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ABSTRACT

A series of four studies tested two methods of revising instructional text to improve students' learning from it. In one method, the revisions untangled the "cognitive knots" in the text; in the second method, the revisions highlighted the "point" of the text. Subjects for the various studies were 40 students in an intact high school biology class (study 1); 30 ninth-grade students in English and History and 29 college freshmen (study 2); 41 college students (study 3); and 12 students from the same population used in studies 1-3 and 5 professors from the University of Georgia (study 4). Both methods were tested by giving original, naturally occurring textbook excerpts to one group of students and the revised versions to a separate group, and then giving the same tests of learning to both groups. In all cases, the groups who read the revised version got significantly higher scores on the test than those who read the original version. Findings suggest that the revision techniques were effective in increasing learning. (Contains nine tables of data. Appendixes provide a pair of texts for the "cognitive knots" study, texts used in experiment 2, and instructions for experiment 3.) (Author/RS)

ED 396 258

Improving Instructional Text: Tests of Two Revision Methods

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The National Reading Research Center (NRRC) is funded by the Office of Educational Research and Improvement of the U.S. Department of Education to conduct research on reading and reading instruction. The NRRC is operated by a consortium of the University of Georgia and the University of Maryland College Park in collaboration with researchers at several institutions nationwide.

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Abstract. *This paper reports tests of two methods of revising instructional text to improve students' learning from it. In one method, the revisions untangled the "cognitive knots" in the text; in the second method, the revisions highlighted the "point" of the text. Both methods were tested by giving original, naturally occurring textbook excerpts to one group of students and the revised versions to a separate group, and then giving the same tests of learning to both groups. In all cases, the groups who read the revised version got significantly higher scores on the test than those who read the original version. Since this shows that more was learned from the revised version than from the original, it shows that the revision techniques were effective in increasing learning.*

The purpose of this project was to develop effective techniques for revising instructional text to improve students' learning from it. This was felt to be necessary because we are a long way from achieving our national educational goals; and while textbooks are virtually ubiquitous in schools and thus are potentially a major resource for effective learning, we believed that textbooks are not nearly as effective as they might be.

We believed this because of the results of our recent review of the literature on attempts to improve textbooks in order that students would learn more from them. The review showed that of the 56 studies in which researchers tried to improve the textbook excerpts from grade 1 to college level, 50 were successful (Britton, Gulgoz, & Glynn, 1993). This showed that textbooks could be improved.

In examining the previous successful attempts to improve textbook excerpts by revising them, we discerned a theme which suggested a quite general reason why students found it difficult to learn from some textbooks, and a correspondingly general set of solutions to the problem. The general theme was that textbooks were often difficult because they were too close to the author's mental structures, and not close enough to the mental structures that the students needed to understand them. It appeared that this often happened because authors of textbooks are experts in the subject matter of their textbooks, and consequently they have very well developed mental structures about their special subject matter. Having a very well developed mental structure about a subject matter can cause problems in writing a text about that subject matter for several reasons.

First, experts' mental structures for their own special subject matter tend to be very large, too large to communicate fully on any one occasion. They also tend to have many levels, with the more general ideas subsuming more specific ones, and those subsuming yet more specific ones, with the whole structure very highly interconnected. When experts think about their subject, they can jump from one idea to another without having to go painfully through the intermediate steps required of a novice. Since experts think about their subject in this way, they tend to talk and write about it in this way too, and this is the source for the novices' common failure to understand the talk of experts as well as failure to understand their writings.

A second important property of experts is that, because their subject matter is obvious to them, there is a natural tendency for them to assume it is obvious to others as well. The result of this is that experts often present ideas which are obvious to them without making them obvious to the novice. The kind of ideas which cause particular difficulty in this regard are those which involve more than one idea. This is especially so when the different ideas are in complex interrelationships with each other, and particularly when the relationships among the ideas are intrinsically difficult. Some examples of intrinsically difficult ideas are negative feedback relationships, several causes interacting to produce several effects, several effects from one cause, and so forth. We call such complexly intertwined ideas "cognitive knots." When cognitive knots are presented to the novice without carefully untangling all the complexities which are obvious from long experience to the expert, the novice is likely to fail to understand them. One of our revision techniques is based on the untangling of cognitive knots.

A third thing that experts tend to do is to fail to make clear what is the "point," or main idea, of what they are trying to communicate to the novice. This occurs because the point is so obvious to the expert that it seems superfluous to say what it is. One of our revision techniques is based on identifying and then marking the point of textbook excerpts so that novices will be more likely to get the point.

Table 1. Percent Correct on the Biology Tests

Topic	Original	Revised
Mitosis	27	39
Evolution	37	43
Photosynthesis	32	37
Female Reproductive Cycle	41	41
Cell Respiration	36	35

Experiment 1: Untangling Cognitive Knots in Text

In this study, we took the five most important and difficult ideas in high school biology, as rated by teachers, and wrote a text which was intended to untangle the cognitive knots that involved those ideas. The best way to see what we did is to compare our texts with the corresponding textbook excerpts. They are included in Appendix A. We untangled the cognitive knots in several ways. We used both the text and the graphics, and also coordinated the text with the graphics. The process of constructing these texts was extremely lengthy and complex and does not lend itself to summarization. We had to begin by developing a deep understanding of the topic of the text, and then analyze the topic into its separate strands. This was followed by writing a text which laid out each of the strands individually and then recombined them to try to produce the original deep understanding in the reader.

Method

Subjects. Forty high school biology students at a local public high school were tested. They were the members of an intact biology class.

Procedure. At the point in time when the topic of a pair of texts would normally be presented in class, the teacher began by giving each student one or the other version of the text (determined randomly) on that topic for self-paced reading, followed by a test that the teacher had made up to be fair to both versions.

Texts. Five pairs of texts were used, one each on *Mitosis*, *Cell Respiration*, *Photosynthesis*, *Evolution*, and the *Female Reproductive Cycle*. The revised versions of the texts were written first, and then self-contained textbook excerpts on the same topics were selected to match approximately the overall length of the set of revised texts. The set of revised texts was 42 pages long; the set of original texts was 46 pages long. One of the pairs of text is shown as Appendix A. The reader should be cautious about drawing overbroad conclusions about the differences between the original and rewritten texts from this one example. All the texts are available upon request.

Results

The group that read the *original* version got 35% correct on the test, while the group that read the *revised* version got 39% correct on the test. This was a significant difference, $F(1,409) = 6.64, p < .05$. The significance of this difference supports the reliability and validity of the test. There was a significant effect of topic, $F(4,409) = 3.36, p < .05$, but there was no interaction of version with topic, $F(4,409) = 1.78, p > .10$.

The means are shown in Table 1. This indicates that the differences for some of the texts were much greater than for others; one pair of texts tied; and for one text, there was a small reversal.

These results show that the revisions were learned better than the excerpts from real textbooks. However, the modest size of the differences for some and the mean reversal for one of the texts indicate that the method may have been differentially effective for the different texts. One reason for this may be that students at this level often fail to understand the topics of cell respiration and the female reproductive cycle, according to our biology teacher/coauthor (m.s.).

Experiment 2: Marking the Point of a Text

Colomb and Williams (1987) have proposed that writing a good text depends on making clear what the point is of the text. In his research on the writing process, Colomb has developed a method for the writer to use in identifying the point of his or her text. The method involves selecting the sentence(s) which the writer would choose to keep as the only message to be transmitted if the rest of the text had to be eliminated. Sometimes this is described as selecting the telegram that the writer would send if all that could be sent is a one-sentence telegram.

For this experiment, Colomb chose some expository texts and selected the point sentences of them. Then we presented each text either with the point underlined or not, instructing the subjects who had the point underlined that it was the point of the text. We expected that those subjects would be likely to get the point, while the other subjects would be less likely to get the point. We expected that those who got the point would understand the text more completely and so remember it better. Then we measured their free recall of the texts in the two conditions. Because we wanted our conclusions to apply across the range of high school students, we tested students at either end of that range, including ninth graders and freshmen at a local public university; intending to infer that if the effects were present in such a group, they would also be present by interpolation in the grade levels between the two extremes.

Method

Subjects. Thirty 9th-grade students in English and History at a local public high school were tested, along with 29 college freshmen.

Procedure. Students were given a booklet that included all three texts, followed by three sets of free-recall sheets. They were asked to read all three texts, and then to "write down

Table 2. Mean Number of All the Content Units Free Recalled in Experiment 2

Group	Point Condition	Control Condition
Ninth-Grade Students	26	22
College Students	42	31

Table 3. Mean Number of Point Units Free Recalled in Experiment 2

Group	Point Condition	Control Condition
Ninth-Grade Students	3.13	2.33
College Students	3.73	2.50

everything you can remember" from them. Such a free-recall test calls on both text comprehension and writing fluency.

Texts. The subjects in the Point condition had the point underlined, and the meaning of the underlining was specified at the top of their sheet. The texts with instructions are included as Appendix B.

Scoring. The texts had been analyzed into content units in advance, and each free-recall protocol was scored against the template of content units. A subset of the protocols was independently scored by another investigator blind to group membership, and the correlation between the two sets of scores was .80.

Results

Table 2 shows the results for mean free recall of all the content units. Overall, the subjects in the point condition got an average of 34 units correct, while those in the control condition got 27 correct. This led to a significant effect of condition, $F(1,55) = 9.79$, $p < .05$. The interaction between condition and level in school was not significant, but there was a significant effect of level in school, $F(1,55) = 25.009$, $p < .05$.

We also analyzed separately the free recall of the content units that had been identified as points, and the content units that had not been identified as points. One part of our rationale for these analyses was that anyone would expect that any material that was underlined and identified in the instructions as the point of a text would be likely to be recalled because the reader would attend to it more. So we expected that the content units identified as points would be recalled more when they had been underlined than when they had not. As Table 3 shows, the content units corresponding to the points were recalled more when they were underlined than when they were not, leading to a significant effect of condition,

Table 4. Mean Number of Non-Point Units Free Recalled in Experiment 2

Group	Point Condition	Control Condition
Ninth-Grade Students	23	20
College Students	39	29

$F(1,55) = 9.58$, $p < .05$. There were no significant effects of level in school, nor an interaction between level in school and condition.

The other part of our rationale for these analyses was more critical to this study. Our hypothesis was that those subjects who got the point of the text would understand the text more completely and so remember it better. Such increased understanding should be reflected in better memory for content units in addition to the units in the point itself. We therefore calculated how many content units each subject recalled, excluding those content units that were included in the underlined material (i.e., the points).

The results are shown in Table 4. They show that students at both grade levels recalled more non-point units when the point was emphasized than when it was not. There were significant effects of condition, $F(1,55) = 8.07$, $p < .05$, and level in school, $F(1,55) = 26.71$, $p < .05$, and no interaction.

Experiment 3: Replication of Point Study with Modified Instructions

A reviewer of an earlier version of this paper pointed out that the written instructions for Experiment 2 had told students to read the point sentence first, and then read the whole text again, presumably including the point sentence. Any such rereading of the point sentence might have been responsible for the results. We therefore changed the instructions, and arranged the subjects' booklets so the instructions appeared on the page previous to the text and thus did not permit the subject to read the point sentence in advance of the rest of the passage, unless they chose to do so. An additional advantage of placing the instructions on a separate page from the text was that it permitted the measurement of reading times for the text unconfounded by the time the subjects took to read the instructions.

In addition, we added a condition in which a randomly chosen sentence was underlined, and said to be the point in the instructions. This would deal with the hypothesis that the effects observed in Experiment 2 were due to no more than the presence of an underlined sentence in the text.

Method

Subjects. Forty-one college students were assigned randomly to conditions, with 13 in the Point Condition, 13 in the Control Condition, and 12 in the Random Condition, in which a randomly chosen sentence was underlined.

Table 5. Mean Number of All Content Units Free Recalled in Experiment 3

Point Condition	Control Condition	Random Condition
37	26	26

Table 6. Mean Number of Point Units Free Recalled in Experiment 3

Point Condition	Control Condition	Random Condition
3.0	1.9	1.2

Table 7. Mean Number of Non-Point Units Free Recalled in Experiment 3

Point Condition	Control Condition	Random Condition
32.86	23.79	24.85

Procedure. The procedure was the same as in Experiment 2.

Texts. The Point and Control conditions were the same as in Experiment 2, except that the instructions appeared only on a separate sheet preceding each text. The instructions are included as Appendix C. In the Random Condition, a different sentence was chosen randomly for each subject, with the restrictions that it was not the same sentence for any two subjects and that it was not the point sentence.

Scoring. The scoring was the same as in Experiment 2.

Results

Table 5 shows the mean free recall of all the content units. There was a significant effect of Condition, $F(2,38) = 3.80$, $p < .05$, $eta^2 = .17$. Comparison between pairs of conditions showed that recall in the Point Condition significantly exceeded that in the Control Condition, $t(26) = 2.30$, and in the Random Condition, $t(26) = 2.31$, but the Control Condition did not differ from the Random Condition.

Table 6 shows the mean free recall of the point units. There was a significant effect of condition, $F(2,38) = 6.51$, $p = .004$, $eta^2 = .26$. Comparisons between pairs of conditions showed that recall in each condition differed from recall in each other condition, all ts > 2.03. Also, recall of the point differed from zero in all conditions, all ts > 5.20.

Table 7 shows the recall of non-point units. There was a significant effect of condition,

Table 8. Reading and Recall Times in Minutes in Experiment 3

	Point Condition	Control Condition	Random Condition
Reading Time	7.77	9.05	6.80
Recall Time	17.31	15.03	15.10

Table 9. Percent of the Points Identified by Students and Experts

Students	**Experts**
49.5%	86.4%

$F(2,38) = 3.074$, $p = .058$, and recall in the Point Condition differed from that in the other conditions, $ts > 1.79$.

Table 8 shows the reading and recall times for all conditions. Neither the reading times nor the recall times differed significantly.

Experiment 4: Can Students and Experts Identify Points?

Can students identify the point sentences of texts? If so, this might account for some of the recall observed in Experiments 1–3. In Experiment 4, we asked students to read each text and underline the single sentence they thought was the point, in the sense that it should be the sentence sent by telegram if only one sentence could be sent. For comparison, we asked experts who were professors from the Departments of English, Comparative Literature, and Romance Languages to do the same task.

Method

Subjects. Twelve students from the same population as used in Experiments 1–3 and 5 professors from the Departments of English, Comparative Literature, and Romance Languages at the University of Georgia were tested.

Procedure. Subjects were asked to underline the sentence in each text that they thought should be sent by telegram to communicate the ideas of the text, if only one sentence could be sent.

Results

Table 9 shows the results. There was a significant difference between the groups: $t(15) = 3.94$, $p < .001$, $\text{eta}^2 = .51$. Both groups differed from zero, both $ts > 8.60$. These results indicate that expertise plays a role in the identification of points, but that even some students can identify points.

Conclusions

Both revision techniques have been shown to have significant effectiveness. Since both techniques were based on our diagnosis that the reason why textbooks are often difficult is because they are too close to the authors' mental structures, and not close enough to the novices', that diagnosis receives some indirect support. Since another such technique based on the same diagnosis was described and tested successfully by Britton and Gulgoz (1991), there are three sources of support for our diagnosis.

Of the two techniques tested in this report, the second is much easier to apply. But even after it has been applied, there is room for further improvement in comprehension as measured by free recall. It may be that the techniques described in the first experiment, as well as that described by Britton and Gulgoz (1991), could profitably be applied in addition to the point-marking technique described in Experiments 2, 3, and 4. In addition, it may be possible to train students to look for the point of a text segment, and this may achieve some or all of the advantages provided by externally provided marking of the point.

In comparing the present studies with others directed at improving the learnability of instructional text, we attach considerable significance to one methodological feature of our studies, namely the use of naturally occurring textbook excerpts as the control conditions. This seems to us to be superior to the commonly used procedure of using artificially constructed texts as the control condition, because it is likely to increase the ecological validity of the conclusions.

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Appendix A

One pair of texts for the "Cognitive Knots" study

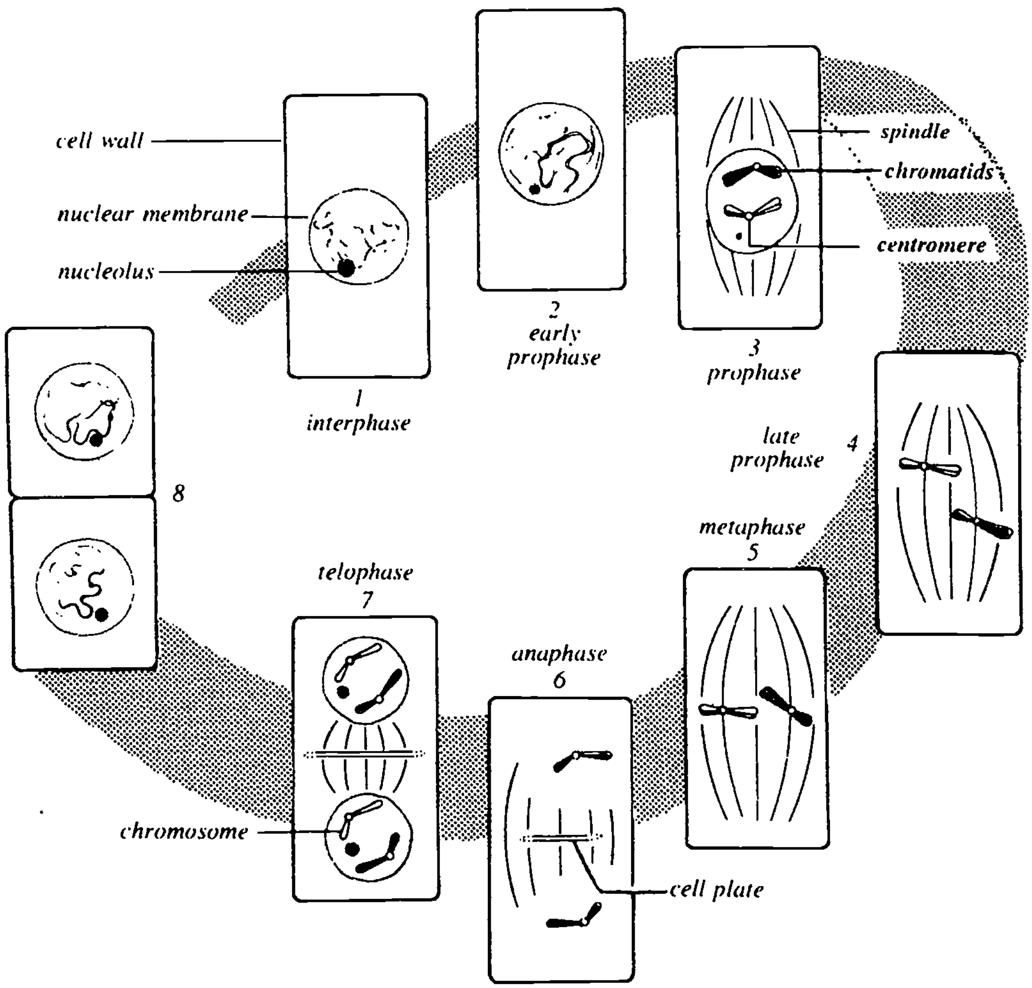


Figure 1 This diagram outlines mitosis and cell division in a generalized plant cell. For simplicity, only one pair of chromosomes is shown, although such a cell would contain many pairs. The process is divided into several stages according to microscopic examination of fixed (dead) plant cell specimens. In a living cell the process is continuous; there are no stops or stages.

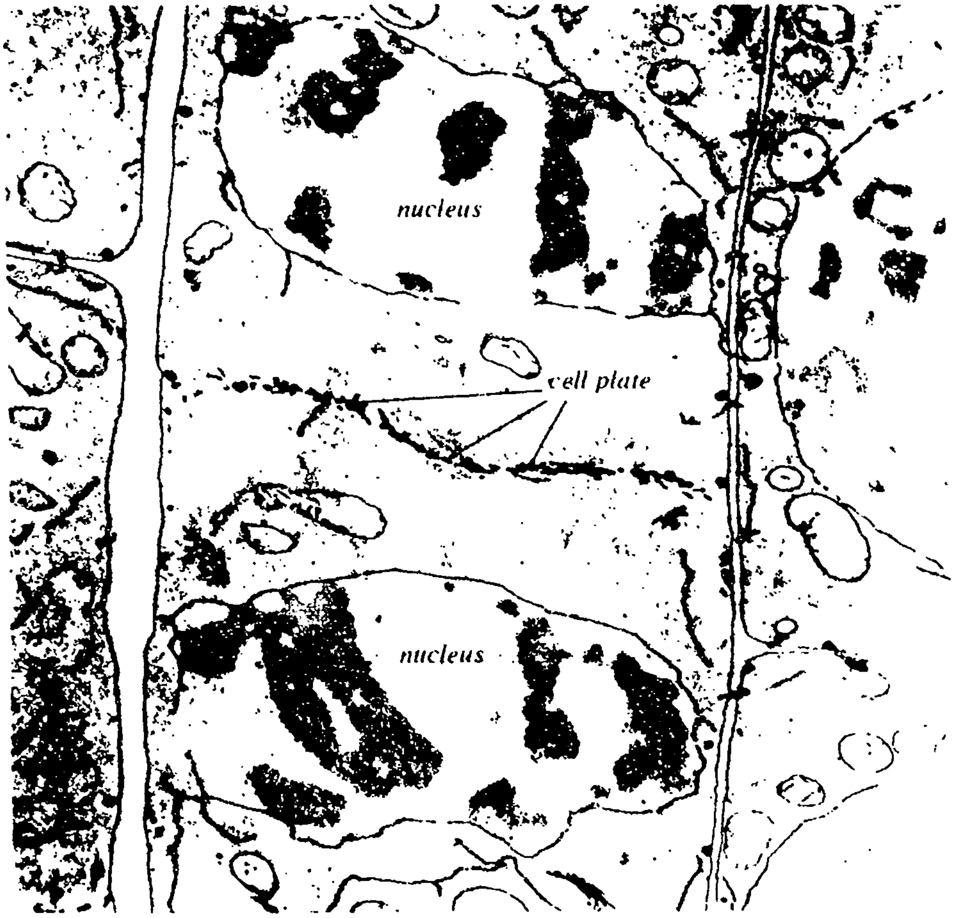


Figure 2 As a plant cell divides, a new cell plate (middle of photograph) begins to form between the two new nuclei (top and bottom). By contrast, in animals (Figure 4), a dividing cell usually pinches partly in two before new plasma membrane forms. This photograph, taken through an electron microscope, shows stage 7 of Figure 1 . (×12,000)

Mitosis and Cell Division Follow a Pattern in Plants

The formation of two cell nuclei from one, each with a complete set of chromosomes as in the parent nucleus, is called **mitosis** (my-TOH-sis). Mitosis begins with the replication of the chromosomes represented by stage 1 in Figure 1 .

Mitosis ends with the formation of two new nuclei represented by stage 7.

Does the cell divide while mitosis is taking place? The answer for plant cells is usually no. The cell begins to divide when mitosis is ending, as evidenced by the formation of a cell plate during stage 7. Figure 2 shows a photograph of cell division under way with the formation of the cell plate.

Because mitosis and cell division usually occur together in a continuous series of events, they are often referred to as a single process, mitotic cell division. The names of the phases in Figure 1, beginning with **interphase,** correspond to particular events as they occur in sequence. Cells are often fixed and stained for study of these events (Figure 3).

During interphase the chromosomes are replicated. Strung out in their chromatin network they are very difficult to see. However, during **prophase** the replicated chromosomes condense. Shortened and thickened, they become easy to see under the compound microscope when stained. Each chromosome is a doubled (replicated) structure joined at the **centromere** (SEN-troh-meer—Figure 1). The two replicas of a chromosome are called **chromatids** (KROH-muh-tids) until they later separate. During prophase, however, they remain together.

Also during prophase a fibrous spindle forms in the cell. The chromosomes become attached by the centromeres to the fibers of the spindle.

During the next stage of mitosis, **metaphase,** the chromosomes become arranged on the spindle across the center of the cell, approximately where a cell plate will later form. At this stage it is sometimes possible to count the chromosomes. As **anaphase** begins, the centromeres divide, and the two chromatids separate into individual chromosomes on the spindle fibers. Notice in stage 6 of Figure 1 that a set of replicated chromosomes is moving toward either end of the cell.

During **telophase,** a nucleolus appears near each set of chromosomes (the darkened spots in stage 7, Figure 1). New nuclear membranes form as mitosis is completed. A cell plate begins to form across the middle of the cell, signaling the start of cell division.

By stage 8, cell division has been completed. Each new cell is only about half the size of the parent cell but will begin to grow. As growth occurs, new material will be made that extends the cell walls around the cells. Added cell wall materials will also thicken the walls as the new cells mature.

Mitosis and Cell Division Are Similar in Plants and Animals

Only a few differences occur in mitosis and cell division in animals as compared to plants. The processes are so similar that you can easily follow the events in animal cells once you are familiar with them in plant cells. Figure 4 illustrates the differences:

1. Animal cells contain a pair of **centrioles.** As mitosis begins, the centrioles are duplicated. One pair gradually moves toward the opposite side of the nucleus from the other pair. The spindle fibers begin to form between these two poles as the nuclear membrane breaks down.
2. No cell plate forms. Instead the cell constricts, or pinches, across the middle as cell division begins. A new plasma membrane forms across the constricted portion of the cell.

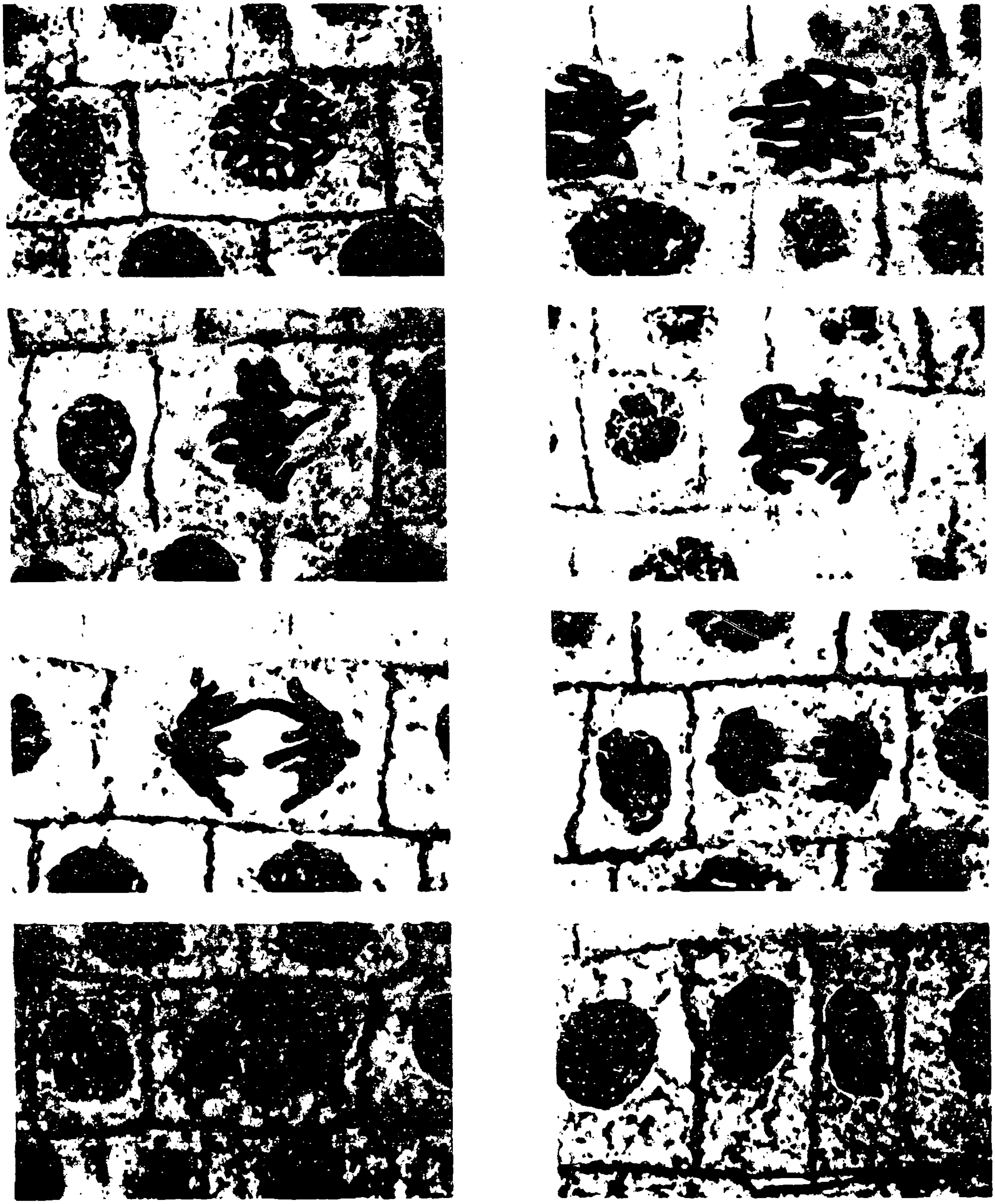


Figure 3 Dividing cells in onion root tip. The stages of mitosis seen here are (left to right, top to bottom) early prophase, prophase, metaphase, anaphase, anaphase, telophase, and telophase. Two newly divided cells are seen in the last view.

3. Cell division is usually evident earlier during mitosis in animal cells (anaphase) than in plant cells (telophase). The cells in Figure 4 are shown in anaphase. A constriction is already evident across the cells. Cell division may even be completed before new nuclear membranes are completed around each nucleus.

In some animal cells, the new plasma membrane that forms deepens the pinching effect until the cell appears to pinch in two. In others the new plasma membrane forms across the neck of the constriction before the pinching effect becomes complete. In both cases the new plasma membrane is forming between the dividing cells.

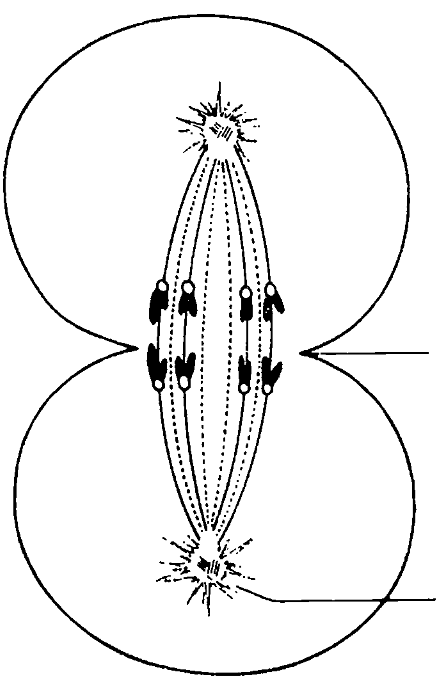


Figure 4 Two distinctive characteristics of mitosis and cell division in an animal cell are the presence of centrioles and the absence of a cell plate. A third characteristic is also evident in the drawing and photograph shown here. An indication that the cell is about to divide usually occurs in anaphase, one stage earlier in the mitosis of animal cells than in most plant cells. Here the cells in both the drawing and the photograph show constrictions.

How Cells Produce More Cells: Mitosis and Cell Division

In the life of every cell there comes a time when it is ready to reproduce itself. In this section of the text, you will read a step-by-step description of the sequence of events that occurs during reproduction of a cell. First, a brief description of the overall process will be presented. Then a detailed description, with all of the technical terms, will be given. You should closely examine the diagrams and photographs, because they will help you visualize the sequence of events that occurs during cell reproduction. When you have read all of this section, you should be able to run visual images of the sequence of events through your mind *and* describe the process in words by using the proper technical terms.

Brief Description of Mitosis

"Re-production" means to "produce again, to make a copy." This is exactly what the ***parent cell*** must do when it reproduces: make a copy of itself. The copy, to be accurate, must contain all the important parts that the parent cell contained. The most important parts for reproduction are the ***chromosomes***. ("Chromo" means dark-colored, and "somes" comes from "soma," which means "body" in Greek, so "chromosome" means "dark-colored body.") Figures 2 - 5 show what chromosomes look like in the cell during reproduction. The

chromosomes - thread-like structures in the nucleus that contain the genes

chromosomes are very important because they carry the information for all the genetic characteristics of the cell. The sequence of events in reproduction is as follows:

- First, the parent cell must make one copy of all of the chromosomes it contains, so that it has two of each (the original plus the copy).
- Second, the parent cell must move one copy to one side of the cell, and the other copy to the opposite side.
- Finally, the parent cell must split in two, with each half containing a copy of all of the chromosomes.

The end result of reproduction is two identical cells where there was one before, with each cell containing an identical set of chromosomes.

Formal Description of the Five Phases of Mitosis: Interphase, Prophase, Metaphase, Anaphase, Telophase

The name of the process of cell reproduction is ***mitosis***. The word "mitosis' comes from a Greek word meaning "threads," from the tiny threadlike structures that appear in the cells during mitosis.

mitosis - process of division of the duplicated chromosomes which precedes cell division

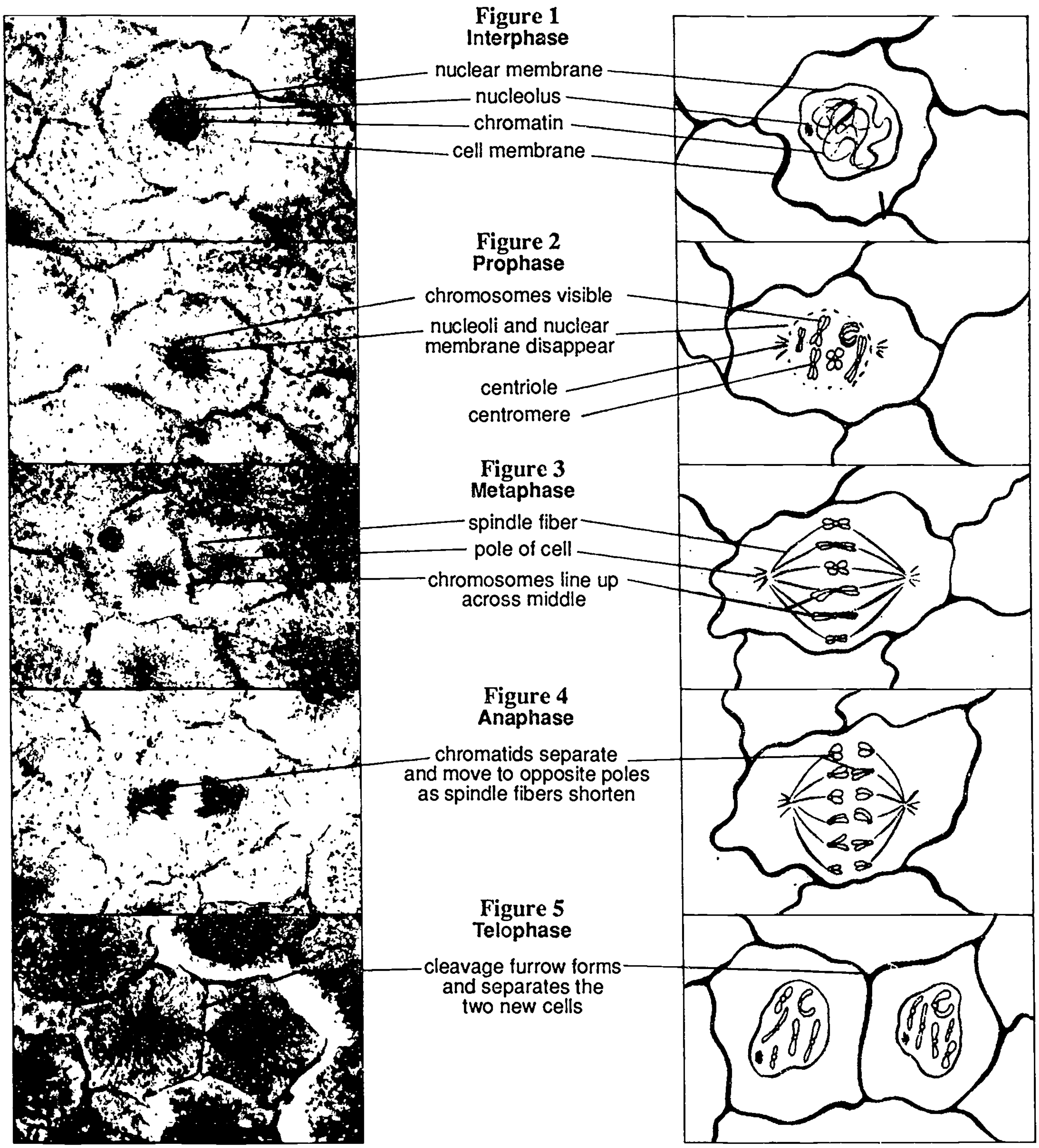
The process of mitosis has five stages, also named in Greek-derived words. To make clear what the words mean, the English translations of the Greek terms will be included in parenthesis. The English words will help you learn the technical terms.

Interphase (Between-Phase)

The between-phase, or ***interphase***, is the stage in which the cell remains for most of its life, except when it is actually reproducing. The word "inter" means "between," so you can see where the name of this stage comes from: it is the stage between reproductions. Figure 1 shows a photograph of a cell in interphase (between-phase) on the left, and a drawing of the same cell on the right. Some of the key parts of the cell that will be involved in reproduction are labeled. *Look at Figure 1 now.*

The most important thing that happens during the interphase (between-phase) is that the cell makes a copy of its chromosomes. So later, when the cell

THE PHASES OF MITOSIS



— (left) *Photos of each phase of mitosis (450X).* (right) *Diagrams showing same phases.*

is ready to reproduce, it already contains (along with the original chromosomes) the copy that it will need. The individual chromosomes cannot be seen during interphase (between-phase). You can think of them at this stage as being like rubber bands stretched out so tight that they are too thin to be seen.

Prophase (First-phase)

In the first-phase, or ***prophase***, visible changes first begin to occur, as shown in Figure 2. Notice these changes in the diagram:

1. The chromosomes become visible in the nucleus when you look at the cell under a light microscope. Think of the chromosome "rubber bands" as twisting more and more and becoming shorter and thicker until they become visible. They look like long double strands. Each strand is one of the copies. Each copy is called a ***chromatid***. Each pair of chromatids is connected by a ***centromere***, which looks like a dot in the center of the doubled strand in Figure 2.

chromatid - half of a copied chromosome

centromere - point of attachment of two chromatids

2. The membrane around the ***nucleus*** disappears, along with the ***nucleolus***. The chromatids later will be able to move away to opposite sides of the cell without the nuclear membrane getting in the way.

nucleus - control center of the cell containing the chromosomes

nucleolus - small, spherical body within the nucleus

3. Finally, at opposite sides of the cell you can see ***spindle fibers*** begin to form and radiate outward from the ***centrioles***. The spindle fibers will make an oval structure called a ***spindle***. You can think of this spindle as a set of guide wires, ready to guide the movement of the two copies --the chromatids-- towards the opposite ends of the cell.

spindle fiber - protein fibers that attach to the chromatids and move them to ends of the cell

centriole - small body outside the nucleus of animal cells from which spindle fibers radiate

Metaphase (Middle-phase)

In the middle-phase, or ***metaphase***, shown in Figure 3, the chromatid pairs line up across the middle of the cell. (To remember that metaphase is the middle phase, it may help you to notice that the first letter of "metaphase" is the same as the first letter of "middle.") One spindle fiber attaches to the centromere of each pair of chromatids to guide it. The chromatids are now ready to separate and begin to move to opposite ends of the cell.

Anaphase (Moving-away-phase)

The moving-away-phase, or ***anaphase***, begins when the chromatids separate, as shown in Figure 4. From now on they will be called chromosomes again. The chromosomes move away from the middle toward the opposite sides of the cell. (To remember that anaphase is the moving-away phase, it may help you to notice that the first letter of "anaphase" is the same as the first letter of "away.") The spindle fibers appear to pull the chromosomes along by their centromeres. When they reach opposite sides, anaphase (moving-away- phase) is over.

Telophase (End-Phase)

During the end-phase, or ***telophase***, the chromosomes arrive at opposite sides of the cell. (See

Figure 5.) These final changes put things back the way they were before the process of mitosis began:

1. The spindle slowly disappears.
2. The nuclear membrane re-forms around the chromosomes.
3. The nucleolus reappears in each cell.
4. The cell pinches across the middle, forming a *cleavage furrow*. (Plant cells separate in a slightly different way. A ***cell plate*** forms in the middle of the plant cell and grows towards the sides, dividing the cell in two.)

cleavage furrow - groove formed in animal cell membrane which divides cell in two

cell plate - wall which forms in plant cell that divides cell in two

Cell Division

When the cleavage furrow (in animal cells) or the cell plate (in plant cells) is complete, two cells exist where there was originally only one. Reproduction has successfully been completed. (See Figure 6.) Each of the two new cells has a copy of the same chromosomes that the original cell had.

Comparison of Mitosis in Plant and Animal Cells

Mitosis and cell division are nearly the same in plant cells as they are in animal cells. There are, however, three major differences:

1. Animal cells have centrioles. One centriole can be seen as a dot at each of the spindles. Plant cells do not have centrioles, but they do form spindles.
2. When cell division begins, animal cells divide by pinching across the middle, forming a cleavage furrow. Plant cells divide by forming a cell plate which separates the original cell into two offspring cells. Figure 6 shows these differences.
3. Cell division usually begins earlier in animal cells than in plant cells. The cleavage furrow may begin to divide an animal cell while it is still in anaphase. Plant cells do not begin forming a cell plate until telophase.

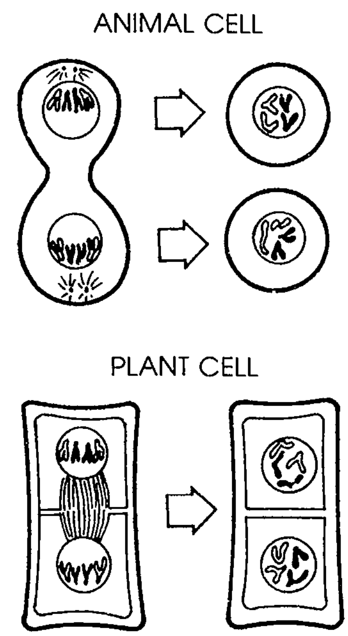


Figure 6 Comparison of Mitosis and cell Divison in Plant and Animal Cells

Do You Understand Mitosis and Cell Division?

At this point, you should be able to create a "mental movie" of the whole process of mitosis and cell division. When you can picture the events in mitosis with your eyes closed, you probably understand the process. The whole process takes from 20 minutes to 3 hours, depending on the type of cell, so you will need to "fast-forward" your movie as you watch it. You should be able to visualize what is happening in the cell at each stage and be able to name the stages in order.

Appendix B

Texts used in Experiment 2

Please begin by reading the sentence expressing the point of the text, which is shown underlined. When you have read the sentence expressing the point, please write your initials on the following line. ______
Then read the rest of the instructions.

Please read the whole text below until you understand it completely. Then turn over the page.

Then please write down *everything you can remember* from the text. Write in complete sentences. You can use your own words or the words from the text, or any combination of your own words and the words from the text.

Please write down both main ideas and details, or any combination of main ideas and details. Write as much as you can.

When you have finished, please go on to the next text.

Visit an expensive restaurant, an exclusive club, or even a suburban dinner party and you can observe the elaborate social rituals of table manners. You'll find special forks for salads, cocktail forks for appetizers, yet other forks for desert, not to mention all the specialized knives, spoons, glassware, and china. And you'll find just as many specialized "rules" for how to behave when using them. We tend to think of the rituals of table manners as signs of civilization, and to think that refined table manners distinguish the finer sort of people. *But those who practice "good" manners have always thought that their manners made them special, even when their manners would look unpleasant to us.*

In the middle ages, European nobility boasted of their fine table manners and talked about how manners set the nobles apart from crude peasants; but by our modern standards, these manners were not exactly refined. While dining, feudal lords drank from a finely crafted goblet: a single goblet that they passed around throughout the meal. They ate with unwashed hands, which they used to scoop food from a common bowl shared by as many as six diners. They would carefully extend a finger, keeping it free of grease for dipping into bowls of spices and condiments. (That may be where we get the hyper-polite custom of extending the little finger while holding a spoon or teacup.) If there were bones, diners would toss them back into the common bowl once they had gnawed off all of the meat. If they had soup, they would drink it from a common bowl. If the meat was served with a sauce, diners would sip it from the serving bowl. Everyone wolfed down their food, and used the tablecloth to wipe their mouths and blow their noses; but lords and nobles would never think of spitting on the table as a peasant would—they preferred to spit on the floor.

About the beginning of the sixteenth century, there was a reform movement to improve table manners. The philosopher Erasmus published a tremendously successful book that advocated some very advanced ideas about the polite way to eat. He believed, for example, that an upper class diner was distinguished by putting only three fingers of one hand into the bowl, instead of the entire hand in the manner of the lower class. Wait a few minutes after being seated before you dip into it, he advised. Finish chewing what is in you mouth before reaching for another piece. Do not poke around the dish for a good piece, but take the first one you touch. Erasmus' idea of good table manners may have been an advance, but it was far from ours. You have to wonder if our table manners might one day seem just as crude.

Please begin by reading the sentence expressing the point of the text, which is shown underlined. When you have read the sentence expressing the point, please write your initials on the following line. ______ Then read the rest of the instructions.

Please read the whole text until you understand it completely. Then turn over the page.

Then please write down *everything you can remember* from the text. Write in complete sentences. You can use your own words or the words from the text, or any combination of your own words and the words from the text.

Please write down both main ideas and details, or any combination of main ideas and details. Write as much as you can.

When you have finished, please go on to the next text.

Most people think of themselves as independent souls who are not easily bossed around. And it is easy to find situations that seem to confirm that view. If you walk up to someone sitting in a bank and ask them to remove their shoes, they are almost certain to refuse. Demand that someone in a barber shop show you their driver's license, and they are unlikely to comply. If you pull out a razor in front of someone in a shoe store and ask them to lift their chin and expose their neck, chances are their response will be rude or even violent.

This apparent independence is not, however, absolute. People are quick to refuse unexpected requests from someone who has no right to make the request. Change the context so that the request makes sense and comes from someone in authority, and people become quite obedient. People sitting in a shoe store do not hesitate to remove their shoes when strangers ask them to. In a bank, a demand to see a drivers' license is readily obeyed. Barbers easily get people to expose their bare necks to razor blades. In the right context—when faced with someone who seems to be an authority—humans are remarkably obedient creatures.

Just how obedient people can be in the right context was shown in a series of experiments conducted at Yale University. Those participating in the experiments were told to press a switch that would administer an electric shock to another person whenever that person answered a question incorrectly. The switch was not connected to anything, and so could not really administer a shock, and the person answering the question was an actor playing along with the experiment. Nevertheless, the participants thought they really were administering a shock. Even though the participants thought they were hurting the person answering the questions and felt uncomfortable about it, they repeatedly administered shocks when told to do so by an authoritative person supposedly directing the experiment. Some participants continued to administer shocks even after the person answering the questions appeared to be in great pain.

The importance of context was demonstrated when the scene of the experiment was shifted from a lab on the Yale campus to a bare office in a run-down building downtown. In the university lab, participants reported that while they did not like administering the shocks, they felt confidence in the experimenters and were assured that a Yale experiment would be run safely and with only the best motives. Because the context made them think that the person asking them to administer the shocks was an authority, they readily obeyed. In the office, however, participants were much less willing to do as they were told. When the experiments were sponsored by an unknown organization and conducted in an unpromising location, participants reported that they did not like administering the painful shocks, that they distrusted the motives of the experimenters, and that they wanted to stop. Nevertheless, participants in the office were almost as likely to obey the instructions to administer the shocks as were the participants in the lab.

Context matters, and in the right contexts people readily conform to the wishes of a figure in authority. But even when the context is not right, in response to the instructions of someone who acts as an authority, people can be remarkably obedient.

Please begin by reading the sentence expressing the point of the text, which is shown underlined. When you have read the sentence expressing the point, please write your initials on the following line. ______ Then read the rest of the instructions.

Please read the whole text below until you understand it completely. Then turn over the page.

Then please write down *everything you can remember* from the text. Write in complete sentences. You can use your own words or the words from the text, or any combination of your own words and the words from the text.

Please write down both main ideas and details, or any combination of main ideas and details. Write as much as you can.

When you have finished, please go on to the next text.

One of the best skis for beginning skiers is the Hart Queen, which is durable and versatile, with the strength and flexibility that beginners need. The Hart Queen is designed to be used with all conventional bindings, and it works best with the Salomon Double, which is a binding especially designed for beginners. The Queen can be ordered in any of six different colors. Its construction joins tried-and-true materials with an innovative design. The core of the Queen consists of a very thin layer of tempered ash, direct from the hardwood forests of Kentucky. This core is surrounded by two outer layers that employ major innovations to provide extra strength and flexibility. For increased strength, the layer of ash has molded to it two sheets of ten-gauge steel. For increased flexibility, the two steel sheets are then wrapped with highly active fiberglass. This layered construction makes the Queen a durable ski that adapts to a variety of conditions and to the growing skill levels of the skier.

Appendix C

Instructions for Experiment 3 for Point, Random, and Control Conditions

1. READ THESE DIRECTIONS CAREFULLY.

2. AFTER YOU HAVE READ THEM, TURN THE PAGE AND RECORD THE TIME AS INSTRUCTED.

3. AFTER YOU WRITE DOWN THE TIME, TURN TO THE FIRST PASSAGE AND READ IT CAREFULLY. <u>NOTICE THAT ONE SENTENCE OF EACH PASSAGE IS UNDERLINED. IT IS THE POINT OF THE PASSAGE. PUT YOUR INITIALS HERE TO SHOW THAT YOU UNDERSTAND THAT THE UNDERLINED SENTENCE IS THE MAIN POINT OF THE PASSAGE</u> _____.

4. AFTER READING THE PASSAGE, TURN THE PAGE AND RECORD THE TIME.

5. AFTER WRITING DOWN THE TIME, TURN THE PAGE AND WRITE DOWN AS MUCH AS YOU CAN REMEMBER. INCLUDE BOTH MAIN IDEAS AND DETAILS. WRITE AS MUCH AS YOU CAN IN YOUR OWN WORDS, OR THE WORDS OF THE TEXT.

6. WHEN YOU HAVE WRITTEN ALL THAT YOU CAN REMEMBER, TURN THE PAGE AND RECORD THE TIME.

7. COMPLETE ALL THREE (3) PASSAGES IN THIS MANNER. PUT YOUR INITIALS HERE TO SHOW THAT YOU HAVE READ AND UNDERSTAND THE INSTRUCTIONS. _____

1. READ THESE DIRECTIONS CAREFULLY.

2. AFTER YOU HAVE READ THEM, TURN THE PAGE AND RECORD THE TIME AS INSTRUCTED.

3. AFTER YOU WRITE DOWN THE TIME, TURN TO THE FIRST PASSAGE AND READ IT CAREFULLY.

4. AFTER READING THE PASSAGE, TURN THE PAGE AND RECORD THE TIME.

5. AFTER WRITING DOWN THE TIME, TURN THE PAGE AND WRITE DOWN AS MUCH AS YOU CAN REMEMBER. INCLUDE BOTH MAIN IDEAS AND DETAILS. WRITE AS MUCH AS YOU CAN IN YOUR OWN WORDS, OR THE WORDS OF THE TEXT.

6. WHEN YOU HAVE WRITTEN ALL THAT YOU CAN REMEMBER, TURN THE PAGE AND RECORD THE TIME.

7. COMPLETE ALL THREE (3) PASSAGES IN THIS MANNER. PUT YOUR INITIALS HERE TO SHOW THAT YOU HAVE READ AND UNDERSTOOD THESE INSTRUCTIONS. ______

NRRC National Reading Research Center

318 Aderhold, University of Georgia, Athens, Georgia 30602-7125
3216 J. M. Patterson Building, University of Maryland, College Park, MD 20742