 12.8, the yellow version 11.6 and the green version 11.0. The BSCS second year text had 11.0, the BSCS slow learner text had 9.2, and the highest general biology book had 11.0 grade level. According to Mallinson's rule that a science text should always be one grade level below the reading level of the students, the one general biology book with the 9.2 grade level is the only text in this study that meets the standard of the rule.²

Many BSCS teachers have felt that there is a psychological flaw in the program. In all three versions less familiar material was taught to students before they studied any biology that was familiar to them.³

Thibodaux High School in Louisiana gave a very favorable report after using the green version for one year.

It was the consensus of students that BSCS biology is different from anything that they encountered before; they enjoyed it and found it very interesting. The writer has found BSCS to be more demanding on the teacher, but the rewards seem to be greater and therefore the extra effort put forth is certainly not in vain.1

BSCS teaches science as inquiry whereas traditional texts teach dogmatic science facts. The intellectual history of biological concepts is also taught to BSCS students for conveying discoveries to future scientists.2

Mayer predicted in 1967 that the lag time between scientific discoveries and their presence in school texts will be drastically cut.3 "Studies of the 1960's are a tentative step for preparing scientific literate citizens in the 21st century."4

The second edition of the three versions of BSCS biology was published in 1968. According to a letter dated October 9, 1970, from BSCS director Mayer, the average

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4 Ibid., p. 361.
corrected Dale-Chall readability grade level of the 1968 green version is about 10, the yellow version is 9-10, and the blue version is 11-12 with technical words and 9-10 without technical words.\textsuperscript{1}

The second edition of the yellow version simplified the sections on cell chemistry and cell physiology to be more meaningful to the student.\textsuperscript{2}

Three major weaknesses can be found in all three 1968 BSCS textbook versions. Too much biological knowledge has been included in each of the texts for students to absorb intelligently, problems of society are not interacted into the texts, and all three texts are written for college bound students.\textsuperscript{3}

... Thus, the blue version is not recommended for most 10-grade biology students. On the other hand, yellow version students have demonstrated significant and consistent superiority in various aspects of achievement as well as in attitude.\textsuperscript{4}

Mayer, in a 1970 summary article on BSCS, discussed many of the open criticisms, but still has great hopes and expectations for the future of the program.

\textsuperscript{1}A copy of the Mayer letter is found in Appendix I.  
\textsuperscript{2}Panchas Tamir, "Long-Term Evaluation of BSCS," \textit{American Biology Teacher} XXXII (September, 1970), p. 358  
\textsuperscript{4}Tamir, "Evaluation of BSCS," p. 358
In the past ten years, it has accomplished a great deal. In the next decade, even more needs to be done. The concept of a relevant biology for the voting citizenry of the future needs maximal implementation. The BSCS is an instrumentality dedicated to this goal. It is hoped that it can make an impact in the next decade equal to that it has made in the past.  

Physical Characteristics of Biology Textbooks  

Between 1908 and 1923, 1.5% less space was given to illustrations in biology texts than was given in texts published between 1934 and 1940. More than one-fifth of the total space was given to all illustrations in 1940.  

Miller and Blaydes, in 1938, stressed the importance of clear, attractive, and appropriate illustrations, graphs and charts. The use of type and arrangement of material should make the physical part of reading easy. The book should have a pleasant color, good grade of cover, clearly printed title, and good quality and weight of paper.  

Dolch listed the same important physical factors for any textbook which make a difference in the "ease of reading" and a "child's attitude to reading."  

---  

Burtt agreed with Dolch on the physical aspects which may affect readability. In 1949, he made the following statement.

... None of the experiments, to the writer's knowledge, have related typography uniquely to reading comprehension. ... It is probable that typography's greatest effect relates to those reading habits of noting a few characteristic letters or landmarks in a word and inferring the rest from these cues.¹

Crombie suggested the use of a checklist or score card for the evaluation of science texts in 1951. The mechanical makeup should include an attractive and durable binding, good quality finish and color of paper, size, clearness and attractiveness of page (length of line, width of margins, and footnotes), size, clearness and attractiveness of type, and a convenient size and shape of the book.²

Behnke, in 1957, warned publishers that illustrations should be instructive and pictorially effective. They should be as near to the appropriate textual material as possible. Photographs, photomicrographs, or even figures should not be added to discourage the reader if the reproduction of the picture is less than perfect.³

Hurd agreed with all of the suggestions already made on the physical characteristics of biology texts, but

in 1958, he added a very important comment. "Format. Attractive typography and binding can help make the use of a book a pleasurable experience, but a selection based primarily on these elements is certainly unwise." ¹

McCullough, in 1968, also agreed with Hurd and the others. Some of her well quoted questions are as follows:

... Is the paper off-white and dull in finish? Is the print black enough to make a clear contrast with the paper? ...
Is the type highly legible, so that the letters are not confused with one another? Is the print placed clear of the illustrations?

... Do the illustrations assist the recognition of words? Do the illustrations attract the child by the use of color? ...

The importance of physical study aids in biology books was stressed by Ferguson in 1969. Important concepts, theories, and terms should be printed in colored boldface type when introduced. Italics should be used for special vocabulary and scientific names. ³

Harding, Volka, and Fagle, in 1969, told authors of biology texts never to add illustrations as a second thought.

¹Hurd, Biological Education in Schools, p. 123.

²Constance M. McCullough, Preparation of Textbooks in the Mother Tongue, (Newark, Delaware: International Reading Association, 1968), pp. 116-17.

They are of no value because illustrations must depend on the text. A picture must make an instant impression.\(^1\)

Another type of illustration is the transparency. The writer observed transparencies in various biology texts and the scientific sections of encyclopedias.

Lester listed nine physical makeup points to be used in the checklist for evaluating new textbooks in 1970. The ratings included excellent, good, fair, poor, and not applicable. The nine points stressed all of the important suggestions discussed in the preceding section on physical characteristics of biology texts.\(^2\)

**Summary**

The readability of biology textbooks, or any textbook for that matter, refers to the difficulty of the printed pages. Students reading the pages must be able to comprehend as well as decode them. If they fail to understand the concepts, the reading material is too difficult. A wise teacher will attempt to match the reading level of the child to the reading level of the book.

Readability formulas are the instruments used by reading specialists to estimate the difficulty of textbooks.

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The 1968 Fry readability graph was chosen for the study because of the simplicity of the formula. Three current BSCS biology texts using the analytical approach and three current traditional general biology texts using the naturalistic approach were tested by the Fry formula.

The six books used in the study and all other science books present certain readability problems because of the large technical vocabularies. The important physical characteristics of biology texts are also discussed in some detail. The actual appearance of the outside and inside of a book can greatly influence the readership of a student.

Harris summarized the vocabulary burden in textbooks.

The vocabulary problem is more acute in the textbook of the content subjects than it is in general reading material. Many of the books used as texts in the elementary and secondary schools are written by specialists who have little understanding of the reading limitations of the children who are expected to use them.  

CHAPTER III

PROCEDURE

Since high school biology teachers often select textbooks that are too difficult for individual students to understand, the writer has chosen six current sophomore biology textbooks for this readability study.

Letters requesting the readability rating and method used to obtain it were written to the publishers of the three independent biology books and the director of the BSCS series. ¹

Authors of the six books used in this paper are listed in Table 1.

TABLE 1

AUTHORS OF BOOKS

<table>
<thead>
<tr>
<th>Book Titles</th>
<th>Authors</th>
</tr>
</thead>
<tbody>
<tr>
<td>Biological Science An Inquiry into Life</td>
<td>Moore et al.</td>
</tr>
<tr>
<td>Biological Science Molecules to Man</td>
<td>Welch et al.</td>
</tr>
<tr>
<td>Biology</td>
<td>Smallwood-Green</td>
</tr>
<tr>
<td>Foundations of Biology</td>
<td>McElroy et al.</td>
</tr>
<tr>
<td>High School Biology</td>
<td>Grobman et al.</td>
</tr>
<tr>
<td>Modern Biology</td>
<td>Otto-Towle</td>
</tr>
</tbody>
</table>

¹A sample copy of one letter is located in Appendix I, p. 71.
Table 2 includes important information about dates and BSCS versions. The yellow version has the cellular approach, the green version has the ecological approach and the blue version has the molecular approach. In the extreme right-hand column, "No" means that the text is not part of the BSCS series.

**TABLE 2**

**PUBLISHERS AND BOOKS STUDIED**

<table>
<thead>
<tr>
<th>Book Titles</th>
<th>Publishers</th>
<th>Date</th>
<th>BSCS Text</th>
</tr>
</thead>
<tbody>
<tr>
<td>Biological Science</td>
<td>Harcourt-Brace-World</td>
<td>1968</td>
<td>Yes</td>
</tr>
<tr>
<td>An Inquiry into Life</td>
<td>HBW</td>
<td></td>
<td>Yellow</td>
</tr>
<tr>
<td>Biological Science</td>
<td>Houghton-Mifflin</td>
<td>1968</td>
<td>Yes</td>
</tr>
<tr>
<td>Molecules to Man</td>
<td>HM</td>
<td></td>
<td>Blue</td>
</tr>
<tr>
<td>Biology</td>
<td>Silver-Burdett</td>
<td>1968</td>
<td>No</td>
</tr>
<tr>
<td></td>
<td>SB</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Foundations of Biology</td>
<td>Prentice-Hall</td>
<td>1968</td>
<td>No</td>
</tr>
<tr>
<td></td>
<td>PH</td>
<td></td>
<td></td>
</tr>
<tr>
<td>High School Biology</td>
<td>Rand-McNally</td>
<td>1968</td>
<td>Yes</td>
</tr>
<tr>
<td></td>
<td>RM</td>
<td></td>
<td>Green</td>
</tr>
<tr>
<td>Modern Biology</td>
<td>Holt-Rinehart-Winston</td>
<td>1969</td>
<td>No</td>
</tr>
<tr>
<td></td>
<td>HRW</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Fry's easy readability formula and the time-saving graph were used on each of the six books. It involved work with average number of syllables and average number of sentences.¹

¹Fry, "Readability Formula," pp. 513-16, 575-78.
The four areas in each of the six books used included pages on mitosis in heredity, photosynthesis in botany, circulation in zoology, and conservation in ecology.

Steps Used to Complete Readability
Formula and Graph

1. For each area three one-hundred-word passages were chosen from three different pages.

2. The total number of sentences in each hundred-word sample was counted. These three numbers were averaged.

3. The total number of syllables in each hundred-word sample was counted. These three numbers were also averaged.

4. The average number of sentences per hundred words and the average number of syllables per hundred words were then plotted on the graph.\(^1\)

As a result of the findings, the writer obtained a composite average score from the four area averages for each book.

To complete this part of the study, a table ranking the six composite scores according to grade level readability was compiled.

The writer also observed these physical characteristics of each of the six books: attractiveness and appeal of the book cover, size and color of print, number and kind

\(^1\)Ibid., p. 514.
of illustrations, number and type of transparencies, actual size of book, variety of page arrangement, contrast between print and paper, and number of pages.

Using the answers received from the publishers about their suggested readability level and method used to obtain it, the information plotted on Fry's readability graph, and the chart showing the obvious physical characteristics of the texts, the writer made a comparative evaluation of the readability of the six books involved.
CHAPTER IV

INTERPRETATION OF RESULTS

In order to assist high school biology teachers in the selection of textbooks, the writer has used the Fry readability formula and graph on six current sophomore textbooks in a readability study.

The four areas studied included pages on mitosis in heredity, photosynthesis in botany, circulation in zoology, and conservation in ecology. Copies of the six Fry readability graphs are located in Appendix II.¹

The readability scores for the heredity area are found in Table 3.

TABLE 3
READABILITY RESULTS: MITOSIS IN HEREDITY

<table>
<thead>
<tr>
<th>Book Titles</th>
<th>Grade Level</th>
</tr>
</thead>
<tbody>
<tr>
<td>Biological Science An Inquiry into Life</td>
<td>10</td>
</tr>
<tr>
<td>Biological Science Molecules to Man</td>
<td>13</td>
</tr>
<tr>
<td>Biology</td>
<td>11</td>
</tr>
<tr>
<td>Foundations of Biology</td>
<td>10</td>
</tr>
<tr>
<td>High School Biology</td>
<td>11</td>
</tr>
<tr>
<td>Modern Biology</td>
<td>11</td>
</tr>
</tbody>
</table>

¹Appendix II, pp. 78-83.
Biological Science An Inquiry into Life and Foundations of Biology have a grade 10 level. Biological Science Molecules to Man has a grade 13 (or college) level. The remaining three books have a grade 11 level.

The readability scores for the botany area are found in Table 4.

**TABLE 4**

READABILITY RESULTS: PHOTOSYNTHESIS IN BOTANY

<table>
<thead>
<tr>
<th>Book Titles</th>
<th>Grade Level</th>
</tr>
</thead>
<tbody>
<tr>
<td>Biological Science An Inquiry into Life</td>
<td>10</td>
</tr>
<tr>
<td>Biological Science Molecules to Man</td>
<td>10</td>
</tr>
<tr>
<td>Biology</td>
<td>12</td>
</tr>
<tr>
<td>Foundations of Biology.</td>
<td>11</td>
</tr>
<tr>
<td>High School Biology</td>
<td>11</td>
</tr>
<tr>
<td>Modern Biology</td>
<td>10</td>
</tr>
</tbody>
</table>

Foundations in Biology and High School Biology have a grade 11 level. Biology has a grade 12 level. The remaining three books have a grade 10 level.

The readability scores for the zoology area are found in Table 5. High School Biology and Modern Biology have a grade 10 level. Biological Science Molecules to Man has a grade 9 level. The remaining three books have a grade 11 level.
TABLE 5
READABILITY RESULTS: CIRCULATION IN ZOOLOGY

<table>
<thead>
<tr>
<th>Book Titles</th>
<th>Grade Level</th>
</tr>
</thead>
<tbody>
<tr>
<td>Biological Science An Inquiry into Life</td>
<td>11</td>
</tr>
<tr>
<td>Biological Science Molecules to Man</td>
<td>9</td>
</tr>
<tr>
<td>Biology</td>
<td>11</td>
</tr>
<tr>
<td>Foundations of Biology</td>
<td>11</td>
</tr>
<tr>
<td>High School Biology</td>
<td>10</td>
</tr>
<tr>
<td>Modern Biology</td>
<td>10</td>
</tr>
</tbody>
</table>

The readability scores for the ecology area are found in Table 6.

TABLE 6
READABILITY RESULTS: CONSERVATION IN ECOLOGY

<table>
<thead>
<tr>
<th>Book Titles</th>
<th>Grade Level</th>
</tr>
</thead>
<tbody>
<tr>
<td>Biological Science An Inquiry into Life</td>
<td>10</td>
</tr>
<tr>
<td>Biological Science Molecules to Man</td>
<td>13</td>
</tr>
<tr>
<td>Biology</td>
<td>12</td>
</tr>
<tr>
<td>Foundations of Biology</td>
<td>13</td>
</tr>
<tr>
<td>High School Biology</td>
<td>13</td>
</tr>
<tr>
<td>Modern Biology</td>
<td>10</td>
</tr>
</tbody>
</table>

Biological Science An Inquiry into Life and Modern Biology have a grade 10 level. Biology has a grade 12 level. The remaining three books have a grade 13 level.

Tables 3, 4, 5 and 6 record twenty-four grade levels in the four biological areas of heredity, botany, zoology,
and ecology. Grade 9 level appears only once; grade 10 level nine times; grade 11 level eight times; grade 12 level twice, and grade 13 level four times.

The six biology books are used in sophomore or grade 10 classes. Only nine readability scores were at tenth grade level and just one score was at the ninth grade level. All of the other scores were in grades eleven, twelve, or thirteen. Hence, a mere 41.6% of the scores ranked in the tenth grade readability level. Less than 50% of the reading matter found in the six books cannot be read by average tenth grade students.

The Fry readability results for the six composite average scores are found in Table 7. Biological Science An Inquiry into Life with a 10.6 grade level and Modern Biology with a 10.9 grade level were the only two books that ranked at sophomore level. The other four books ranked at the eleventh grade level in the following order: Biological Science Molecules to Man and High School Biology both had 11.3 grade level, Foundations of Biology had 11.5 grade level, and Biology had 11.8 grade level.

The answers received from the director of the BSCS series and the three independent biology book publishers to the writer's letters requesting the readability and the method used to obtain it are also recorded on Table 7.¹

¹Copies of the four letters are located in Appendix I, pp. 72-76.
TABLE 7

COMPARISON OF FRY'S READABILITY COMPOSITE SCORES WITH PUBLISHER'S METHOD OF OBTAINING READABILITY

<table>
<thead>
<tr>
<th>Book Titles</th>
<th>Publishers</th>
<th>Method</th>
<th>Grade Level</th>
</tr>
</thead>
<tbody>
<tr>
<td>Biological Science An Inquiry into Life</td>
<td>HBW*</td>
<td>DC</td>
<td>9-10</td>
</tr>
<tr>
<td>Biological Science Molecules to Man</td>
<td>HM</td>
<td>DC</td>
<td>11-12</td>
</tr>
<tr>
<td>Biology</td>
<td>SB</td>
<td>DC</td>
<td>9-10</td>
</tr>
<tr>
<td>Foundations of Biology</td>
<td>PH</td>
<td>TE</td>
<td>10</td>
</tr>
<tr>
<td>High School Biology</td>
<td>RM</td>
<td>DC</td>
<td>10</td>
</tr>
<tr>
<td>Modern Biology</td>
<td>HRW</td>
<td>DC</td>
<td>9-10</td>
</tr>
</tbody>
</table>

*HBW = Harcourt, Brace & World, Inc.
HM = Houghton Mifflin Co.
SB = Silver Burdett Co.
PH = Prentice-Hall, Inc.
RM = Rand-McNally & Company
HRW = Holt, Rinehart and Winston, Inc.

Biological Science Molecules to Man was ranked 11-12 grade level by Houghton Mifflin Co. Foundations of Biology and High School Biology were both ranked 10 grade level by Prentice-Hall, Inc. and Rand McNally & Company respectively. The remaining three books were ranked 9-10 grade level by Harcourt,
The Dale-Chall (DC) readability formula was the method chosen by five publishers to determine the readability level. Prentice-Hall, Inc., had biology teachers evaluate (TE) the book in its manuscript form and give subjective estimates of the reading level of the book. The publisher's letter made reference to the "easy readability" of the text. ¹

Three publishers, Harcourt, Brace & World, Inc., Houghton Mifflin Co., and Holt, Rinehart and Winston, Inc., ranked the grade level (a two-year span) within the same range as Fry's graph. Silver Burdett Co., with the 9-10 grade level, has a readability score that ranked about two years below Fry's 11.8 grade level. Prentice-Hall, Inc., with the 10 grade level, has a readability score that ranked a year and one-half below Fry's 11.5 grade level. Rand McNally & Company, with the 10 grade level, has a readability score that ranked a year and one-quarter below Fry's 11.3 grade level.

Mayer, BSCS Director, explained in the readability letter that the Dale-Chall readability formula and Fry's graph were the major instruments used to determine the readability levels of the three BSCS books. Using the Dale-Chall formula on Biological Science Molecules to Man, without

¹A copy of the Prentice-Hall, Inc. letter is located in Appendix I, p. 75.
technical words averaged 9-10 grade level and with the technical words included averaged 11 grade level. The writer's readability average grade level, using the Fry formula with technical words included, on the same book was a composite score (including four areas) of 11.3.

The BSCS Director also mentioned the importance of the age of readability formulas. The 1948 Dale-Chall formula is accompanied by word lists which are not relevant to modern science books. The 1968 Fry Graph does not use word lists in determining readability. It is based on sentence length and number of syllables in 100 word passages.

Only one of the BSCS biology texts ranked at grade 10 readability level according to the writer's results using the Fry formula. Biological Science An Inquiry into Life, the yellow version, has a 10.6 grade level. It is the easiest of the six books for sophomores to read. Biological Science Molecules to Man, the blue version, and High School Biology, the green version, were both ranked at eleventh grade level.

Only one of the individual biology textbooks ranked at grade 10 readability level according to the writer's results using the Fry formula. Modern Biology has a 10.9 grade level. It is the second easiest of the six books for sophomores to read. Biology and Foundations of Biology were both

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1 A copy of Mayer's letter is located in Appendix I, pp. 72-73.

2 Ibid.
ranked at eleventh grade level. *Biology*, with a Fry score of 11.8, is the most difficult of the six books for sophomores to read.

Examination of eight physical characteristics of the six biology texts resulted in data presented in Table 8.

Book cover appeal is of prime importance since students often judge a book by its cover. In the writer's opinion, *Foundations of Biology* with the luminous green toadstools on the front and back cover is misleading to the students. Toadstools belong to the subphylum Fungi in botanical classification. Fungi are plants without chlorophyll. Hence, toadstools are never green in color. The other five books have attractive covers with true, life-like pictures of plants and animals.

Another important characteristic which determines the number of times the book is read and actually used for study is the size and color of the print on the pages of a book. *Foundations of Biology* has 10 point light black print for paragraph use. The other five books have 10 point medium black print for paragraph use. All six books use italics and have headings that are varied in the size (usually larger than paragraph letters) and color (a variety of primary and secondary colors) of the print.

Hundreds of black and white as well as colored drawings, photographs, and photomicrographs are found in various chapters of the six books. In the writer's opinion, illustra-
### TABLE 8
PHYSICAL CHARACTERISTICS OF BIOLOGY TEXTBOOKS

<table>
<thead>
<tr>
<th>Book Title</th>
<th>Book Cover Appeal</th>
<th>Size and Color of Print</th>
<th>No. and Kind of Illustrations</th>
</tr>
</thead>
<tbody>
<tr>
<td>Biological Science An Inquiry into Life</td>
<td>Honey bee in comb</td>
<td>10 pt. med. black in paragraphs. Headings are varied.</td>
<td>Hundreds black &amp; white, colored drawings &amp; photos</td>
</tr>
<tr>
<td>Biological Science Molecules to Man</td>
<td>Plant and animal colleges</td>
<td>10 pt. med. black in paragraphs. Headings are varied.</td>
<td>Hundreds of black &amp; white, colored drawings &amp; photos</td>
</tr>
<tr>
<td>Biology</td>
<td>Sphinx moth and daisy</td>
<td>10 pt. med. black in paragraphs. Headings are varied.</td>
<td>Hundreds of black &amp; white, colored drawings &amp; photos</td>
</tr>
<tr>
<td>Foundations of Biology</td>
<td>Luminous green toad stools</td>
<td>10 pt. lgt. black in paragraphs. Headings are varied.</td>
<td>Hundreds of black &amp; white, colored drawings &amp; photos</td>
</tr>
<tr>
<td>High School Biology</td>
<td>Tree trunk in woods</td>
<td>10 pt. med. black in paragraphs. Headings are varied.</td>
<td>Hundreds of black &amp; white, colored drawings &amp; photos</td>
</tr>
<tr>
<td>Modern Biology</td>
<td>Green algae filaments</td>
<td>10 pt. med. black in paragraphs. Headings are varied.</td>
<td>Hundreds of black &amp; white, colored drawings &amp; photos</td>
</tr>
</tbody>
</table>
TABLE 8—Continued

<table>
<thead>
<tr>
<th>No. and Type of Transparencies</th>
<th>Size of Book</th>
<th>Variety of Page Arrangement</th>
<th>Contrast Between Print and Paper</th>
<th>No. of Pages</th>
</tr>
</thead>
<tbody>
<tr>
<td>None</td>
<td>9.25&quot; long</td>
<td>2 columns of words with 17.5-picas in each--Illus. interspersed.</td>
<td>Med. black print on dull white enamel paper</td>
<td>840</td>
</tr>
<tr>
<td></td>
<td>7.50&quot; wide</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>None</td>
<td>9.25&quot; long</td>
<td>2 columns of words with 16 picas in each--Illus. interspersed.</td>
<td>Med. black print on white enamel paper</td>
<td>840</td>
</tr>
<tr>
<td></td>
<td>6.75&quot; wide</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>None</td>
<td>9.25&quot; long</td>
<td>1 column of words with 24 picas--Illus. interspersed.</td>
<td>Med. black print on dull white enamel paper</td>
<td>755</td>
</tr>
<tr>
<td></td>
<td>7.50&quot; wide</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>None</td>
<td>9.68&quot; long</td>
<td>1 column of words with 23 picas--Illus. interspersed.</td>
<td>Light black print on white enamel paper</td>
<td>746</td>
</tr>
<tr>
<td></td>
<td>7.00&quot; wide</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>None</td>
<td>9.25&quot; long</td>
<td>1 column of words with 22 picas--Illus. look crowded.</td>
<td>Med. black print on white enamel paper</td>
<td>823</td>
</tr>
<tr>
<td></td>
<td>6.87&quot; wide</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>2 on frog structures</td>
<td>9.25&quot; long</td>
<td>2 columns of words with 16 picas in each--Illus. interspersed.</td>
<td>Med. black print on white enamel paper</td>
<td>783</td>
</tr>
<tr>
<td>2 on the human body</td>
<td>7.12&quot; wide</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
tions are not only superior in quality, but are also well-distributed for a good learning situation.

Transparencies are not found in any of the six books except Modern Biology. Two colored ones on the frog and two colored ones on the human body are inserted in the respective chapters.

Book size of the six biology books remains quite uniform. Foundations of Biology, the longest book, is 9.68" long. The other books are 9.25" long. Biological Science An Inquiry into Life and Biology, the widest books, are 7.50" wide. Biological Science Molecules to Man, 6.75" wide, High School Biology, 6.87" wide, Foundations of Biology, 7.00" wide, and Modern Biology, 7.12" wide, clearly show the uniformity of widths in biology texts.

Page arrangement needs variety in order to keep students from becoming bored and losing interest in the reading material. Biological Science Molecules to Man and Modern Biology have two columns of words on each page with 16 picas in each. Illustrations are interspersed. Biological Science An Inquiry into Life also has two columns, but with 17.5 picas in each. The illustrations are interspersed. High School Biology has one column of words with 22 picas. The illustrations and side captions are crowded. Foundations of Biology has one column of words with 23 picas. Illustrations and side captions are interspersed. Biology has one column of words with 24 picas. Illustrations and side captions are interspersed.
Contrast between print and paper is an important characteristic to be considered in the selection of a textbook. Certain sections of the six books have black and colored print that varies in size, but the actual paragraphs are usually in medium black print. Biological Science An Inquiry into Life and Biology have medium black print on dull white enamel paper. Foundations of Biology has light black print on white enamel paper. The remaining three books have medium black print on white enamel paper.

Biology textbooks vary a small degree in the total number of pages in each book. Biological Science An Inquiry into Life and Biological Science Molecules to Man, the two longest BSCS texts, have 840 pages. High School Biology, the third BSCS text, has 823 pages. The independent biology texts do not contain as many pages as the BSCS texts. Modern Biology has 783 pages. Biology has 755 pages and Foundations of Biology, the book with the least number of pages, has 746 pages.

To conclude the above discussion on physical characteristics of biology textbooks, the writer suggests the possible relationship of the eight characteristics to the readability of the book itself. Physical characteristics cannot be measured by any definite formula as the Fry graph measures grade level readability, but the positive or negative effects of the characteristics will aid or hinder the readability of a book.
CHAPTER V

SUMMARY

Readability is not a new idea in the reading field. Talmudist scholars made word counts in books as early as 900 A.D.

Judd made the following important statement concerning readability in 1918.

Every textbook, whatever its source, has characteristics which can be accurately tabulated and described. Each book has a kind of personality which can be measured no less accurately than the physical characteristics of a man... Scientific studies of books can be made and accurate descriptions can be given along with the books themselves to anyone who is going to use them.¹

After Thorndike published The Teachers' Word Book of 10,000 Words in 1921, readability formulas were used to measure the difficulty of textbooks.²

Many people have contributed to the problem of readability since 1921. Many formulas to measure readability were devised since Thorndike's famous Word Book was published.


Some of the prominent ones included the Flesch "readability ease score", Dale-Chall formula, Spache formula, Taylor "cloze procedure", Fry graph, and the Bormuth "factor analysis of linguistic variables".

Science textbooks have presented readability problems to teachers and authors even before the 1924 Pressey study determined the technical vocabulary found in biology and other science texts. Curtis, Cole, Mallinson, Lee, and Shepherd were only a few of the many people who conducted science readability investigations to help solve the difficult problems.

The 1968 Fry graph was chosen by the writer for the study because it saves space and time. Fry worked out a graph that could determine the readability level of all books from grades 1-13. The average number of syllables and the average number of sentences were counted in 100 word passages and then plotted on the graph.

The Fry formula was used on three BSCS biology texts: Biological Science An Inquiry into Life, Biological Science Molecules to Man, and High School Biology. It was also used on three independent books: Biology, Foundations of Biology, and Modern Biology.

The Fry formula was used in four areas of each book: mitosis in heredity, photosynthesis in botany, circulation in zoology, and conservation in ecology. A composite score was calculated from the results of the four areas.
Biological Science An Inquiry into Life, the yellow version BSCS text, was the only BSCS text that ranked at grade 10 level. Modern Biology was the only independent text that ranked at grade 10 level. The other four texts ranked at grade 11 level.

When the composite Fry scores were compared to the publisher's grade level ratings, the Fry readability score was within the same grade level range for three of the books and at least one year higher for the other three books.

Eight physical characteristics of six biology texts were examined: Book cover appeal, size and color of print, number and kind of illustrations, types of transparencies, size of book, variety of page arrangement, contrast between print and paper, and number of pages.

It was interesting to note that Modern Biology was the only book to use transparencies.

The writer also noticed that in ecology, now stressed in schools, that three books were at the grade 13 level, one was at the grade 12 level, and only two were at the grade 10 level. Therefore, it is quite evident that in the area of ecology only two of the six books can be read by average tenth grade students.

All of the eight characteristics will in some way affect the readability of any textbook just as readability formulas determine the grade level of the text.
Dale and Chall made a summary statement on the broad meaning of readability.

In the broadest sense, then readability is the sum total (including the interactions) of all those elements within a given piece of printed material that affects the success that a group of readers have with it. The success is the extent to which they understand it, read it at an optimum speed, and find it interesting.¹

It is the writer's hope that the Fry graph and other new readability formulas will be used in the future on all secondary science textbooks.

SELECTED BIBLIOGRAPHY

Books


McCullough, Constance M. Preparation of Textbooks in the Mother Tongue. Newark, Delaware: International Reading Association, 1968.


**Articles and Periodicals**


_____ "Readability Graph Validated at Primary Levels." Reading Teacher, XXII (March, 1969), pp. 534-38.


_____ "Look at the BSCS Blue Version." Catholic School Journal, LXIII (April, 1963), pp. 68-70


Unpublished Material

In partial fulfillment of a master's degree in reading at Cardinal Stritch College in Milwaukee, I am writing a research paper on the readability of biology textbooks. Three 1968 BSCS books are being used in the study: Harcourt, Brace and World’s Biological Science An Inquiry into Life by Moore et al, Houghton-Mifflin’s Biological Science Molecules to Man by Welch et al, and Rand-McNally’s High School Biology by Grobman et al. Would it be possible to send me the suggested readability level of these three books? Was a readability formula used to obtain this level or some other method?

Thank you very much for your anticipated reply.

Sincerely yours,

Mrs. June Dorak

Mrs. June Dorak
Dear Mrs. Dorak:

As your work will undoubtedly show, readability scales have been under a great deal of criticism. They are generally regarded as being quite unreliable. Most of them are based on simple formulas that involve sentence length, paragraph length and other mechanical features. None seems to be concerned with comprehension which, of course, is the aim of readability. Many, such as the Dale-Chall, are accompanied by word lists that are antiquated and not applicable to science. Thus, science texts normally rate higher in readability because of their vocabulary than companion materials in, let us say, English.

We have used a number of these formulae with scientific terms included and with scientific terms removed. The Dale-Chall Readability Formula and the Fry Readability Graph have been our major instruments. For Biological Science: Molecules to Man, the Dale-Chall with technical words included averaged 11th to 12th grade; without technical words, 9th to 10th grade. Using the Fry Graph with technical words, it averaged 11th grade; without technical words, 9th to 10th grade. I am enclosing for your information a work sheet on the Yellow Version which indicates the average corrected grade level to be 9-10. For the Green Version, readability scores at about the 10th grade level.

However, so much depends in text materials upon clear, complete, relevant illustrations, graphs, photos, charts, tables, etc., that the readability tests are suspect because none take these factors into consideration. In the Green Version, for example, marginal notes provide derivations, pronunciations and definitions of terms and phrases deemed unfamiliar. Again, a formula score has no way to take this material into account. Scoring a text with Dale-Chall is purely a mechanical and repetitive task which leaves no room for what we are supposedly looking for, namely, readability. Attempting to ascertain
readability by scores and word lists that were never designed for science materials; the age of the formula, now 22 years, and the skepticism of reading specialists regarding such activities, all tend to make the concept of readability, as it is now determined, somewhat suspect.

We have gone through the motions, here at BSCS, of using currently existing formulae. We have applied them not only to the BSCS texts, but to others as well. It is not our policy to denigrate other materials but even with the fallible instruments as noted above, the BSCS materials were more readable than those in other biology textbooks currently on the market. I would, therefore, like to suggest that your Master's Degree program include texts other than those of the BSCS in order to get a true cross section of books currently available to secondary schools.

Sincerely,

William V. Mayer
Director

WVM/jb
Enclosure
November 19, 1970

Mrs. June Dorak
3422 Lindbergh Drive
Manitowoc, Wisconsin 54220

Dear Mrs. Dorak:

Thank you for your letter inquiring of the readability of biology textbooks, and more particular, of Modern Biology, 1969, by Otto and Towle.

It has always been the practice of our company to administer a readability formula for each of our school publications. For the text of your concern, Modern Biology, the Dale-Schall formula has been used. This formula produced a Grade 9-10 reading level.

Your concern of our text is most appreciated, and we wish you continued success in your work towards your master's degree. Please accept our apology for the apparent delay in answering your previous letters.

My best to you and thank you for stopping at our WEA display booth.

Sincerely yours,

Gary D. Knutson
Midwest Division Manager

GDK:tm

645 N. Michigan Ave.
Chicago, Ill.
Mrs. June Dorak  
3422 Lindbergh Drive  
Manitowoc, Wisconsin 54220  

Dear Mrs. Dorak:

Thank you for your letter of November 17. Your two earlier letters never reached our office, which is the reason there has been no response. I can appreciate the inconvenience this has caused you. Mr. Kean is on jury duty at the present time, so I am answering your letter in his stead.

I have gone through the files on FOUNDATIONS OF BIOLOGY, and can find nothing more specific about its readability level than a reference to "easy readability" as one of the features of the text. The book is, as you know, designed for tenth graders. My guess is that the estimate of the reading level was subjective, based upon the reactions of the biology teachers who reviewed the text when it was in manuscript. That estimate most likely implied some kind of comparison with the B.S.C.S. texts--again, probably subjective. At the time FOUNDATIONS OF BIOLOGY was conceived, the first editions of the three B.S.C.S. texts had just appeared and were receiving a mixed reaction, in part because of the difficulty of reading.

It is our practice now to run reading level tests on our books while they are in manuscript, and to make changes in the manuscript as needed to bring the reading level within the range appropriate for the intended users of the text. Generally, we use the Fog Index or the Flesch Formula or both. But, I don't know if this was done on FOUNDATIONS OF BIOLOGY.

I considered running the Fog Index on the text now, and forwarding my results to you. But, undoubtedly you are doing your own readability level tests on the texts examined in your research, using the formula of your choice and a consistent pattern of sampling.

I hope this information will be of some value to you. If we can be of further help, please let us know.

Sincerely,

(Miss) N. Sue Barnes  
Associate Editor, Science  
Educational Book Division
October 6, 1970

Mrs. June Dorak
3422 Lindbergh Drive
Manitowoc, Wisconsin 54220

Dear Mrs. Dorak:

Thank you for your letter telling us that you are doing a research paper on the readability of Biology textbooks.

The readability level of our textbook, BIOLOGY, is in the 9th to 10th grade range. This readability level was checked by the Dale-Chall system.

Sincerely yours,

James Cutler, Manager
Sales Correspondence

JC:al
Graph for Estimating Readability

by Edward Fry, Rutgers University Reading Center

Average number of syllables per 100 words

---

BOOK TITLE BIOLOGICAL SCIENCE - AN INQUIRY INTO LIFE

Key Used

+ Mitosis in Heredity . . . . . . Pages 128, 135, 472

o Photosynthesis in Botany . . . . . Pages 241, 289, 699

x Circulation in Zoology . . . . . Pages 406, 409, 436

o Conservation in Ecology . . . . . Pages 736, 746, 755

* Composite Average Score . . . Pages See the above

---

1Fry, "Readability Formula," p. 514.
Graph for Estimating Readability

by Edward Fry, Rutgers University Reading Center

Average number of syllables per 100 words

---

BOOK TITLE: BIOLOGICAL SCIENCE  MOLECULES TO MAN

Key Used

+  Mitosis in Heredity  Pages 254, 272, 306

○  Photosynthesis in Botany  Pages 176, 291, 465

Χ  Circulation in Zoology  Pages 483, 487, 491

☆  Conservation in Ecology  Pages 736, 740, 743

☆  Composite Average Score  Pages See the above

---

1 Fry, "Readability Formula," p. 514.
Graph for Estimating Readability
by Edward Fry, Rutgers University Reading Center
Average number of syllables per 100 words

BOOK TITLE  BIOLOGY

Key Used

+ Mitosis in Heredity  ...  ...  Pages  38, 155, 561
o Photosynthesis in Botany  ...  ...  Pages  64, 100, 104
x Circulation in Zoology  ...  ...  Pages  392, 400, 418
* Conservation in Ecology  ...  ...  Pages  705, 708, 715

* Composite Average Score  ...  ...  Pages  See the above

---

1 Fry, "Readability Formula," p. 514.
Graph for Estimating Readability

by Edward Fry, Rutgers University Reading Center
Average number of syllables per 100 words

---

BOOK TITLE FOUNDATIONS OF BIOLOGY

Key Used

+ Mitosis in Heredity . . . . . . Pages 81, 306, 368
o Photosynthesis in Botany . . . . . . Pages 258, 479, 501
x Circulation in Zoology . . . . . . Pages 613, 615, 622
• Conservation in Ecology . . . . . . Pages 108, 110, 549
♦ Composite Average Score . . . . . . Pages See the above

---

1 Fry, "Readability Formula," p. 514.
Graph for Estimating Readability

by Edward Fry, Rutgers University Reading Center

Average number of syllables per 100 words

Short words

Long words

BOOK TITLE
HIGH SCHOOL BIOLOGY

Key Used

+ Mitosis in Heredity Pages 394, 400, 685
o Photosynthesis in Botany Pages 20, 426, 474
x Circulation in Zoology Pages 494, 500, 509
- Conservation in Ecology Pages 94, 291, 349
* Composite Average Score Pages See the above

1 Fry, "Readability Formula," p. 514.
Graph for Estimating Readability

by Edward Fry, Rutgers University Reading Center

Average number of syllables per 100 words

Short words

<table>
<thead>
<tr>
<th>Average number of syllables per 100 words</th>
<th>Long sentences</th>
</tr>
</thead>
<tbody>
<tr>
<td>Short sentences</td>
<td></td>
</tr>
</tbody>
</table>

Long words

<table>
<thead>
<tr>
<th>Approximate Grade Level</th>
</tr>
</thead>
<tbody>
<tr>
<td>2, 4, 6, 8, 10, 12, 14, 16, 18, 20</td>
</tr>
</tbody>
</table>

BOOK TITLE  MODERN BIOLOGY

Key Used

+ Mitosis in Heredity . . . . . Pages 106, 108, 110
0 Photosynthesis in Botany . . . Pages 80, 90, 317
x Circulation in Zoology . . . . Pages 411, 491, 598
• Conservation in Ecology . . . . Pages 707, 714, 725

* Composite Average Score . . . . Pages See the above

1 Fry, "Readability Formula," p. 514.
# WORKSHEET FOR FRY READABILITY FORMULA

**BOOK TITLE**: BIOLOGICAL SCIENCE - AN INQUIRY INTO LIFE  
**DATE**: 12/15/70

## I. Mitosis in Heredity (100 word samples)

<table>
<thead>
<tr>
<th>Pg. No.</th>
<th>From:</th>
<th>To:</th>
<th>Sentences Per 100 Words</th>
<th>Syllables Per 100 Words</th>
</tr>
</thead>
<tbody>
<tr>
<td>128</td>
<td>Think of it</td>
<td>it is a</td>
<td>8.6</td>
<td>142</td>
</tr>
<tr>
<td>135</td>
<td>In some exceptionally</td>
<td>part of mitosis</td>
<td>3.0</td>
<td>149</td>
</tr>
<tr>
<td>472</td>
<td>The Fusion of</td>
<td>always be meiosis</td>
<td>4.0</td>
<td>176</td>
</tr>
<tr>
<td></td>
<td></td>
<td>total 3)15.6</td>
<td></td>
<td>total 3)467</td>
</tr>
<tr>
<td></td>
<td></td>
<td>average 5.2</td>
<td>total 3)15.6</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>average 5.2</td>
<td></td>
<td>155+156</td>
</tr>
</tbody>
</table>

## II. Photosynthesis in Botany (100 word samples)

<table>
<thead>
<tr>
<th>Pg. No.</th>
<th>From:</th>
<th>To:</th>
<th>Sentences Per 100 Words</th>
<th>Syllables Per 100 Words</th>
</tr>
</thead>
<tbody>
<tr>
<td>241</td>
<td>How important are</td>
<td>evidence to give</td>
<td>6.4</td>
<td>136</td>
</tr>
<tr>
<td>289</td>
<td>What other source</td>
<td>step must be</td>
<td>6.8</td>
<td>148</td>
</tr>
<tr>
<td>699</td>
<td>The productivity of</td>
<td>greater the productivity</td>
<td>6.2</td>
<td>196</td>
</tr>
<tr>
<td></td>
<td></td>
<td>total 3)19.4</td>
<td></td>
<td>total 3)480</td>
</tr>
<tr>
<td></td>
<td></td>
<td>average 6.4+6.5</td>
<td></td>
<td>160</td>
</tr>
</tbody>
</table>

## III. Circulation in Zoology (100 word samples)

<table>
<thead>
<tr>
<th>Pg. No.</th>
<th>From:</th>
<th>To:</th>
<th>Sentences Per 100 Words</th>
<th>Syllables Per 100 Words</th>
</tr>
</thead>
<tbody>
<tr>
<td>406</td>
<td>Capillaries are</td>
<td>of the body</td>
<td>6</td>
<td>161</td>
</tr>
<tr>
<td>409</td>
<td>The blood always</td>
<td>the blood into</td>
<td>6.5</td>
<td>157</td>
</tr>
<tr>
<td>436</td>
<td>As cells become</td>
<td>individual cells alive</td>
<td>6</td>
<td>170</td>
</tr>
<tr>
<td></td>
<td></td>
<td>total 3)18.5</td>
<td></td>
<td>total 3)438</td>
</tr>
<tr>
<td></td>
<td></td>
<td>average 6.1+6.2</td>
<td></td>
<td>162+163</td>
</tr>
</tbody>
</table>
**WORKSHEET FOR FRY READABILITY FORMULA**

**BOOK TITLE** BIOLOGICAL SCIENCE - AN INQUIRY INTO LIFE

**DATE** 12/15/70

**IV. Conservation in Ecology (100 word samples)**

<table>
<thead>
<tr>
<th>Pg. No.</th>
<th>From:</th>
<th>To make sure</th>
<th>To:</th>
<th>Sentences</th>
<th>Syllables</th>
</tr>
</thead>
<tbody>
<tr>
<td>736</td>
<td></td>
<td></td>
<td>man by getting</td>
<td>3.9</td>
<td>143</td>
</tr>
<tr>
<td>746</td>
<td>Although much</td>
<td></td>
<td>has never been</td>
<td>3.9</td>
<td>157</td>
</tr>
<tr>
<td>755</td>
<td>From our present</td>
<td></td>
<td>changes, some of</td>
<td>4.8</td>
<td>148</td>
</tr>
</tbody>
</table>

**total** 3) 12.6 3)448

**average** 4.2 149

***. Composite Score (4 areas included)**

<table>
<thead>
<tr>
<th></th>
<th>I</th>
<th>II</th>
<th>III</th>
<th>IV</th>
<th>total*4</th>
<th>average *</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>5.2</td>
<td>6.5</td>
<td>6.2</td>
<td>4.2</td>
<td>22.1</td>
<td>5.5</td>
</tr>
</tbody>
</table>

|       | 156 | 160 | 163 | 149 | 628 | 157 |
# WORKSHEET FOR FRY READABILITY FORMULA

**BOOK TITLE**: BIOLOGICAL SCIENCE MOLECULES TO MAN

**DATE**: 12/17/70

## I. Mitosis in Heredity (100 word samples)

<table>
<thead>
<tr>
<th>Pg. No.</th>
<th>From:</th>
<th>To:</th>
<th>Sentences Per 100 Words</th>
<th>Syllables Per 100 Words</th>
</tr>
</thead>
<tbody>
<tr>
<td>254</td>
<td>In all organisms</td>
<td>Form in the</td>
<td>6.6</td>
<td>161</td>
</tr>
<tr>
<td>272</td>
<td>Almost the first</td>
<td>Of the cytoplasm</td>
<td>6.0</td>
<td>174</td>
</tr>
<tr>
<td>306</td>
<td>Through the process</td>
<td>a very much</td>
<td>7.4</td>
<td>172</td>
</tr>
<tr>
<td><strong>total</strong></td>
<td><strong>3)20.0</strong></td>
<td></td>
<td><strong>3)507</strong></td>
<td></td>
</tr>
<tr>
<td><strong>average</strong></td>
<td><strong>6.6±0.7</strong></td>
<td></td>
<td><strong>169</strong></td>
<td></td>
</tr>
</tbody>
</table>

## II. Photosynthesis in botany (100 word samples)

<table>
<thead>
<tr>
<th>Pg. No.</th>
<th>From:</th>
<th>To:</th>
<th>Sentences Per 100 Words</th>
<th>Syllables Per 100 Words</th>
</tr>
</thead>
<tbody>
<tr>
<td>176</td>
<td>Photosynthesis breaks</td>
<td>carbon dioxide was</td>
<td>6.1</td>
<td>161</td>
</tr>
<tr>
<td>291</td>
<td>Since a plant</td>
<td>At the tip</td>
<td>5.1</td>
<td>155</td>
</tr>
<tr>
<td>465</td>
<td>Sugar the simplest</td>
<td>the entire plant</td>
<td>7.0</td>
<td>153</td>
</tr>
<tr>
<td><strong>total</strong></td>
<td><strong>3)18.2</strong></td>
<td></td>
<td><strong>3)469</strong></td>
<td></td>
</tr>
<tr>
<td><strong>average</strong></td>
<td><strong>6.0±0.1</strong></td>
<td></td>
<td><strong>156</strong></td>
<td></td>
</tr>
</tbody>
</table>

## III. Circulation in Zoology (100 word samples)

<table>
<thead>
<tr>
<th>Pg. No.</th>
<th>From:</th>
<th>To:</th>
<th>Sentences Per 100 Words</th>
<th>Syllables Per 100 Words</th>
</tr>
</thead>
<tbody>
<tr>
<td>483</td>
<td>During the years</td>
<td>in the other</td>
<td>6.0</td>
<td>152</td>
</tr>
<tr>
<td>487</td>
<td>The whole circulatory</td>
<td>moving backward figure</td>
<td>6.1</td>
<td>155</td>
</tr>
<tr>
<td>491</td>
<td>Throughout the circulatory</td>
<td>zero. The heart</td>
<td>6.2</td>
<td>152</td>
</tr>
<tr>
<td><strong>total</strong></td>
<td><strong>3)18.3</strong></td>
<td></td>
<td><strong>3)459</strong></td>
<td></td>
</tr>
<tr>
<td><strong>average</strong></td>
<td><strong>6.1</strong></td>
<td></td>
<td><strong>153</strong></td>
<td></td>
</tr>
</tbody>
</table>
IV. Conservation in Ecology (100 word samples)

<table>
<thead>
<tr>
<th>Pg. No.</th>
<th>From:</th>
<th>To:</th>
<th>Sentences Per 100 Words</th>
<th>Syllables Per 100 Words</th>
</tr>
</thead>
<tbody>
<tr>
<td>736</td>
<td>Food chains and</td>
<td>this energy and</td>
<td>6.3</td>
<td>167</td>
</tr>
<tr>
<td>740</td>
<td>Biological surveys of</td>
<td>and communities money</td>
<td>7.0</td>
<td>174</td>
</tr>
<tr>
<td>743</td>
<td>During the years</td>
<td>management of other</td>
<td>4.9</td>
<td>170</td>
</tr>
<tr>
<td>total</td>
<td></td>
<td></td>
<td>3.18.2</td>
<td>3.511</td>
</tr>
<tr>
<td>average</td>
<td></td>
<td></td>
<td>6.0±=6.1</td>
<td>170</td>
</tr>
</tbody>
</table>

*. Composite Score (4 areas included)

<p>| | | |</p>
<table>
<thead>
<tr>
<th></th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>I</td>
<td>6.7</td>
<td>169</td>
</tr>
<tr>
<td>II</td>
<td>6.1</td>
<td>156</td>
</tr>
<tr>
<td>III</td>
<td>6.1</td>
<td>153</td>
</tr>
<tr>
<td>IV</td>
<td>6.1</td>
<td>170</td>
</tr>
<tr>
<td>total</td>
<td>25.0</td>
<td>4.648</td>
</tr>
<tr>
<td>average*</td>
<td>6.24=6.3</td>
<td>162</td>
</tr>
<tr>
<td>BOOK TITLE</td>
<td>BIOLOGY</td>
<td></td>
</tr>
<tr>
<td>------------</td>
<td>---------</td>
<td></td>
</tr>
<tr>
<td>DATE</td>
<td>12/18/70</td>
<td></td>
</tr>
</tbody>
</table>

### I. Mitosis in Heredity (100 word samples)

<table>
<thead>
<tr>
<th>Pg. No.</th>
<th>From:</th>
<th>To:</th>
<th>Sentences Per 100 Words</th>
<th>Syllables Per 100 Words</th>
</tr>
</thead>
<tbody>
<tr>
<td>38</td>
<td>general statement</td>
<td>nuclear material</td>
<td>6.3</td>
<td>164</td>
</tr>
<tr>
<td>155</td>
<td>If you have</td>
<td>the centromere, or</td>
<td>6.3</td>
<td>156</td>
</tr>
<tr>
<td>561</td>
<td>First there was</td>
<td>genetics became permanently</td>
<td>6.5</td>
<td>172</td>
</tr>
<tr>
<td></td>
<td></td>
<td>total</td>
<td>3)19.1</td>
<td>3)492</td>
</tr>
<tr>
<td></td>
<td></td>
<td>average</td>
<td>6.3+6.4</td>
<td>164</td>
</tr>
</tbody>
</table>

### II. Photosynthesis in botany (100 word samples)

<table>
<thead>
<tr>
<th>Pg. No.</th>
<th>From:</th>
<th>To:</th>
<th>Sentences Per 100 Words</th>
<th>Syllables Per 100 Words</th>
</tr>
</thead>
<tbody>
<tr>
<td>64</td>
<td>In what living</td>
<td>of the glucose</td>
<td>7.3</td>
<td>143</td>
</tr>
<tr>
<td>100</td>
<td>The energy-transforming machinery</td>
<td>The sum total</td>
<td>6.2</td>
<td>172</td>
</tr>
<tr>
<td>104</td>
<td>In the late</td>
<td>Of time, after</td>
<td>4.7</td>
<td>181</td>
</tr>
<tr>
<td></td>
<td></td>
<td>total</td>
<td>3)18.2</td>
<td>3)496</td>
</tr>
<tr>
<td></td>
<td></td>
<td>average</td>
<td>6.0+6.1</td>
<td>165</td>
</tr>
</tbody>
</table>

### III. Circulation in Zoology (100 word samples)

<table>
<thead>
<tr>
<th>Pg. No.</th>
<th>From:</th>
<th>To:</th>
<th>Sentences Per 100 Words</th>
<th>Syllables Per 100 Words</th>
</tr>
</thead>
<tbody>
<tr>
<td>392</td>
<td>Unless the blood</td>
<td>of two main</td>
<td>5.8</td>
<td>157</td>
</tr>
<tr>
<td>400</td>
<td>So far in</td>
<td>could not continuously</td>
<td>4.2</td>
<td>166</td>
</tr>
<tr>
<td>418</td>
<td>The lobster and</td>
<td>The gills are</td>
<td>7.2</td>
<td>163</td>
</tr>
<tr>
<td></td>
<td></td>
<td>total</td>
<td>3)17.2</td>
<td>3)486</td>
</tr>
<tr>
<td></td>
<td></td>
<td>average</td>
<td>5.7</td>
<td>162</td>
</tr>
</tbody>
</table>
### WORKSHEET FOR FRY READABILITY FORMULA

**Page 2**

- **BOOK TITLE**: BIOLOGY
- **DATE**: 12/18/70

#### IV. Conservation in Ecology (100 word samples)

<table>
<thead>
<tr>
<th>Pg. No.</th>
<th>From:</th>
<th>To:</th>
<th>Sentences Per 100 Words</th>
<th>Syllables Per 100 Words</th>
</tr>
</thead>
<tbody>
<tr>
<td>705</td>
<td>other short-term</td>
<td>the rusts. Again</td>
<td>5.0</td>
<td>152</td>
</tr>
<tr>
<td>708</td>
<td>In dealing with</td>
<td>pollution occurs as</td>
<td>7.4</td>
<td>173</td>
</tr>
<tr>
<td>715</td>
<td>Man is as</td>
<td>look at the</td>
<td>5.5</td>
<td>170</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>**total 3)**17.9</td>
<td><strong>3)495</strong></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td><strong>average 5.94=6.0</strong></td>
<td><strong>165</strong></td>
</tr>
</tbody>
</table>

#### * Composite Score (4 areas included)

<table>
<thead>
<tr>
<th></th>
<th>I</th>
<th></th>
<th>II</th>
<th></th>
<th>III</th>
<th></th>
<th>IV</th>
<th></th>
<th>total</th>
<th></th>
<th>average</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>6.4</td>
<td></td>
<td>6.1</td>
<td></td>
<td>5.7</td>
<td></td>
<td>6.0</td>
<td></td>
<td><strong>3)24.2</strong></td>
<td></td>
<td><strong>6.1</strong></td>
</tr>
<tr>
<td></td>
<td>164</td>
<td></td>
<td>165</td>
<td></td>
<td>162</td>
<td></td>
<td>165</td>
<td></td>
<td><strong>4)656</strong></td>
<td></td>
<td><strong>164</strong></td>
</tr>
</tbody>
</table>
## WORKSHEET FOR FRY READABILITY FORMULA

**BOOK TITLE**  FOUNDATIONS OF BIOLOGY

**DATE**  12/20/70

### I. Mitosis in Heredity (100 word samples)

<table>
<thead>
<tr>
<th>Pg. No.</th>
<th>From:</th>
<th>To:</th>
<th>Sentences Per 100 Words</th>
<th>Syllables Per 100 Words</th>
</tr>
</thead>
<tbody>
<tr>
<td>81</td>
<td>Although all individuals</td>
<td>of opposite mating</td>
<td>5.5</td>
<td>157</td>
</tr>
<tr>
<td>306</td>
<td>The second division</td>
<td>a sexually reproducing</td>
<td>5.4</td>
<td>163</td>
</tr>
<tr>
<td>308</td>
<td>twins are either</td>
<td>occur at the</td>
<td>5.5</td>
<td>155</td>
</tr>
</tbody>
</table>

**Total** 3)16.4  3)475

**Average** 5.4+=5.5  158

### II. Photosynthesis in botany (100 word samples)

<table>
<thead>
<tr>
<th>Pg. No.</th>
<th>From:</th>
<th>To:</th>
<th>Sentences Per 100 Words</th>
<th>Syllables Per 100 Words</th>
</tr>
</thead>
<tbody>
<tr>
<td>258</td>
<td>The oxygen we</td>
<td>serve as a</td>
<td>4.9</td>
<td>153</td>
</tr>
<tr>
<td>479</td>
<td>This equation</td>
<td>to be one</td>
<td>4.2</td>
<td>143</td>
</tr>
<tr>
<td>501</td>
<td>Photosynthesis is carried</td>
<td>This reduces the</td>
<td>5.1</td>
<td>174</td>
</tr>
</tbody>
</table>

**Total** 3)14.2  3)470

**Average** 4.7  1564=157

### III. Circulation in Zoology (100 word samples)

<table>
<thead>
<tr>
<th>Pg. No.</th>
<th>From:</th>
<th>To:</th>
<th>Sentences Per 100 Words</th>
<th>Syllables Per 100 Words</th>
</tr>
</thead>
<tbody>
<tr>
<td>613</td>
<td>The continuous flow</td>
<td>In many ways</td>
<td>6.2</td>
<td>146</td>
</tr>
<tr>
<td>615</td>
<td>Capillaries can be</td>
<td>the veins, Small</td>
<td>6.0</td>
<td>165</td>
</tr>
<tr>
<td>622</td>
<td>The parasympathetic supply</td>
<td>to blood loss</td>
<td>6.5</td>
<td>175</td>
</tr>
</tbody>
</table>

**Total** 3)18.7  3)486

**Average** 6.2  162
# WORKSHEET FOR FRY READABILITY FORMULA

**BOOK TITLE**  
FOUNDATIONS OF BIOLOGY

**DATE**  
12/20/70

## IV. Conservation in Ecology (100 word samples)

<table>
<thead>
<tr>
<th>Pg. No.</th>
<th>From:</th>
<th>To:</th>
<th>Sentences Per 100 Words</th>
<th>Syllables Per 100 Words</th>
</tr>
</thead>
<tbody>
<tr>
<td>108</td>
<td>During the first</td>
<td>they have persisted</td>
<td>5.8</td>
<td>169</td>
</tr>
<tr>
<td>110</td>
<td>For example many</td>
<td>about a situation</td>
<td>6.3</td>
<td>171</td>
</tr>
<tr>
<td>549</td>
<td>In the wild</td>
<td>volumes of soil</td>
<td>4.3</td>
<td>165</td>
</tr>
<tr>
<td></td>
<td></td>
<td>total</td>
<td>3)16.4</td>
<td>3)505</td>
</tr>
<tr>
<td></td>
<td></td>
<td>average</td>
<td>5.4+=5.5</td>
<td>168</td>
</tr>
</tbody>
</table>

## *Composite Score (4 areas included)*

<p>| I      | 5.5 | 158 |
| II     | 4.7 | 157 |
| III    | 6.2 | 162 |
| IV     | 5.5 | 168 |
| total  | 21.9| 645 |
| average| 5.4+=5.5| 161 |</p>
<table>
<thead>
<tr>
<th>Section</th>
<th>Title</th>
<th>Pages</th>
<th>Sentences Per 100 Words</th>
<th>Syllables Per 100 Words</th>
</tr>
</thead>
<tbody>
<tr>
<td>I. Mitosis in Heredity</td>
<td></td>
<td>394, 400, 685</td>
<td>5.1, 4.6, 5.9</td>
<td>172, 141, 171</td>
</tr>
<tr>
<td></td>
<td>From: Division of the</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>To: events, So much</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>From: Buried in the</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>To: Known about this</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>From: What tends to</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>To: that offspring resemble</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Total</td>
<td></td>
<td>3)15.6</td>
<td>3)484</td>
</tr>
<tr>
<td></td>
<td>Average</td>
<td></td>
<td>5.2</td>
<td>161</td>
</tr>
<tr>
<td>II. Photosynthesis in botany</td>
<td></td>
<td>20, 426, 474</td>
<td>5.9, 5.7, 6.5</td>
<td>146, 158, 179</td>
</tr>
<tr>
<td></td>
<td>From: The energy we</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>To: energy-a process</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>From: All living cells</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>To: a glass jar</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>From: All algae carry</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>To: this chapter has</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Total</td>
<td></td>
<td>3)18.1</td>
<td>3)483</td>
</tr>
<tr>
<td></td>
<td>Average</td>
<td></td>
<td>6.0</td>
<td>161</td>
</tr>
<tr>
<td>III. Circulation in Zoology</td>
<td></td>
<td>494, 500, 509</td>
<td>5.1, 4.9, 3.9</td>
<td>136, 168, 146</td>
</tr>
<tr>
<td></td>
<td>From: In a playful</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>To: from them. For</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>From: whole blood contains</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>To: Leaving hemoglobin (a</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>From: Blood pressure which</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>To: that surround the</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Total</td>
<td></td>
<td>3)13.9</td>
<td>3)450</td>
</tr>
<tr>
<td></td>
<td>Average</td>
<td></td>
<td>4.6</td>
<td>150</td>
</tr>
</tbody>
</table>
### WORKSHEET FOR FRY READABILITY FORMULA

**BOOK TITLE**  
HIGH SCHOOL BIOLOGY

**DATE**  
12/19/70

### IV. Conservation in Ecology (100 word samples)

<table>
<thead>
<tr>
<th>Pg. No.</th>
<th>From:</th>
<th>To:</th>
<th>Sentences Per 100 Words</th>
<th>Syllables Per 100 Words</th>
</tr>
</thead>
<tbody>
<tr>
<td>94</td>
<td>It is certainly</td>
<td>of an ecosystem</td>
<td>5.2</td>
<td>184</td>
</tr>
<tr>
<td>291</td>
<td>Man has wandered</td>
<td>and barley have</td>
<td>5.2</td>
<td>155</td>
</tr>
<tr>
<td>349</td>
<td>For a century</td>
<td>of the history</td>
<td>3.7</td>
<td>156</td>
</tr>
</tbody>
</table>

**total** 314.1  31495

**average** 4.7   165

### *Composite Score (4 areas included)*

<table>
<thead>
<tr>
<th>I</th>
<th>5.2</th>
<th>161</th>
</tr>
</thead>
<tbody>
<tr>
<td>II</td>
<td>6.0</td>
<td>161</td>
</tr>
<tr>
<td>III</td>
<td>4.6</td>
<td>150</td>
</tr>
<tr>
<td>IV</td>
<td>4.7</td>
<td>165</td>
</tr>
</tbody>
</table>

**total** 420.5  4637

**average** 5.1  159
### WORKSHEET FOR FRY READABILITY FORMULA

**BOOK TITLE** MODERN BIOLOGY

**DATE** 12/16/70

### I. Mitosis in Heredity (100 word samples)

<table>
<thead>
<tr>
<th>Pg. No.</th>
<th>From:</th>
<th>To: genes and chromosomes</th>
</tr>
</thead>
<tbody>
<tr>
<td>106</td>
<td>Following the inter-phase</td>
<td>5.0</td>
</tr>
<tr>
<td>108</td>
<td>Additional fibers develop</td>
<td>5.0</td>
</tr>
<tr>
<td>110</td>
<td>Did it ever</td>
<td>5.3</td>
</tr>
<tr>
<td></td>
<td>total</td>
<td>3)15.3</td>
</tr>
<tr>
<td></td>
<td>average</td>
<td>5.1</td>
</tr>
</tbody>
</table>

### II. Photosynthesis in botany (100 word samples)

<table>
<thead>
<tr>
<th>Pg. No.</th>
<th>From:</th>
<th>To: of a complex</th>
</tr>
</thead>
<tbody>
<tr>
<td>80</td>
<td>To explore the</td>
<td>4.8</td>
</tr>
<tr>
<td>90</td>
<td>were it not</td>
<td>7.9</td>
</tr>
<tr>
<td>317</td>
<td>Parenchyma tissue is</td>
<td>8.5</td>
</tr>
<tr>
<td></td>
<td>total</td>
<td>3)21.2</td>
</tr>
<tr>
<td></td>
<td>average</td>
<td>7.0≈7.1</td>
</tr>
</tbody>
</table>

### III. Circulation in Zoology (100 word samples)

<table>
<thead>
<tr>
<th>Pg. No.</th>
<th>From:</th>
<th>To: earthworm moves through</th>
</tr>
</thead>
<tbody>
<tr>
<td>411</td>
<td>As food is</td>
<td>4.5</td>
</tr>
<tr>
<td>491</td>
<td>The circulatory system</td>
<td>6.0</td>
</tr>
<tr>
<td>598</td>
<td>The tissue Fluid</td>
<td>5.7</td>
</tr>
<tr>
<td></td>
<td>total</td>
<td>3)16.2</td>
</tr>
<tr>
<td></td>
<td>average</td>
<td>5.4</td>
</tr>
</tbody>
</table>
**WORKSHEET FOR FRY READABILITY FORMULA**

**BOOK TITLE** MODERN BIOLOGY

**DATE** 12/16/70

**IV. Conservation in Ecology** (100 word samples)

<table>
<thead>
<tr>
<th>Pg. No.</th>
<th>From:</th>
<th>To:</th>
<th>Sentences Per 100 Words</th>
<th>Syllables Per 100 Words</th>
</tr>
</thead>
<tbody>
<tr>
<td>707</td>
<td>Think of the</td>
<td>remains of animals</td>
<td>6.0</td>
<td>151</td>
</tr>
<tr>
<td>714</td>
<td>As another means</td>
<td>irrigation, and has</td>
<td>5.6</td>
<td>166</td>
</tr>
<tr>
<td>725</td>
<td>Both state and</td>
<td>that cannot supply</td>
<td>6.5</td>
<td>160</td>
</tr>
</tbody>
</table>

**total** 3/18.1                  **total** 3/477

**average** 6.0                   **average** 6.0

**Composite Score** (4 areas included)

<table>
<thead>
<tr>
<th>Area</th>
<th>Sentences</th>
<th>Syllables</th>
</tr>
</thead>
<tbody>
<tr>
<td>I</td>
<td>5.1</td>
<td>160</td>
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**total** 4/23.6                  **total** 4/637

**average** 5.9                   **average** 5.9