

Falk, H., Brill, G., and Yarden, A. (2003). *The Secrets of Embryonic Development: Study Through Research*. (A teacher guide, The Amos de-Shalit Israeli Center for Science Teaching, grades 10-12).

### **Short summary of the main features**

This teacher guide is aimed to assist the teaching of an adapted-primary-literature (APL) based developmental biology curriculum, in the framework of the high-school biology majors program in Israel. Learning through APL requires novel and challenging modes of teaching, as high-school biology teachers' use of scientific articles in class is almost exclusively limited to secondary literature. Besides coping with new content knowledge, teachers are concomitantly faced with the promotion of skills which are associated with learning through research articles. Thus, the teacher guide is aimed to convey our perspective on the pedagogical content knowledge (PCK) that we consider adequate for the teaching process.

The guide contains the following textual information:

1. An introductory section entitled: "Why and how to teach through research articles". This section presents the developers' opinion about the need to expose the students to research articles and their recommendations about possible means to teach through adapted primary literature;
2. Remedial measures for the difficulties encountered by the students;
3. Activities aimed at enhancing the understanding of different forms of scientific communication;
4. A list of the main biological principles of the articles;
5. Assessment questions from matriculation examinations.

The guide is accompanied with a CD-ROM that enabled us to present the teachers with:

1. Authentic teaching episodes;
2. Visual models of molecular topics;
3. A gallery of all the pictures in the student's book in a format that allows their use for presentations in the classroom;
4. Web-quest assignment in bioethics;
5. A pool of questions and activities to the introductory section of the curriculum and to the research articles.

The sections of the guide that we consider most relevant to the process of studying through APL and which were purposely developed in order to provide support for this novel mode of teaching biology in high school in Israel, will be described below.

**Teaching strategies:** The teaching strategies presented to the teachers in the section "Why and how to teach through research articles?" were previously described in detail (Yarden *et al.* 2001). The main strategy we developed is the "conversational model" based upon an iterative process of constructivist discourse between the students and the article, according to the following stages:

1. The article is read in class, section by section. The students raise questions on each section of the article.
2. Some of the questions are answered by the students by reading the following section.
3. The students make predictions about key elements of the research (research questions, results, suitable methods, conclusions) before reading about them in further sections of the article.
4. This study process can be repeated for each section of the article.

Other teaching strategies proposed are peer-group cooperative reading, answering questions, and jigsaw-groups presentation of different methods or experiments from the article. The teachers are guided to choose the strategy that suits them best or to use any strategy they feel would suit their pedagogical aims. Only two main recommendations are given: (a) to proceed gradually, using more guided strategies at the beginning of the teaching process and moving toward strategies that offer the student more independence, and (b) to vary the teaching strategies as much as possible.

**Authentic teaching episodes:** The video taped teaching episodes, lasting from 3 to 10 minutes are subtitled and accompanied by the following texts:

1. Description of the background of the recorded episode: school, class grade, previous articles studied by the students, the aim of the study session and the teaching sequence of the session including the recorded episode;
2. Description of the episode: stage-by-stage description of the events occurring during the episode, without any comments (e.g. "The teacher waits for a long time before the first student answers");

3. Pedagogical comments on some of the main didactic and cognitive processes which occurred in the episode. The teachers are explicitly told that these comments solely reflect the authors' view and they are prompted to elaborate upon their own interpretation of the events whenever they feel it necessary.

4. Open questions, asking the teachers to compare the interventions in two or more episodes, or to elaborate on alternative teaching strategies.

The episodes can be watched without viewing the accompanying texts or concomitantly with the scrolling of one of the texts.

We expected that watching the teaching episodes and analyzing them would lead the teachers to:

- a. Realistic expectations which may enhance the self-confidence needed for successfully coping with the novel teaching environment of using APL.
- b. Context-sensitive modeling stemming from a "virtual" apprenticeship of the novice teachers with the "role models".
- c. Critical analysis which would include an inherent comparison between the novice teacher's personal teaching style and the "role model" teacher performing in the episode.

***Pool of questions and activities:*** A copious number of questions and activities were developed for each section of the introductory unit and research articles. The teachers are presented with the questions and their answers and in some cases pedagogical comments are added. In the introduction to this section of the curriculum guide, the teachers are presented with a categorization of the questions and are encouraged to use the examples provided (similar to the ones presented in Table 1) as a template in order to formulate their own questions.

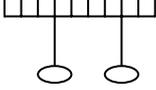
By integrating a variety of questions into the teaching process through primary literature, we hope to facilitate the creation of a dialogue between the student and the content of the article. The logically structured order of the article sections sometimes conveys, to the novice reader, a false feeling of comprehension. The questions on the article are supposed to unravel this false feeling and to compel the student to look for a deeper understanding and for new connections between the ideas presented in the article and the students' previous knowledge (Brill *et al.* 2004). The teachers are encouraged to use only those questions and activities they feel are best suited for their aims and their students' cognitive level and to modify them using the standard Word tools. The fact that teachers can choose from a collection of questions and modify

them according to their needs may enhance the appropriation of the questions and their usage.

The questions provided are classified according to the cognitive skills required from the student and the content field sampled by the question, as shown in Table 1. We found this categorization to be suitable for addressing the main aims of teaching through APL (Yarden *et al.* 2001): acquaintance of the students with the nature of scientific research, understanding of the rationale behind the research plan and methods and critically asserting the goals and conclusions of the scientific research. Some of the activities are in accordance with the stages of the "conversational model"- formulating questions, making predictions and finding answers in the subsequent sections of the article. Several questions and activities are added as remedial measures after mapping students' difficulties in studying the APL.

**Table 1: Sample questions from the teacher guide**

Category	Sample question or activity from the teachers' guide
Knowledge organization	Write down the differences between maternal and zygotic genes that determine the embryonic development, considering: the cells in which these genes are transcribed, the transcription time since the fertilization and the stage in which the protein products of these genes are active in the cell. (for the article "Genetic regulation of head development in <i>Drosophila</i> ").
Inquiry skills	Design an experiment in order to investigate the hypothesis that during two and a half hours after fertilization, the embryo's genes are not transcribed. (for the article "Genetic regulation of head development in <i>Drosophila</i> ").
Critical assessment of the article conclusions	"From this evidence it is possible to conclude that <i>myogenin</i> is not essential when cells begin to differentiate to muscle cells, but...without <i>myogenin</i> expression the differentiation will not occur." Write down evidence for each part of this statement from the Discussion section. (for the article "Lack of skeletal muscles in new born mice bearing a mutated <i>myogenin</i> gene").
Application of the main ideas of the article in other contexts	The biotechnology company "Moneygen" reported a sensational success: the production of <i>myogenin</i> containing pills for athletes interested to improve their performances without sweating. The competing company "Musclegen" is also advertising a natural product intended for athletes: their product is a natural plant extract that was shown to increase the <i>myogenin</i> production in mice embryos. As a gym fan, would you use these products? Justify for each of the applications. (for the article "Lack of skeletal muscles in new born mice bearing a mutated <i>myogenin</i> gene").
Understanding the methods rationale	Which of the following methods could be used in order to establish when and where are the myogenic genes expressed during embryonic development? <ul style="list-style-type: none"> <li>a. extraction and analysis of DNA from different embryo tissues</li> <li>b. extraction and analysis of m-RNA from different embryo tissues</li> <li>c. in situ hybridization of embryo tissues with c-DNA of a myogenic gene</li> <li>d. protein extraction and analysis</li> <li>e. <i>in-situ</i> reaction of embryo tissue with antibodies against myogenic proteins</li> <li>f. detection of muscle cells in different tissues. (for the article "Lack of skeletal muscles in new born mice bearing a mutated <i>myogenin</i> gene").</li> </ul>

	<p>Draw the molecular complex that is formed in embryos when using the c-RNA detection method. (for the article "Genetic regulation of head development in Drosophila")</p> <p style="text-align: center;">m-RNA </p> <p style="text-align: center;">c-RNA connected to enzyme molecules </p> <p style="text-align: center;">substrate </p>
<p>Highlight the main developmental biology ideas of the article</p>	<p>Three groups of genes influence the embryonic development according to the following hierarchy:</p> <ul style="list-style-type: none"> <li>- genes that regulate the expression of the <i>bicoid</i> gene</li> <li>- the <i>bicoid</i> gene that encodes for the morphogene of the head formation</li> <li>- genes involved in the head tissue formation and controlled by the product of <i>bicoid</i> gene</li> </ul> <p>Which group would you expect to be expressed earlier during the development? If a mutation occurs in a gene belonging to one of the three groups, in which group is it expected to have a more critical influence? (for the same article).</p>