COOPERATIVE LEARNING

PREPARED FOR THE
READING & WRITING FOR CRITICAL THINKING PROJECT

GUIDEBOOK V

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This guidebook is intended as supplement to an interactive course. It is not intended for general distribution without an accompanying course presentation. It is intended as a guide for educators participating in the RWCT project who are being prepared to deliver workshops/courses to fellow educators.

CONTENTS

INTRODUCTION

The purpose of this course is to outline instructional methods that promote cooperative learning among students. As in the previous guidebooks, this presentation will follow a similar pattern. A discussion will be offered about establishing a classroom environment that promotes critical thinking and encourages cooperative learning among students in thoughtful ways. This will be followed by sample lessons that support cooperative learning. The sample lessons are practical classroom-ready strategies that can be applied directly in classrooms or that may serve as guides for developing other strategies. First the lessons are presented as they would be experienced by students and then discussed in detail. In this way, the effects of the lessons can be directly felt by participants and then examined from a pedagogical perspective to better understand the various components of the lesson and how they go together.

What is important to reflect on while working through this guidebook is the kind of classroom environment teachers can create by employing cooperative learning approaches and the kind of outcomes teachers can seek for their students through cooperative learning applications. The underlying assumptions of this course are that classrooms should be

- places of thinking for teachers and students,
- purposeful places where students engage in meaningful learning experiences,
- places where expectations for student development are clearly defined and openly shared with students,
- places that are intellectually stimulating, and
- safe settings for innovative thought and multiple voices.

The philosophy underpinning this guidebook embodies what Arthur L. Costa (1992) says about thinking and content: The process of thinking must also become the content of instruction. Student decision making, opinion formation, problem solving, working collaboratively, learning to learn from many sources, and creatively integrating ideas and information must always be considered part of the content of curriculum and never separated from the content. Instructional process combines both mechanisms by which the rest of the curriculum becomes meaningful, valuable, and purposeful and the foundation of the content being taught.

The teaching strategies presented here are consistent with the ideas presented in the previous Reading & Writing for Critical Thinking (RWCT) guidebooks. They are placed within the Framework for Critical

Thinking presented in *Guidebook I*. Strategies presented fit either into one of the stages of the framework, Evocation, Realization of Meaning, Reflection, or they incorporate all three stages. Many of the cooperative learning strategies offered here are either part of or consistent with the cooperative learning activities of other Open Society Institute programs such as Step-by-Step. Teachers who have participated in those cooperative learning initiatives should find this course content compatible.

Expected Outcomes

At the conclusion of this course participants will (1) understand what is meant by an environment for thinking, (2) be able to plan and implement a number of cooperative learning strategies in their classrooms, and (3) be able to identify what stage or stages of the framework the various strategies include.

Course Structure

Part I Review

This course should begin with discussion about the strategies that participants have been implementing in their classrooms since the last course. The discussion should include issues shared at the monthly meetings and questions that have arisen.

Part II Rationale for Cooperative Learning

This phase of the course involves presentation of cooperative learning. It will be necessary to present information and a rationale before moving to actual strategies. Though this phase will be interactive at times, it will also require some direct presentation.

Part III Presentation of Cooperative Learning Strategies

This part engages participants in experiences with the strategies, which will be presented through experiential learning.

Part IV Analysis of Strategies

After experiencing the strategies as students, participants will review and discuss their experiences, examining the various components of the strategies and looking at several characteristics. First, participants will determine how the strategies were implemented—what the actual process was. Next, they will consider how they responded as students, analyzing their own learning experience as a way of understanding what their students will experience. Finally, they will review the strategies in terms of where they fit in the RWCT framework for thinking and learning.

In this guidebook, analysis of the various strategies immediately follows their presentation (thus, Part III and Part IV are combined). This analysis will be repeated for each strategy offered. Any discussion may be quite brief or extended depending on the depth of the strategy.

Part V Planning for Implementation

In this part, participants will develop actual lesson plans using their own curricular content and incorporating the cooperative learning strategies presented here. These plans then will be shared in small groups or with the whole group.

Part VI Planning for Monthly Meetings

The various cooperative learning implementation plans should be posted for all to see. Participants should schedule and discuss plans for their upcoming monthly meetings at this time.

Part VII Course Evaluation

Distribute the evaluation form (see page 55) and outline the evaluation procedures, including free writes.

Reminder: It is important for participants to respond to the three informational questions at the end of each day. It takes approximately 5 minutes to fill out the index cards responding to the three questions:

1. What were the most important ideas or concepts discussed today?

2. What questions do you have at this point in the course?

3. Please make any general comments about how the workshop is going for you.

Participants do not have to sign their names, although it is helpful to have names if they ask questions that are not clear. A name on the card makes it possible to ask for clarification. Explain there are no right responses and the purpose of the cards is to collect feedback, which will make the course better, answer questions, and guide course direction.

Time should be taken each day to respond to the questions on the cards. Responses do not have to be lengthy, but the resulting discussion can be informative.

Course Timing

This course places heavy emphasis on active engagement by participants. The time it takes to complete activities can vary from group to group, so determining exact timing is difficult. Further, presenters may choose to present all the activities included in this guidebook or select a few and refer participants to the guidebook for learning about the others. For example, two variations of the cooperative teaching strategy Jigsaw are presented. Presenters may choose one to do with the group and refer to the other or choose to do both as group activities. If all activities are included, this course will take 20 to 22 hours to complete.

Materials Required

Chart paper, easels, and markers
Overhead projector, blank overheads, and markers
Plain sheets of paper
Six or seven sets of number cards (each set from 0–9)
Six or seven sets of large-number target cards (each set includes 20, 30, 40, 50, 60)
Tape or pins to hang posters and chart paper
Index cards for daily monitoring
Course evaluation forms

Articles for the two Jigsaw activities and Paired Reading/Pair Summaries Activity

Expert sheets for Jigsaw II:

Halloween Thought: Bats Are Beautiful and Do Good Deeds by Ken Wells

The Heart Beat by Robert I. Macey

Corn or Maize: What Good Is It ?

PART I
DISCUSSION OF PREVIOUS PROGRESS

Since the previous workshop, participants will have tried some of the techniques that were introduced and will have shared the results of their efforts during one or more interim meetings with their peers. They may be eager to discuss the results, any problems encountered, or unanswered questions from the interim meetings.

The discussion about previous implementation can be structured in a number of ways depending upon group size and geographic dissemination of the participants. Some participants hold monthly meetings by region, so it may be interesting to divide the large group and mix the participants geographically so the sharing will be among participants who do not attend the same monthly meeting. Another format would be to group participants by grades or content areas.

Once the groups are formed, invite them to share their experiences with implementation. Encourage them to discuss successes and failures and to describe any modifications they may have made to the strategies they implemented. Allow at least 20–30 minutes. Then encourage sharing among the whole group. Ask one or two participants to share briefly an implementation they consider successful. Ask one or two to share an implementation experience that was not as successful as they had hoped. Finally, it is important to answer as many questions as possible that may have come up during the monthly meetings.

PART II
COOPERATIVE LEARNING

Begin this part of the course by asking the group to think privately or write a few notes about the following question:

What are the two or three most important things we can teach our students to prepare them for their future?

Allow a few minutes and then ask the participants to share their thoughts with the person sitting next to them. Sharing should be in groups of only 2 or 3.

Again, allow a few minutes for sharing. Then ask the groups to share their thoughts in a few words and write them on chart paper so all can see the ideas. Be responsive to the ideas but do not offer judgment or evaluative comments. Accept all suggestions with equal validity. However, it is important to make connections among the various responses when the connections are apparent or when they emerge from the ensuing discussion.

When participants have finished sharing, a number of ideas should be listed about what students should gain from their schooling. There may be general but not total agreement. Total agreement would be surprising since this question has been one of the greatest sources of controversy in education since the beginning of schooling. Ideas may emerge that feed directly into conversation about cooperative learning and creating environments for thinking.

Explain to the groups that you would like to present a view about schooling that might be similar to their own beliefs, or somewhat different, with respect to the most important outcomes of schooling. Then begin the following presentation.

Classrooms as Environments for Thinking

This part of the course involves sharing some basic beliefs about what outcomes of schooling we ought to strive for and how cooperative learning strategies contribute to those outcomes. This should build on the group work just completed.

The contention here is that one primary outcome of schooling is maximizing the intellectual growth of students and their capacity to solve problems, advance understandings, become innovative, make decisions, and communicate effectively. One of the RWCT volunteers, Donna Ogle (1992), stated, "one of the goals of our educational system is to develop citizens who can contribute intelligently to the resolution of issues con-

fronting our society, citizens who can think critically and help to solve problems in local communities as well as in the national and international arena" (p. 25). To accomplish this goal schools and classrooms must provide an atmosphere that promotes thinking and supports thoughtful discussion and the sharing of ideas, beliefs, and philosophies. In other words, schools must become intellectually stimulating centers for thinking and learning where information (content) becomes the catalyst for thinking rather than the end point of thinking.

One means of creating thinking environments is to introduce cooperative learning methods into classroom instructional practices. Vygotsky, as Costa (1992) points out, made it clear that intellectual growth is the product of both internal processes and external or social processes. He suggested that higher level thinking emerged from relationships, that is to say, the dialogue between people. Costa adds, "Together, individuals generate and discuss ideas, eliciting thinking that surpasses individual effort. Together and privately, they express different perspectives, agree and disagree, point out and resolve discrepancies, and weigh alternatives" (p. 177).

In schools there is a tremendous emphasis on subject content. Students have seized on this and learn enormous amounts of factual information. It is a strength of the present education system that students are highly motivated to learn and succeed at this task. We know that the greater the knowledge base the more sophisticated concept development becomes and the better able we are to integrate knowledge across content areas. We also know that the more broadly and well developed our context is for information, the more information we are able to retain and use effectively. There is a reciprocal relation between knowledge and process: Each contributes to the other.

In reality it is not possible to separate content from process and maximize learning. Knowledge without the capacity for practical application is like a computer without electricity. It may hold a great deal of information but it is without utility. Process and content must be considered of equal importance in the instructional process. Students will apply their knowledge constructively when they understand that its value is in its vitality. They must understand learning as stored energy ready to provide electrical current to a problem, rather than seeing learning as the collection of artifacts from one's educational experience to be recalled and recited at random intervals.

What Is Cooperative Learning?

Cooperative learning occurs when students work together, in pairs or in small groups to address a common problem, explore a common topic, or build on mutual understandings to create new ideas, new combinations, or unique innovations.

At this point ask the group to do some paired brainstorming on how cooperative learning classrooms might look, and what the teachers' and the students' roles should be in a cooperative learning class. Give participants a few minutes for discussion. Many will recognize that the strategies they already have been implementing are often cooperative learning strategies.

Ask members from the large group to share their thoughts and track them on chart paper. Ask for clarity if some of the ideas are not fully explained.

Classroom Characteristics

It has been suggested that cooperative classrooms have certain general characteristics that include the following:

- positive interdependence,
- individual accountability,
- heterogeneous membership and grouping,
- shared leadership,
- direct social skills teaching,
- teacher observation and intervention, and
- effective group work.

From Richardson, J. (1996/1997). Leading the way to cooperative schools. *School Team Innovator*.

Cooperative Learning Outcomes

It is believed that learning outcomes are enhanced through cooperative learning classrooms. Johnson and Johnson (1989) suggest the following results from participating in cooperative learning environments:

higher achievement and increased retention;

more frequent higher level reasoning, deeper level understanding, and critical thinking;

more on-task and less disruptive behavior;

greater achievement motivation and intrinsic motivation to learn;

greater ability to view situations from others' perspectives;

more positive, accepting, and supportive relationships with peers regardless of ethnicity, sex, ability, social class, or handicapped differences;

greater social support;

greater psychological health, adjustment, and well-being;

more positive self-esteem based on basic self-acceptance;

greater social competencies;

more positive attitudes toward subject areas, learning, and school; and

more positive attitudes toward teachers, principals, and other school personnel.

Basic Elements of Cooperative Learning

Positive Interdependence

Students perceive that they need each other in order to complete a group task. Teachers may structure positive interdependence by establishing mutual goals (learn and make sure all group members learn), joint rewards (bonus points for group achievement), shared resources (one paper for each group or for part of the required information each member receives), and assigned roles (summarizer, encourager of participants, elaborator).

Face-to-Face Supportive Interaction

Students promote each other's learning by helping, sharing, and encouraging efforts to learn. Students explain, discuss, and teach what they know to classmates. Teachers structure the groups so that students sit together and talk through each aspect of the assignment.

Individual Accountability

Each student's performance is assessed frequently and the results are given to the group and the individual. Teachers may structure individual accountability by giving an individual test to every other student or randomly selecting one group member to give the answer. This must be done with care and in a positive context—to demonstrate progress, not to catch someone contributing less than their share.

Interpersonal and Small-Group Skills

Groups cannot function effectively if students do not have and use the necessary social skills for collaborative work. Teachers need to teach these skills as purposefully as they teach academic skills. Collaborative skills include leadership, decision making, trust building, communication, and conflict management.

Group Processing

Groups need specific time to discuss how well they are achieving their goals and maintaining effective working relationships among members. Teachers structure group processing by assigning tasks such as (a) list at least three member actions that helped the group be successful, and (b) list one action that could be added to make the group more successful. Teachers also monitor the groups and give feedback to the groups and the whole class on how well the groups are working together.

Guiding Principles

Finally, as we create classrooms for thinking, we should keep a few guiding principles in mind. Donna Ogle (1992) has stated them best:

> Children will only become better thinkers if they have numerous opportunities to practice the approaches to thinking to which they are introduced. We should focus on a few thinking strategies that are most useful and transferable from one area to another so that students will be likely to use the skills and strategies regularly. (p. 26)

PARTS III & IV
SAMPLE COOPERATIVE LEARNING LESSONS

Jigsaw Method

First, divide the large group into groups of four, mixing participants so they are working with different people for each lesson. When they are in their home groups, have them count off to four so each member is assigned a number 1–4.

Next, direct the participants' attention to the article in this guidebook (or prepared as a handout) entitled "Halloween Thoughts: Bats Are Beautiful and Do Good Deeds" by Ken Wells, briefly discussing the title and the topic of the article. Explain that the first task is for everyone to understand the article, which will be taught by participants in sections so that it will be fully understood by the whole group.

Point out that the article is divided into four parts and that each numbered group will be responsible for one part. Have the numbered groups gather together. If the group sizes are large, it may be necessary to split each group. Subgroups should have no more than four individuals. If there are, subdivide the groups again to form two or more sets of each numbered group. (In large classes, it may be useful to divide the class in half first, having one half work on Jigsaw and the other half work on another topic or article.)

These groups of 1s, 2s, 3s, and 4s are called *expert groups*, and it is their task to learn thoroughly the material presented in their section of the article. They are to read their section and discuss it as partners to be sure they fully understand the article. The group then must decide how to best teach the material to their original cooperative home group. It is important that each member of the expert group understand that he or she is responsible for teaching that portion of the text to their original home group. It is up to each expert group, as a whole, to determine the teaching strategies and materials that will be used. Be sure they understand that several participants from each group will be asked to teach their section to the whole group for demonstration purposes. Ask the participants to form their expert groups and begin working on their task. This will take considerable time as they work through their article section, discuss the content, and develop teaching strategies.

When the expert groups have completed their work, they may return individually to their cooperative groups and teach the others their content. Point out that it is important that individuals within each home group are mastering the content of all sections of the article. Cooperative group members should note any questions they may have about the material in any sections of the article. These questions should be di-

rected to the group expert who is responsible for that section. If they are still uncertain or confused, they should ask the expert group for that section to clarify. If uncertainty persists, they should consider this a question for further research.

Point out that it is important for the teacher to monitor the teaching to be sure information is being transferred well, and he or she can serve as a resource for questions that arise. If expert groups are stymied by something, the teacher can assist to be sure the expert group understands well.

Analysis of Jigsaw Lesson

After the teaching has been completed and questions asked, begin a discussion of the Jigsaw method:

- How did the process work for you in general?
- How did you feel as an expert and a teacher?
- How did you feel in the home group learning from your peers?

You might probe for conversation about the responsibility they had for carrying the information back to the cooperative learning group from their expert group and how this influenced their approach to the task as learners. You might ask

- What was your reaction in the cooperative group when you were being taught by your group colleague?
- How does this strategy change the role of the classroom teacher?

Next, discuss how the Jigsaw instructional method and its various elements fit into the RWCT framework. Ask participants for their thoughts on this. In general, Jigsaw is a realization of meaning-stage activity. However, the teaching strategies the experts develop may contain elements of all three stages of the framework. When the group begins to monitor their own learning, ask questions, and check their own understandings, they are engaging in reflection-stage activities.

As a final note to participants, refer them to the Appendixes (in this guidebook) for two additional examples of how to divide into subgroups for Jigsaw.

Paired Reading/Paired Summaries Demonstration Lesson

This strategy was developed by Don Dansereau and his colleagues at Texas Christian University. Begin this lesson by explaining that this cooperative reading strategy is useful particularly when text is dense. It is a helpful strategy in content courses where reading material might be complicated or laden with factual material.

1. The article "The Heart Beat" by Robert I. Macey will be used to demonstrate this strategy. Before turning to the article ask people to join in pairs. They will be partners for this entire process.

2. Explain to the pairs that they are going to read the article in a particular way. Explain that they will be responsible for knowing what is in the entire article, but for now they will be focusing on just one section. Have the pairs count off by 4s. Each pair will then be assigned a 1, 2, 3, or 4. Explain that the article is divided into sections 1 through 4 and assign each pair the section of the article corresponding to their number.

3. This step is the most important in this strategy and must be explained carefully. Explain that each member of the pair is going to play two distinct roles. Each will take one role, then switch roles as they read.

a. The first role is that of reporter. The reporter's job is to read the section carefully and summarize the content. After reading the section, the reporter will tell his partner in his own words what the reading was about.

b. The second role is the responder, which is equally important. The responder reads the section, then listens carefully to the reporter. When the reporter has finished, the responder then asks the reporter any questions that might clarify the reading or reveal more information:

What about...?

Do you recall...?

Was there something about...?

It might be helpful for the two workshop presenters to model these roles with a short paragraph from a text and a brief reporter-responder interchange. Be sure everyone understands the two roles clearly before going on.

4. The final step can be a bit confusing. Each person in the pairing will play both roles, so the article will be divided twice. The first divi-

sion is into the four sections corresponding to the numbering of the pairs, and each section is assigned to a pair according to their number. Within each of the sections, the section will be divided in half. This is done so that in the first half, one person in the pair will be the reporter and the other the responder. Then the roles are reversed for the second half of the section.

5. After the pairs are assigned their section and have decided which role they will play first, they are ready to read. Emphasize that they will be responsible for reporting back to the whole group, so they should understand thoroughly their section.

6. Tell the pairs to find a comfortable spot in the room to work together (at desks, tables, on the floor away from others, or in corners of the classroom). Remind them to moderate conversations or the room will become too noisy. Tell them to begin. The process will take some time until students become comfortable with the roles. Allow enough time for all pairs to complete the task.

7. Reporting to the whole group can take many forms. One method that works particularly well with paired reading/paired summaries is post-graphic organizers. Graphic organizers were presented in an earlier guidebook and offer an excellent way for students to summarize their understandings from the text. In the "Heart" article, graphic organizers are particularly suited to the content. Participants may be given colored markers and a blank transparency sheet or paper to summarize their understandings. Encourage them to be creative in their summary representations.

8. After each pair has created their overhead summary, ask them to come to the overhead by sections—beginning with the first section of the article—and present their summaries. Both members of the pair should come forward, even if only one speaks.

9. After each presentation, give a round of applause.

Analysis of Paired Reading/Pair Summaries

Begin the analysis by asking participants to describe how the process worked for them. There are many parts to this strategy so be sure the discussion hits most of the components. Ask how they felt and behaved in the role of (1) the reporter and (2) responder.

These are quite different roles and their reactions are likely to be quite different for each. Ask if they felt any added responsibility knowing they would have to teach others. Ask if they believe this feeling of re-

sponsibility increased their attention to content and if they think it will do the same for their students.

After discussion explain that this strategy has several instructional advantages. The first advantage is that when students are confronted by difficult text, two heads are often better than one. By pairing students they can put their minds together to bring understanding to the text, solve areas of confusion, apply their mutual language skills for summarizing, share independent perspectives, and build larger understandings.

The second advantage is that the roles do two things:

1. They focus readers on the content and serve to maintain student engagement while reading difficult text.

2. They allow immediate opportunity for review and reflection as well as allowing students time to put their understandings in their own words.

The third advantage in pairing to create a joint summary is that pairs must engage in dialogue about content while developing a concise language that will adequately convey what their section is about.

The fourth advantage of this strategy is that it requires students to be thoughtful about and attentive to text. It also demands that students listen carefully to each other and share responsibility for teaching and learning in their classroom.

The fifth advantage is that by having several pairs assigned to each section, the whole-group sharing presents the content to the students in different ways, offering a variety of opportunities for understanding as well as opportunities for repeated exposure to the content. Further, through whole-group sharing, the teacher can monitor understandings and correct misunderstandings.

After the discussion, review where this strategy fits in the RWCT framework. This may be complicated because parts of the strategy fit into different stages of the framework. Encourage discussion about this and fill in the framework chart accordingly.

Corners

Corners is a cooperative learning activity that is intended to generate debate and use group processes to stimulate constructive arguments. Corners can be used as an active and enjoyable means of managing debates on controversial issues where two or more positions might be pre-

sented. It can be used following a class reading of a text, following a lecture or film presentation, or simply following a topic prompt for students to consider. Whatever the medium for the topic, the presentation might well include evocation and realization of meaning activities such as those described in previous guidebooks.

The directions for Corners are fairly straightforward and are intended to get students to take a stand on an issue and be able to defend it. They also encourage listening carefully to others and emphasize the option to change opinions if the thoughts of others are sufficiently persuasive. In fact, this particular activity encourages students to change their minds as they listen to the thoughts and arguments of others.

Corners Demonstration

Because of time restraints, this lesson will be on a topic offered by a simple prompt identified below. While Corners can be used this way, it is more frequently used following reading a text, listening to a lecture, or observing a film with a controversial topic or issue.

If time permits, use the poem, "Best She Could" by Donald Jones (see Guidebook IV). This poem tells of an old woman who has gone to the public assistance office where she is treated with bureaucratic indifference and dies before receiving any help. Or ask the group what controversial issues or topics they currently are facing in their own community and have them discuss one of those issues. Be careful about choosing a topic in this way. Remember that a class that meets almost every day can serve as a place for continuing discussion on controversial topics. However, in the workshop format, controversial topics with deep historical roots may not be suitable for the brief time available for this demonstration.

After choosing the issue or topic, proceed as follows:

1. Explain to the participants that they are to begin thinking about a particular issue related to current world events. It will be necessary for them to think about the issue and come to some tentative conclusion about their thinking. If the Chinese dam project is selected the issue for this lesson is to discuss and decide on whether the Chinese government should build the world's largest dam across the Yangtze River.

It may be necessary to review this issue if the group is not well informed about the project. You may want to select other topics such as the continuation of United Nations-imposed sanctions on Iraq, global

warming and continued use of fossil fuel for automobiles, nuclear power as viable sources of electricity, NATO expansion into Central and Eastern Europe, or whether children should watch television. If a brief evocation-stage review of the Chinese dam project is necessary, it may be helpful to point out a few pros and cons presented in the media about the project:

> It is estimated that the dam will provide approximately 20% of the nation's electrical power (and will be clean non-nuclear energy) when completed. It will provide thousands of jobs in an area of China with a large unemployment problem and provide flood control over a river that has caused widespread flood devastation for centuries. On the other hand, it will flood a vast area of China including one of the most scenic valleys and mountain gorges on earth. The dam will necessitate the relocation of as many as 2 million people whose homes and villages are in what will eventually be the lake basin created by the dam; and some engineers do not think the design will work, and others think the dam will cause irreparable environmental harm.

2. Determine what positions participants can take on the issue. In the Chinese dam example, students can either be in favor of its construction, opposed to it, or undecided. It is important to give students two or more options to consider. The teacher may determine the various positions students can take on an issue in advance, or students may brainstorm various stances.

3. Ask participants to write for 3 minutes in support of their position, generating their own argument in support of their position while attempting to be as compelling and persuasive as possible.

4. When they have completed writing, ask the participants who are in support of building the dam to go to one corner of the room. Those who oppose building the dam go to another corner of the room. Those undecided could move to another corner. If there are other predetermined opinion groups, they should have their own place to go in the room as well.

5. For 5 minutes or so, participants in each group should share their papers within their group and review the reasons for their positions. The group will also have to select one or two spokespersons to represent the group in the debate that will follow.

6. Call for the debate by inviting one group to state succinctly its position and the major reasons for supporting their view. Ask each group, in turn, to do the same.

7. Once the formal debate has been presented by the spokespersons, other group members should now be encouraged to participate in the conversation. If the groups need encouragement, ask some probing questions:

- Why should those of you in group A not accept the opinion of group B?
- Where do you disagree with what group B has to say?
- What about the undecided group?
- What have you heard that moves you toward a clearer opinion?
- Why are those of you in group B unconvinced by what group A has said?

8. Explain that some participants may have changed their minds by the discussion and should feel free to change groups at any time. They simply have to walk from the group they are in to the group they now agree with. In fact, encourage participants to move as their opinion shifts. Also, encourage members in the groups to convince others not to leave their group. This puts the burden on the members within each group to be persuasive and to keep group members and draw more adherents. Participants should take notes on their thinking as they listen and discuss, which will help later when they have to write about their position on the issue and defend it.

9. Once the discussion has ended and everyone has moved to their final group, ask each group to summarize its position and the reasons that support it. Then ask all students to write a position paper, setting out their individual positions and the reasons behind them. (A more elaborate paper will take opposing arguments into account but defend the chosen position in the face of them.)

Analysis of Corners

Begin the analysis by asking participants to describe how the process worked for them. There are several steps in this strategy, some which require individual work while some entail group work. Encourage participants to discuss their impressions as learners throughout the process, looking at the various steps as they went along.

After this discussion, review the various steps if some were left out and go through them one at a time with the framework as the guide.

Step 1 presented the topic for consideration and some background information, which provided a brief introduction within the evocation stage. For this strategy to be successful, students will have to know something about a topic so they can develop an informed opinion from the beginning. However, even when moving to **Step 2**, it is not necessary to be an expert on the issue. It is rare that we can be experts on issues before we have to formulate an opinion. In reality, our opinions are often based on factors not directly related to an issue, and we only discover those factors when we are asked to defend our opinions.

Step 3 asks participants to work individually to formulate their own position on the issue. This requires each student to take an initial stand before hearing from others. While it may be difficult for some to do this, it is an important part of the process. We know that learners are more likely to become engaged in the learning process and learn best when they have a stake in what is being discussed. By taking a position from the beginning, students are making their stands in the conversation. This step can involve two stages of the framework, depending on whether you are looking at the strategy globally or at this particular step in the process. From a global perspective, the Corners strategy is a reflection-stage activity where everyone has been informed on a topic. However, from an individual-experience perspective, the thinking being done also could be considered an evocation-stage activity. This is because the strategy at this stage would allow for much more discussion, activate awareness of previous knowledge and beliefs, and encourage engagement in debate prior to subsequent in-depth exploration of a topic.

Step 4 is a powerful component of this strategy, because it requires participants to commit actively to a position. A public statement of their thinking commits them more definitively to a viewpoint and emphasizes that everyone has opinions and that those opinions count.

Steps 5, **6**, and **7** can all be considered, within the microcontext of the strategy, to be a realization of meaning activities as students listen to the voices of their peers and consider the meanings being constructed about the issue. Within these steps, it is important to monitor the conversation to be sure that many voices are heard from all the groups.

Step 8 is central to the strategy and provides participants with permission and the opportunity to change their minds publicly. If students are to think critically, they must understand that thinking is a continuous process that can lead to different conclusions, and that changing opinions is one legitimate outcome of thought. They must understand that changing one's opinion is a natural and predictable consequence

of careful thought. This step also requires students to articulate their thoughts in ways that communicate them clearly to others. It is important to have opinions, but they are more valuable when we share them with others in meaningful and thoughtful ways.

Summarizing the group's position and rationale and then writing individual position papers, as suggested in **Step 9**, are reflection-stage activities within this strategy. Asking for both group and individual activity reinforces students' understanding that they are ultimately responsible for their opinions and beliefs, and they must offer their own justification for their views. Certainly their views can have, as their source, the thoughts and wisdom of others, but in the end they must be able to express their views in their own words.

After this discussion, review where this overall strategy fits into the framework and add it to the framework chart.

Jigsaw II

This lesson demonstrates a well-known cooperative learning technique, Jigsaw II (Slavin, 1990), a variation of the Jigsaw teaching strategy. Jigsaw II is more directed than the Jigsaw method presented previously.

Jigsaw II Demonstration

1. Explain Jigsaw II (Slavin, 1990) by telling participants that they will be responsible for learning all parts of a text about corn, but each person will become an expert on one part of the text and will teach others about it.

2. Assign everyone to cooperative home groups of four or five members.

3. Distribute and read copies of the article "Corn Or Maize: What Good Is It?" to all participants (Appendix F in this guidebook). Distribute a different expert sheet to each participant in a home group. (If there are more than four people in a home group, distribute enough different expert sheets, so no more than two people have the same expert sheet). The expert sheet contains questions to guide that person's reading of the text. The expert sheets differ, because later each person will be responsible for helping the others in the home group learn about the aspects of the reading covered by his or her expert sheet.

Allow 20 minutes for everyone to read the article. Everyone should read the whole text, paying special attention to the material that answers the questions on his or her expert sheet. Participants who finish early should take notes on portions of the text that pertain to the questions on their expert sheet.

4. Study the text in expert groups. Set up four tables or clusters of chairs to seat four expert groups. If there should be more than six participants in any one expert group, divide that group into two groups. Appoint a discussion leader for each expert group. Spend a few minutes going over the rules of participation. Everyone participates. No one dominates.

The group agrees on what the question means or what the task is before answering. If anyone is not clear about something that is said, restate it in your own words. Have everyone stick to the task at hand.

Allow the expert groups 20 minutes to discuss their questions and answers. They should have previously located answers to the questions in the text and taken notes on answers their group offers to the questions. The teacher should circulate among the expert groups to help them stay on task and provide any necessary clarification.

5. Experts teach the text to home groups. When the study time is up, have the participants leave the study groups and return to their home groups. Each participant should take about 5 minutes to present to the home group what she or he learned in the expert group. The expert's task is not just to report, but to ask and entertain questions from the group to ensure everyone learned his or her piece of the text.

6. Evaluate the process. Ask everyone to write about what he or she contributed to the discussion and ways to improve the activity.

Expert Sheet 1

In what ways have humans adapted corn to their own uses?

How long have humans been manipulating corn plants for their own purposes?

Some people claim that it is unnatural, and therefore wrong, for people to "tinker" with nature. Using what you know about corn, construct an argument that agrees or disagrees with that position.

Expert Sheet 2

What appear to be the two most important benefits derived from corn?

What is it about the corn plant that makes it especially useful in so many parts of the world?

What are the chances that humans will discover another plant in nature with benefits as plentiful as those of corn?

Expert Sheet 3

What are the advantages of hybridizing corn? What are the dangers?

Name and describe all the kinds of technology that are involved in taking full advantage of corn.

Who is most likely to profit from corn, the people who grow it or the people who process it? Why?

Expert Sheet 4

Describe the composition of a kernel of corn.

Name one use or product derived from each part.

What skills and technology are required to take advantage of each of these parts?

Brief Cooperative Strategies

There are many strategies that promote cooperative learning and take very little time to orchestrate. These simple strategies are often excellent means of introducing students to working in pairs or small groups. This section will describe a number of such strategies, which participants should go through and discuss in terms of their own experience with them. They should also discuss where and how they fit into the framework and how to modify them to fit their content area.

Paired Predictions

The first of these is called Paired Predictions, which can be used in many content areas. The following example is used in children's literature

classes, where students will read a children's novel titled *Tonight By Sea* by Francis Temple. Ask if has anyone has read the story previously. If yes, tell them to listen again, now. Ask them to group in pairs with paper and pencil. Tell them to listen carefully as you read the following list of words, which refer to the characters, the setting, and some to the story itself.

Paulie	freedom
bravery	home
Haiti	Macoutes
Karyl	terror
sea	life

Have them discuss with their partner a mutual idea of what this story might be about and make some prediction about the story. Allow 5 or 6 minutes for discussion and to write their predictions to refer to later as they read the story. Of course, here they will not be reading the story, but in class students would then begin reading the story. Explain that this prediction activity can be done only one time at the beginning, or the pairs can come together at points throughout the story to modify their predictions as the story unfolds.

Think/Pair/Share (Kagan, 1992)

Tell the group you are now going to assign a topic for their individual consideration. The topic or issue should be something interesting like teachers' salaries, the value of space exploration, or global warming. Ask them to think individually about the topic for a few minutes. Next, ask them to pair with a partner and share their thinking. This should take only a few minutes.

Explain that Think/Pair/Share is a quick, simple cooperative learning technique that can be incorporated into most content areas. It works well with large groups and is excellent to use at the beginning of a talk.

Summarize/Pair/Share

Ask the groups to recall the "Heart" article they read earlier. Have them summarize the article in two or three sentences. When they are

done, they should turn to their partner to share their summary statements and discuss any similarities or differences, or they can come up with a mutual summary. Allow only 2 or 3 minutes for each part of this activity.

Explain that this simple paired activity is an extension of Think/Pair/Share and can be used in similar situations following a presentation, reading, or discussion of a topic.

Formulate/Share/Listen/Create (Johnson, Johnson, & Bartlett, 1990)

This is a similar activity in which teammates first privately formulate responses, then share and listen in turn, and together create a new answer or perspective through discussion and elaboration. This activity has widespread application and encourages students to stretch their thinking.

By promoting focused, short-term, purposeful talk among students, informal cooperative learning techniques such as Think/Pair/Share can ease students into cooperative peer relationships. As students learn to work cooperatively on more complex team tasks, these informal structures can be used to facilitate group interaction.

These short, cooperative learning techniques and strategies can be incorporated into instruction easily and quickly, applied to all content areas, and can offer students an opportunity to work cooperatively during all stages of the RWCT framework.

It might be valuable at this time to add these cooperative learning strategies and techniques to the framework chart.

Cooperative Math Activities

Making the Target Number

Mathematicians Glenn Nelson and Earl Ockenga (1997) have developed a number of cooperative activities for use in mathematics instruction, including Making the Target Number, which has several variations.

Divide the large group into groups of four or five and give each group a set of digit or number cards, 0–9.

1. Ask a member in each small group to select (without looking) three number cards and one target card.

Example:

2 • 3 • 6 4

The target card is 4.

2. The task for each group (each group will have different numbers) is to use each of the numbers only once in a combination of mathematical operations to reach the target number.

3. The groups can use only addition, subtraction, multiplication, and division to reach the target number.

Two solutions to the example above are:

$(6 \div 3) \times 2 = 4$ or $\frac{6}{3} \times 2 = 4$

Have the groups work through several trials. One suggestion is to have the groups look closely to find more ways to reach the target number. For older students, add more numbers and operations.

For middle-level math students and above, another variation of this task is to have the groups keep the cards numbered 1–6 and the numbers 20, 30, 40, 50, and 60. This time the numbers 1–6 are put in a hat or box. A member of the group draws one of the numbers. The number drawn is written down and returned to the container (so it may be drawn again). The numbers in the container are mixed, and the drawing continues until six numbers are drawn. Then from the cards numbered 20, 30, 40, 50, and 60, one is drawn as the target number.

The task now is similar to the previous activity. Each group is asked to use each drawn number only once (but each drawn number must be used) in any combination of mathematical operations to reach the target number. Multiple answers are encouraged. For this activity, each group can draw their own numbers, or one set of numbers can be drawn for all.

Now draw a set of numbers and have the small groups solve a few of these numerical mysteries.

Example:

number cards					target number
3	5	5	6	4	50

One solution is

$$\frac{3 \times 5 \times 4}{6} \times 5 = 50$$

What's the Number?

This is a math detective task that can be done in pairs or small groups. It also can be modified to apply to other content areas such as geography—Where am I? or history—Who am I?

Ask participants to look at the What's the Number? number chart with example clues below the chart. Have participants group in pairs. Ask each one in the pair to pick a number silently and lead their partner through a series of clues until the partner chooses the number.

For example: I am thinking of a number.

1st clue: It is an even number.

2nd clue: It is divisible by 8.

3rd clue: It is between 20 and 40.

4th clue (if necessary): The sum of the digits is 6.

5th clue (if necessary): The tens digit is half the ones digit.

6th clue (if necessary): The number is divisible by 6 and 3.

The example target number is 24.

WHAT'S THE NUMBER?

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

Clue A
Even number

Clue B
Odd number

Clue C
Less than 20

Clue D
Between 19 and 41

Clue E
Sum of the digits is 6

Clue F
Numbers is divisible by 4

Clue G
Number is divisible by 3

Clue H
Sum of the digits is 5

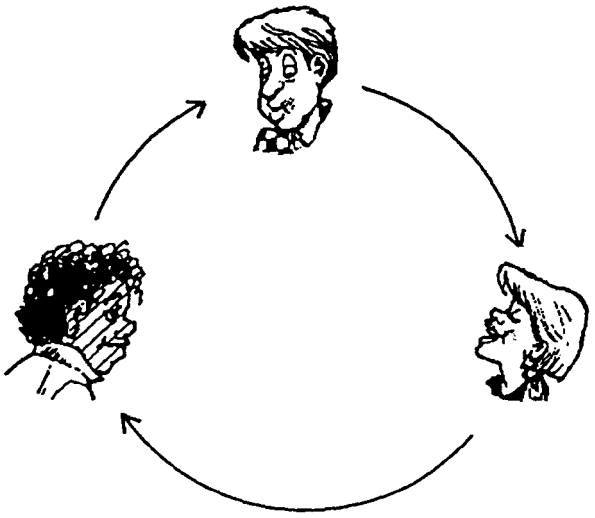
Clue I
Tens digit is greater than the ones digit

Roundtable–Roundrobin

Roundtable (Kagan, 1992) is a cooperative structure in which one paper and pencil are systematically passed around a small group. One partner writes an idea and passes the paper and pencil to the partner on the left. That partner adds to the idea presented and passes the paper to the next. A variation of the procedure is to have each partner use a different colored writing tool when the paper is passed. This visually enforces all partners to contribute equally and allows the teacher to document individual contributions.

Roundrobin (Kagan, 1992) is the oral form of Roundtable. Each teammate verbally contributes an idea to the group in a systematic, around-the-group fashion.

Roundtable
(written contribution, then paper passes to the left)



Roundrobin
(verbal contribution, then turn passes to the left)

Three-Step Interview

Three-Step Interview (Kagan, 1992) is a cooperative structure in which partners interview one another on a particular topic. For example, in a team of three, Partner A interviews Partner B, while Partner C records key aspects of the response. Roles rotate after each interview, allowing all members the opportunity to be interviewed.

In a group of four, the steps can progress as follows:

A interviews B, while C simultaneously interviews D.

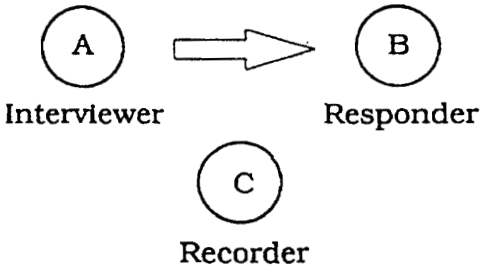
Roles reverse and B interviews A, and D interviews C. The group of four reconvenes with each person sharing his or her partner's response.

Three-Step Interview can be incorporated into any type of lesson, while the content of the interview can be virtually anything. For example,

- as an anticipatory set: What are the questions you would like to explore related to this topic? What do you already know about this topic?
- to share personal experiences or express opinions: What three qualities do you most value in a friend and why? If you could go "back to the future," where would you go? What time period would you choose? What social changes would you make?
- to summarize the learning in a lesson: What would you like to know more about as a result of our lesson today? What was the most meaningful idea for you today and why? How will you apply today's learning?
- to review homework: What were the key points from the last reading? What was the most interesting part of your homework? The most difficult?
- to explore concepts in content areas: How do you attend to environmental issues? How did you solve the math problem? What is your hypothesis or prediction at this point?

Three-Step Interview

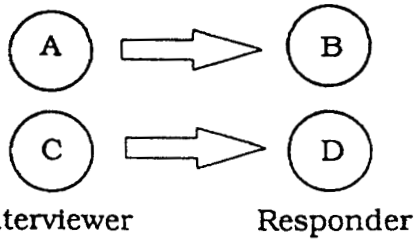
Group of 3



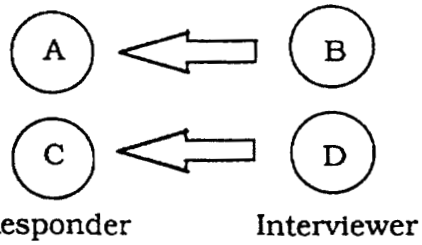
Roles rotate after each interview.

Group of 4

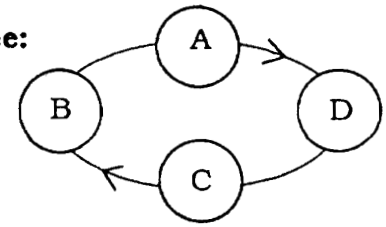
Step One:



Step Two:



Step Three:

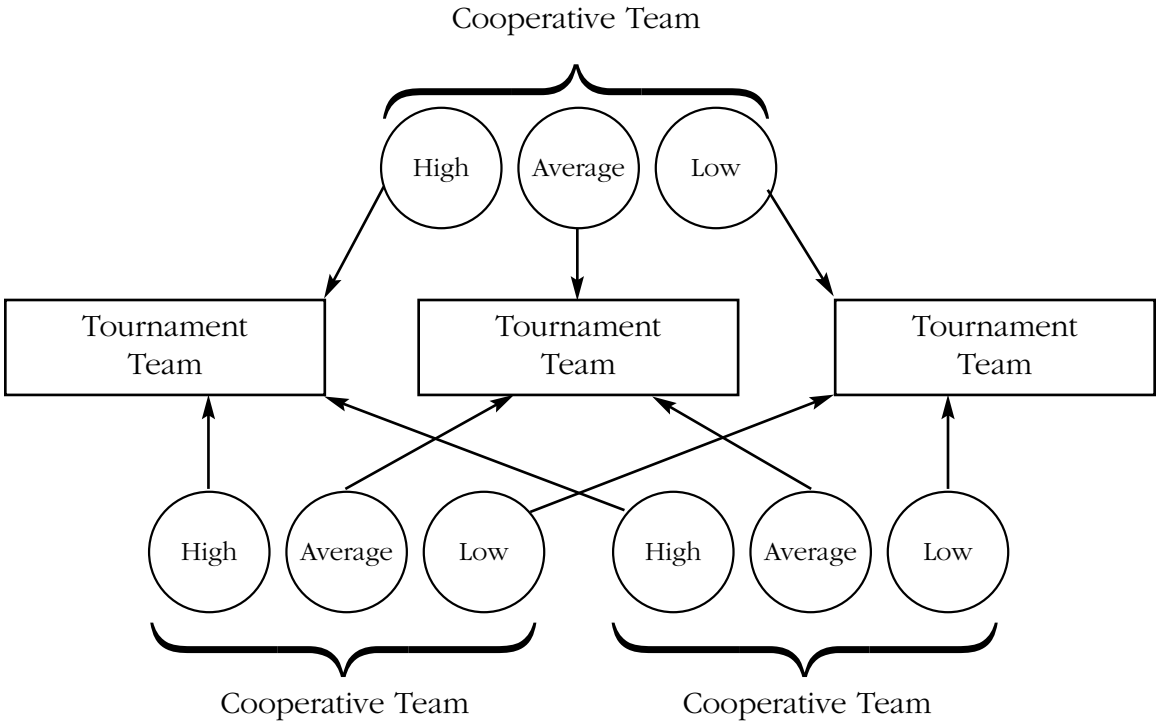


Each person shares partner's response.

Teams/Games/Tournaments

Teams/Games/Tournaments (Slavin, 1986) is a cooperative structure in which teammates cooperatively study to master learning, then individually apply their learning in a competitive game. Specifically, heterogeneous Cooperative Teams (i.e., mixed-ability groups) are formed to study or review learning from previous teaching. Then, individuals move to homogeneous Tournament Teams (i.e., equal-ability groups) to compete in a game based on the learning. Typically, the game is one in which students take turns answering questions. Individuals win points for each question correctly answered. After the tournament, students return to their Cooperative Teams with their individual scores. Each Cooperative Team calculates a total team score and winning teams are recognized.

In addition to providing students with opportunities to practice cooperative skills necessary for productive study and review, Teams/Games/Tournaments also provides opportunities to practice and process social skills that comprise good sportsmanship. Prior to the tournaments, discuss with students what it means to be a good sport, asking them for specific examples. Also, discuss the benefits of good sportsmanship to increase the likelihood that students will compete with one another in fun, appropriate ways. Some participants may object to engaging in com-



petitive activities and may argue that it will break the cooperative or collaborative spirit. This objection would make a good discussion to have among participants, one in which Corners could be used as a tool to manage this discussion.

Teams/Games/Tournaments Sample Directions

1. Select a name for your Cooperative Team (three teammates).
2. With your Cooperative Team, study or review _____. Time: _____.
3. Move to your Tournament Team (three people).
4. Each Tournament Team gets:
   One envelope of Question Cards
   One Tally Sheet

Roles:
- Quizzer ☞ Reads Question Cards
- Responder ☞ Answers the question
- Recorder ☞ Marks points for correct answers on the Tally Sheet

Note: Roles and materials rotate after each turn.

Every individual gets the same number of turns to answer questions (e.g., 10 turns each).

5. Return to your Cooperative Team with your individual score.
6. Calculate a total Cooperative Team score by adding individual scores. Record the total on your Cooperative Team Total Score Sheet, and submit the sheet to the teacher.
7. Winning teams will be recognized.

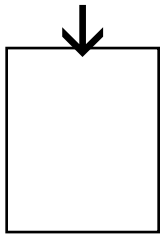
Teams/Games/Tournaments
Cooperative Team Total Score Sheet

Team name _____

Your name _____ Score _____

Your name _____ Score _____

Your name _____ Score _____



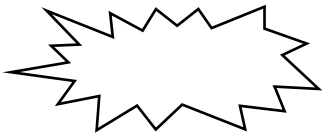
Cooperative teams use this page to calculate their total team score after participating in the tournament.

Teams/Games/Tournaments: Individual Tally Sheet

Your Name _____

Directions: Mark ✔ or ✘

1. _____
2. _____
3. _____
4. _____
5. _____
6. _____
7. _____
8. _____
9. _____
10. _____



= Total Correct

It may be easier for students to use Individual Tally Sheets during the tournament instead of the Group Tally Sheet. When this option is chosen, each student brings an Individual Tally Sheet to the competition, and after the tournament, individuals bring their completed tally sheets back to their Cooperative Teams.

Teams/Games/Tournaments: Tally Sheet

Cooperative Team Name	Question										
	1	2	3	4	5	6	7	8	9	10	Total

Tournament Teams may use this tally sheet to record individual points for correct answers. Enter the Cooperative Team name that each individual represents on the sheet before the tournament begins. Individuals take their scores back to their respective Cooperative Teams.

Brief Exercises for Problem Solving and Discussion

This section presents additional cooperative learning strategies, which are described in greater detail in Baloche (1998), Kagan (1992), and Johnson, Johnson, and Holubec (1993).

Think/Pair/Share

1. The teacher asks a question or poses a problem.
2. Each student considers the problem alone.
3. Students pair up, share answers, and discuss the problem further.
4. Pairs join other pairs to make a foursome and share their thoughts.

Numbered Heads Together

1. Students form small groups of three or four.
2. Students count off within their small groups from 1 to 3 or 1 to 4.
3. The teacher poses a question or problem.
4. The students consider the problem alone.
5. The students then discuss the problem as a group.
6. The teacher calls a number, and each student with that number reports to the whole class on the group's discussion.

Pens in the Middle

As students begin to share ideas in the typical cooperative learning group (3 to 7 members), each student marks his or her contribution by placing a pen or pencil on the table in the middle of the group. That individual may not contribute again until all pens are in the middle.

All members are equal in their ability to contribute, and no one may dominate. The teacher may also select a pen and ask what contribution it represents.

Three-Step Interview

1. The teacher asks a question or poses a problem to students grouped in 3s or 4s. Each student considers the problem alone, possibly writing a response.

2. Students pair up and interview each other as a way of sharing their answers.
3. The pairs join other pairs to make a foursome. Within the foursome, each student shares his other partner's ideas with the other pair.

Trade a Problem

1. The teacher gives a lecture or assigns a reading. (Appropriate evocation activities should be used.)
2. Students are assigned to random pairs.
3. The pairs identify four or five main points in the lecture or reading.
4. These pairs join other pairs to form foursomes and discuss the main points and clarify uncertainties.
5. Each pair now writes a set of questions to answer or problems to solve for the other pair.
6. The pairs link up again and quiz each other.
7. The four students reflect on what they have learned from the exercise.

Blind Hand

1. The teacher divides the material to be studied into several sections. Each student in each group is given one or two sections of material.
2. Each student looks over his or her material to become sufficiently familiar with it to be able to describe it to his or her group mates.
3. The students in each group work together to determine the logical sequence of the sections of information they have or other ways in which the materials might fit together.
4. Students may describe their sections and ask about each other's sections, but they may not look at each other's sections.
5. After the material has been organized, the students discuss how well the sections fit together and solve the problem and derive implications. While working, students should be prepared to rearrange the material they find a more sensible arrangement.
6. Students should reflect on the strategies used to organize the sections. What plan did they use? Who did what?

Exercises That Require Movement Around the Class

Stirring Up the Class

1. Students count off within their home groups of three or four.
2. The teacher poses a question or problem.
3. The students consider the problem in their home groups.
4. All the students with the number 1 then rotate to the adjacent group and share the results of their home group's deliberations.
5. Students return to their home groups.
6. The teacher asks another question or poses another problem.
7. The students discuss their ideas within their groups.
8. All the students with the number 2 rotate two groups away and share the results of their home group's deliberations.
9. This idea continues with numbers 3 and 4 doing likewise. Number 4s should not move over four groups because that will bring them back to their home group.

Mix/Freeze/Pair

1. The students stand and mix freely around the classroom.
2. The teacher says "freeze," and the students stop.
3. The teacher says "pair," and each student pairs up with the nearest person, taking whatever seats are available.
4. The teacher asks a question and the students discuss it.
5. The process is repeated several times.
6. A variation is to have students form an inner and outer circle with an equal number of students. The circles then rotate in opposite directions until someone says "freeze." The persons opposite each other at that point become partners.

Rotating Review

1. A number of questions (6 to 8) are written on numbered sheets of newsprint and posted around the room.
2. Groups of three or four students are assigned a question. They move to the sheet with the question on it, discuss the question for 4 to 5 minutes, and write their answers on the sheet.

3. At a signal from the teacher, the groups move to a new sheet, read the question and the answer that has been written, and add their comments on that sheet.
4. The teacher calls for the groups to move on—repeating the process, if possible, until the groups return to their original sheets.

Gallery Tour

1. In groups of three or four, students first work through a problem, preferably with varied possible approaches, and produce a demonstrable product such as a diagram on chart paper.
2. The products are taped to the walls around the room.
3. At the teacher's signal the groups rotate around the room to examine and discuss each product. They take notes on their observations and may leave written comments on the display.
4. After the gallery tour, the groups reexamine their products in comparison to the others and review the comments left on their own work by others.

One Stay, Three Stray

1. The students first work through a problem with varied possible approaches, and produce a demonstrable product such as a diagram on chart paper.
2. The students within groups count off (1–3).
3. Each group is numbered, too.
4. At the teacher's signal, students rotate: Student 1 rotates one group, Student 2 rotates two groups, Student 3 rotates three groups—but one student does not move. Note: It is best to do these rotations one step at a time.
5. The student who stays in the home group explains the group's work to the rotating students.
6. The rotating students ask questions and take notes in preparation for reporting back to their home groups. Each visitor makes one specific comment on the work he or she has been shown and thanks the home-group student for the presentation.
7. Students all move back to their home groups.

a. The home-group student who did not rotate reports to the other students on the rotating students' comments on the work.
b. Students 1, 2, and 3 now report on what they observed in the other groups, noting similarities and differences with their own work.
c. The students discuss their work further.

At this point it might be good to stop and ask participants to form groups to discuss the strategies they have just covered. They should check for understanding and ask questions if anything is unclear. Then they should discuss how these strategies may work in their own content area classes.

Exercises That Elicit Opinions and Independent Inquiry

Value Line

1. The teacher poses a question on which answers may vary along a continuum.
2. Each student considers the question alone and may write their answers.
3. The students seek to line up in an order that reflects their position on the question. To do so, they must discuss with other students in the line their responses to the question.
4. Students may continue to discuss their responses with the students on either side of them.
5. As an option, the formed line may be "folded in the middle," so that students with more divergent views may discuss their responses.

Academic Controversy

1. The teacher prepares statements for discussion that are likely to elicit at least two justifiable positions from students.
2. Students are assigned to groups of four.
3. Within the groups, pairs of students are assigned a position on the issue that they must defend.

4. The pairs list reasons that support their position.
5. The pairs temporarily split and form new pairs with classmates who are defending the same positions. They share the reasons listed by each of the original pairs in support of the position.
6. Students return to their original partners and make a position statement supported by reasons: "We want to argue for _____ because of X, Y, and Z..."
7. Each pair presents its argument to the other pair within their group who listens and takes notes.
8. The two pairs then debate.
9. As an option, the pairs within each group may switch positions and repeat steps 4 though 8.
10. Finally, the students stop defending all views and construct a position on which they can find consensus, supported by the best reasons from the previous discussion.

Group Investigation

1. The teacher (or the class) chooses a motivating and personally interesting major topic for the class to investigate. The topic should support investigation from many angles or in several parts. (Before launching the topic, the teacher should assemble sufficient resources to support the investigation.)
2. The teacher introduces the topic and displays the preliminary collection of resources.
3. The class members review the resources, raise questions for investigation, and divide the topic into subtopics.
4. As an option, the students may brainstorm and discuss, with the teacher's participation, other sources of information on the topic.
5. The students sign up or otherwise organize themselves into research groups and plan their investigations. The teacher circulates among them and may request a written proposal for the investigation.
6. Members of each group come together as a steering committee to ensure the pieces of the investigation form a coherent coverage of the topic.
7. The students carry out their investigations over a period of time ranging from minutes to days. The teacher passes among the

groups to help them investigate their topic and to ensure every student has a responsible role in the work.

8. The groups plan a presentation to make to the whole class. They decide on their most important findings. The presentations should be active and interesting, and all the members of the group should be involved. The presentations may involve short explanations, graphic displays, or may be a chapter of a class book.
9. The groups make their presentations.
10. The groups discuss their work.

Roles Students Play

Within each group, roles students play may be task oriented or group-maintenance oriented, or both. Because students should become adept at behaviors related to both main roles, teachers sometimes assign students to explicit roles within groups, such as those listed.

Checker:	Makes sure everyone understands the work in progress.
Scout:	Seeks needed information from other groups or occasionally from the teacher.
Timekeeper:	Keeps the group focused on the task and enforces the time limits.
Active listener:	Repeats or restates what has been said by others.
Questioner:	Elicits ideas and task-oriented contributions from all members of the group.
Summarizer:	Draws together the group's conclusions so that they make sense as a whole.
Encourager:	Congratulates, helps, and encourages every member of the group.
Materials manager:	Distributes and collects needed materials for the group.
Reader:	Reads any written material to the group.

Calling attention to the roles in isolation is done to help the students become conscious of the need to play that role. Note, however, that students should rotate among roles from activity to activity, since the goal is for students to become adept at playing all of these roles simul-

taneously. Additional roles may be invented as needed. For example, there may be a Reporter who reports the group's findings to the whole class, or a Gadfly who suggests alternatives to the group's solution.

Skills Required for Working in Groups

Teachers cannot assume that students will possess and practice the skills needed to make their work in cooperative learning groups go smoothly. Since one of the goals of having students working in cooperative groups is to have them learn to work amicably and productively with others, time invested in teaching the skills of cooperation is time well spent.

Teaching the Skills of Cooperation

Explain why cooperation is important in school and in the world.

Explain each skill you want them to use, and show how and when to use it.

Watch and listen to the students as they work in groups, and take notes on the students' use of the skill.

Talk to the students about their use of the skill. Encourage them to think about how the skill made their group work go better, and how they might improve their use of the skill.

Provide more opportunities to use skills so that students become comfortable with them (Baloche, 1998).

Again, it may be useful to have participants form small groups to discuss these strategies, which have been presented briefly. The various groups should try to develop a content-related example to share with the whole group that would provide greater context for understanding the strategies. Obtain concrete examples from several content areas.

PARTS V & VI PLANNING FOR IMPLEMENTATION AND FOLLOW UP

Planning for Implementation

At the end of this course, it will be important for participants to develop specific implementation plans for their classrooms. Ultimately, each participant must have their own plan and be responsible for implementation in their own setting. However, as we know from cooperative learning classrooms, planning often is accomplished better in small groups first. It is suggested that planning teams be formed by grade or content areas for discussion and general brainstorming about how to implement cooperative learning strategies and techniques.

After the group has explored a number of implementations, individual teachers should begin work on their own plans. In some cases, it may make sense for teachers to work in pairs to plan jointly, especially if they teach at the same grade level. The results of planning time will be a detailed written plan for how implementation will be accomplished. It should identify specific strategies as well as the content to be covered.

Planning for Follow Up

Participants will need support and feedback for their implementation efforts. It is important to plan for discussion and feedback sessions between workshop programs. Specific dates for these activities should be identified. Participants should plan when they will implement (remember to encourage participants to implement the strategies on many occasions—not just once), and set dates for convening the monthly meetings for follow-up discussion. Participants at the monthly meetings should be prepared to discuss the following:

- How did the implementation go?
- What were the successes or most successful parts?
- What failures or difficulties were encountered?
- How did students respond?
- How might you do it differently next time?
- How would you gauge the level of student interest in learning?
- How did the lesson feel? Did it feel right or were there times that felt difficult or cumbersome?
- How many times was implementation attempted?

Participants should be encouraged to share their experiences in small groups and then share with the larger group. Discussion should be encouraged regarding successes and failures and how procedures might be modified to fit local culture, circumstances, and teacher preferences.

PART VII COURSE EVALUATION

Final Evaluation

At the conclusion of the workshop, set aside time for two kinds of evaluations: a free write and completion of an evaluation form.

Before beginning the evaluation process, review with participants the importance of evaluation and explain that their responses are taken seriously and are an important part of the course. In this way, participants shape the future of the course so it will better address their needs and context.

Free Write

Distribute paper to the participants. Ask them to write for 10 minutes about the workshop they completed. Have your translator write on the chalkboard or transparency:

What are your thoughts on the workshop you just completed?

Evaluation Form

Distribute the evaluation form on the next page and ask the participants to complete it.

Evaluation Form

Name of Workshop: _____

Date and Place: _____

Questions:

What in the workshop was most valuable to you?

_____

_____

_____

To what extent did this workshop meet your expectations?

1 2 3 4 5
very little met all expectations

What would have made this workshop more meaningful?

What changes will you make in your teaching as a result of this workshop?

What was your overall impression of this workshop?

1 2 3 4 5
little value great value

Please suggest topics you would like to see in future workshops.

Please make any general comments on the workshop.

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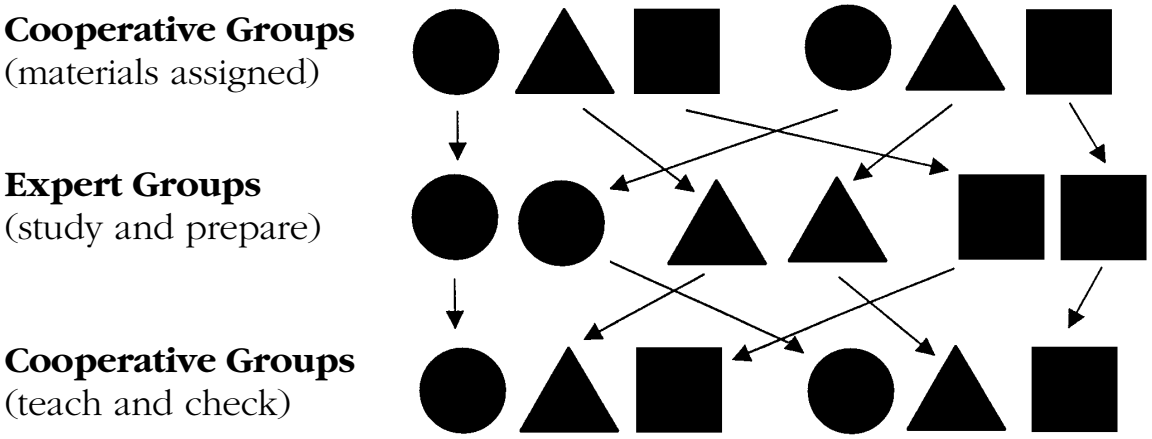
APPENDIX A

Jigsaw Schemata

Cooperative Jigsaw structures (e.g., Aronson, 1980; Johnson, Johnson, & Holubec, 1993; Kagan, 1992) are basically characterized by teammates within a cooperative group each becoming expert on different aspects of one topic of study. For example, if a cooperative group is studying the topic of "Japanese Culture," one teammate could become an expert on "traditional values," another an expert on "government structures," and the third an expert on "current issues." After developing individual expertise on the assigned subtopic, teammates take turns teaching one another. The cooperative group goal is that all teammates master all aspects of the major topic.

Before presenting and teaching to the cooperative group, students from expert groups composed of individuals from different cooperative groups who have the same assigned subtopic (e.g., two students from different groups studying "current issues" would meet as expert partners on that subtopic). Together, expert partners study their subtopic and plan effective ways to teach important information to their cooperative groups when they return. After teaching and checking take place back in cooperative groups, individual mastery of the topic is evaluated (e.g., students respond when called on during whole-class questioning, write individual exams, or draw individual concept maps). The following diagram illustrates the basic jigsaw process.



APPENDIX B

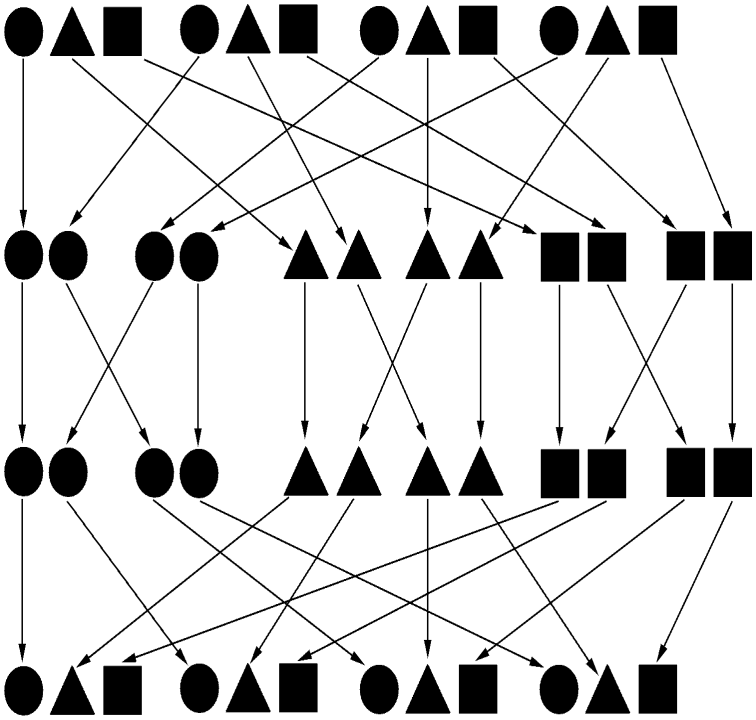
Jigsaw Variation

Cooperative Groups
meet and each teammate is assigned different material to learn.

Preparation Pairs
meet and students with the same assigned material read and prepare together to teach their material.

Practice Pairs
meet to rehearse and fine-tune presentations as well as gain additional ideas from one another.

Cooperative Groups
reconvene and teammates take turns presenting and teaching their material to one another.



Mastery
is assessed through whole class debriefing, oral quizzing, individual exams, and class presentations.

Adapted from Johnson, D.W., Johnson, R.T., & Holubec, E.J. (1990). *Co-operation in the classroom* (Rev. ed.). Edina, MN: Interaction.

APPENDIX C

Basic Jigsaw

Step 1: Arrange cooperative groups and assign material

Within each cooperative group, teammates are assigned different material to learn and present to one another (e.g., the first teammate is assigned page l, the second teammate is assigned page 2, and the third teammate is assigned page 3).

Step 2: Expert groups study and prepare presentations

Expert groups are formed by pairing students with the same assigned material (e.g., the person in Cooperative Group A who was assigned page 1 will meet with the person in Cooperative Group B who was assigned page 1). Expert partners read and study their material together, plan effective ways to teach their material, and plan ways to check for comprehension of cooperative group teammates.

Step 3: Return to cooperative groups for teaching and checking

Individuals return to their cooperative groups and take turns presenting their material to one another. The team goal is for all group members to master all the material presented.

Step 4: Individual and group accountability

Groups are accountable for ensuring that all members master all of the material. Individuals may be asked to demonstrate mastery in a variety of ways (e.g., by writing an exam, responding orally to random questions, or making a presentation on material taught by teammates).

APPENDIX D

(Please note: This article has been subdivided for demonstration purposes. It is not necessary to reproduce the text when applying the various methods to text in your textbooks. Simply orally identify breakpoints so students will be clear what parts they are to read.)

Halloween Thought: Bats Are Beautiful and Do Good Deeds

Ken Wells

Section 1

Bats are creepy. Bats are ugly. Bats get tangled in your hair. Bats spread lots of diseases. Turn your back and bats will suck your blood.

"People think those things," says Merlin D. Tuttle. "But bats are probably the most misunderstood creatures on the face of the earth."

Mr. Tuttle, among a few dozen of the world's scientists, who seriously study bat biology, should know. He has traveled the globe investigating bats. He has braved nights in jungles, scaled mountains, climbed trees and wandered deep into caves just to get to know bats better.

Bats, Mr. Tuttle concludes, not only have enormous scientific value—current bat research holds promise for improving birth control, fighting cancer and treating speech defects—but also are often highly intelligent and easily trained. Some large, fruit-eating bats, raised as pets, have shown the affection and loyalty usually associated with the family dog.

Experts in Sonar

The 41-year-old Mr. Tuttle, who earned a doctoral degree studying the winged mammals, adds, "Bats have mastered the night sky like dolphins have mastered the sea." The bat's sonar navigation system, known as echolocation, is so advanced, in fact, that it goes beyond current scientific understanding.

But new, intriguing knowledge that casts more favorable light on the shy, nocturnal creature hasn't seemed to help the bat's rather gloomy public reputation. Because of fear and ignorance, millions of bats all over the world are being needlessly destroyed, Mr. Tuttle says. A few species already are extinct, and several more are on the endangered list, he adds.

But Mr. Tuttle and other friends of the bat are striking back. They formed Bat Conservation International, a group that intends to boost bats globally. The organization recently helped set aside a preserve for Britain's endangered horseshoe bats; it began ambitious efforts to preserve bat-cave habitats in the United States, and it is lobbying for increased private and public spending on bat research.

Section 2

But a large part of Bat Conservation International mission will be to handle the bat's public relations.

"An important part of our job is to rehabilitate the image of the bat," says Stephen Kern, the organization's sole employee.

Currently, Bat Conservation International, based at the Milwaukee Public Museum, where Mr. Tuttle is the curator of mammals, is rich in aspirations, if not in money or members. But the group already has struck on the pro-bat propaganda front, publishing a pamphlet that obviously reflects Mr. Tuttle's attitude toward bats.

Among the pamphlet's bat stats:

- Bats, for their size, are the world's longest-lived mammals, with some species surviving 30 years or more. ("If humans could duplicate bat physiology, we'd all live to be as old as Methuselah," Mr. Tuttle says.)

- About 1,000 bat species exist. They amount for about one fourth of the world's mammal species. An estimated 70 million bats living in a series of caves near San Antonio, Texas, are probably the largest concentration of vertebrates on the planet.

- The world's smallest mammal happens to be a variety of bat the size of a bumblebee. It lives in Thailand.

- One species of bat almost single-handedly pollinates a $90 million fruit crop in Asia. Bats may be the most important seed-dispersing animals in some tropical rain forests.

- Bats eat bugs by billions. A single gray bat, an American species considered endangered, eats about 3,000 insects a night. A 20-million-member colony of Mexican free-tail bats in Texas eats about 250,000 pounds of bugs in a single feeding cycle.

- Bat guano mined from caves is a major source of fertilizer in numerous developing countries. It helps grow about one third of the world's black pepper.

- Bats are considered quite edible in Asia and Africa and throughout the Pacific. A good bat dinner in a nice restaurant on the island of Guam will cost you $25.

Section 3

Mr. Tuttle doesn't eat bats, but he thinks the fact that others do shows that bats have a usefulness not usually ascribed to them, particularly in Western culture, where bat phobia is most rampant. Bats in America, Europe and Latin America, he adds, suffer persecution more than bats in other parts of the world, principally for two reasons: the Dracula-vampire syndrome and overblown fears that they spread disease, particularly rabies.

Dracula, says Bat Conservation's Mr. Kern, is all literary and movie hype. The 14th-century Romanian nobleman upon whom the legend is based seems to deserve a bad reputation, considering his penchant for impaling unruly peasants on long wood stakes. But the bat seems to have just got dragged haplessly into the tale, since there were and are no blood-sucking bats in all of Europe, Mr. Kern says.

Still, the legend was so persistent that Spanish conquistadors got to the New World expecting to find a blood-sucking bat. When they did, they named it the "vampire," after its fictitious Transylvanian cousin.

The Blood Suckers

Of the three species of blood-sucking bats found in Central and South America, only one is prevalent enough to be considered a dangerous pest. But "it's just a little fellow—about three to four inches long" and clearly prefers cattle to people.

"To judge all bats by the vampire is the same way people used to shoot every hawk they saw because one hawk stole the chicken. Most

people treat hawks better than that now, but today all bats suffer because of the vampire's bad reputation," Mr. Tuttle says.

Rabies is a more serious problem, Mr. Tuttle concedes, but even the rabies threat in bats is slight compared with other wild animals such as skunks, raccoons and foxes in particular. And even compared with household dogs and cats. Of 28 confirmed rabies cases in the United States since 1963, only five have been traced to bats (dogs were the main culprit). And even some of these bat cases are "suspect as to origin," says Denny Constantine, a veterinarian for California's public health service. In Asia, where rabies control is poorer, only a single case of human rabies has been linked to a bat bite since records have been kept. But 15,000 cases have been linked to dogs, Mr. Tuttle says.

Moreover, Mr. Constantine says, "bats don't go through the aggressive stage of rabies," meaning they don't usually attack people or other animals unless harassed or touched. So to avoid problems, Mr. Constantine suggests staying away from sick or injured bats or those acting peculiarly.

Section 4

The Ugliness Issue

But on a clear, warm California morning, Philip Leitner has his hands all over bats. Mr. Leitner, a professor of biology at St. Mary's College near San Francisco, is an avid bat hobbyist. He has driven out to a barn in California's wine country to collect a few so-called pallid bats for an upcoming science exhibition.

These tiny, pale brown bats, like most bats, are insect eaters by night and sleepers by day. After climbing into the darkened loft where the bats roost, Mr. Leitner deftly shakes a few into a net and brings them down into the light of day, where an essential question of the bat debate is being discussed: Are bats really ugly?

Whimsical as the question is, Mr. Leitner doesn't mind offering an opinion. An elemental requirement of a bat fancier, he says, is to be someone who "doesn't take himself too seriously." Mr. Leitner, whose fascination with bats goes back to his childhood, thinks these bats "are kind of cute."

Actually, they are. On close inspection, pallid bats have endearingly large ears and a kind of friendly, canine face. The pallid bat, Mr. Leitner

says, is an ordinary-looking bat. He once saw a rare spotted bat that even the most grudging bat-baiter might agree is "spectacular," he says.

Beauty and the Bat

Ask Mr. Tuttle about bat beauty and you get an earful. A crested bat has colors rivaling a peacock's, an African signing bat sports colors so striking that he calls it a "gorgeous little beast."

Most people, Mr. Tuttle says, don't get to see bats in all their beauty. In zoos, bats are usually displayed under unflattering infrared lights to simulate their cave environment, although many bats can tolerate a little daylight, according to Mr. Tuttle. So one campaign of Bat Conservation International will be to persuade zoo keepers to get bats out of the spooky glare of infrared and into the more flattering light of day, Mr. Tuttle says.

Bat beauty, Mr. Tuttle says, is more than skin deep. Though he has studied bats since he was a teenager, he says he continued until recently to underestimate the bat's intelligence. But a certain Panamanian frog-eating bat helped change his mind.

The bat, Mr. Tuttle recalls, was a captive that quickly adapted itself to researchers by learning to take frogs from their hands. That done, Mr. Tuttle then hoped to coax the bat to begin swooping on frogs placed in a mock pond, where its tactics could be studied more closely. But the bat, by then, "already was too clever for that," preferring instead to beg frogs from the researchers, Mr. Tuttle says.

So Mr. Tuttle released the bat and marched a couple of miles through the jungle contemplating how to capture another.

And who should follow? "Our bat flying out of the jungle, trying to land on our hands," Mr. Tuttle says.

From *The Wall Street Journal*, (1983, October 27).

APPENDIX E

(Please note: This article has been subdivided for demonstration purposes. It is not necessary to reproduce the text when applying the various methods to text in your textbooks. Simply orally identify breakpoints so students will be clear what parts they are to read.)

The Heart Beat

Robert I. Macey

Section 1, Part A

(1) Like any muscle, the heart can be stimulated, and it will conduct action potentials. In many ways, it behaves like a skeletal muscle, but there are some exceptions. Skeletal muscles contract only if they receive some external stimulus. Ordinarily, the stimulus is a nerve impulse leading to the muscle. This is not true of the heart muscle, which seems to be capable of exciting itself. Even if we cut all the nerves leading to the heart, it will continue to beat. This capacity for self-excitation is common to all heart tissue.

(2) If we remove the heart of a cold-blooded animal (a frog, say) place it in a dish, and cover it with Ringer's solution, the heart continues to beat—even when it is completely disconnected from the body. If we now cut the heart into pieces, even the pieces continue to beat. However, some pieces beat faster than others. Those from the upper parts of the heart (the *atrium*) beat faster than those from further down (the *ventricle*).

Section 1, Part B

(3) We do not know what causes this built-in rhythm of the heart. In a normal heart, the various parts do not beat at different times and with independent rhythms. This is because there is an excellent conduction system in the heart. The first piece of tissue that becomes excited generates an action potential. The action potential is then quickly

transmitted to all parts of the heart, exciting the entire tissue. As a result, the entire heart beat is coordinated, pumping with maximum force, and sending the blood surging into arteries.

(4) Figure 1 shows the heart in more detail. In addition to being divided into a right and left side, each side is subdivided into two chambers—the atrium and the ventricle. At the rest, the atrium serves as a storage depot for blood returning from a veins toward the heart. When the heart begins its beat, the atrium contracts first. Although it may help fill the ventricles with blood, it plays a very minor role in the pumping of blood. A moment later the ventricles contract, sending the blood into arteries. The ventricles contribute most of the pumping action in the heart. The right ventricle is responsible for pumping blood through the lungs; the left ventricle is responsible for pumping blood through the rest of the body.

Section 2, Part A

One-Way Flow

(5) When the heart muscles contract, why isn't blood squirted backward into the veins as well as forward into the arteries? And when the heart relaxes, why doesn't blood flow into it from the veins and arteries?

(6) Imagine that the heart is transparent and that we can watch the action of blood flowing in and out of it (Figure 1). First we see the heart at rest and notice valve flaps between the atrium and ventricle (A–V valves) on each side of the heart. Blood is pushing down on them from above. Below the flap there is very little pressure, because the heart is relaxed. This means that the pressure of the blood from above pushes the flaps open and fills the ventricle.

Section 2, Part B

(7) Now the muscles in the walls of the heart start pumping. They begin contracting and squeezing the blood in the ventricles. This is the time when we might expect blood to flow back into the veins through which it entered , but as we watch we notice something happening to the valve flaps. The pressure below the flaps is now much greater than

that above. This forces the flaps of the valve toward one another until they close up tight. Blood cannot push its way back into the atria. Instead, it is forced into the arteries. The opening into the arteries is guarded by two other sets of valves, located between the ventricles and their arteries. When the heart was at rest, these valves were closed tight. The pressure in the arteries was greater than the pressure in the ventricles; this kept the valves shut and prevented blood backing up from the arteries into the ventricles. (Notice that the flaps of these valves do not hang down into the ventricle like A–V valves. Instead, they point upward into the arteries.)

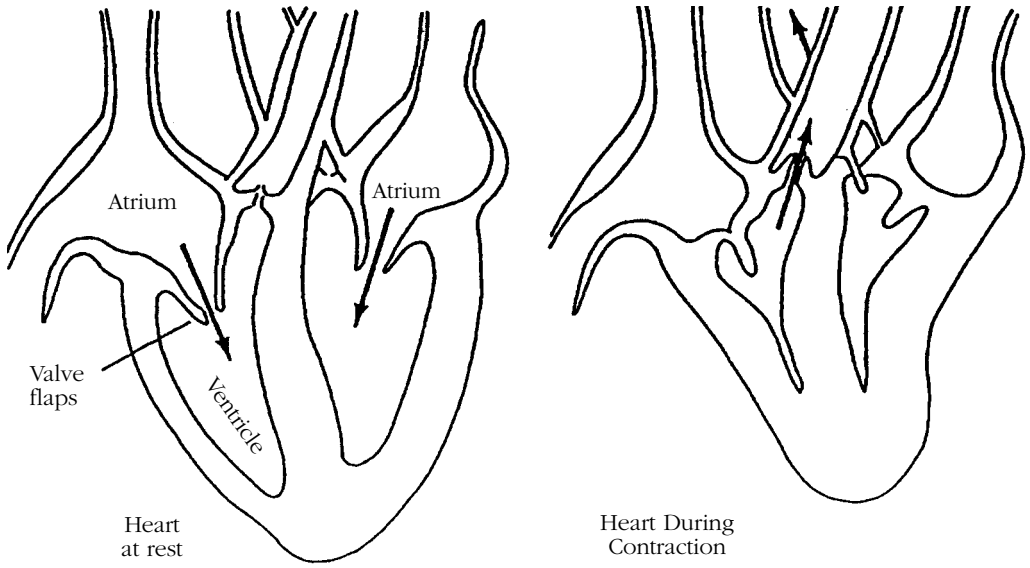


Figure 1. Blood flows into the heart from the veins when the heart is at rest. When the heart contracts, blood is forced into the arteries. Valves in the heart prevent blood from flowing in the reverse direction.

When the heart makes its pumping stroke, the high pressure of the blood in the ventricle pushes on the flaps of the valves guarding the arteries and forces them open. Blood now flows through the open valves, because the pressure of blood in the ventricle is now greater than the pressure in the artery. Each time the valves open and close they produce a sound. If you listen closely to your heart beat, you hear two distinct sounds: "lub-dup." The first sound corresponds to closure of the A–V valves, the second to snapping shut of the valves between the ventricles and arteries. When these valves are damaged, the sounds change. For example, damaged valves between the left ventricle and aorta convert the sound to "lub-shh."

Section 3, Part A

Cardiac Output

(8) The amount of blood pumped by the heart is staggering. When you are at complete rest, your heart pumps enough blood to fill four automobile gasoline tanks each hour. Let's break this down into more precise figures. During rest, the heart beats about 70 times per minute. During each beat, each side of the heart pumps roughly 70 ml of blood. The amount of blood pumped during each minute would then equal 70 ml per beat × 70 beats per minute, or 4,900 ml per minute (almost 5 liters, or 5.25 quarts, per minute).

(9) The amount of blood pumped by each side of the heart during each minute is called the cardiac output. During activity, the cardiac output changes. When you exercise strenuously, your cardiac output may rise to as much as 25 liters per minute. When a trained athlete exercises, his output may go as high as 40 liters per minute.

Section 3, Part B

(10) The cardiac output is controlled in part by nerves of the autonomic nervous system. Impulses carried by sympathetic nerves to the heart tend to increase cardiac output by increasing both the rate of the heart beat and the strength of each beat. Impulses carried by the parasympathetic nerves to the heart tend to decrease cardiac output by slowing the rate of heart beat.

Section 4, Part A

Coronary Circulation

(11) Blood leaving the heart enters the aorta enroute to the organs of the body. The heart itself is one of these organs and its thick muscular walls must be supplied with fresh blood. This is accomplished through the coronary circulation. You can see from Figure 2 that coronary arteries arise from the base of the aorta and send blood back into the walls of the heart. These vessels branch into smaller arteries and capillaries which are imbedded in the heart muscle and, finally, blood is conveyed into the right atrium primarily through a large vein called the *coronary sinus*.

(12) When one of the coronary vessels becomes occluded, the por-

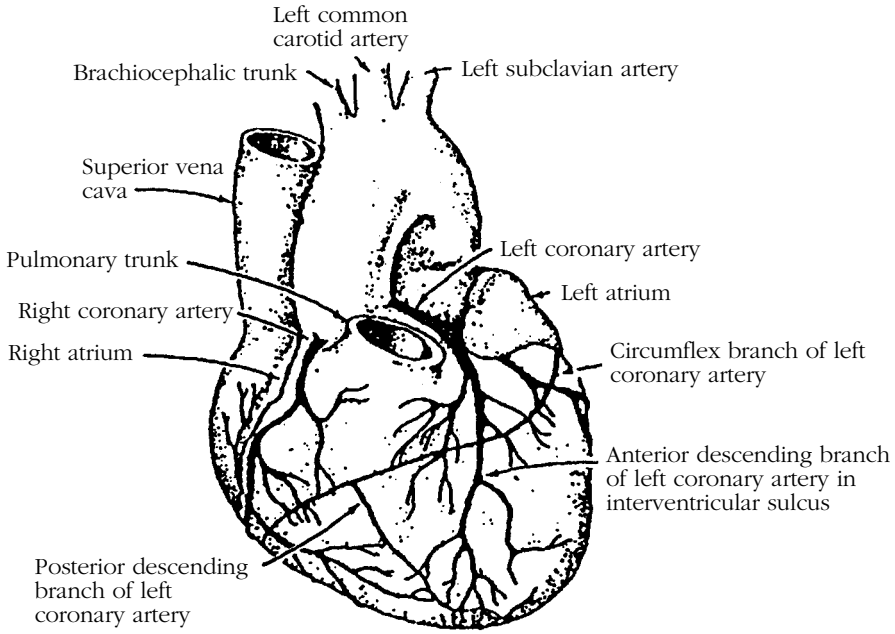


Figure 2. The coronary arteries.

tion of the heart supplied by that vessel is deprived of oxygen and energy sources and it stops contracting. This is what we call a heart attack. When a large portion of the heart is involved it will no longer pump enough blood for survival. Coronary occlusion is responsible for about 30 percent of all deaths.

Section 4, Part B

(13) Coronary occlusion often results from a disease called *atherosclerosis* in which fatty substances containing large amounts of cholesterol are deposited in the walls of arteries. In later stages of *arteriosclerosis*, fibrous tissue and calcium compounds intermingle with the fatty deposit so that the vessel walls become more rigid; this is called *arteriosclerosis* (hardening of the arteries).

If the fatty deposits break through the inside lining of a blood vessel, they form a surface on which blood can clot. The vessel may become occluded at the site where the clot has formed or the clot may break loose only to occlude another vessel downstream. Death occurs if a coronary occlusion is severe. If only a small coronary vessel is involved, the heart is weakened but may improve with time as connections with neighboring blood vessels enlarge to supply new blood.

APPENDIX F

(This article has not been subdivided. Before beginning, decide where it should be divided.)

Corn or Maize: What Good Is It?

People cannot agree on its name. It yields a food of low nutritional value to humans. Yet this plant is essential to the world's food supply, and is often highly profitable to growers. How can this be?

Known to science as *Zea mays*, the corn of the United States, Canada, and Australia is referred to in South Africa as mealies. In England the word "corn" refers to wheat, and in Scotland and Ireland it refers to oats.

For Humans, or For Animals?

For humans, corn is less desirable nutritionally than for livestock. The protein value is of low quality, and corn is devoid of niacin one of the B-vitamins that is essential to humans. People who rely heavily on corn in their diets are subject to such niacin-deficiency diseases as pellagra. Corn cannot be used to make leavened bread, although it is much used in Latin America to make dough for such flat breads as tortillas.

Animals, however, can thrive on corn, which is why it is the most popular diet or diet supplement for cattle, hogs, and chickens—and even for pond-raised catfish. Most of the corn the farmers grow is the coarser kind called field corn. It is not grown for people to eat. Out of every 100 bushels grown, farmers store about 90 bushels in silos or in bins for feeding livestock. Thus a large part of the world's corn harvest never reaches the grain market.

Besides feeding animals, corn has an amazing variety of uses, both in and out of the food chain. In North and South America (unlike Europe and Asia, where corn is usually not eaten), manufacturers make corn meal, breakfast foods, and hominy from the whole kernels of corn. Distillers make alcohol and whiskey from whole corn kernels.

What Is In a Kernel of Corn?

A kernel of corn is wrapped in a tough, fibrous outer hull called bran. Inside the bran is the germ, from which the new plant develops. Around the germ is a food supply, which is mostly starch. When the kernel germinates it draws its nourishment from the starch until it can put forth roots and leaves and get food from the soil and the air.

Besides the moisture content, about 80% of a corn kernel is starch (carbohydrates). About 10% is gluten (protein), found in a shallow layer just under the hull. The remainder is fat or oil in the germ (4.5%), fiber in the hull (3.5%), and minerals (2%). Food processors have been able to use these different parts of the corn plant for very specific purposes.

By wet-milling corn, processing plants are able to make a great variety of products from different parts of the corn kernel. Wet milling is so called because the kernels are steeped in tanks of water to soften them, and water is used in the processes that separate germ, gluten, and starch.

The Many Uses of Corn

From the germ, refined and crude corn oil are extracted; and these have many uses as human and animal food and in industry. After the oil is pressed from the germ a hard cake is left, which is ground into stock feed.

Gluten is the next product to be separated out, and it yields a protein called *zein*. A synthetic fiber is made from it. Zein is also used in lacquer, plastics, textile colors, and printing inks.

The final product of the wet-milling separation process is starch. Household cooks, food manufacturers, and laundries have many uses for cornstarch. Paper manufacturers use more starch than any other industry to toughen and size paper ("size" means to fill its pores and give it a smooth surface). Textile manufacturers are second. Cotton and synthetic yarns and fabrics are sized (or filled out) with starch.

A huge amount of starch is converted into corn syrups (glucose), sugars, and dextrin by cooking and chemical treatment. These too have countless uses in cooking and in various industrial processes. Even the steep water in which the kernels are soaked is important. Evaporated to a thick, soupy liquid, it is used as a food for the molds that produce penicillin and other wonder drugs.

Corncobs are ground for a coarse livestock feed. They are used also in a polishing powder, insulation, and a form of sandblasting. Furfural, an oily liquid extracted from corncobs, goes into man-made fibers, drugs, and solvents. Some specially grown cobs are made into pipes for smoking.

Millions of tons of cornstalks are made into a rubber substitute, maizolith. A large quantity is used for making paper and wallboard. Even the gases from fermenting corn are used to make methyl alcohol. Ethanol, another corn by-product, is used as a clean-burning motor fuel.

Where Did Corn Originate?

The corn or maize plant puzzles botanists because they cannot find its wild ancestors. The Native Americans cultivated corn. But even in the time of Columbus, corn could not take care of itself like a wild plant or a recent descendant of a wild plant. The greatest weakness lay in the way corn produces its seed. The top of the stalk has a many-spiked tassel which grows pollen. The plant also has ears with filaments called silks which receive pollen. But the ears are completely wrapped with leaves, and the ends of the silks protrude only from the tips. Therefore the silks cannot get ample pollen unless the plants have many neighbors, as they do in a cultivated field. Botanists think that the plants could hardly survive in the wild state. Corn was apparently unknown in ancient times in the Old World. No evidence of it has ever been found in archaeological remains. There is no reference to it in the Bible or other ancient literature or in primitive art. The word corn in the Bible refers to wheat, not the American maize.

In the New World, however, all the principal types of corn that scientists recognize today were already in existence and under cultivation when the first explorers arrived. The wild ancestor of corn probably came from the Western Hemisphere.

Some botanists think the plant may be descended from teosinte, a grass that grows wild in Mexico and Guatemala. Another theory is that it originated in South America from a primitive pod corn which was also a popcorn. Pod corn kernels are enclosed in pods or chaffy shells. Such a wild corn has not been found.

How Experimenters Developed Hybrid Corn

In 1905 George H. Shull and Edward M. East began developing new kinds of corn by placing pollen from one desirable strain of corn onto the silks of another strain. The process produced crossbred strains called hybrid corn. After World War I, Henry A. Wallace (who became U.S. Secretary of Agriculture in 1933) and Lester Pfister began hybridizing experiments. By 1926 they had made hybrid pollination completely workable.

The hybrid plants are remarkable growers. They commonly grow to be 18 or 20 feet tall; some have grown as high as 28 feet. A more important factor is that they have added millions of dollars to the income of corn farmers.

Before farmers had hybrid corn, an average acre of corn yielded 30 bushels. But farmers had to spend the money they received for 25 bushels to pay their costs for each acre planted, leaving only 5 bushels an acre for profit. Hybrid corn has raised the national average to more then 95 bushels an acre. Some states average more than 130 bushels an acre.

A hybridizer produces hybrid seed by first inbreeding. This fixes desirable qualities in the seed. He covers the ears of selected plants to keep airborne pollen from the silk. Later, he takes pollen from the tassels of a plant and dusts it on the silks of the same plant. After inbreeding each strain for several generations, he starts crossbreeding. He takes pollen from the tassel of a plant having one desirable strain and dusts it on the silk of a plant with some other strain. The crossbred product, or hybrid, has the qualities of each parent strain.

Next comes double-crossing. The experimenter dusts pollen from one hybrid onto a hybrid with two other strains. The seed from this cross produces a super corn with four strains bred in. This corn is sold to farmers as seed. Their crop cannot be used as seed next year because hybrid corn is not self-perpetuating. Farmers must buy new seed each year. Great use of hybrid corn threatens the supply of corn pollinated naturally. This loss would restrict improving hybrid strains and prevent developing new ones. To preserve seed of native varieties, the government of the United States stores seed in corn banks.

Where Corn Grows, and How

Corn will grow wherever it has suitable soil, freedom from frost and cold nights, and plenty of hot sun when it is maturing. It also needs ample soil moisture during the hot season.

These conditions are found in much of North, Central, and South America, around the Mediterranean, in India, and in South Africa. The largest producers of corn are the United States, China, and Brazil. Other large corn-producing countries are Mexico, Argentina, France, Hungary, and Italy.

Corn draws heavily on the plant food in the soil. Production is higher when corn crops are rotated on a 3-year cycle. The first year a legume, such as alfalfa or sweet clover, builds up the soil with nitrogen and humus. The next year corn grows tall on these, its favorite foods. The third year a small grain is planted. Then the cycle is renewed with a legume.

More than 350 insect pests attack the grain. The most destructive are the corn-ear worm, the European corn borer, and the corn rootworm. Fungus growths, such as smut and various rots, are costly foes. In most cases insecticides are too expensive to be practical. Therefore the farmer uses the less expensive methods of clean culture and crop rotation. Clean culture means harvesting or destroying every part of the plant. Careful farmers either burn or plow under the stubble. This rids the cornfield of pests that live above the ground. Crop rotation suppresses root pests that live on corn by depriving them of food for 1 or 2 years.

Known Varieties of Corn

American Indians had many kinds of corn, and there are now more than 1,000 named varieties. The smallest is the golden thumb popcorn plant, about 18 inches (46 centimeters) high. Some varieties have only 8 rows of kernels; others, as many as 48 rows. Colors include white and shades of yellow, red, and blue.

The chief types of corn are pod, soft, sweet, pop, flint, and dent corn. Pod corn has each kernel enclosed in a pod or husk. Soft corn is used for corn flour and for roasting ears. Sweet corn has the smallest amount of starch; popcorn, the highest. Flint and dent corns lead all other varieties on the grain markets and for livestock feeding.

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