Multimedia Learning in Primary Schools: Multimedia Effects, Modality Effects and Attentional Guidance

Dissertation

zur Erlangung des akademischen Grades Dr. phil.

der Fakultät für Bildungswissenschaften

(am Lehrstuhl für Lehr-Lernpsychologie)

an der Universität Duisburg-Essen

vorgelegt von

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Juni 2011

Datum der mündlichen Prüfung: 14. Dezember 2011

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Table of Contents

Introduction

In the technological age of the 21st century, text and pictures are still the most important (prominent) media for learning. To comprehend written texts and to "read" pictures enables people to be part of the society and to fulfil social duties. The importance of texts and pictures for the flow of information is reflected in the research on the comprehension of texts and pictures as well. At the beginning, researchers rather investigated text and picture comprehension in an unsystematic way, but, through the years, more and more light was cast on the underlying cognitive processes, leading to corresponding design recommendations (e.g., Mayer, 2009). In this context, the work of Mayer and colleagues on the design of multimedia instructional messages has a strong influence on the current research field, especially with regard to the definition of certain terms (such as *multimedia* and *multimedia learning*; Mayer, 2005a). Therefore, the terms used in this dissertation largely follow Mayer's definitions (2005a; 2009). With this in mind, the term *multimedia* refers to the presentation of words (e.g., spoken or printed) and pictures (e.g., photos, animations, video, illustrations). Thereby, the term *words* focuses on material that is presented in *verbal form*, whereas the term *pictures* focuses on material that is presented in *pictorial form*. Thus, when the term *multimedia learning* is referred to, it is meant that learners construct mental representations from words and pictures. In this context, the active component of learning is emphasized as well, that is, the learner *has to be* cognitively active during learning; otherwise, no meaningful learning will occur.

As has been already mentioned, many instructional principles and recommendations giving guidelines for the design of learning materials were established by Mayer and colleagues (see Mayer, 2005b, for an overview). A major amount of this research has investigated the multimedia and modality principles. Following the multimedia principle, people learn better from text and pictures than from text alone (Fletcher & Tobias, 2005). Whenever text and pictures are presented together, the modality principle claims that learning can be further promoted by using spoken instead of written text (Low & Sweller, 2005). Although the results of many studies are in line with the above-mentioned principles (e.g., Carney & Levin, 2002; Ginns, 2005), there are also studies that failed to show the effects (e.g., De Westelinck, Valcke, De Craene, & Kirschner, 2005; Mann, Newhouse, Pagram, Campbell, & Schulz, 2002; Tabbers, Martens, & van Merriënboer, 2004). Especially with regard to primary school children, more research is needed on both principles. Even if some of the research literature describes multimedia learning with children (Levie & Lentz, 1982; Levin, Anglin, & Carney, 1987; Peeck, 1994), only few studies examined multimedia and modality effects with expository science texts in realistic school settings (Segers, Verhoeven, & Hulstijn-Hendrikse, 2008; Tabbers et al., 2004). Thus, one aim of this dissertation was to focus on the question whether the multimedia and modality principles hold true with expository science texts in realistic primary school settings. This question is addressed in Chapter 5 (Experiment 1) and Chapter 6 (Experiment 2). More specifically, by applying Peeck's procedure (1974) to the learning material, it was possible to investigate whether the multimedia effect as well as the modality effect show up for (1) text-only information, (2) picture-only information, (3) illustrated-text information[1], and (4) transfer information. In this context, it could also be examined whether children equally split their attention between the text and the corresponding picture.

Although being the very common format of learning, learners often have difficulties in the processing of multiple representations (e.g., Van Someren, Reimann, Boshuizen, & de Jong, 1998). Therefore, the second aim of this dissertation was to investigate whether attentional guidance is effective for children's learning from science texts (Experiment 2, Chapter 6). More specifically, it was examined whether guiding learners' attention to relevant aspects of the material by means of instructional design devices will further enhance learning (the overall learning and the learning on certain sources of information). According to Mayer's *Cognitive Theory of Multimedia Learning* (CTML; 2005c; 2009) as well as the *coherence formation approach* (Seufert, 2003; Seufert & Brünken, 2006), paying attention to relevant elements is a kind of prerequisite for meaningful learning to occur.

Overview of the Dissertation

Chapter 1 provides the theoretical background for the research field of multimedia learning. In the following chapters, the learning materials (Chapter 2) as well as the three experiments (Pilot Study, Experiment 1 and Experiment 2) conducted in the dissertation are described (Chapter 3, 4 and 5). The pilot study aimed at testing the learning materials. In Experiment 1 and 2, the above-mentioned aims of the dissertation were addressed: (1) Do both the multimedia principle and modality principle hold true for primary school children with expository science texts in a realistic setting? Or, in other words: Do children equally split their attention between text and corresponding pictures? Furthermore, Experiment 2 focused on (2) whether attentional guidance further enhances children's learning. In Chapter 6, the findings are discussed in the context of the research literature, including theoretical and practical implications. Finally, future research directions are presented.

[1] The term *illustrated-text information* was used by Levie and Lentz (1982) in order to refer to the common amount of information between text and picture.

1 Theoretical Background

1.1 Multimedia Learning

Exploring the usefulness of pictures has a long tradition in scientific literature (e.g., see Carney & Levin, 2002; Peeck, 1987; Willows & Houghton, 1987). Generally, two kinds of literature contributions can be distinguished: "Learning to read" literature is concerned with "the contributions of pictures to the overall development of children's literate behavior" (Fang, 1996, p. 137), whereas "reading to learn" literature is concerned with the contributions of pictures to the enhancement of children's or students' text comprehension (e.g., see Levie & Lentz, 1982). In the following, the "reading to learn" literature is focused on. In addition, the focus of interest lies on those references that refer to pictures "as *text-provided visual illustrations* (on the page, or on the computer screen)" (Carney & Levin, 2002, p. 11).

1.1.1 Usefulness of Pictures: Reasons, Conditions and Learner Characteristics

Depending on the focus of interest that has varied more or less over the decades, different questions have been addressed to by researchers with respect to multimedia learning (Carney & Levin, 2002). Early studies were interested in whether pictures generally enhance text comprehension (e.g., Dwyer, 1970; Vernon, 1954) and if so, to which extent. But only when researchers started to take into account the relationship between text and pictures and the respective retention tests, as suggested by Peeck (1974), a progress in investigating the effects of pictures on learning outcome (e.g., retention, transfer) could be made. Thus, by following Peeck's (1974; 1987) procedure that divides presented information into text-only information, picture-only information and illustrated-text information, a positive impact of pictures on the reading-to-learn process could be shown (e.g., Levie & Lentz, 1982; Levin et al., 1987; Schallert, 1980). According to Carney and Levin (2002), later studies aimed at exploring the reasons ("why"), conditions ("when") and learner characteristics ("for whom") of picture facilitation, whereby several explanations were offered: With respect to the "why" question, Peeck (1993; 1994) suggests several reasons for the learning enhancement due to pictures: (1) Providing pictures might increase motivation, (2) providing pictures might focus attention, (3) providing pictures might lead to a deeper processing, (4) providing pictures might serve as an adjunct aid for difficult text content, and (5) providing pictures might contribute to the construction of mental models (e.g., Hegarty & Just, 1989; Mayer & Gallini, 1990). Simultaneously, Levin and

Mayer (1993) introduced seven principles aiming at explaining why pictures might enhance learning. According to the authors, adding pictures to text facilitates learning because, due to the pictures, the text becomes (1) concentrated, (2) compact/concise, (3) concrete, (4) coherent, (5) comprehensible, (6) correspondent and (7) codable. Furthermore, Peeck (1993; 1994) as well as Levin and Mayer (1993) emphasize some variables that influence the pictures' impact on the learning outcome – thereby touching Carney and Levin's (2002) "when" and "for whom" questions: (1) the measures of performance outcome (e.g., retention, transfer, problem solving), (2) the nature of the learning materials (both of pictures and texts; e.g., the picture's complexity, the difficulty of the text), (3) the learner characteristics (e.g., the age or the reading ability of the learner) and (4) the learning activities (e.g., specific learning instructions to foster the picture's processing). With respect to the nature of the learning materials, Mayer (1989) assumes that pictures especially facilitate learning when (1) a cause-and-effect system is described in the text (as is often the case with scientific or technical concepts) and (2) the system, respectively the sequence of the system, is depicted in the pictures in a clarifying way.

Recent research on the principles of multimedia learning (for an overview, see Mayer, 2005b; Mayer, 2009) incorporates the above-mentioned variables by exploring boundary conditions ("when") and individual differences ("for whom"). Furthermore, present theories of multimedia learning, as the *Cognitive Theory of Multimedia Learning* (CTML; Mayer, 2005c; Mayer, 2009) and the *Integrated Model of Text and Picture Comprehension* (ITPC model; Schnotz, 2005; Schnotz & Bannert, 1999, 2003; Schnotz, Seufert, & Bannert, 2001), are based on the assumption that pictures contribute to the construction of mental models and thus concentrate on one potential reason for pictures' positive impact on text processing ("why", Carney & Levin, 2002). Finally, it should be mentioned that previous research focused mainly on text-based (or book-based) multimedia learning whereas more recent research most often deals with computer-based and web-based multimedia learning (for an overview, see Mayer, 2005b). Nevertheless, text-based multimedia learning is still the most common form of multimedia learning in our society (e.g., at schools and universities).

1.1.2 Functions of Pictures in Text Processing

According to Levin and colleagues (Levin, 1981; Levin et al., 1987), pictures can fulfil five functions in text processing: (1) a decorational function, that is, pictures just decorate the page without being related to the text content, (2) a representational function, that is, pictures accurately illustrate the text content, (3) an organizational function, that is, pictures "organize" the text content by providing a kind of "framework", (4) an interpretational function, that is, pictures "help to clarify difficult text" (Carney & Levin, 2002, p. 7), and (5) a transformational function, that is, pictures provide recoded text information as adjunct mnemonic. As Carney and Levin (2002) note, a great amount of studies in the 1990s used interpretational pictures for making difficult scientific or technical learning contents more comprehensible (e.g., Mayer & Anderson, 1992; Mayer & Gallini, 1990; Mayer & Moreno, 1998). Mayer (2009) himself describes pictures that depict cause-and-effect systems as explanative illustrations.

When working with present multimedia learning environments (or *multimedia instructional messages*; Mayer, 2009), learners are typically provided with interpretational (or explanative) pictures as well. More specifically, learners are provided with "a series of illustrations, each depicting a key step […], along with corresponding text segments […] that each describe a key step" (Mayer, 2009, p. 33). Indeed, both the text paragraphs and the pictures focus on the essential elements of the learning content, according to "less is more". Hence, the application of Peeck's procedure (1974; 1994) which results in text-only information, picture-only information and illustrated-text information does not seem to be as necessary as it used to be for previous studies on multimedia learning. Interpretational (or explanative) pictures might elucidate difficult text segments and therefore lead to a comprehensive understanding of the subject matter. Even Peeck (1993) already noted that "many of the studies reviewed show that retention of text content is improved by illustrations, but mainly, and perhaps exclusively, inasmuch as the illustrations concerned actually depict what it says in the text" (p. 227). In conclusion, it might be stated that, following Peeck's ideas (1974), Mayer and colleagues mainly focus on illustrated-text information.

1.2 Theories of Multimedia Learning

The most prominent theories in the field of multimedia learning aiming at explaining the above-mentioned principles are Mayer's CTML (Mayer, 2005c; Mayer, 2009), Schnotz's ITPC model (Schnotz, 2005; Schnotz, & Bannert, 1999, 2003; Schnotz et al., 2001) and Sweller's *Cognitive*

Load Theory (CLT; Chandler, 2004; Chandler & Sweller, 1991; Sweller, 1999; 2003). Hence, these theories will be presented in the following sections.

1.2.1 The Cognitive Theory of Multimedia Learning

Following Mayer (2005c; 2009) the CTML is based on the work of Paivio (*Dual Coding Theory*; Clark & Paivio, 1991; Paivio, 1986), Baddeley (*Model of Working Memory*; 1986; 1999), Chandler and Sweller (*Cognitive Load Theory*; 1991), and Wittrock (*Generative-Learning Theory*, 1974; 1989) and aims at explaining how knowledge is constructed from words and pictures. Thereby, the following three assumptions are made: (1) dual-channel assumption, (2) limited capacity assumption, and (3) active processing assumption.

(1) The dual-channel assumption states that there are two information processing channels, namely an auditory/verbal channel and a visual/pictorial channel. It has to be noted that there are two different approaches which aim at conceptualizing the differences between these two channels. The first approach is called *presentation-mode approach* and emphasizes the *form / format* (verbal or pictorial/nonverbal) in which a stimulus is presented[2]. Thus, verbal material (e.g., printed and spoken words) is processed in one channel, whereas pictorial and nonverbal material (e.g., pictures, animation) is processed in the other channel. The second approach, the so-called *sensory-modality approach*, refers to "whether learners initially process the presented materials through their eyes (such as for illustrations, video, animation, or printed words) or ears (such as for spoken words or background sounds)" (Mayer, 2009, p. 65). To sum up, "whereas the presentation-mode approach focuses on the format of the stimulus-as-presented (i.e., verbal or nonverbal), the sensory-modality approach focuses on the stimulus-as-represented in working memory (i.e., auditory or visual)" (Mayer, 2005c, p. 34).

(2) The limited capacity assumption states that both the auditory/verbal channel and the visual/pictorial channel can process only a limited amount of information at a time in working memory. According to Mayer (2005c; 2009), the limited capacity forces people to decide which information of words and pictures they should pay attention to and which connections between information should be built.

[2] With respect to his comments on the dual-channel assumption, Mayer (2005c; 2009) is not consistent with the labelling of the "presentation-mode approach". For example, Mayer (2005c) uses the term "presentation-mode approach" when referring to "what is processed in each channel" (p. 34), whereas Mayer (2009) uses the term "representation-mode approach" (p. 65). As Mayer himself (2005c; 2009) notes, more clarification is needed with respect to the auditory/verbal channel and the visual/pictorial channel.

(3) The active processing assumption states that learners play an active role during learning and construct a coherent mental representation of incoming information, including the cognitive processes of selecting, organizing and integrating.

Apart from these assumptions, the CTML specifies five cognitive processes that have to be engaged in by learners for meaningful learning to occur. Thereby, these cognitive processes do not have to occur in a certain order, so that learners "might move from process to process in many different ways" (Mayer, 2005c, p. 38). These cognitive processes are: (1) selecting relevant words, (2) selecting relevant images, (3) organizing selected words, (4) organizing selected images, and (5) integrating the verbal and pictorial model, including prior knowledge (cp., Figure 1).

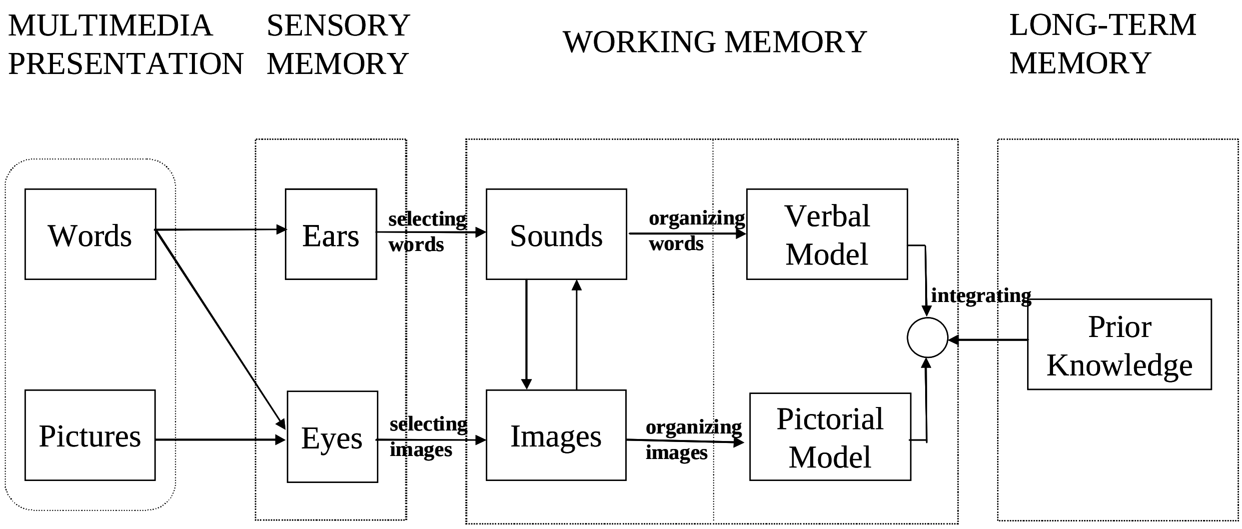


Figure 1. Cognitive Theory of Multimedia Learning (adapted from Mayer, 2005c, p. 37).

In this context, Mayer (2005c; 2009) draws upon previous theories on memory and connects the cognitive processes with memory stores. Thereby, working memory is assumed to have a great impact on the information processing of words and pictures because there information can be held and manipulated. When words and pictures are processed (cp., Figure 1), the information is firstly perceived through the ears and/or eyes. By focusing on certain pieces of information (cp., selecting relevant words and images), the learner helps the information to be transferred into working memory. There, the information has to be organized (cp., organizing selected words and images) and, as a product, mental models (cp., verbal model; pictorial model) are built up. Finally, for meaningful learning to occur, both models have to be integrated, including prior knowledge.

Recently, Mayer (2009) extended the CTML by including three kinds of cognitive processing which are derived from the CLT (Chandler, 2004; Clark, Nguyen, & Sweller, 2006; Chandler & Sweller, 1991; Sweller, 1999). Following the CLT, Mayer (2009) distinguishes between (1) *extraneous cognitive processing*, (2) *essential cognitive processing*, and (3) *generative cognitive processing*. The first kind of processing is triggered by inappropriately designed learning materials which make the students' learning unnecessarily difficult (for example, by presenting information in a split-attention format). *Extraneous cognitive processing* induces *extraneous cognitive load* according to Sweller (1999; 2003). *Essential cognitive processing* refers to the kind of processing that is caused by the complexity of the material and thus leads to Sweller's (1999; 2003) *intrinsic cognitive load*. Accordingly, prior knowledge is an influencing factor: Learners with low prior knowledge perceive the material as more complex than learners with high prior knowledge. Thus, learners with low prior knowledge have to engage in more *essential cognitive processing*, that is, the cognitive processes of selecting relevant words and selecting relevant images are more time-consuming for them. As Mayer (2009) further argues "if learners engage mainly in essential cognitive processing during learning, the result will be rote learning, as reflected in good retention and poor transfer performance" (p. 80/81). Finally, *generative cognitive processing* refers to the kind of processing that takes place when learners really try to understand the subject matter and thus are engaged in organizing and integrating the learning material. Again, Mayer's term corresponds with Sweller's (1999; 2003) *germane cognitive load*. In conclusion, meaningful learning is most likely to occur when essential and generative cognitive processes are carried out.

1.2.2 The Integrated Model of Text and Picture Comprehension

There is a considerable overlap between the ITPC model (Schnotz, 2005; Schnotz & Bannert, 1999; 2003; Schnotz et al., 2001) and the CTML (Mayer, 2005c; 2009), even though the former is more elaborate on the conceptualization of both channels and mental representations. More specifically, according to Schnotz, "one can distinguish only two basic forms of representations: descriptions and depictions" (Schnotz, 2005, p. 52). The former is based on symbols which represent certain objects, events, relations, attributes and so forth. "Symbols are signs that have no similarity with their referent" (Schnotz, 2005, p. 52). In contrast to descriptions, depictions are based on icons. "Icons are signs that are associated with their referent by similarity or by another structural commonality (Schnotz, 2005, p. 52). Thus, texts (or words) belong to the category of descriptive representations, whereas pictures belong to the category of depictive representations. Following Schnotz (2005), this distinction applies to both external representations (i.e., words and pictures) and internal (i.e., mental) representations. By additionally taking multiple sensory modalities into account (i.e., incoming information through the eyes or ears), Schnotz can distinguish between a perceptual processing level comprising the transmission of environmental information to working memory and a cognitive processing level comprising the "information processing within working memory and the exchange of information between long-term and working memory" (Schnotz, 2005, p. 57). According to the ITPC model (Figure 2), information is processed through the auditive and visual channel at the beginning and through the verbal and pictorial channel in the further course of processing. Thus, Mayer's (2005c; 2009) first assumption (dual-channel assumption) of an auditory-verbal channel and a visual-pictorial channel is presented in a more elaborate way in the ITPC model. That is, the sensory modality and the representational format are considered to be more separated from each other. For example, in contrast to the CTML, the ITPC model assumes that pictorial information can not only be conveyed by the visual modality but also by other ones (e.g., sound images). If a car's horn is heard, followed by a smash, this information is processed in the auditive channel and transmitted to auditive working memory. On condition that sufficient prior knowledge is available, the information can be further processed in the pictorial channel, resulting in the construction of the mental model of a car accident. Furthermore, both theories differ on the construction of mental models. Thereby, the CTML assumes that both a verbal and a pictorial mental model is built which then have to be integrated by learners, whereas the ITPC model assumes that only one "general" mental model is built which is a depictive representation of the subject matter (Schnotz, 2005).

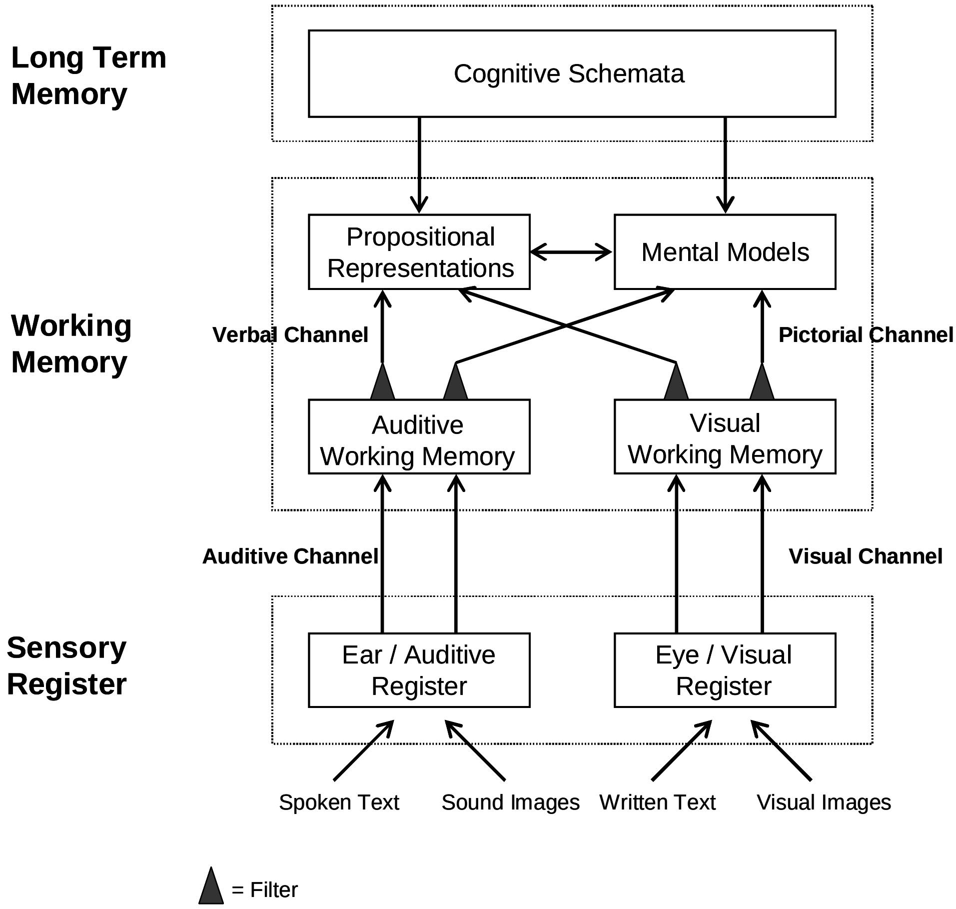


Figure 2. Integrated Model of Text and Picture Comprehension (adapted from Schnotz, 2005, p. 57).

1.2.3 The Cognitive Load Theory

The CLT (Chandler, 2004; Chandler & Sweller, 1991; Sweller, 1999; 2003) is based on the results of the cognitive psychology on human cognitive architecture, especially on working memory and long-term memory. Thereby, the CLT falls back on the work of Baddeley (*Model of Working Memory*; 1986; 1992); additionally, it takes into account findings concerning schema construction (e.g., Chase & Simon, 1973; De Groot, 1965; Larkin, McDermott, Simon, & Simon, 1980) and automation (Kotovsky, Hayes, & Simon, 1985; Schneider & Shiffrin, 1977; Shiffrin & Schneider, 1977). It should be emphasized that the CLT focuses on working memory, whereby it touches the relations between working memory and long-term memory as well (Sweller, 2005a).

According to the CLT, the following three kinds of cognitive load imposed on the working memory can be distinguished: (1) *extraneous cognitive load*, (2) *intrinsic cognitive load*, and (3) *germane cognitive load*. Extraneous cognitive load is caused if the learning materials are designed in an inappropriate way that is not in line with the human cognitive architecture. For example, presenting graphics with written text in a split-attention format increases the extraneous cognitive load because the learners are required to split their attention between two information sources. Intrinsic cognitive load refers to the complexity of the to-be-processed information. For example, information with high complexity, that is, high element interactivity, results in a high intrinsic cognitive load and the other way round. Lastly, germane cognitive load is caused by the cognitive resources that are invested by learners in schema construction (the categorization and organization of multiple elements) and automation (Sweller, 2005a). The process of schema construction might be similar to the construction of a mental model. The schemas are stored in long-term memory and reduce the cognitive load. For example, learners with high domain-specific prior knowledge can use schemas to help them to reduce the total cognitive load. However, applying schemas can interfere with instructional design as well, resulting in lower learning outcome (for an overview over the prior knowledge principle in multimedia learning, see Kalyuga, 2005). Finally, it has to be mentioned that extraneous, intrinsic and germane cognitive load are additive.

Thus, according to the CLT, multimedia learning environments (e.g., book-based, computer-based, web-based ones) should be designed in a way that reduces extraneous cognitive load and, simultaneously, increases germane cognitive load. This recommendation should be especially kept to in case of presenting complex learning material (cp., Sweller & Chandler, 1994): High element interactivity material means high intrinsic cognitive load, and high element interactivity material is likely to be related to a higher germane cognitive load as well (that is, compared to low element interactivity material, more mental effort has to be invested in successful schema construction). Thus, additionally adding high extraneous cognitive load through an inappropriate design might exceed the working memory capacity resulting in a cognitive overload (cp., Paas, Renkl, & Sweller, 2004; Paas & van Merriënboer, 1994). However, adding high extraneous cognitive load to low element interactivity material is not likely to overload memory capacity. Material that can be easily understood is related to a low intrinsic cognitive load and a low germane cognitive load (that is, less mental effort has to be invested in successful schema construction). Hence, the total cognitive load is lower. Even if a high extraneous cognitive load is added, a sufficient amount of cognitive capacity for schema construction is most likely to be still available (Sweller, 2005a).

1.3 Principles of Multimedia Learning

The research field of multimedia learning covers many principles and recommendations giving guidelines for the design of learning materials that are adapted to human cognitive architecture (see Mayer, 2005b, for an overview). Several studies show that these principles can be applied to different media, for example, to computers and textbooks (cp., Mayer, 1997; Mayer, 2003; Moreno, 2006). Apart from advanced principles of multimedia learning, such as the self-explanation principle (Roy & Chi, 2005) or the worked-out examples principle (Renkl, 2005), the following basic principles are assumed to promote learning: redundancy principle, coherence principle, split-attention principle (including spatial and temporal contiguity principle), modality principle, and multimedia principle. In the following sections, these principles are explained in more detail, including the underlying theoretical rationale. As mentioned in section 1.2.2, the CTML (Mayer, 2005c; 2009) and the ITPC model (Schnotz, 2005) are similar with respect to their conceptualizations and hence explain the principles in a similar manner.

1.3.1 Redundancy Principle

The redundancy principle states that presenting additional redundant information to learners reduces the learning outcome. Mayer (2009) uses the term *redundancy principle* in order to refer to the better learning resulting from graphics with spoken text, compared to graphics with spoken *and* written text. Redundant information can be presented in the same sensory modality (e.g., words in written form), the same form (e.g., animation and diagrams), different sensory modalities (e.g., words in both written and auditory form) and different forms (e.g., words and pictures; cp., Sweller, 2005b). It should be noted that the four categories are not exclusive, that is, the same example may match several categories, depending on the focus (sensory modality vs. form).

In order to decide whether additional information is indeed redundant, the prior knowledge of the learners has to be taken into account as well (e.g., Yeung, Jin, & Sweller, 1997). In this context, the *expertise reversal effect* (also cp., *general redundancy effect*; Schnotz, 2005) is likely to be the best known example of the detrimental impact of high prior knowledge on the effects of instructional design methods (e.g., Kalyuga, Chandler, & Sweller, 2000; Kalyuga, Ayres, Chandler, & Sweller, 2003).

Finally, it should be noted that recent research specifies some conditions under which redundancy can also support learning. For example, this is the case, “when it minimizes extraneous processing – by placing text near rather than far from corresponding graphics" or "when it fosters essential processing – by highlighting key portions of the text rather than presenting all text" (Mayer & Johnson, 2008, p. 385).

Theoretical Rationale

According to Mayer's CTML (2009), the following explanation is given for the redundancy principle: (a) Presenting graphics with redundant written text overloads the capacity of the visual/pictorial channel and (b) presenting written text with spoken text forces the learner to unnecessarily compare the written information with the spoken information. This results in lower learning outcome.

The ITPC model offers a similar explanation (Schnotz, 2005): (a) When the same text is presented in a visual as well as in an auditory manner, learners are not able to ignore the written text; thus, presenting pictures with written text still results in a visual split-attention situation. (b) Learners might have difficulties concerning the synchronization of reading and listening. These aspects might hinder the successful construction of a joint mental model.

Following CLT (Sweller, 2005a), the elimination of redundant information reduces extraneous cognitive load. Thus, the freed working memory capacity might be available for effective schema construction (with a possible increase in germane cognitive load) resulting in better learning outcome.

1.3.2 Coherence Principle

The coherence principle states that extraneous material (such as irrelevant words, pictures, background music or sounds) should be minimized in a multimedia presentation (Mayer, 2009). Following Mayer (2009) learners with (a) low working memory capacity, and (b) low prior knowledge might especially benefit from applying the coherence principle.

According to Sweller (2005b), Mayer's (2009) coherence principle results in the same effect as the redundancy principle, namely that redundant information may interfere with learning. For example, providing additional detailed information in a text, which is presented to the eyes or ears (e.g., words in written form), may be redundant, thus interrupting the coherence and resulting in a redundancy effect.

Theoretical Rationale

Following the CTML (Mayer, 2009), the theoretical explanation for the coherence principle refers to the limited cognitive resources in working memory. Presenting inessential information can draw the attention away from essential information, thus hindering the cognitive processes of organizing selected words and images.

According to the ITPC model, presenting semantically non-related information in the text and picture hinders the successful construction of a general mental model of a subject matter (Schnotz, 2005).

The CLT's explanation (Sweller, 2005a) for the coherence principle is identical to the one given for the redundancy principle: The elimination of interesting but irrelevant information reduces extraneous cognitive load and enables an increase in germane cognitive load.

1.3.3 Split-Attention Principle

The split-attention principle states that presenting words and pictures in a physically and temporally integrated format increases the learning outcome (for a meta-analysis of spatial and temporal contiguity effects, see Ginns, 2006). This principle only applies when each source of information is essential for understanding the learning material. Additionally, high element interactivity material, that is, complex and difficult material, must be used to obtain a medium or large effect according to Cohen's classification (1988). The split-attention principle can be derived from the fact that using formats that require learners to split their attention between multiple sources of information result in the need for learners to mentally integrate these multiple sources. Thus, the cognitive resources that would be invested in mental integration reduce the resources for learning (Ayres & Sweller, 2005).

It has to be noted that the split-attention principle is applied to both physical integrated material and temporal integrated material, whereby the former is similar to Mayer's spatial contiguity principle (Mayer, 2005d; 2009) and the latter to Mayer's temporal contiguity principle (Mayer, 2005d; 2009). However, the term split-attention effect was often used as a synonym for the spatial contiguity effect in previous studies (Sweller, Chandler, Tierney, & Cooper, 1990; Tarmizi & Sweller, 1988; Tindall-Ford, Chandler, & Sweller, 1997).

Theoretical Rationale

With respect to the spatial and temporal contiguity principle (both versions of the split-attention principle), the CTML (Mayer, 2009) offers the following explanation: Since words and pictures can simultaneously be held in working memory, referential connections are more likely to occur. Furthermore, with regard to the spatial contiguity principle, there is no need for additional search processes.

Following the ITPC model, the theoretical explanation is similar: Since corresponding text and picture information can simultaneously be held in working memory, a joint mental model construction is more likely to occur. Furthermore, there is no need for additional search processes (Schnotz, 2005).

According to the CLT (Sweller, 2005a), both the requirement to split the attention between different sources of information and the necessity to mentally integrate them enhance extraneous cognitive load. Thus, avoiding a split-attention format in instructional designs reduces extraneous cognitive load.

1.3.4 Modality Principle

The modality principle states that presenting graphics with spoken text (narration) instead of written text (printed text) increases the learning outcome. As for the split-attention effect, the prerequisite for the modality effect is that the learning materials, namely graphics with written text, are "…unintelligible in isolation and so must be mentally integrated in order to be understood" (Low & Sweller, 2005, p. 148). Otherwise, if both sources of information are not essential for understanding, the redundancy principle might be effective. Thus, the relation between different sources of information is crucial.

In contrast to the split-attention principle which uses a physically integrated format of graphics and written text in order to overcome the split-attention situation, the modality principle requires that the written text is converted to spoken text (Low & Sweller, 2005). Thus, the modality principle can be considered as a special case of the split-attention principle because both principles aim at avoiding a visual split-attention situation resulting in a reduction of unnecessary cognitive load. Apart from the prerequisite that each source of information must be essential for understanding the learning material, the following conditions must be fulfilled for a modality effect to occur: (1) high element interactivity of the learning material (e.g., Tindall-Ford et al., 1997), (2) students' low control of the pace of presentation (system-paced conditions; Tabbers, Martens, & van Merriënboer, 2001; 2004).

Overall, the modality effect is empirically well established (e.g., Brünken, Plass, & Leutner, 2004a; Ginns, 2005).

Theoretical Rationale

Following the CTML (Mayer, 2009), the modality principle can be explained with help of the dual channel assumption and the limited capacity assumption. To say it in greater detail, presenting graphics with written text results in a cognitive overload in the visual/pictorial channel. But in the case of presenting graphics with spoken text, both channels (visual/pictorial channel and auditory/verbal channel) can be used and, thus, a cognitive overload is avoided.

According to the ITPC model, presenting written text with pictures results in a visual split-attention situation and, thus, the amount of information which can be conveyed and processed through the visual channel at a certain time is reduced, compared to spoken text with pictures. Hence, less information reaches the working memory. Furthermore, involving both the visual and auditive working memory results in a greater amount of working memory capacity available for information storage and further processing (Schnotz, 2005).

Following the CLT (Sweller, 2005a), the modality effect is assumed to be based on a greater amount of effective working memory capacity due to the use of two sensory modalities (visual and auditory). Furthermore, extraneous cognitive load is reduced. However, Tabbers et al. (2004) note that a reduction in visual search processes might also be a possible explanation for the results obtained.

1.3.5 Multimedia principle

The multimedia principle states that presenting words and accompanying pictures enhances the learning outcome (Fletcher & Tobias, 2005; Mayer, 2009). However, the following characteristics (concerning both the learner and the learning material) can have an impact on multimedia learning: (1) Students with low prior knowledge seem to benefit more from applying the multimedia principle than students with high prior knowledge (e.g., Mayer & Gallini, 1990). (2) Students with high spatial ability seem to benefit more from applying the multimedia principle than students with low spatial ability (Mayer & Sims, 1994). (3) Accompanying pictures must have an appropriate relation to the learning subject matter, because the form of visualization seems to influence the mental model structure (Schnotz & Bannert, 2003). Thus, in the case of a task-inappropriate form of visualization, detrimental effects on mental model construction might occur. It has to be noted that Schnotz and Bannert's (2003) findings go beyond the five functions "...that pictures serve in text processing – four conventional functions (decorational, representational, organizational, interpretational) and one more unconventional one (transformational)" (Carney & Levin, 2002, p. 7). Thus, both the function of pictures (e.g., decorational) and the respective form of visualization (e.g., task-inappropriate) can be limiting factors for the multimedia principle to be applied effectively.

Theoretical Rationale

According to the CTML (Mayer, 2009), the theoretical explanation for the multimedia principle is that words and accompanying pictures result in both a verbal model and a pictorial model, whereby further connections between these two models can be drawn. Thus, compared to words alone, meaningful learning is more likely to occur.

The ITPC model (Schnotz, 2005) offers a similar explanation: Presenting text and accompanying pictures results in more routes of constructing a general mental model of the subject matter. Thus, the resulting mental model is more likely to be more elaborate.

Following the CLT (Sweller, 2005a), presenting text and accompanying pictures should increase germane cognitive load, thus successful schema construction is more likely to occur.

1.4 Research on the Multimedia and the Modality Principles

A major amount of the research on multimedia learning has investigated the multimedia and modality principles. Following the multimedia principle, learning outcomes are better when people learn from text and pictures than from text alone (Fletcher & Tobias, 2005). Whenever text and pictures are presented together, the modality principle claims that learning can be further promoted by using spoken instead of written text (Low & Sweller, 2005). Both effects build up on each other in some way.

Multimedia principle

As mentioned in section 1.3.5, the multimedia principle states that presenting words and accompanying pictures enhances the learning outcome (Fletcher & Tobias, 2005; Mayer, 2009). Generally, this principle is supported by numerous studies conducted by Mayer and his colleagues (e.g., Mayer & Anderson, 1992; Mayer & Gallini, 1990). Indeed, Fletcher and Tobias (2005) conclude in their contribution on the multimedia principle that this principle “appears to be well supported by findings from empirical research” (p. 128). However, it has to be noted that there is still a number of recent studies that could not find the multimedia effect (e.g., De Westelinck et al., 2005; Segers et al., 2008). Following Peeck (1993; 1994) as well as Levin and Mayer (1993), there might be several reasons for the absence of the multimedia effect, as for example (1) inadequate measures of performance outcome, (2) unsuitable nature of the learning materials, (3) learner characteristics, and (4) learning activities. Furthermore, investigating design principles of multimedia learning in more realistic educational settings is more difficult due to higher unsystematic variance. Thus, medium effects (cp., Cohen, 1988) cannot be found as easily as in laboratory studies. As Mayer (1989) notes, pictures should especially facilitate learning when (1) a cause-and-effect system is described in the text (as is often the case with scientific or technical concepts) and (2) the system, respectively the sequence of processes in the system, is depicted in the pictures in an elucidating way. However, by following Peeck's (1974) procedure, a thorough division of the information presented in text and picture in (1) text-only information, (2) picture-only information, and (3) illustrated-text information might be helpful for clarifying the relationship between text passages and pictures and their respective learning outcome tests.

As reviews of research on early studies in the field of multimedia learning show (e.g., Levie & Lentz, 1982), adding pictures to text does not enhance the learning outcome *of all sources of information*. Indeed, Levie and Lentz (1982) conclude in their review that representational illustrations have no impact *on the learning of text-only information.* Furthermore, Levie and Lentz (1982) report a clear positive impact of representational illustrations *on the learning of illustrated-text information.* Concerning picture-only information, no clear pattern of results shows up, with some studies finding no impacts of representational illustrations *on the learning of picture-only information* (e.g., Jahoda, Cheyne, Deregowski, Sinha, & Collingbourne, 1976), but others still doing so (e.g., Peeck, 1974). The latter pattern of results already indicates that pictures are often processed in a superficial way (cp., Mokros & Tinker, 1987; Weidenmann, 1989), resulting in the need of providing additional processing aids (cp., Bernard, 1990; Peeck, 1993; Weidenmann, 1994).

Although, generally, the positive influence of pictures on knowledge acquisition can be regarded as confirmed, pictures can also have negative effects. From a cognitive load perspective (Chandler, 2004; Chandler & Sweller, 1991; Sweller, 1999; 2003), presenting written text plus pictures in a split-attention format is expected to increase extraneous cognitive load because the learners are required to split their attention between two information sources (cp., section 1.3.3, split-attention principle). As Kalyuga (2009) notes (p. 403), "in cognitive load theory, acquisition and automation of schemas in LTM [long-term memory] are considered as the most significant factors in preventing cognitive overload in learning (Sweller, van Merriënboer, & Paas, 1998)". Compared to adults, children's schemas are not "fully developed" yet (cp. Sweller et al., 1998). Thus, for children, it might be expected that presenting written text plus pictures in a split-attention format results in a cognitive overload (due to high extraneous cognitive load and "less developed" schemas), with detrimental effects on the learning of information presented. As children are expected to be more influenced by picture information than adults would be expected to be (Goldstein & Underwood, 1981), pictures might draw the attention away from the text (cp., Goldsmith, 1984). This might prevent a cognitive overload. Thus, it is possible that children will focus more strongly on *picture-only information* than on *text-only information* when written text plus pictures are presented in a split-attention format. Thus, children receiving written text plus pictures should be worse on the learning of text-only information than children receiving only written text ("reversed multimedia effect"). Brookshire, Scharff, & Moses (2002) indeed report a non-significant[3] tendency for children who received text plus pictures to perform worse on text-only questions (on text-only information, respectively) than children who received text alone. Consequently, the authors note that pictures might act as distractors and emphasize the thoughts of Elster and Simons (1985), who took the negative potential of pictures into account.

To sum up, by taking sources of information into account when knowledge acquisition is measured (e.g., text-only information, picture-only information, illustrated-text information; Peeck, 1974), a more elaborate measure of the performance outcome is possible. Furthermore, it should be possible to determine by means of the multimedia principle whether pictures draw children's attention away from text. If pictures really do so, text-only information should be less well remembered by children receiving written text plus pictures compared to children receiving written text alone. Simultaneously, picture-only information should be remembered better from children receiving text plus pictures compared to children receiving text alone. In other words, by looking at the multimedia effects on text-only information and picture-only information, it should be possible to determine whether children split their attention equally between all sources of information. Traditionally, text-based (or book-based) multimedia learning is implemented in schoolbooks or worksheets in a typical split-attention format: By providing text passages on the one side and the corresponding picture on the other side, children are required to split their attention between written text and pictures. Thus, the question whether children split their attention equally between all sources of information also has practical relevance.

Modality principle

As mentioned in section 1.3.4, the modality principle states that presenting graphics with spoken text (narration) instead of written text (printed text) increases the learning outcome. Generally, with regard to older students and adults, the modality effect is supported by numerous studies (e.g., Brünken et al., 2004a; Harskamp, Mayer, & Suhre, 2007; Mayer & Moreno, 1998; Mousavi, Low, & Sweller, 1995; Tindall-Ford et al., 1997). However, it has to be noted that there is still a number of studies that could not find the modality effect in more authentic classroom settings (e.g., Mann et al., 2002; Tabbers et al., 2004; Witteman & Segers, 2010). As

[3] Since the sample size in this study was small the power might not have been sufficient for detecting an effect. For this reason, this result seems to be noteworthy.

with the multimedia effect, different reasons might be conceivable for the absence of the modality effect.

As Ginns (2005) reports in his meta-analysis, two significant moderators of the modality effect are (1) element interactivity and (2) pacing of presentation. With respect to the latter, the modality effect reliably shows up under system-paced conditions, whereas it “may disappear or reverse under self-paced conditions” (Ginns, 2005, p. 327). Ginns (2005) further notes that only few studies so far have examined the modality effect with young children. For example, Jeung, Chandler, and Sweller (1997) examined the impact of visual search processes on the modality effect with primary school children. Following the authors, the modality principle only seems to hold true when unnecessary visual search processes between verbal and pictorial information can be avoided. In the case of high demand on visual search processes, visual indicators must be included in the instructional format, because, otherwise, the “spoken text + pictures” condition is not likely to be superior to the “written text + pictures” condition. Levin and Divine-Hawkins (1974) also investigated the modality effect with primary school children. These authors instructed children to imagine what was happening in a story as they read or heard it. It was found that children in the “spoken text + visual imagery” condition were superior to children in the “written text + visual imagery” condition.

In a study of Brünken and Leutner (2001), who partly follow Peeck’s ideas (1974), a modality effect for the learning outcome concerning verbal information was found, whereas no modality effect occurred for the learning outcome concerning pictorial information. In other words, the written text plus pictures group was worse than the spoken text plus pictures group in the learning of verbal information, whereas both groups did not differ in the learning of pictorial information. According to the authors, this pattern of results might indicate not only split-attention between written text and pictures but also a shift of attention *from text to pictures*. That is, learners who received written text plus pictures are supposed to have paid more attention to pictures than to written text, which could have spoiled the modality effect for pictorial information. Such a shift of attention might be even greater for children than for adults because of a lower reading ability and a possibly greater tendency to disregard information presented in text and instead focus on information presented in pictures. To sum up, by taking sources of information into account when knowledge acquisition is measured (e.g., text-only information, picture-only information, illustrated-text information; Peeck, 1974), a more elaborate measure of the learning performance outcome is possible. Furthermore, it should be possible to determine whether pictures draw children’s attention away from text. If pictures really do so, text-only information should be less well remembered by children receiving written text plus pictures compared to children receiving spoken text plus pictures (modality effect). Simultaneously, with respect to picture-only information, there should be no differences between the above-mentioned groups of children (no modality effect). In other words, by looking at the modality effects on text-only information and picture-only information, it should be possible to determine whether split-attention holds true for all sources of information.

1.5 Attentional Guidance in Multimedia Learning

Following Mayer's CTML (Mayer, 2005c; Mayer, 2009), for meaningful learning to occur, learners have to select relevant words and images, organize them and finally integrate them taking prior knowledge into account as well. However, as many studies show, learners often have difficulties in paying sufficient attention to relevant information presented in pictures as well as in relating different representations to each other (cp., Ainsworth, Bibby, & Wood, 1998; Lowe, 1999; Peeck, 1993). Hence, researchers have developed different instructional devices for facilitating the processing of multiple representations.

1.5.1 Active and Passive Aids for Attentional Guidance

As has been already mentioned in section 1.4, many studies point out that pictures are often processed in a superficial way (cp., Mokros & Tinker, 1987; Weidenmann, 1989) resulting in the necessity of providing additional processing aids (e.g., Bernard, 1990; Peeck, 1993). Processing aids (such as, for example, instructional captions or arrows that highlight important aspects of the material to be learned) are assumed to have a positive impact on learners' knowledge acquisition and construction. Thereby, it is important that learners are required

> *to come up with an external and controllable product in response to the picture-oriented instructions, for instance by entering responses into a workbook, labeling features of the illustrations that accompany text to be learned (see, e.g., Dean & Kulhavy, 1981), or by other ways of acting upon the information the picture contains* (Peeck, 1993, p. 234).

According to Mayer (2009), it has to be noted that instructing students to create a product (such as the labeling of relevant parts of the picture) will only be effective if students engage in cognitive activity as well. Thus, cognitive activity (*active processing assumption*; Mayer, 2005c; 2009) is viewed as being essential for meaningful learning to occur. Hence, meaningful learning may also occur when students are not required to engage in behavioral activities, in creating products; as long as they are still cognitively active during learning. Nevertheless, external products possibly indicate more clearly whether children engaged in the learning tasks.

As Peeck (1994, pp. 75-76) notes, several studies have found differences in the processing of pictures between adults and children. Thus, instructional devices for locating relevant information might even be more important for children than for adults. Indeed, research on visual cueing strategies with children has shown that the picture processing can be effectively supported by additional cues (e.g., Beck, 1984). But learners do not only have difficulties in the processing of picture information.

Research on learning with multiple representations has shown that learners do not always benefit from providing multiple representations (e.g., Chandler & Sweller, 1992; Van Someren et al., 1998; for an evaluative review of the conflicting results on the learning with multiple representations, see Ainsworth, 1999). Thus, for meaningful learning to occur, it seems to be essential to support the learners' processes of knowledge acquisition: This support can be provided by applying instructional design principles of multimedia learning to the to-be-learnt material (cp., Mayer, Moreno, Boire, & Vagge, 1999; Mayer & Moreno, 2002), like Mayer's (2009) basic principles (see above). By doing so, extraneous cognitive load can be reduced; thereby yielding effective working memory capacity that might be used for effective schema construction by learners (with a possible increase in germane cognitive load). However, a shortcoming of these original principles is that "the learner was more or less confronted with materials that were well designed from a cognitive-load or multimedia-processing perspective, but knowledge acquisition and construction was assumed to take place automatically" (Brünken, Plass, & Leutner, 2004b, p. 118). As several studies show, learners can engage in meaningful learning processes even more efficiently when providing additional guidance (e.g., Moreno & Durán, 2004; Stull & Mayer, 2007). Thus, supporting learners with well designed materials that follow the basic principles of multimedia learning (Mayer, 2009) is a "passive" possibility to enhance learning. By providing additional embedded visual and verbal guidance for selecting, organizing and integrating relevant information, learners are further supported in a more active way. Shifting the learners' attention to relevant portions of words and pictures that are essential for understanding a scientific topic (such as, for example, the human blood circulation system) is called *attentional-guidance effect* by Brünken et al. (2004b). It should be noted that several principles discussed by Mayer and colleagues (Mayer, 2005b) emphasize components of visual and verbal guidance as well (e.g., *the guided discovery principle*; de Jong, 2005; *the worked-out examples principle*; Renkl, 2005; *the signaling principle*; Mayer, 2005d).

1.5.2 Coherence Formation

Some recent studies in the field of multimedia learning (e.g. Bodemer, Plötzner, Bruchmüller, & Häcker, 2005; Seufert, 2003) aim at explaining the process of building up mental models/representations with the help of Gentner's structure mapping theory (cp., Gentner, 1983). Accordingly, following Seufert and Brünken (2004), meaningful learning is supposed to occur when relevant elements both within each single representation (*local coherence formation*; Seufert & Brünken, 2004) and between different representations (*global coherence formation*; Seufert & Brünken, 2004) are actively related to each other. Thereby, successful *coherence formation* (both *local* and *global*) can only be achieved when learners cognitively engage in semantic processing: Regardless of whether it is a *local* or *global coherence formation*, learners can use two different strategies. One possible strategy is to focus first on corresponding surface characteristics of the representations (*surface feature level*; Seufert & Brünken, 2006) and then to make a deeper processing of these corresponding elements. Another strategy is to focus immediately on conceptual characteristics of the representations (*deeper structure level*) and to search for semantically related elements. According to Seufert and Brünken (2006), during the last years, a number of studies aimed at supporting the process of *coherence formation* by providing aids on both the *surface feature level* (e.g., Kalyuga, Chandler, & Sweller, 1998; Tabbers et al., 2004) and the *deeper structure level* (Olina, Reiser, Huang, Lim, & Park, 2006). With regard to aids on a *surface feature level*, a potential danger is that learners might only rely on the surface characteristics without making a deeper processing of the representations. In fact, when surface processing aids for relevant information in dynamic pictures are provided, empirical studies with animations demonstrate that learners often do not engage in further active processing and fail to build up a coherent representation of the subject matter (cp., Schnotz et al., 2001).

When the aim is to foster semantic processing by providing deeper processing aids, the following questions/issues must be clarified in advance (Seufert & Brünken, 2004): Which coherence formation process should be fostered (*local* or *global coherence formation*)? Should learners be supported by explicit or implicit aids (*directive* or *non-directive help*)? Should learners receive appropriate strategy trainings on coherence formation in advance or should aids be offered simultaneously with the learning phase? To sum up, empirical studies seem to suggest that promoting global coherence formation (cp., Bodemer, Plötzner, Feuerlein, & Spada, 2004; Bodemer et al., 2005), giving directive help (e.g., Peeck, 1993; Seufert, 2003) and offering help simultaneously with the learning phase will result in promising knowledge gains (for *negative* *effects of strategy training* on coherence formation, compare Seufert & Brünken, 2004). Thus, a coherent mental representation of the subject matter is favored. Additionally, help seems to be especially effective when aids on a *deep structure level* are combined with aids on a *surface structure level* (Seufert & Brünken, 2006). However, the learner's prior knowledge seems to be a boundary condition for the effectiveness of coherence formation aids (Seufert, 2003; Seufert & Brünken, 2004): Aids seem to be effective for learners with middle levels of prior knowledge; learners with low prior knowledge should also benefit to a certain extent from coherence formation aids, even if only a small knowledge gain might be possible. With respect to the learning outcome of experts, providing aids might have negative effects (cp., the *expertise reversal effect*; Kalyuga et al., 2003) or might not influence the learning outcome at all (cp., Seufert, 2003). Furthermore, coherence formation aids should be provided in a way that takes into account the limited working memory capacity of learners and thus avoids a cognitive overload.

In conclusion, as Mayer's (2005c) CTML, the *coherence formation* approach suggests that learners should be supported in their mental model construction. But, in contrast to the CTML or to the ITPC model (Schnotz, 2005), the *coherence formation* approach focuses more strongly on the "guidance process per se" by taking into account different processing strategies of learners (*surface structure level* vs. *deep structure level*). Although Mayer's CTML (2005c) emphasizes the processes of selecting, organizing and integrating, it does not say anything about the guidance process.

Building up on the above-mentioned research, the present dissertation aims at determining whether the multimedia principle and the modality principle hold true for different sources of information with primary school children. By applying Peeck's procedure (1974) to the learning material, it will be possible to investigate whether the multimedia effect as well as the modality effect show up for text-only information, picture-only information, illustrated-text information, and transfer information. Previous research on both the multimedia effect and the modality effect indicates that children are not likely to split their attention equally between different sources of information. For example, with respect to the multimedia effect, reviews of research on early studies in the field of multimedia learning (e.g., Levie & Lentz, 1982) show that adding pictures to text does not enhance the learning outcome *of all sources of information*. In this context, the children's learning outcome on text-only information and picture-only information might give hints for a potential *shift of attention*. Additionally to these findings on the multimedia effect, Brünken and Leutner (2001) report that the modality effect showed up for verbal information whereas it could not be found for pictorial information. Following the authors, this pattern of results might indicate not only split attention between written text and pictures but also a shift of attention *from text to pictures*. Since children are especially expected to be influenced by pictures (cp., Goldstein & Underwood, 1981), this shift of attention might even be larger for younger or less competent children (cp., Goldsmith, 1984). Thus, one aim of this dissertation was to explore, by means of the multimedia effect and the modality effect, whether pictures draw children's attention away from text. Or, in other words, the aim was to investigate whether the multimedia effect and the modality effect show up for all sources of information (text-only information, picture-only information, illustrated-text information and transfer information).

A further aim of this dissertation was to investigate whether providing aids for selection, organization and integration will improve the learning outcome. Following the research on coherence formation (e.g., Bodemer et al., 2005; Seufert, 2003; Seufert & Brünken, 2004), relevant elements *within* each single representation will be promoted by selection/organization aids. Furthermore, for some children, relevant elements *between* different representations, that is between the text paragraphs and the respective picture (*global coherence formation*; Seufert & Brünken, 2004) will be fostered by integration aids. Children who will be provided with *aids for selection/organization* will receive attentional guidance on a *surface structure level* (e.g., Seufert & Brünken, 2006), whereas children who will be provided with *aids for selection/organization and integration* will be supported on both a *surface structure level* and a *deep structure level* (Seufert & Brünken, 2004).

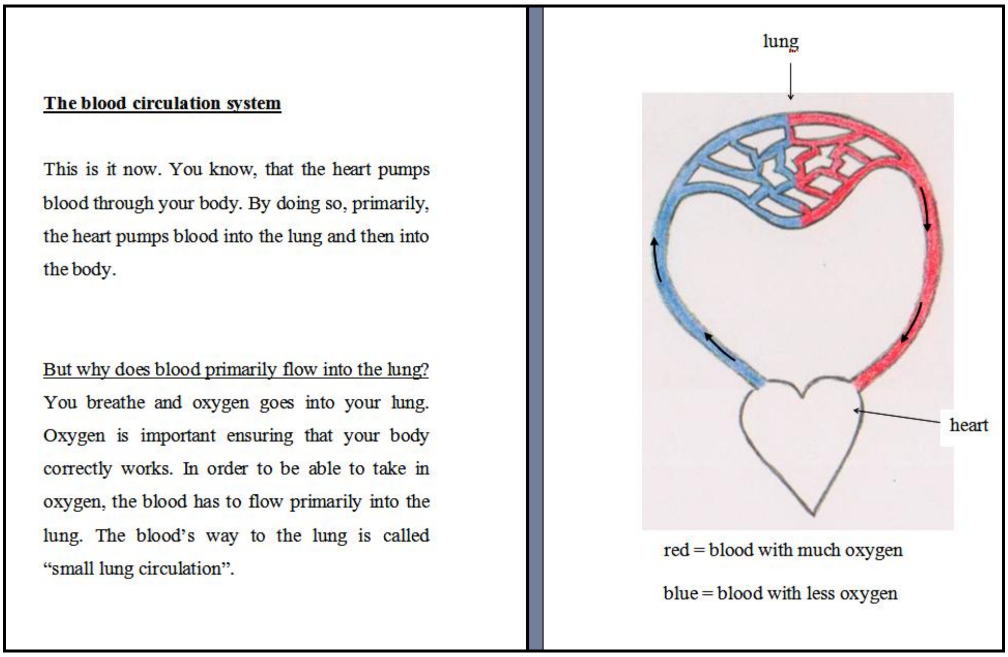
2 Learning Units and Further Study Materials

2.1 Learning Units

Since schoolbooks are still the most important media for providing information, the learning units to be constructed were designed in a paper-pencil based format. The learning units (Learning Unit 1 and Learning Unit 2) consisted of two biological texts that were created in cooperation with primary school teachers and biology teachers. The first text gave an overview over the heart and the blood circulation system and focused on functions of the pulmonary circulation as well as the systemic circulation. The second text described the structure of the heart as well as the process of blood circulation. According to Carney and Levin (2002), representational and/or interpretational pictures were used. These pictures illustrated the complex topic of the blood circulation as well as the structure of the human heart.

Both texts were divided into small coherent “paragraphs”. Overall, there were five paragraphs in the first text (number of words: 405, approximately 81 words per paragraph) and six paragraphs in the second text (number of words: 440, approximately 74 words per paragraph). Altogether, the first learning unit consisted of five text paragraphs and, in the case of picture presentation, five respective pictures. The second learning unit consisted of six text paragraphs and four pictures, whereby the first as well as the last text paragraph were presented without accompanying pictures. These learning units were used in all three experimental studies of the dissertation.

As has been already mentioned, the learning units consisted of text and pictures. In all three experimental studies, children were randomly assigned to different conditions which were derived from the respective study design. These conditions are related with the placement of text paragraphs and pictures. Hence, in the following, the condition is used as a “structuring device” for how text paragraphs and pictures were placed. In both the Pilot Study and Experiment 1, the following placement was implemented: For the “written text” condition, each paragraph was individually placed in the middle of a page (see Appendix A and Appendix E). For the “written text + pictures” condition, each text paragraph was presented on the left side accompanied by a picture on the right side of a sheet of paper (see Appendix B and Appendix F). The participants in the “spoken text” condition (see Appendix C and Appendix G), which was not realized in the Pilot Study, listened to the respective text paragraphs from a compact disk. The same was true for the “spoken text + pictures” condition, with pictures being presented in the middle of the page while the spoken text was played (see Appendix D and Appendix H). Figure 3 gives an example of the "written text + pictures" condition of how the text paragraph and the corresponding picture were placed.

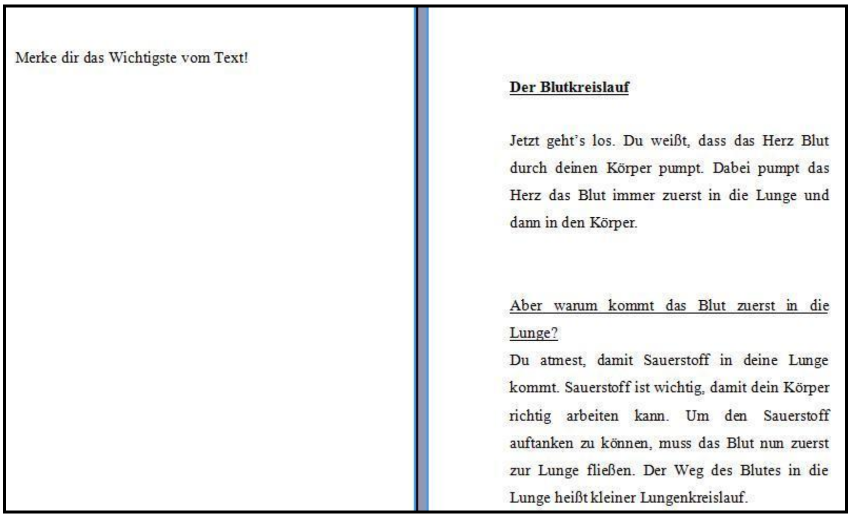

The blood circulation system

This is it now. You know, that the heart pumps blood through your body. By doing so, primarily, the heart pumps blood into the lung and then into the body.

But why does blood primarily flow into the lung?
You breathe and oxygen goes into your lung. Oxygen is important ensuring that your body correctly works. In order to be able to take in oxygen, the blood has to flow primarily into the lung. The blood's way to the lung is called "small lung circulation".

Figure 3. Text and picture arrangement of the "written text + pictures" condition in the Pilot Study and in Experiment 1.

In Experiment 2 (cp., Table 1), the text paragraphs and their respective pictures had to be arranged in another manner due to the use of selection/organization and integration aids that had to be placed on the sheet of paper as well. Hence, for the "written text" condition (see Appendix I and Appendix Q), each text paragraph was presented on the right side accompanied by a retention task (e.g., "Keep the most important information given in the text in mind.") on the left side of a sheet of paper. For the "written text + pictures" condition (see Appendix J and Appendix R), each text paragraph was presented on the right side accompanied by a retention task (e.g., "Keep the most important information given in the text in mind.") on the left side of a sheet of paper (also cp., Figure 4). This arrangement was the same as for the "written text" condition. The text paragraph's accompanying picture was individually placed on the right side of a new sheet of paper, accompanied by the retention task on the left side (e.g., "Keep the most important information given in the picture in mind."). Finally, on a third sheet of paper, the text paragraph and the accompanying picture were presented together, whereby the paragraph was placed on the left and the picture on the right side. Thereby, children were required to search for aspects presented in both the text paragraph and the accompanying picture. Figure 4 gives an example of the "written text + pictures" condition of how the text paragraph and the corresponding picture were placed on the three sheets of paper.



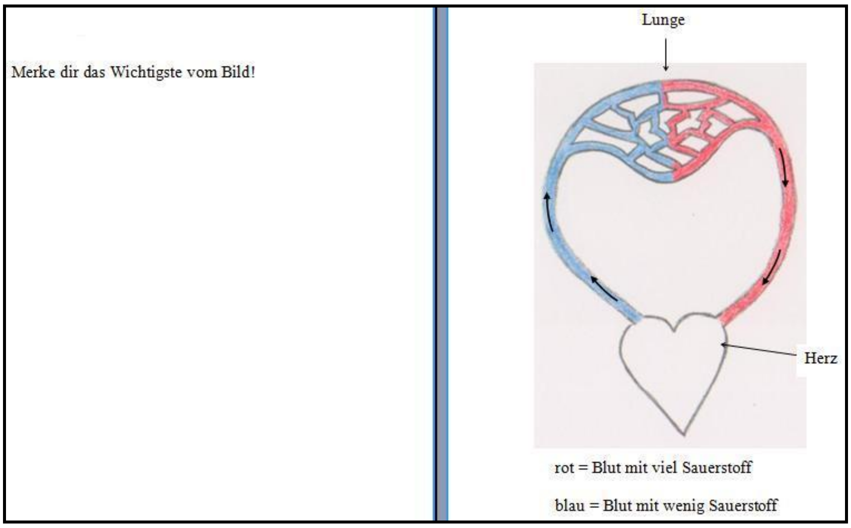
Merke dir das Wichtigste vom Text!

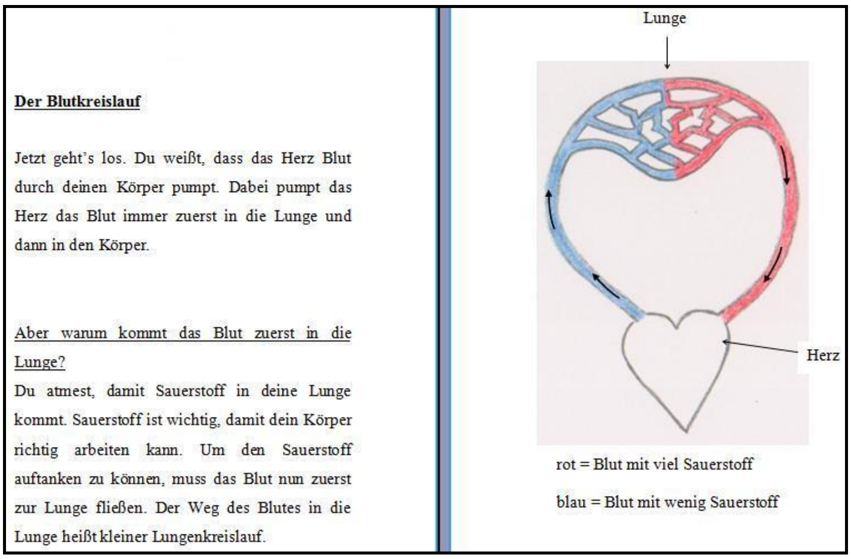
Der Blutkreislauf

Jetzt geht's los. Du weißt, dass das Herz Blut durch deinen Körper pumpt. Dabei pumpt das Herz das Blut immer zuerst in die Lunge und dann in den Körper.

Aber warum kommt das Blut zuerst in die Lunge?

Du atmest, damit Sauerstoff in deine Lunge kommt. Sauerstoff ist wichtig, damit dein Körper richtig arbeiten kann. Um den Sauerstoff auftanken zu können, muss das Blut nun zuerst zur Lunge fließen. Der Weg des Blutes in die Lunge heißt kleiner Lungenkreislauf.





Der Blutkreislauf

Jetzt geht's los. Du weißt, dass das Herz Blut durch deinen Körper pumpt. Dabei pumpt das Herz das Blut immer zuerst in die Lunge und dann in den Körper.

Aber warum kommt das Blut zuerst in die Lunge?

Du atmest, damit Sauerstoff in deine Lunge kommt. Sauerstoff ist wichtig, damit dein Körper richtig arbeiten kann. Um den Sauerstoff auftanken zu können, muss das Blut nun zuerst zur Lunge fließen. Der Weg des Blutes in die Lunge heißt kleiner Lungenkreislauf.

Figure 4. Text and picture arrangement of the "written text + pictures" condition in Experiment 2.

Table 1

Experiment 2: Placement of Text Paragraphs and Pictures on the Sheets of Paper, Depending on the Condition

	Placement of text paragraphs and pictures					
	First sheet of paper		Second sheet of paper		Third sheet of paper	
	Left	*Right*	*Left*	*Right*	*Left*	*Right*
Condition						
Written text	retention task	text	---	---	---	---
Written text + pictures	retention task	text	retention task	picture	text	picture
Written text + pictures + selection/organization aids	retention task + sel./org. aids	text	retention task + sel./org. aids	picture	text	picture
Written text + pictures + selection/organization aids + integration aids	retention task + sel./org. aids	text	retention task + sel./org. aids	picture	text + int.aids	picture + int. aids
Spoken text	retention task	---	---	---	---	---
Spoken text + pictures	retention task	---	retention task	picture	---	picture
Spoken text + pictures + selection/organization aids	retention task + sel./org. aids	---	retention task + sel./org. aids	picture	---	picture
Spoken text + pictures + selection/organization aids + integration aids	retention task + sel./org. aids	---	retention task + sel./org. aids	picture	int.aids	picture + int. aids

The participants in the “written text + pictures + selection/organization aids” condition (see Appendix K and Appendix S) received the same arrangement of text paragraphs, pictures and respective tasks as the “written text + pictures” condition. In addition to the retention task (e.g., “Keep the most important information given in the text/in the picture in mind”), selection/organization aids were provided in the form of tasks which had to be worked on by the children. More specifically, children were required to put in the correct words in completion/cloze tasks, to encircle the correct word, to draw in missing information or to caption parts of the pictures on tasks concerning picture information. Thus, the aids' focus was on drawing the children's attention to relevant portions of words and pictures (selection) and on organizing them. The same was true for the "written text + pictures + selection/organization aids + integration aids" condition (see Appendix L and Appendix T). Additionally, this group was provided with integration aids (mainly in the form of completion/cloze tasks) that were to draw children's attention to information to-be-integrated.

The participants in the "spoken text" condition listened to the respective text paragraphs from a compact disk, whereby the accompanying retention task (e.g., "Keep the most important information given in the text in mind.") was presented on the left side of a sheet of paper (see Appendix M and Appendix U). For the "spoken text + pictures" condition, again, each text paragraph was played from a compact disk while the accompanying retention task (e.g., "Keep the most important information given in the text in mind.") was presented on the left side of a sheet of paper (see Appendix N and Appendix V). Furthermore, as for the "written text + pictures" condition, the text paragraph's accompanying picture was individually placed on the right side of a new sheet of paper, accompanied by the retention task on the left side (e.g., "Keep the most important information given in the picture in mind."). Finally, the respective picture was presented on the right side of a third sheet of paper, while the spoken text was played. Thereby, children were required to search for aspects presented in both the text paragraph and the accompanying picture. The participants in the "spoken text + pictures + selection/organization aids" condition (see Appendix O and Appendix W) received the same procedure as the participants in the "written text + pictures + selection/organization aids" condition with just one exception: The text was spoken, namely played from a compact disk, rather than written. The material for the participants in the "spoken text + pictures + selection/organization aids + integration aids" condition (see Appendix P and Appendix X) was identical to that for the participants in the "written text + pictures + selection/organization aids + integration aids" condition, with spoken instead of written text. The second learning unit consisted of six text paragraphs and four pictures, whereby the first as well as the last text paragraph were presented without accompanying pictures. In Learning Unit 1 and Learning Unit 2, the text paragraphs and the accompanying pictures were arranged in the same manner.

Additionally, following suggestions of Peeck (1974; 1994), the learning units were organized in such a way that the information about the functionality of the human heart and the blood circulation was carefully divided between text and pictures. Thus, there were three sources of information: (1) information presented in text only, (2) information presented in pictures only, and (3) information presented in both text and picture (illustrated-text information). In order to depict the pure learning content, that is, the essential part to be learnt, Klauer's (1987) guidelines for constructing basal texts (Basaltexte) were followed for both learning units: For each of the two biological texts, all redundant text paragraphs, repetitions, examples, summaries, didactic stylistic devices and so forth were crossed out – resulting in basal texts. It has to be noted that there was no need to apply these guidelines to the pictures, because the representational or interpretational pictures used to already depict the pure learning content. Following Klauer (1987), the different sources of information (such as text-only information, picture-only information, illustrated-text information) were also taken into account. For example, for information presented in text only, the following basal sentence was drawn up for Learning Unit 1: "Primarily, the heart pumps blood into the lung, and then into the body" (cp., Figure 3, text paragraph); an example of illustrated-text information is "The blood flows within small tubes, being called blood vessels or veins". Colors, arrows and lettering were used for representing picture-only information. For example, the arrows in the picture in Figure 3 illustrate in which direction the blood flows.

2.2 Multiple-Choice Tests

Criterion-referenced multiple-choice-items, including transfer items, were developed by applying the procedures of Klauer (1987) and Feger (1984) to the basal sentences and the pictures from both learning units. According to Klauer (1987), three rules were followed in order to draw up single-select multiple-choice items with four options to select from: First, a word/a group of words was underlined in each basal sentence. Second, three false but plausible alternatives (distractors) were developed by means of *context strategy* (“Kontextstrategie”) or *contrasting strategy* (“Gegensatzstrategie”). In the case of the application of the context strategy (“Anwendung der Kontextstrategie”), distractors were chosen from the basal text’s context. In the case of the application of the contrasting strategy (“Anwendung der Gegensatzstrategie”), appropriate distractors were drawn up by negating the underlined word/group of words and simultaneously searching for positive terms for this negation. Third, the underlined word/group of words and the three distractors were distributed among reply options by chance.

In addition to Klauer’s recommendations for developing distractors, Feger’s (1984) strategy of semantic features (“Strategie der semantischen Merkmale”) was also taken into account. This strategy, based on linguistic considerations, assumes that each word is largely or even totally determined by semantic features. Thus, the procedure aims at finding semantic features for each underlined word/group of words; while searching for features, the text content might serve as an orientation aid. Then, some of the found features must be changed by negating them. Finally, distractors can be drawn up by searching for words which match both the origin features as well as the negated features. Basically, the same procedure was applied to the pictures. The transfer items were created by relating text and picture components to each other, embedding them into an everyday context. Thus, transfer items were intended to measure how well children integrate information from multiple representations and how well a transfer to everyday situations can be managed.

The application of the procedures of Klauer (1987) and Feger (1984) resulted in a multiple-choice test for each of the learning units (Learning Unit 1: 37 items; Learning Unit 2: 38 items). The multiple-choice test included a retention subscale for each of the three sources of information with 10 items each and a transfer subscale referring to the concepts of “blood circulation”, “heart and veins” and “oxygen” in everyday contexts (Learning Unit 1: 7 transfer items; Learning Unit 2: 8 transfer items). Concerning their fit to the four scales, the items were rated by two independent raters, resulting in a satisfactory agreement of 91.9 % for Learning Unit 1 and of 92.1 % for Learning Unit 2.

The above-mentioned multiple-choice test items were tested in an item analysis in the Pilot Study. Based on these item analyses, in Experiment 1 and 2, the number of multiple-choice test items was changed: For Learning Unit 1, a 32-item multiple-choice test (see Appendix Y) was used (8 text-only items, 7 picture-only items, 8 illustrated-text items, 9 transfer items). For Learning Unit 2, a 32-item multiple-choice test (see Appendix Z) was used as well, but with 8 items for each kind of information. Concerning their fit to the four scales, the items were rated by two independent raters, resulting in a satisfactory agreement (Learning Unit 1: 93.8 %; Learning Unit 2: 90.6 %)[4]. The procedure was the same for Learning Unit 2.

The theoretical basis for participants' learning objectives was Bloom's revised taxonomy (Anderson et al., 2001) corresponding to learning factual and conceptual knowledge.

2.3 Further Study Materials

In addition to the learning units and their respective multiple-choice tests, the paper-pencil-based materials consisted of a participant questionnaire, motivational judgement items, cognitive load items, a distractor task, a text difficulty question, a question on the difficulty of the multiple-choice test, and a question on reading time and testing time. Furthermore, reading comprehension (ELFE test; Lenhard & Schneider, 2006) and non-verbal intelligence (KFT intelligence test; Heller & Perleth, 2000) were assessed.

Participant Questionnaire and Motivational Judgements

The participant questionnaire solicited information concerning the participant's class, language spoken at home, sex, date of birth, and prior knowledge. As the blood circulation system does not belong to the topics of the curriculum at primary schools, children's prior knowledge was expected to be very low. Nevertheless, children's prior knowledge was assessed with five items.

With respect to motivation, children were required to rate how strongly they were looking forward to getting to know about the blood circulation system on a scale which ranged from 0 to 100:

0 = I am not looking forward to getting to know the blood circulation system at all!
100 = I am really over the moon to get to know the blood circulation system.

Overall, children had to rate their motivation three times on each learning unit: firstly, at the beginning of the learning phase, secondly, directly after the learning phase, and thirdly, directly

[4] It has to be noted that the same pattern of results was found for each rater's classification.

after the testing phase. The instructions for the second and third ratings were adjusted as follows: “Do you enjoy getting to know the blood circulation system?” and “Did you enjoy getting to know the blood circulation system?”

Cognitive Load Items

The two cognitive load items adapted from Paas (1992) were as follows: (1) “How easy or difficult was the learning material to understand?” (“very easy”, “easy”, “fairly easy”, neither easy nor difficult”, “fairly difficult”, “difficult” and “very difficult”) and (2) “How much mental effort did you invest in working on the learning material?” (“very low mental effort”, “low mental effort”, “rather low mental effort”, “neither low nor high mental effort”, “rather high mental effort”, “high mental effort” and “very high mental effort”).

Distractor Tasks

In order to avoid primacy and recency effects, children were given a distractor task between the learning phase and the testing phase. With regard to Learning Unit 1, children had to find seven mistakes in a target illustration and to color it, subsequently. With regard to Learning Unit 2, children had to complete a partial illustration and, again, to color it, subsequently.

Reading Time, Testing Time, Text Difficulty, and the Difficulty of the Multiple-Choice Tests

The text difficulty question was “Was the text too difficult, too easy or just appropriate?” The multiple-choice test difficulty question was “Was the multiple-choice test too difficult, too easy or just appropriate?” The reading time question was “Did you have enough time for reading the text?”, whereas the testing time question was “Did you have enough time for answering the multiple-choice items?”

Reading Comprehension and Non-Verbal Intelligence

Reading comprehension was controlled by using the ELFE test, version A (Lenhard & Schneider, 2006), which contains three different subscales measuring word, sentence and text comprehension. Participants either had to underline the correct (one out of four) word next to a picture, to choose the appropriate (one out of five) word that would fit into a certain sentence, or to choose the correct sentence (one out of four) explaining the content of a little text passage in the right way.

Non-verbal intelligence was assessed by using three subscales of the KFT intelligence test, version A (Heller & Perleth, 2000). The first subscale requires participants to view three figures and judge which of the five alternative test figures matches the target figures. The second subscale requires participants to view a pair of figures and to decide which connection there is between the two target figures. The same connection has to be found between a third target figure and five other alternative test figures. The third subscale is a paper-folding task indicating spatial ability.

2.4 Common Procedure for All Experiments

Altogether, each of the three studies (Pilot Study, Experiment 1, and Experiment 2) consisted of three phases taking place on three different days within a week, whereby each phase lasted approximately for two lessons (90 minutes). All three study phases either took place in the first and second lesson or in the third and fourth lesson. Within their classes, children were randomly assigned to the different conditions, whereby the distributions of Grade Point Average (GPA) and sex were roughly balanced. Then, they were simultaneously tested in one of two classrooms. In the Pilot Study, in one classroom, participants received written text with accompanying pictures ("written text + pictures" condition), whereas in the other classroom participants received written text without accompanying pictures ("written text" condition). In Experiment 1, in one classroom participants had to *listen to* the text, whereby half of them received accompanying pictures. In the other classroom participants had to *read* the text; half of them also received accompanying pictures. In Experiment 2 (Table 2), in one classroom participants had to *listen to* the text, whereby ¾ of them received accompanying pictures, that is, ¼ of them received spoken text + pictures, ¼ of them received spoken text + pictures + selection/organization aids and ¼ of them received spoken text + pictures + selection/organization aids + integration aids. In the other classroom participants had to *read* the text; ¾ of them also received accompanying pictures (¼ of them received written text + pictures, ¼ of them received written text + pictures + selection/organization aids and ¼ of them received written text + pictures + selection/organization aids + integration aids).

Table 2

Experiment 2: Proportion of Children in Each Condition, Depending on the Classroom

	Classroom 1	Classroom 2
Condition		
Written text	¼	---
Written text + pictures	¼	---
Written text + pictures + selection/organization aids	¼	---
Written text + pictures + selection/organization aids + integration aids	¼	---
Spoken text	---	¼
Spoken text + pictures	---	¼
Spoken text + pictures + selection/organization aids	---	¼
Spoken text + pictures + selection/organization aids + integration aids	---	¼

In both the Pilot Study and Experiment 1, participants were told they would receive a text or a text with pictures about the blood circulation system and should learn as much as possible from text only and text + pictures, respectively. In Experiment 2, participants were told they would receive a text or a text with pictures about the blood circulation system. First, they should read the tasks, second, they should read the text, and third, they should follow the instructions and work on the tasks. The same was true for the pictures: First, children should read the tasks, second, they should thoroughly look at the picture, and third, they should follow the instructions and work on the tasks.

On the first day, all participants received the first learning unit. After a short learning phase (Pilot Study: about 15 minutes; Experiment 1: about 8 minutes; Experiment 2: about 18 minutes), learning outcomes were measured with a multiple-choice test (Pilot Study: 37 items, with a 20-min time limit; Experiment 1: 32 items, with a 20-min time limit; Experiment 2: 32 items, with a 20-min time limit). On the second day, participants went through the same procedure again with the second learning unit. In the end, again, learning outcomes were measured with a multiple-choice test (Pilot Study: 38 items with a 20-min time limit; Experiment 1: 32 items, with a 20-min time limit; Experiment 2: 32 items, with a 20-min time limit). On the third day, non-verbal intelligence (KFT intelligence test; Heller & Perleth, 2000) and reading comprehension (ELFE test; Lenhard & Schneider, 2006) were assessed. During all study and testing phases, a teacher and an experimenter[5] were present.

The First Day

On the first day, within their classes, the children were randomly assigned to the different conditions. As has been already described, subsequently, the children were required to go into one of two classrooms, according to the condition assigned to. The children were told that the study aimed at finding out how children learn best from learning materials. The study was introduced by explaining the work of (natural) scientists. Afterwards, the children were instructed with respect to the study's procedure. All children generated a code which consisted of (1) the first letter of the first name, (2) the first letter of the last name, and (3) the day of birth. For pedagogical purposes, it was emphasized that the study was neither an examination nor an exercise with any grades.

Finally, the actual procedure started. First, the experimenter read out all questions of the participant questionnaire whereby the respective answer option had to be chosen by each child individually. Second, the children were required to rate their motivation for the first time. Afterwards, they received the first learning unit. In the Pilot Study as well as in Experiment 1, the children were instructed to learn as much as possible from all representations, whereas in Experiment 2, children were required to follow the instructions next to the representations. The study phase lasted about 15 minutes in the Pilot Study, 8 minutes in Experiment 1, and 18 minutes in Experiment 2. Then, the children rated their cognitive load (mental effort and perceived difficulty) and their motivation (for the second time). Next, they worked on a distractor task with a 5-min time limit. Subsequently, they engaged in answering the multiple-choice test items (Pilot Study: 38 items, Experiment 1: 32 items, Experiment 2: 32 items) – with a maximum time limit of 20 minutes. After having answered the questions on text difficulty, multiple-choice test difficulty, reading time and testing time, the children had to rate their motivation for the third time.

The Second Day

On the second day, the children were told they would receive the same procedure as on the first day, but with the second learning unit. In addition, it was ensured that each child sat down next to his or her first day's seat neighbor and that each child still knew his or her code. Again, it was

[5] Apart from the author of this dissertation, two students having been trained before acted as experimenters.

emphasized that this was no examination. The following procedure was the same procedure as on the first day: First, the experimenter read out all questions of the participant questionnaire whereby the respective answer option had to be chosen by each child individually. Second, the children were required to rate their motivation for the first time. Afterwards, they received the second learning unit. In the Pilot Study as well as in Experiment 1, children were instructed to learn as much as possible from all representations, whereas in Experiment 2, the children were required to follow the instructions next to the representations. The study phase lasted about 15 minutes in the Pilot Study, 8 minutes in Experiment 1, and 18 minutes in Experiment 2. Then, the children rated their cognitive load (mental effort and perceived difficulty) and their motivation (for the second time). Next, they worked on a distractor task with a 5-min time limit. Subsequently, participants engaged in answering the multiple-choice test items (Pilot Study: 38 items, Experiment 1: 32 items, Experiment 2: 32 items) – with a maximum time limit of 20 minutes. After having answered the questions on text difficulty, multiple-choice test difficulty, reading time and testing time, the children had to rate their motivation for the third time.

The Third Day

On the third day, the control variables, non-verbal intelligence (KFT intelligence test; Heller & Perleth, 2000) and reading comprehension (ELFE test; Lenhard & Schneider, 2006) were assessed. Again, it was ensured that each child sat down next to his or her first day's seat neighbor and that each child still knew his or her code. Additionally, it was emphasized that this assessment was no examination.

First, non-verbal intelligence was assessed: The general instructions of the KFT test were read out to the children, followed by the specific instructions for the first subscale. All three examples of the first subscale were commonly worked through by the experimenter and the children. Then, the children dealt individually with similar items (25 items with a 9-min time limit). Next, they received the specific instructions for the second subscale, including two examples. Afterwards, the children dealt individually with similar items (25 items with an 8-min time limit). Finally, they were instructed according to the third subscale, including one example. Again, the children dealt individually with similar items (15 items with an 8-min time limit). Overall, the non-verbal part of the KFT intelligence test lasted about 40 minutes. When they had finished, the children took a break of 10 to 15 minutes in which they had time for coloring, playing games, drinking and eating.

Second, reading comprehension was assessed: The general instructions of the ELFE test were read out to the children, followed by the specific instructions for the word comprehension test, including three examples. Again, all examples were commonly worked through by the experimenter and the children. Then, the children dealt individually with similar items (72 items with a 3-min time limit). Next, they received the specific instructions for the sentence comprehension test, including two examples. Again, the children were required to deal individually with similar items (28 items with a 3-min time limit). Finally, they were instructed according to the text comprehension test, including two examples. Afterwards, the children had to work individually on similar items with a 7-minute time limit. Overall, the ELFE test lasted about 30 minutes, including preparation, division of test booklets, writing the code down, instruction and recollection of test booklets. At the end of the third day, the children were thanked for their participation and debriefed. In addition, they were given some candy.

3 Pilot Study

The pilot study aimed at testing the learning materials for both learning units, including the developed multiple-choice tests. Additionally, it was examined if and to which extent the (overall) multimedia effect will show up.

3.1 Research Questions and Hypotheses

More specifically, the pilot study served to clarify whether the reliabilities of each of the multiple-choice tests are sufficient (item analyses and item selection), the overall multimedia effect shows up and children's judgements on reading time, testing time, text difficulty and multiple-choice test difficulty correspond with statistical measures indicating that the learning materials are appropriate for children. Although these variables have been judged as appropriate by teachers, children's judgements seem to be a useful supplementation.

The main focus of the Pilot Study was on the question whether the (overall) multimedia effect shows up. Thereby, the following hypothesis can be derived from theories of multimedia learning (cp., section 1.2):

H1: The "written text + pictures" condition will exceed the "written text" condition on overall learning scores (multimedia effect).

3.2 Method

3.2.1 Participants and Design

Fifty children from 4th grades of a German primary school participated in the pilot study. The average age was 10.0 years (*SD* = .71), and there were 28 girls and 22 boys.

A 2-group study design with the independent variable *type of learning material* (written text vs. written text plus pictures) was used. This resulted in two experimental conditions: Children in the first condition received written text (n = 25), and children in the second condition received written text plus pictures (n = 24)[6]. Within each class, the teacher divided children into

[6] One child did not work on both learning units; it was only present during the last study phase.

two groups, in which the distributions of Grade Point Average (GPA) and sex were roughly balanced. Then, the two groups were randomly assigned to one of two conditions.

The dependent variables, as measured by criterion-referenced tests, were performance overall, performance on information presented in text only, performance on information presented in picture only, performance on information presented in both text and picture (illustrated-text information), and performance on transfer items. In addition, reading comprehension and non-verbal intelligence were recorded as control variables.

3.2.2 Materials

All materials are described in detail in Chapter 2. Therefore, in this section, materials are just listed up roughly: Apart from the learning units and the respective multiple-choice tests on the blood circulation system, children received a participant questionnaire (including items on learner's prior knowledge), motivational judgement items, cognitive load items, a distractor task, a text difficulty question, a question on the difficulty of the multiple-choice test and a question on reading time and testing time. Furthermore, reading comprehension (ELFE test; Lenhard & Schneider, 2006) and non-verbal intelligence (KFT intelligence test; Heller & Perleth, 2000) were assessed.

Multiple-Choice Tests, Reading Comprehension and Non-Verbal Intelligence

As described in detail in sections 2.2 and 2.3, both multiple-choice tests – one for Learning Unit 1 and one for Learning Unit 2 – comprised retention and transfer items. In the Pilot Study, in order to avoid copying, children sitting next to each other received different test versions of the respective multiple-choice tests. Overall, 25 children (12 in the "written text" condition, 13 in the "written text + pictures" condition) worked on version A, whereas 24 children (13 in the "written text" condition, 11 in the "written text + pictures" condition) worked on version B of the respective multiple-choice tests. The different versions of the respective multiple-choice tests only differ with respect to the order of the items.

Additionally, in order to avoid copying, children who sat next to each other received different but parallel versions (A and B) of the ELFE test and of the KFT intelligence test.

3.2.3 Procedure

Altogether, the study consisted of three phases taking place on three different days within a week, whereby each phase lasted approximately for two lessons (90 minutes). On the first day, all participants received the first learning unit. After a short learning phase (about 15 minutes) in which participants were instructed to keep as much information in mind as possible, learning outcome was measured by means of a multiple-choice test (37 items, with a 20-min time limit). On the second day, participants went through the same procedure again with the second learning unit, whereby learning outcome was measured by means of a multiple-choice test with 38 items. On the third day, non-verbal intelligence and reading comprehension were assessed. The procedure is described in more detail in section 2.4.

3.3 Results

In a first step, the reliability analyses will be presented. In a second step, the aforementioned hypothesis concerning the multimedia effect will be addressed by analyzing the learning outcome of the two experimental conditions. In conclusion, descriptive data on children’s judgements on reading time, testing time, text difficulty and multiple-choice tests difficulty will be presented.

3.3.1 Reliability Analyses

With respect to both learning units, three of four subscales consisted of 10 items each, namely the text-only subscale, the picture-only subscale and the illustrated-texts subscale. The transfer subscale comprised 7 items for Learning Unit 1 and 8 items for Learning Unit 2.

All reliability analyses were based on the data of 48 children[7], each of them having worked on both learning units. However, children with missing data were automatically excluded from the analyses by SPSS. Reliability analyses for each multiple-choice test as well as for the respective subscales were conducted. Having used two different versions of each multiple-choice test, reliability analyses were also done individually for each version. Data on the original internal consistencies (Cronbach’s α) for the multiple-choice tests of both learning units (separated for version A and B) and their respective subscales can be found in Table 3. As can be seen, the internal consistencies showed unsatisfactory values for all subscales of the

[7] As has been already mentioned, one child was only present during the last study phase. A further child worked only on one of the two learning units.

respective multiple-choice test's versions. For version B of the multiple-choice test, the internal consistencies even seemed to be lower than the ones for version A, especially for Learning Unit 2 (Table 3).

Table 3

Original Internal Consistencies for the Multiple-Choice Tests of Both Learning Units – Separated for Multiple-Choice Test Version

	Original internal consistencies[a]				
Learning Unit and multiple-choice test version	*Text-only subscale (r_{tt})*	*Picture-only subscale (r_{tt})*	*Illustrated-text subscale (r_{tt})*	*Transfer subscale (r_{tt})*	*Overall scale (r_{tt})*
Learning Unit 1					
Version A	.58 (7 items)	.59 (10 items)	.46 (10 items)	.31 (7 items)	.77 (31 items)[b]
Version B	.54 (6 items)	.74 (10 items)	.31 (10 items)	.25 (7 items)	.72 (33 items)
Learning Unit 2					
Version A	.56 (10 items)	.66 (10 items)	.61 (10 items)	.53 (8 items)	.83 (38 items)
Version B	.41 (10 items)	.16 (10 items)	.34 (10 items)	.04 (8 items)	.36 (38 items)

[a] If the number of text-only items, picture-only items or illustrated text items is less than 10, the missing items had a variance of "0" and were automatically excluded from reliability analysis.
[b] With respect to overall reliability, three further items were automatically excluded from reliability analysis due to a variance of "0".

Table 4 presents the internal consistencies for the multiple-choice tests of both learning units, aggregated over the multiple-choice test's respective versions.

Table 4

Original Internal Consistencies for the Multiple-Choice Tests of Both Learning Units – Aggregated over the Multiple-Choice Test Versions

	Original internal consistencies[a]				
Learning Unit and multiple-choice test (aggregated)	*Text-only subscale (r_{tt})*	*Picture-only subscale (r_{tt})*	*Illustrated-text subscale (r_{tt})*	*Transfer subscale (r_{tt})*	*Overall scale (r_{tt})*
Learning Unit 1					
Multiple-choice test (aggregated)	.55 (7 items)	.68 (10 items)	.39 (10 items)	.25 (7 items)	.73 (33 items)[b]
Learning Unit 2					
Multiple-choice test (aggregated)	.55 (10 items)	.52 (10 items)	.57 (10 items)	.37 (8 items)	.77 (38 items)

[a] If the number of text-only items, picture-only items or illustrated text items is less than 10, the missing items had a variance of "0" and were automatically excluded from reliability analysis.

[b] With respect to overall reliability, one further item was automatically excluded from reliability analysis due to a variance of "0".

Thus, to improve the reliability of the subscales of the respective multiple-choice tests, item analyses with subsequent item selections were conducted for each multiple-choice test version, for both learning units. Additionally, item analyses with subsequent item selections were conducted for the aggregated multiple-choice tests. Finally, the results of all item analyses and selections were thoroughly compared in order to determine those items which could be used in further experiments. It has to be noted that the internal consistencies for the transfer subscale of each learning unit did not reach satisfactory values. Therefore, new transfer items had to be created for the further planned experiments. With regard to the item selections, corrected item-total correlation, item difficulty as well as "Cronbach's α if the item were deleted" were taken into account. However, some recommendations arising from the item analyses had to be weighed up against recommendations regarding validity (*reliability-validity dilemma*; Fisseni, 1997). For example, very easy items (item difficulty > .80) as well as very difficult items (item difficulty < .20) were sometimes kept in the scale to ensure validity. Furthermore, not all values of the corrected item-total correlation reached a value above .30 (Field, 2009).

Turning out to be less reliable than multiple-choice test version A, version B was not realized any more in further experiments. The final internal consistencies of the multiple-choice tests of both learning units, aggregated over the multiple-choice test versions, are presented in Table 5. For each subscale, internal consistencies may be regarded as acceptable. As can be seen in Table 5, in order to get the same amount of items on each subscale (with 8 + / − 1 items on the text-only subscale, the picture-only subscale and the illustrated-texts subscale each), new items had to be created.

Table 5

Final Internal Consistencies for the Multiple-Choice Tests of Both Learning Units Following Item Analyses and Selections – Aggregated over the Multiple-Choice Test Versions

	Final internal consistencies				
Learning Unit and multiple-choice test (aggregated)	*Text-only subscale* (r_{tt})	*Picture-only subscale* (r_{tt})	*Illustrated-text subscale* (r_{tt})	*Transfer subscale* (r_{tt})	*Overall scale* (r_{tt})
Learning Unit 1					
Multiple-choice test (aggregated)	.62 (6 items)	.75 (7 items)	.63 (8 items)	-----	.82 (20 items)[a]
Learning Unit 2					
Multiple-choice test (aggregated)	.61 (7 items)	.52 (5 items)	.64 (8 items)	-----	.75 (20 items)

[a] With respect to overall reliability, one variable had a variance of „0“ and was automatically excluded from reliability analysis.

Finally, it has to be noted that the average difficulty of each subscale as well as of all subscales together (the whole multiple-choice test) was appropriate for both learning units. For Learning Unit 1, the overall mean was M = .53, SD = .24 for the text-only subscale, M = .34, SD = .12 for the picture-only subscale[8], M = .62, SD = .25 for the text and picture subscale, and M = .48, SD = .21 for all subscales together (the whole multiple-choice test). For Learning Unit 2, the overall mean was M = .48, SD = .28 for the text-only subscale, M = .24, SD = .15 for the picture-only subscale[9], M = .50, SD = .21 for the text and picture subscale, and M = .44, SD = .25 for all

[8] It has to be noted that the specific statistical values for the picture-only subscale were based upon the data of all children. With regard to those children who actually received pictures, the overall mean was M = .50, SD = .17 for the picture-only subscale.

[9] With regard to those children who actually received pictures, the overall mean was M = .34, SD = .23 for the picture-only subscale.

subscales together (the whole multiple-choice test). To sum up, both multiple-choice tests as well as their respective subscales had a medium difficulty level for learners – except for the picture-only subscale of Learning Unit 2 which had a higher difficulty level. As has been described in section 1.4, pictures are often processed superficially (cp., Mokros & Tinker, 1987; Weidenmann, 1989). Thus, with respect to those children who actually received pictures, it might be possible that more complex pictures were processed even more superficially resulting in a mean of M = .34, compared to a mean of M = .50 for Learning Unit 1.

3.3.2 Multimedia effect

The following analyses aimed at determining whether the multimedia effect will show up for "good" items identified by previous reliability analyses. The analyses were based on the data of 44 participants: Four children were omitted because they did not take part in the whole study, whereas two other children consequently marked more than one option per multiple-choice item.

In a first step, participants' scores (relative frequencies of correct answers) on the multiple-choice tests (overall scales and subscales) were adjusted for reading comprehension and non-verbal intelligence. Although these covariates did not account for a large amount of variance in the learning-test scores (overall test scores of Learning Unit 1: $eta^2 = .078$; Learning Unit 2: $eta^2 = .020$), the two conditions differ significantly on reading comprehension, $F(1,45) = 10.67$, $p = .002$, *partial* $eta^2 = .19$. Thus, adjusting is a useful means to increase the statistical power of study designs by reducing within-group or error variances (Lipsey, 1990).

After that, a multivariate analysis of variance (MANOVA) was computed with the adjusted overall test scores of the multiple-choice tests of Learning Unit 1 and Learning Unit 2 as dependent variables, and the type of learning material as factor (Figure 5). This revealed a multivariate main effect for type of learning material, $F(2,41) = 10.01$, $p < .001$, *partial* $eta^2 = .33$. Text plus pictures led to better scores for Learning Unit 1, $M_{\text{written text}} = .39$, $SD_{\text{written text}} = .16$, $M_{\text{written text plus pictures}} = .60$, $SD_{\text{written text plus pictures}} = .15$, $F(1,42) = 20.05$, $p < .001$ (directional hypothesis), *partial* $eta^2 =.32$, as well as for Learning Unit 2, $M_{\text{written text}} = .35$, $SD_{\text{written text}} = .15$, $M_{\text{written text plus pictures}} = .50$, $SD_{\text{written text plus pictures}} = .19$, $F(1,42) = 8.91$, $p < .01$ (directional hypothesis), *partial* $eta^2 = .18$.

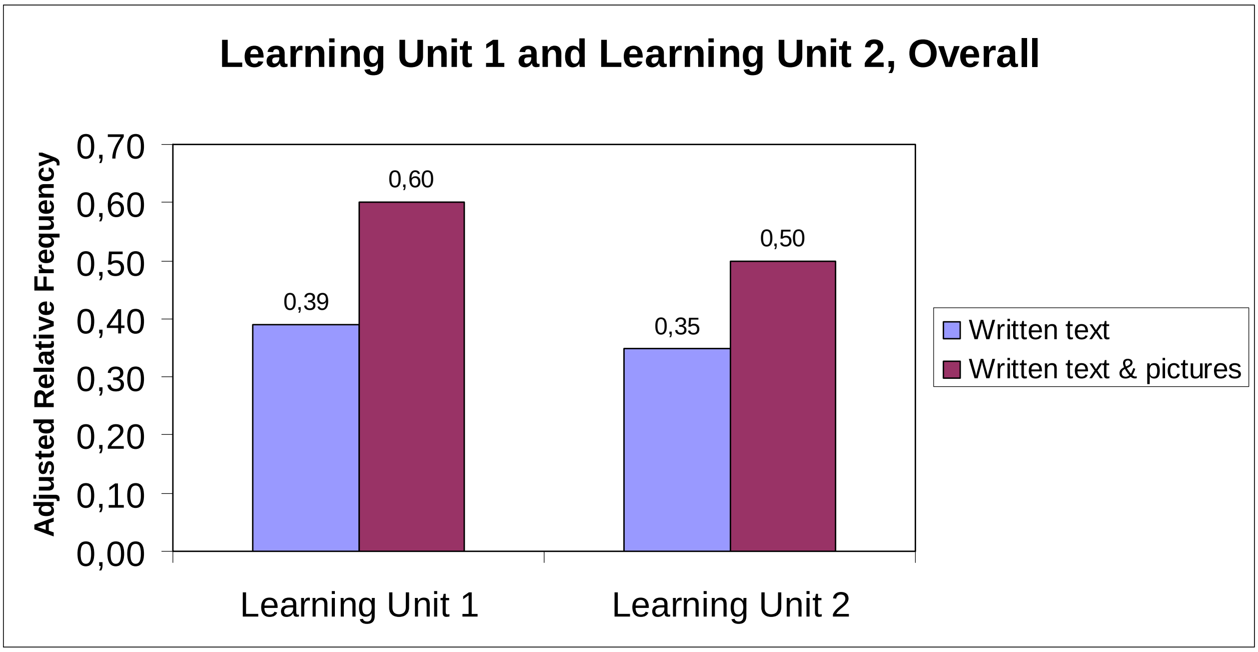


Figure 5. Learning Results (Overall) Depending on Type of Learning Material [Written Text (N = 24), Written Text & Pictures (N = 20)] for Learning Unit 1 and Learning Unit 2.

3.3.3 Children's judgements

All descriptive analyses on reading time, testing time, text difficulty and multiple-choice tests difficulty were based on the data of 48 children, each of them having worked on both learning units. For Learning Unit 1, about 95 % of the participants reported that the time given for reading and testing was sufficient (Table 6). Furthermore, following children's judgements, the blood circulation text implemented in Learning Unit 1 was too difficult for 10.4 % of the participants, whereas the corresponding multiple-choice test was too difficult for 22.9 %.

Table 6

Children's Judgements in Percent on Reading Time, Testing Time, Text Difficulty and Multiple-Choice Test Difficulty – Learning Unit 1

	Children's ratings in percent				
	Yes	No	Too difficult	Too easy	Appropriate
Did you have enough time for reading the text?	95.8 %	4.2 %	---	---	---
Did you have enough time for answering the multiple-choice items?	97.9 %	2.1 %	---	---	---
Was the text too difficult, too easy or just appropriate?	---	---	10.4 %	31.3 %	58.3 %
Was the multiple-choice test too difficult, too easy or just appropriate?	---	---	22.9 %	12.5 %	64.6 %

For Learning Unit 2, again, about 95 % of the participants reported that the time given for reading and testing was sufficient (Table 7). Furthermore, following children's self-information, the blood circulation text implemented in Learning Unit 2 was too difficult for 14.6 % of the participants, whereas the corresponding multiple-choice test was too difficult for 29.2 %.

Table 7

Children's Judgements in Percent on Reading Time, Testing Time, Text Difficulty and Multiple-Choice Test Difficulty – Learning Unit 2

	Children's ratings in percent				
	Yes	No	Too difficult	Too easy	Appropriate
Did you have enough time for reading the text?	95.8 %	4.2 %	---	---	---
Did you have enough time for answering the multiple-choice items?	95.7 %	4.3 %	---	---	---
Was the text too difficult, too easy or just appropriate?	---	---	14.6 %	18.8 %	66.6 %
Was the multiple-choice test too difficult, too easy or just appropriate?	---	---	29.2 %	16.7 %	54.1 %

3.4 Discussion

The aim of the Pilot Study was to investigate whether the reliabilities (internal consistencies) of each of the multiple-choice tests are satisfactory, the overall multimedia effect shows up and whether children's judgements are congruent with statistical values, for example concerning the difficulty of the multiple-choice tests. In summary, the results are in line with the expectations.

With respect to internal consistencies, the text-only subscale (Learning Unit 1: 6 items, Learning Unit 2: 7 items), the picture-only subscale (Learning Unit 1: 7 items, Learning Unit 2: 5 items) and the illustrated-text subscale (Learning Unit 1: 8 items, Learning Unit 2: 8 items) of each multiple-choice test reached satisfactory values, while the transfer subscale did not. One possible explanation might refer to the way of how transfer items have been created. In order to answer the transfer items successfully, children were required to fulfil two steps: In a first step, they had to integrate information from multiple representations in the learning phase, followed by a subsequent recall in the testing phase. In a second step, they had to apply the integrated knowledge to everyday situations. Fulfilling these two steps might have been too difficult for children. Thus, for Experiment 1, new transfer items (Learning Unit 1: 9 transfer items, Learning Unit 2: 8 transfer items) were created by focusing on the first step, that is, children were only required to integrate information from multiple representations. In addition to the transfer items, new text-only items (Learning Unit 1: 2 items, Learning Unit 2: 1 item) as well as picture-only items (Learning Unit 1: 0 items; Learning Unit 2: 3 items) were created for Experiment 1.

With respect to the multimedia effect, results indicated that adding pictures to written text enhances the learning outcome. As expected in hypothesis H1 which was derived from theories of multimedia learning (cp., section 1.2), the "written text + pictures" condition outperformed the "written text" condition on overall learning scores (multimedia effect). This is in line with previous research (e.g., Fletcher & Tobias, 2005). Thus, pictures indeed seem to be useful for learning the content of both learning units.

It has to be noted that only "good" items identified by previous reliability analyses were used for the multimedia effect analysis. The rationale is that the pilot study aimed at testing the learning material of both learning units, including reliability analyses. Therefore, it makes sense to take exclusively "good" items into account when investigating the multimedia effect. Furthermore, the "good" items represent the core items for both learning units and will be implemented in further experiments.

With respect to children’s judgements, results show that reading time, testing time, text difficulty and multiple-choice tests difficulty were appropriate. Since both learning units had been constructed in cooperation with primary school teachers (text difficulty) who rated the children’s need for reading the text (reading time) and answering the multiple-choice questions (testing time), this result had been expected. Additionally, children’s judgements are also largely in line with the mean difficulty of both multiple-choice tests. Thus, both learning units as well as their respective multiple-choice tests may be regarded as being appropriate for children of the 4th grade.

4 Experiment 1

The purpose of the first experiment was to determine whether pictures draw children's attention away from text or, in other words, whether a different amount of split-attention is given to the sources of information by exploring the multimedia and modality effects on text-only information, picture-only information as well as illustrated-text information (and transfer information). Thus, the main interest was to figure out to which extent the multimedia and modality principles hold true for different sources of information.

4.1 Research Questions and Hypotheses

The multimedia principle and the modality principle were assumed to be helpful for examining whether different sources of information receive the same amount of attention. As has been shown in section 1.2, the CTML as well as the ITPC do not differentiate between different sources of information (like text-only information, picture-only information, and illustrated-text information; Peeck, 1974). Thus, according to both theories, the multimedia effect as well as the modality effect would be expected for all sources of information, including transfer information[10]. However, there are various studies indicating that both the multimedia effect and the modality effect do not hold true for all sources of information (Brünken & Leutner, 2001; Levie & Lentz, 1982; Peeck, 1994).

Therefore, to examine how attention is split in a split-attention format, the following four experimental conditions were realized: (1) a "written text" condition, (2) a "written text + pictures" condition, (3) a "spoken text" condition, and (4) a "spoken text + pictures" condition. Taking the results of the above-mentioned studies into account as well as potential expectations from the CTML or the ITPC, the following pattern of results was predicted:

Multimedia effect

H1: The "written text + pictures" condition will exceed the "written text" condition on overall learning scores ("overall multimedia effect").

H1.1: The "written text + pictures" condition will outperform the "written text" condition on a picture-only information scale ("multimedia effect").

[10] Although the ITPC does not explicitly take into account different sources of information, it has to be noted that, according to this model, it is possible that the learning of text information is reduced when pictures are added (cp., Schnotz, 2005).

H1.2: The "written text" condition will outperform the "written text + pictures" condition on a text-only information scale ("reversed multimedia effect", see section 1.4 for a theoretical explanation).

H1.3: Consequently, the "written text + pictures" condition will not outperform the "written text" condition on transfer achievement ("no multimedia effect"), because it will not be possible to adequately build up referential connections between picture-only information and text-only information, which are important for answering the transfer questions.

H1.4: The "written text + pictures" condition will exceed the "written text" condition on illustrated-text information ("multimedia effect").

Modality effect

H2: The "spoken text + pictures" condition will exceed the "written text + pictures" condition on overall learning scores ("overall modality effect").

H2.1: The "spoken text + pictures" condition will not outperform the "written text + pictures" condition on a picture-only information scale, because learners in the "written text + pictures" condition will shift their attention (*shift-of-attention effect*; Brünken & Leutner, 2001) from text to pictures ("no modality effect").

H2.2: The "spoken text + pictures" condition will outperform the "written text + pictures" condition on a text-only information scale ("modality effect").

H2.3: Consequently, the "spoken text + pictures" condition will outperform the "written text + pictures" condition on transfer achievement ("modality effect").

H2.4: The "spoken text + pictures" condition will exceed the "written text + pictures" condition on illustrated-text information ("modality effect").

4.2 Method

4.2.1 Participants and Design

Participants in the first experiment were 151 children from 4^{th} grades of four German primary schools. The average age was 10.1 years (*SD* = .56), and there were 71 girls and 80 boys.

A 2x2 study design with two independent variables, namely *type of learning material* (text vs. text plus pictures) and *mode of text presentation* (written vs. spoken) was used. This resulted in four experimental conditions: Children in the first condition received "written text" (see Appendix A and Appendix E; n = 38), children in the second condition received written text plus pictures (see Appendix B and Appendix F; n = 37), children in the third condition received "spoken text" (see Appendix C and Appendix G; n = 37), and children in the fourth condition received spoken text plus pictures (see Appendix D and Appendix H; n = 39). Within each class, the teacher divided participants into four groups, in which the distributions of Grade Point Average (GPA) and sex were roughly balanced. Then, the four groups were randomly assigned to one of four conditions. The dependent variables, as measured by criterion-referenced tests, were performance overall, performance on information presented in text only, performance on information presented in picture only, performance on information presented in both text and picture (illustrated-text information), and performance on transfer items. In addition, reading comprehension and non-verbal intelligence were recorded as control variables.

4.2.2 Materials

The materials used for the first experiment comprised the learning units (Learning Unit 1 and Learning Unit 2) and their respective multiple-choice test (see Appendix Y and Appendix Z), a participant questionnaire (including items on the learner's prior knowledge), motivational judgement items, cognitive load items, a distractor task, a text difficulty question, a question on the difficulty of the multiple-choice test and a question on reading time and testing time. Furthermore, reading comprehension (ELFE test; Lenhard & Schneider, 2006) and non-verbal intelligence (KFT intelligence test; Heller & Perleth, 2000) were assessed. In Chapter 2, a detailed description of all materials is given.

4.2.3 Procedure

Altogether, the study consisted of three phases taking place on three different days within a week, whereby each phase lasted approximately for two lessons (90 minutes). On the first day, all participants received the first learning unit. After a short learning phase (about 8 minutes) in which participants were instructed to keep as much information in mind as possible, learning outcome was measured with a multiple-choice test (32 items, with a 20-min time limit). On the second day, participants went through the same procedure again with the second learning unit. On the third day, non-verbal intelligence and reading comprehension were assessed. In section 2.4, a more detailed description of the procedure is given.

4.3 Results

In a first step, the aforementioned hypotheses concerning the multimedia and modality effects will be addressed by analyzing the learning outcome of the four experimental conditions. In a second step, internal consistencies for both multiple-choice tests and their respective subscales will be presented, followed by children's judgements on questions concerning reading time, testing time, text difficulty and multiple-choice tests difficulty.

4.3.1 Multimedia effects and Modality effects

The analyses were based on the data of 137 participants: Fourteen children were left out of the data analyses because they did not take part in the whole study.

In a first step, participants' scores (relative frequencies of correct answers) on the multiple-choice tests (overall scales and subscales) were adjusted for reading comprehension and non-verbal intelligence. Although the four conditions did not differ significantly on these variables, these covariates account for a large amount of variance in the learning test scores (overall test scores of Learning Unit 1: $eta^2 = .37$; Learning Unit 2: $eta^2 = .28$). Thus, adjusting is a useful means to increase the statistical power of study designs by reducing within-group or error variances (Lipsey, 1990).

After that, a multivariate analysis of variance (MANOVA) was computed with the adjusted overall test scores of the multiple-choice tests of Learning Unit 1 and Learning Unit 2 as dependent variables and the type of learning material and mode of text presentation as factors (Figure 6). This revealed a multivariate main effect for type of learning material, $F(2,132) = 6.96$, $p = .001$, *partial* $eta^2 = .10$. Text plus pictures led to better scores for Learning Unit 1, $M_{\text{text}} = .49$, $SD_{\text{text}} = .10$, $M_{\text{text plus pictures}} = .53$, $SD_{\text{text plus pictures}} = .14$, $F(1,133) = 4.01$, $p = .047$, *partial* $eta^2=.03$, as well as for Learning Unit 2, $M_{\text{text}} = .38$, $SD_{\text{text}} = .11$, $M_{\text{text plus pictures}} = .46$, $SD_{\text{text plus pictures}} = .17$, $F(1,133) = 14.02$, $p < .001$, *partial* $eta^2 = .10$.

In addition, a multivariate main effect for text presentation mode was found, $F(2,132) = 7.14$, $p = .001$, *partial* $eta^2 = .10$. Spoken text led to better scores for Learning Unit 1, $M_{\text{written}} = .48$, $SD_{\text{written}} = .12$, $M_{\text{spoken}} = .55$, $SD_{\text{spoken}} = .12$, $F(1,133) = 11.13$, $p = .001$, *partial* $eta^2 = .08$, as well as for Learning Unit 2, $M_{\text{written}} = .38$, $SD_{\text{written}} = .12$, $M_{\text{spoken}} = .45$, $SD_{\text{spoken}} = .16$, $F(1,133) = 11.16$, $p = .001$, *partial* $eta^2 = .08$. Finally, a multivariate interaction of the type of learning material and the text presentation mode was found, $F(2,132) = 12.50$, $p < .001$, *partial* $eta^2 = .16$, indicating that the pictures aligned to both Learning Unit 1, $M_{\text{written text}} = .48$, $SD_{\text{written text}} = .10$,

$M_{\text{written text plus pictures}} = .48$, $SD_{\text{written text plus pictures}} = .14$, $M_{\text{spoken text}} = .51$, $SD_{\text{spoken text}} = .10$, $M_{\text{spoken text plus pictures}} = .58$, $SD_{\text{spoken text plus pictures}} = .12$, $F(1,133) = 4.25$, $p = .041$, *partial eta²* $= .03$, and Learning Unit 2, $M_{\text{written text}} = .39$, $SD_{\text{written text}} = .11$, $M_{\text{written text plus pictures}} = .36$, $SD_{\text{written text plus pictures}} = .13$, $M_{\text{spoken text}} = .36$, $SD_{\text{spoken text}} = .10$, $M_{\text{spoken text plus pictures}} = .54$, $SD_{\text{spoken text plus pictures}} = .15$, $F(1,133) = 24.55$, $p < .001$, *partial eta²* $= .16$, only enhanced students' learning when the text was spoken rather than written.

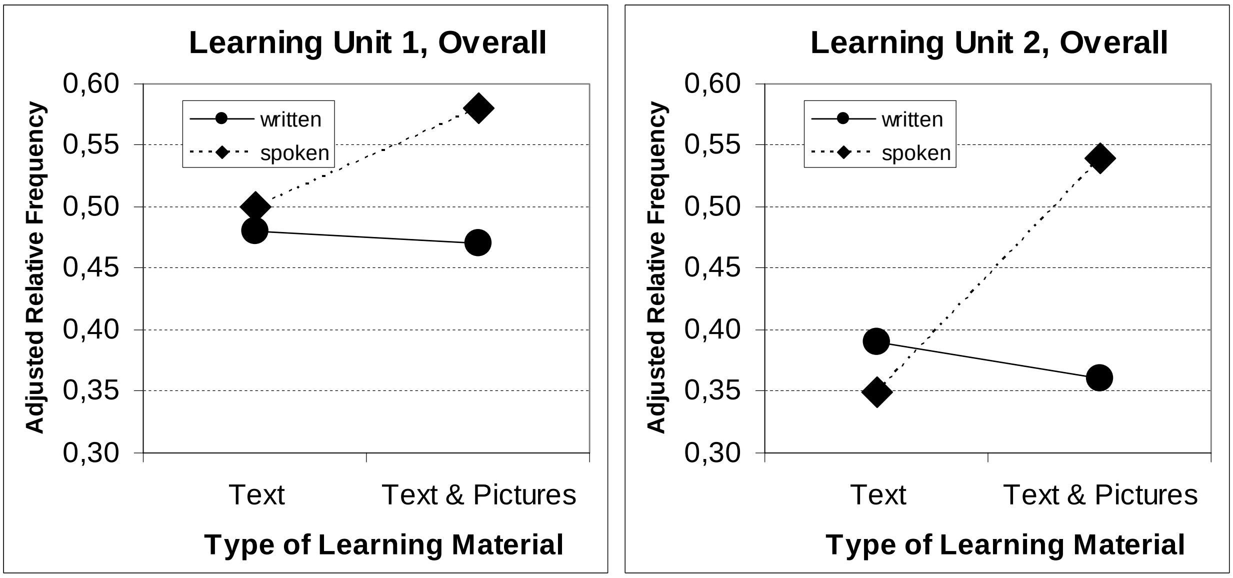


Figure 6. Learning Results (Overall) Depending on Type of Learning Material (Text, Text & Pictures) and Mode of Text Presentation (Written, Spoken) for Learning Unit 1 and Learning Unit 2.

Furthermore, a multivariate analysis of variance (MANOVA) was computed with the adjusted subscales' scores of the multiple-choice test of Learning Unit 1 as dependent variables and the type of learning material and mode of text presentation as factors. This revealed a multivariate main effect for type of learning material, $F(4,130) = 9.78$, $p < .001$, *partial eta²* = .23. In addition, a multivariate main effect for text presentation mode was found, $F(4,130) = 3.65$, $p = .007$, *partial eta²* = .10. Unfortunately, the multivariate interaction between the type of learning material and the text presentation mode did not reach significance, $F(4,130) = 1.42$, $p = .230$, *partial eta²* = .04. Finally, a multivariate analysis of variance (MANOVA) was computed with the adjusted subscales' scores of the multiple-choice test of Learning Unit 2 as dependent variables and the type of learning material and mode of text presentation as factors. This revealed a multivariate main effect for type of learning material, $F(4,130) = 9.01$, $p < .001$, *partial eta²* = .22. In addition, a multivariate main effect for text presentation mode was found, $F(4,130) = 2.89$, $p = .025$, *partial eta²* = .08. Again, a multivariate interaction of the type of learning material and the text presentation mode indicated that the pictures only enhanced students' learning when the text was spoken rather than written, $F(4,130) = 6.53$, $p < .001$, *partial eta²* = .17.

In order to investigate the role of information source, univariate analyses of variance (ANOVAs) with planned comparisons were computed for the subscales of the two learning tests. According to each hypothesis, one-tailed or two-tailed tests were conducted. The means and standard deviations for both learning units are shown in Table 8.

Table 8

Adjusted Average Scores and Standard Deviations by Four Conditions on Different Sources of Information, Including the Number of Children – Learning Unit 1 & Learning Unit 2

	Learning Unit 1		Learning Unit 2		Number of children
Source of information and condition	*M*	*SD*	*M*	*SD*	*N*
Overall scale					
Multimedia effect					
Written text	.48	.10	.39	.11	34
Written text + pictures	.48	.14	.36	.13	33
Modality effect					
Written text + pictures	.48	.14	.36	.13	33
Spoken text + pictures	.58	.12	.54	.15	36
Written text	.48	.10	.39	.11	34
Spoken text	.51	.10	.36	.10	34
Text-only subscale					
Multimedia effect					
Written text	.63	.18	.53	.21	34
Written text + pictures	.51	.21	.44	.19	33
Modality effect					
Written text + pictures	.51	.21	.44	.19	33
Spoken text + pictures	.63	.19	.61	.19	36
Written text	.63	.18	.53	.21	34
Spoken text	.66	.20	.50	.16	34
Picture-only subscale					
Multimedia effect					
Written text	.30	.18	.20	.16	34
Written text + pictures	.44	.30	.27	.16	33
Modality effect					
Written text + pictures	.44	.30	.27	.16	33
Spoken text + pictures	.55	.21	.45	.26	36
Written text	.30	.18	.20	.16	34
Spoken text	.28	.19	.19	.15	34

Table 8 (continued)

Adjusted Average Scores and Standard Deviations by Four Conditions on Different Sources of Information, Including the Number of Children – Learning Unit 1 & Learning Unit 2

	Learning Unit 1		Learning Unit 2		Number of children
Source of information and condition	*M*	*SD*	*M*	*SD*	*N*
Illustrated-text subscale					
Multimedia effect					
Written text	.66	.20	.60	.18	34
Written text + pictures	.68	.18	.52	.20	33
Modality effect					
Written text + pictures	.68	.18	.52	.20	33
Spoken text + pictures	.71	.15	.69	.15	36
Written text	.66	.20	.60	.18	34
Spoken text	.69	.14	.56	.15	34
Transfer subscale					
Multimedia effect					
Written text	.33	.15	.25	.15	34
Written text + pictures	.31	.14	.23	.15	33
Modality effect					
Written text + pictures	.31	.14	.23	.15	33
Spoken text + pictures	.46	.19	.42	.23	36
Written text	.33	.15	.25	.15	34
Spoken text	.38	.18	.20	.15	34

Learning Unit 1

With respect to Learning Unit 1, the following pattern of results could be found (Table 8):

Results of the *overall learning scores* were as follows: (1) Adding pictures to written text did not change the learning of overall information, $M_{\text{written text}} = .48$, $SD_{\text{written text}} = .10$, $M_{\text{written text plus pictures}} = .48$, $SD_{\text{written text plus pictures}} = .14$, $t(133) < 1$. G-Power (Faul, Erdfelder, Lang, & Buchner, 2007) was used to calculate the statistical power for this comparison, given an error probability of $\alpha = .05$, a total sample size of n = 137 and a medium effect size of $f^2 = .15$ (numerator df = 1, number of predictors = 3). The resulting power of $1\text{-}\beta = .99$ indicated that a medium effect would have been detected with sufficient statistical power[11]. (2) Learning with spoken instead of written text increased the learning of overall information from $M_{\text{written text plus pictures}} = .48$, $SD_{\text{written text plus pictures}} = .14$, to $M_{\text{spoken text plus pictures}} = .58$, $SD_{\text{spoken text plus pictures}} = .12$,

[11] It has to be noted that this result is true for all comparisons.

$t(133) = 3.82$, $p < .001$ (one-tailed), $d = 0.90$. Thus, pictures did not induce a "multimedia effect" when added to written text. However, when using spoken instead of written text, pictures had a positive impact on the overall learning scores (modality effect). (3) This modality effect could not be applied to the retention of spoken versus written text: This difference was not significant, $M_{\text{written text}} = .48$, $SD_{\text{written text}} = .10$, $M_{\text{spoken text}} = .51$, $SD_{\text{spoken text}} = .10$, $t(133) < 1$.

Results of *information presented in text only* were as follows: (1) Adding pictures to written text reduced retention of pure text information, $M_{\text{written text}} = .63$, $SD_{\text{written text}} = .18$, $M_{\text{written text plus pictures}} = .51$, $SD_{\text{written text plus pictures}} = .21$, $t(133) = 2.60$, $p = .005$ (one-tailed), $d = 0.63$. (2) Learning with spoken instead of written text increased the retention of text-only information from $M_{\text{written text plus pictures}} = .51$, $SD_{\text{written text plus pictures}} = .21$, to $M_{\text{spoken text plus pictures}} = .63$, $SD_{\text{spoken text plus pictures}} = .19$, $t(133) = 2.65$, $p = .005$ (one-tailed), $d = 0.62$. Thus, pictures led to a "reversed multimedia effect" when added to written text. However, this negative impact of pictures could be compensated by using spoken instead of written text. (3) This modality effect could not be applied to the retention of spoken versus written text: This difference was not significant, $M_{\text{written text}} = .63$, $SD_{\text{written text}} = .18$, $M_{\text{spoken text}} = .66$, $SD_{\text{spoken text}} = .20$, $t(133) < 1$.

Results of *information presented in picture only* were as follows: (1) Adding pictures to written text increased the learning of picture-only information, $M_{\text{written text}} = .30$, $SD_{\text{written text}} = .18$, $M_{\text{written text plus pictures}} = .44$, $SD_{\text{written text plus pictures}} = .30$, $t(133) = 2.44$, $p = .008$ (one-tailed), $d = 0.55$. (2) Learning with spoken instead of written text further increased the learning of picture-only information from $M_{\text{written text plus pictures}} = .44$, $SD_{\text{written text plus pictures}} = .30$, to $M_{\text{spoken text plus pictures}} = .55$, $SD_{\text{spoken text plus pictures}} = .21$, $t(133) = 2.03$, $p = .044$, $d = 0.43$. Thus, pictures induced a "multimedia effect" when added to written text. This positive impact of pictures could be further enhanced by using spoken instead of written text. (3) Again, no modality effect could be found for spoken compared to written text, $M_{\text{written text}} = .30$, $SD_{\text{written text}} = .18$, $M_{\text{spoken text}} = .28$, $SD_{\text{spoken text}} = .19$, $t(133) < 1$.

Results of *illustrated-text information* were as follows: The univariate ANOVA did not reveal statistically significant results. To specify, (1) adding pictures to written text did not change the average performance score on illustrated-text information, $M_{\text{written text}} = .66$, $SD_{\text{written text}} = .20$, $M_{\text{written text plus pictures}} = .68$, $SD_{\text{written text plus pictures}} = .18$, $t(133) < 1$, "no multimedia effect". (2) Learning with spoken instead of written text did not change the average performance score either, $M_{\text{written text plus pictures}} = .68$, $SD_{\text{written text plus pictures}} = .18$, $M_{\text{spoken text plus pictures}} = .71$, $SD_{\text{spoken text plus pictures}} = .15$, $t(133) < 1$, "no modality effect". (3) Again, no modality effect could be found for spoken in comparison to written text, $M_{\text{written text}} = .66$, $SD_{\text{written text}} = .20$, $M_{\text{spoken text}} = .69$, $SD_{\text{spoken text}} = .14$, $t(133) < 1$.

Results of the *transfer subscale* were as follows: (1) Adding pictures to written text did not change transfer achievement, $M_{\text{written text}} = .33$, $SD_{\text{written text}} = .15$, $M_{\text{written text plus pictures}} = .31$, $SD_{\text{written text plus pictures}} = .14$, $t(133) < 1$, "no multimedia effect". G-Power (Faul et al., 2007) was used to calculate the statistical power for this comparison, given an error probability of $\alpha = .05$, a total sample size of n = 137 and a medium effect size of $f^2 = .15$ (numerator df = 1, number of predictors = 3). The resulting power of $1-\beta = .99$ indicated that a medium effect would have been detected with sufficient statistical power. (2) Learning with spoken instead of written text increased transfer achievement, $M_{\text{written text plus pictures}} = .31$, $SD_{\text{written text plus pictures}} = .14$, $M_{\text{spoken text plus pictures}} = .46$, $SD_{\text{spoken text plus pictures}} = .19$, $t(133) = 3.73$, $p < .001$ (one-tailed), $d = 0.89$. (3) Again, this modality effect could not be applied to better retention of spoken versus written text: This difference was not significant, $M_{\text{written text}} = .33$, $SD_{\text{written text}} = .15$, $M_{\text{spoken text}} = .38$, $SD_{\text{spoken text}} = .18$, $t(133) = 1.33$, $p = .187$.

Learning Unit 2

With respect to Learning Unit 2, a similar pattern of results could be found (Table 8):

Results of the *overall learning scores* were as follows: (1) Adding pictures to written text did not enhance the learning of overall information, $M_{\text{written text}} = .39$, $SD_{\text{written text}} = .11$, $M_{\text{written text plus pictures}} = .36$, $SD_{\text{written text plus pictures}} = .13$, $t(133) < 1$. (2) Learning with spoken instead of written text increased the learning of overall information from $M_{\text{written text plus pictures}} = .36$, $SD_{\text{written text plus pictures}} = .13$, to $M_{\text{spoken text plus pictures}} = .54$, $SD_{\text{spoken text plus pictures}} = .15$, $t(133) = 5.86$, $p < .001$ (one-tailed), $d = 1.26$. Thus, pictures did not induce a "multimedia effect" when added to written text. However, when using spoken instead of written text, pictures enhanced the overall learning scores ("modality effect"). (3) This modality effect could not be applied to the retention of spoken versus written text: This difference was not significant, $M_{\text{written text}} = .39$, $SD_{\text{written text}} = .11$, $M_{\text{spoken text}} = .36$, $SD_{\text{spoken text}} = .10$, $t(133) < 1$.

Results of *information presented in text only* were as follows: (1) Adding pictures to written text reduced retention of pure text information, $M_{\text{written text}} = .53$, $SD_{\text{written text}} = .21$, $M_{\text{written text plus pictures}} = .44$, $SD_{\text{written text plus pictures}} = .19$, $t(133) = 2.03$, $p = .022$ (one-tailed), $d = 0.46$. (2) Learning with spoken instead of written text increased the retention of text-only information from $M_{\text{written text plus pictures}} = .44$, $SD_{\text{written text plus pictures}} = .19$, to $M_{\text{spoken text plus pictures}} = .61$, $SD_{\text{spoken text plus pictures}} = .19$, $t(133) = 3.78$, $p < .001$ (one-tailed), $d = 0.90$. Thus, pictures led to a "reversed multimedia effect" when added to written text. However, this negative impact of pictures could be compensated by using spoken instead of written text. (3) This modality effect could not be applied to the retention of spoken text versus written text: This difference was not significant, $M_{\text{written text}} = .53$, $SD_{\text{written text}} = .21$, $M_{\text{spoken text}} = .50$, $SD_{\text{spoken text}} = .16$, $t(133) < 1$.

Results of *information presented in picture only* were as follows: (1) Adding pictures to written text did not increase the learning of picture-only information, $M_{\text{written text}} = .20$, $SD_{\text{written text}} = .16$, $M_{\text{written text plus pictures}} = .27$, $SD_{\text{written text plus pictures}} = .16$, $t(133) = 1.58$, $p = .059$ (one-tailed), "no multimedia effect". (2) Learning with spoken instead of written text increased the learning of picture-only information from $M_{\text{written text plus pictures}} = .27$, $SD_{\text{written text plus pictures}} = .16$, to $M_{\text{spoken text plus pictures}} = .45$, $SD_{\text{spoken text plus pictures}} = .26$, $t(133) = 3.91$, $p < .001$, $d = 0.81$. (3) Again, this modality effect could not be applied to better learning of spoken text versus written text: This difference was not significant, $M_{\text{written text}} = .20$, $SD_{\text{written text}} = .16$, $M_{\text{spoken text}} = .19$, $SD_{\text{spoken text}} = .15$, $t(133) < 1$.

Results of *illustrated-text information* were as follows: (1) Adding pictures to written text did not change the learning score on illustrated-text information, $M_{\text{written text}} = .60$, $SD_{\text{written text}} = .18$, $M_{\text{written text plus pictures}} = .52$, $SD_{\text{written text plus pictures}} = .20$, $t(133) = 1.89$, $p = .06$, $d = 0.42$. (2) Learning with spoken instead of written text increased the average performance score from $M_{\text{written text plus pictures}} = .52$, $SD_{\text{written text plus pictures}} = .20$, to $M_{\text{spoken text plus pictures}} = .69$, $SD_{\text{spoken text plus pictures}} = .15$, $t(133) = 4.10$, $p < .001$ (one-tailed), $d = 0.96$. (3) No modality effect could be found for spoken in comparison to written text, $M_{\text{written text}} = .60$, $SD_{\text{written text}} = .18$, $M_{\text{spoken text}} = .56$, $SD_{\text{spoken text}} = .15$, $t(133) < 1$.

Results of the *transfer subscale* were as follows: (1) Adding pictures to written text did not change transfer achievement, $M_{\text{written text}} = .25$, $SD_{\text{written text}} = .15$, $M_{\text{written text plus pictures}} = .23$, $SD_{\text{written text plus pictures}} = .15$, $t(133) < 1$, "no multimedia effect". Again, G-Power (Faul et al., 2007) was used to calculate the statistical power for this comparison, given an error probability of $\alpha = .05$, a total sample size of $n = 137$ and a medium effect size of $f^2 = .15$ (numerator $df = 1$, number of predictors = 3). The resulting power of $1-\beta = .99$ indicated that a medium effect would have been detected with sufficient statistical power. (2) Learning with spoken instead of written text increased transfer achievement from $M_{\text{written text plus pictures}} = .23$, $SD_{\text{written text plus pictures}} = .15$, to $M_{\text{spoken text plus pictures}} = .42$, $SD_{\text{spoken text plus pictures}} = .23$, $t(133) = 4.49$, $p < .001$ (one-tailed), $d = 0.97$. (3) Again, there was no modality effect for spoken in comparison to written text, $M_{\text{written text}} = .25$, $SD_{\text{written text}} = .15$, $M_{\text{spoken text}} = .20$, $SD_{\text{spoken text}} = .15$, $t(133) < 1$.

Effect sizes of the modality effect

With regard to the comparison of Learning Unit 1 and Learning Unit 2, it has to be noted that the "traditional" modality effect (spoken text plus pictures vs. written text plus pictures) was always larger for Learning Unit 2. Thus, with regard to Learning Unit 2, learning with spoken text plus pictures (compared to written text plus pictures) did not only seem to compensate but even over-compensate the learning outcome. For example, with respect to the overall learning scores, the effect size was $d = 0.90$ for Learning Unit 1 and $d = 1.26$ for Learning Unit 2 ($z_{contrast} = 8.77$[12], $p < .001$). With regard to text-only information, the modality effect had an effect size of $d = 0.62$ for Learning Unit 1, whereas for Learning Unit 2, the effect size was $d = 0.90$ ($z_{contrast} = 4.30$, $p < .001$). A similar observation holds true for picture-only information. The modality effect was larger for Learning Unit 2 ($d = 0.81$) compared to Learning Unit 1 ($d = 0.43$, $z_{contrast} = 5.36$, $p < .001$). When regarding illustrated-text information, again, a similar pattern of results showed up: Not existing for Learning Unit 1 ($d = 0.18$), the modality effect was consistently larger for Learning Unit 2 ($d = 0.96$, $z_{contrast} = 13.45$, $p < .001$). With respect to transfer information, the modality effect was not significantly larger for Learning Unit 2 (effect size: $d = 0.97$) compared to Learning Unit 1 (effect size: $d = 0.89$, $z_{contrast} = 1.38$; $p = .08$).

4.3.2 Reliability analyses

All reliability analyses were based on the data of 139 children, each of them having worked on both learning units. However, children with missing data were automatically excluded from the analyses by SPSS. Reliability analyses for each multiple-choice test as well as for the respective subscales were conducted. Data on the internal consistencies (Cronbach's α) for the multiple-choice tests of both learning units and their respective subscales can be found in Table 9. As can be seen, the internal consistencies showed unsatisfactory values for all subscales of the respective multiple-choice tests – except for the transfer subscale.

[12] ZumaStat software was used to calculate the differences between the effect sizes.

Table 9

Internal Consistencies for the Multiple-Choice Tests of Both Learning Units

	Internal consistencies				
Learning Unit and multiple-choice test	*Text-only subscale (r_{tt})*	*Picture-only subscale (r_{tt})*	*Illustrated-text subscale (r_{tt})*	*Transfer subscale (r_{tt})*	*Overall scale (r_{tt})*
Learning Unit 1					
Multiple-choice test	.54 (8 items)	.59 (7 items)	.42 (8 items)	.66 (9 items)	.76 (32 items)
Learning Unit 2					
Multiple-choice test	.55 (8 items)	.55 (8 items)	.47 (8 items)	.64 (8 items)	.81 (32 items)

Finally, it has to be noted that the mean difficulty of each subscale as well as of all subscales together (of the whole multiple-choice test) was appropriate for both learning units. For Learning Unit 1, the overall mean was M = .62, SD = .18 for the text-only subscale, M = .40, SD = .13 for the picture-only subscale[13], M = .69, SD = .22 for the illustrated-text subscale, M = .38, SD = .28 for the transfer subscale and M = .53, SD = .25 for all subscales together (for the whole multiple-choice test). For Learning Unit 2, the overall mean was M = .53, SD = .23 for the text-only subscale, M = .28, SD = .07 for the picture-only subscale[14], M = .60, SD = .21 for the illustrated-text subscale, M = .29, SD = .17 for the transfer subscale and M = .42, SD = .23 for all subscales together (for the whole multiple-choice test). To sum up, both multiple-choice tests as well as their respective subscales had a medium difficulty level for learners – except for the picture-only subscale of Learning Unit 2 and the transfer subscales of both learning units. The former result might be due to the superficial processing of pictures (cp., Mokros & Tinker, 1987; Weidenmann, 1989): More complex pictures might have been processed even more superficially. This might be a reason for why children remembered less picture-only information in Learning Unit 2 (M = .37) than in Learning Unit 1 (M = .52). With respect to the transfer items, however, the higher difficulty level may be regarded as being appropriate.

[13] It has to be noted that the statistic specific values for the picture-only subscale were based on the data of all children. With regard to those children who actually received pictures, the overall mean was M = .52, SD = .18 for the picture-only subscale.

[14] With regard to those children who actually received pictures, the overall mean was M = .37, SD = .10 for the picture-only subscale.

4.3.3 Children's judgements

All descriptive analyses on reading time, testing time, text difficulty and multiple-choice tests difficulty were based on the data of 139 children, each of them having worked on both learning units. Despite having had less learning time left for both learning units compared to the Pilot Study, children still reported that the reading time and the testing time were sufficient for reading the whole text through and answering the multiple-choice questions, respectively (Learning Unit $1_{\text{reading time}}$ = 94.1 %, Learning Unit $1_{\text{testing time}}$ = 97.8 %; Learning Unit $2_{\text{reading time}}$ = 98.6 %, Learning Unit $2_{\text{testing time}}$ = 99.3 %). Furthermore, the text difficulty and the difficulty of the multiple-choice test were rated as being appropriate as well (Learning Unit $1_{\text{text difficulty}}$ = 80.9 %, Learning Unit $1_{\text{difficulty of multiple-choice items}}$ = 80 %; Learning Unit $2_{\text{text difficulty}}$ = 75.4 %, Learning Unit $2_{\text{difficulty of multiple-choice items}}$ = 77 %). Children's judgements on these aspects seemed to be useful and necessary, not least because the multiple-choice tests of both learning units had been further developed compared to the Pilot Study.

4.4 Discussion

The purpose of Experiment 1 was to investigate whether pictures may draw children's attention away from text. In other words, it was investigated whether children equally split their attention between different sources of information by exploring the multimedia and modality effects on text-only information, picture-only information as well as illustrated-text information (including transfer information). Thus, the main interest was to figure out to which extent the multimedia and modality principles hold true for different sources of information.

Multimedia effect

With respect to the multimedia effect, for Learning Unit 1, the "written text + pictures" condition exceeded the "written text" condition on picture-only information ("multimedia effect", H1.1 was confirmed), whereas the two conditions did not differ on overall learning scores ("no overall multimedia effect", H1 was not confirmed), illustrated-text information ("no multimedia effect", H1.4 was not confirmed), and transfer information ("no multimedia effect", H1.3 was confirmed). The "written text" condition outperformed the "written text + pictures" condition on text-only information ("reversed multimedia effect", H1.2 was confirmed). For Learning Unit 2, a similar pattern of results showed up: The "written text + pictures" condition did not differ from the "written text" condition on overall learning scores ("no overall multimedia effect", H1 was not confirmed), picture-only information ("no multimedia effect", H1.1 was not confirmed), illustrated-text information ("no multimedia effect", H1.4 was not confirmed), and transfer information ("no multimedia effect", H1.3 was confirmed). Again, the "written text" condition outperformed the "written text + pictures" condition on text-only information ("reversed multimedia effect", H1.2 was confirmed). In summary, the results are partly in line with the expectations. For Learning Unit 1, the unexpected result on the illustrated-text information scale ("no multimedia effect", H1.4 was not confirmed) might be due to the content of the first text. As Mayer (1989) notes, pictures should be especially helpful for learning when (1) several key steps in a cause-and-effect system are described in the text and (2) these key steps are shown in the pictures in a clarifying way. Since the first text's focus was on giving a *general overview* over the heart and the blood circulation system (including the functions of the pulmonary circulation as well as the systemic circulation), children were not provided yet with aspects concerning the structure of the heart or the process of blood circulation. Hence, it might be possible that there was no need for learners to use the information in the picture as additional clarifier for the information in the text. However, although the accompanying pictures of the second text clarify the structure of the heart as well as the process of blood circulation, the "written text + pictures" condition was not superior to the "written text" condition concerning the learning outcome on the illustrated-text information scale, either. Possible reasons might be that the key steps were not shown in the pictures in a clarifying way (cp., Mayer, 1989) or that children were not able to decode the information presented in the pictures (cp., Weidenmann, 1994). It has to be noted that the non-significant results on the illustrated-text information scale are in line with some older studies (e.g., Koenke & Otto, 1969: 3rd graders; Peeck, 1974: 4th graders, immediate testing).

Contrary to expectations, presenting pictures did not enhance the learning outcome on the picture-only information scale for Learning Unit 2 ("no multimedia effect", H1.1 was not confirmed). However, this result is in line with the research finding that pictures are often processed superficially (cp., section 1.4; Mokros & Tinker, 1987; Weidenmann, 1989). Additionally, as has been already mentioned on the illustrated-text information, it might be possible that the pictures implemented in the second text were too difficult to read for children. As Weidenmann (1994) notes, it is essential that learners are able to "decode" (or "read") the information presented in pictures. Thus, as indicated by the lacking superiority of the "written text + pictures" condition, the children might not have been able to read the picture-only information in an adequate way.

When looking at the results of each source of information (text-only information, picture-only information, illustrated-text information; including transfer information) of both learning units (Learning Unit 1 and Learning Unit 2), the lacking multimedia effect on the overall learning scores becomes explainable ("no overall multimedia effect", H1 was not confirmed): For Learning Unit 1, the overall multimedia effect might have been partly spoiled by the lacking positive impact of pictures on the illustrated-text information, whereas for Learning Unit 2, the overall multimedia effect might have been partly spoiled by the lacking positive impact of pictures on illustrated-text information, and picture-only information. For both learning units, a further reason might be the worse results of the "written text + pictures" condition on the text-only information scale, compared to the "written text" condition ("reversed multimedia effect", H1.2 was confirmed). Since the information in the pictures as well as in the text paragraphs did not seem to have been processed more deeply, the lacking multimedia effect on the transfer information is not surprising.

Finally, it should be noted that the results of both learning units (Learning Unit 1 and Learning Unit 2) on the text-only information scale ("reversed multimedia effect") and the picture-only information scale ("multimedia effect") indicate a shift of attention from text to pictures (*shift-of-*

attention effect; Brünken & Leutner, 2001). Thus, when providing *written text plus pictures in a split-attention format*, pictures may indeed draw children's attention away from the text.

Modality effect

With respect to the modality effect, for Learning Unit 1, the "spoken text + pictures" condition exceeded the "written text + pictures" condition on overall learning scores ("overall modality effect", H2 was confirmed), picture-only information ("modality effect", H2.1 was not confirmed), text-only information ("modality effect", H2.2 was confirmed), and transfer information ("modality effect", H2.3 was confirmed), whereas the two conditions did not differ on illustrated-text information ("no modality effect", H2.4 was not confirmed). For Learning Unit 2, a similar pattern of results showed up: The "spoken text + pictures" condition exceeded the "written text + pictures" condition on overall learning scores ("overall modality effect", H2 was confirmed), picture-only information ("modality effect", H2.1 was not confirmed), text-only information ("modality effect", H2.2 was confirmed), illustrated-text information ("modality effect", H2.4 was confirmed), and transfer information ("modality effect", H2.3 was confirmed). In summary, the results are largely in line with the expectations. However, in Learning Unit 1, the "spoken text + pictures" condition did not outperform the "written text + pictures" condition on the illustrated-text information scale ("no modality effect", H2.4 was not confirmed). A possible reason might be that, as has been already discussed for the lacking multimedia effect on the illustrated-text information scale, children might not have needed the clarifying picture information for understanding the information presented in the text, because the content of the first text did not comprise any key steps of a cause-and-effect system (cp., Mayer, 1989).

Furthermore, as has been shown in section 4.3.1, Learning Unit 2 induced a larger modality effect on (almost) all sources of information. Thus, it might be that, with regard to Learning Unit 2, distributing information presentation across different modalities did not only compensate but even "over-compensate" the learning outcome. This "over-compensation" might be due to the more difficult learning content (such as the structure of the heart and the process of blood circulation) of Learning Unit 2. This interpretation is in line with research concerning the modality effect. As Ginns (2005) shows in his meta-analysis, the difficulty of the learning material, that is the level of element interactivity (cp., Tindall-Ford et al., 1997), is a potential moderator for the modality effect. The modality effect is more likely to occur when complex learning material is used. Thus, it might be stated that the more difficult the learning material is, up to a certain degree, the larger is the benefit for children when distributing information presentation across different modalities.

Finally, for both learning units (Learning Unit 1 and Learning Unit 2), presenting *spoken text plus pictures* resulted in higher learning outcome on the picture-only information scale than providing written text plus pictures ("modality effect", H2.1 was not confirmed). Contrary to the expectations, this result indicates that children in the "written text + pictures" condition *did not generally* shift their attention (*shift-of-attention effect*; Brünken & Leutner, 2001) from text to pictures. Though, as has been indicated by the "multimedia effect results" on the text-only information scale ("reversed multimedia effect") and the picture-only information scale ("multimedia effect"), pictures may indeed draw children's attention away from the text, when the *written text and the pictures are provided in a split-attention format.*

Reliability Analyses and Children's judgements

With regard to the reliability analyses, the internal consistencies were unsatisfactory for all subscales of the respective multiple-choice tests – except for the transfer subscale. The following aspects might have contributed to this unexpected result: The proportion of children who reported that they do not speak German at home was larger in the Pilot Study (40.8 %) than in Experiment 1 (13.1 %). Thus, it might be that the children who participated in the Pilot Study were not representative for the population of 4th graders. To be more specific, it might be possible that, by chance, the Pilot Study's sample did not match some characteristics (such as "language spoken at home") of the population (sampling variation; Field, 2009). A "biased" sample in the Pilot Study might have been used as a base of the item analyses, resulting in "biased" item selections with respect to the subscales of the multiple-choice tests. Thus, it might be that the items of the subscales were inappropriate for reliably differentiating between competent and less competent children in a "representative" sample. As a result, the internal consistencies of the subscales might have been reduced in Experiment 1.

Another important aspect with respect to the low internal consistencies might be the differing learning time in the Pilot Study and in Experiment 1. In the Pilot Study, children were provided with a learning phase of 15 minutes, whereas in Experiment 1, the learning phase lasted about 8 minutes. As the time limit in Experiment 1 was shortened, internal consistencies of the subscales might have been spoiled. Finally, it might be possible that the newly created items for Experiment 1 (such as the new text-only items and the picture-only items) did not match their corresponding subscales and thus reduced the internal consistencies. However, this explanation conflicts with the results that were obtained for the illustrated-text information scale. Although having used the same items in the Pilot Study and in Experiment 1, the internal consistency for the illustrated-text information scale was reduced to α = .42 (Learning Unit 1), and to α = .47 (Learning Unit 2) in Experiment 1, respectively.

The lower reliabilities of some subscales in Experiment 1 seem to have been caused by higher within-group or error variances. Generally, high within-group or error variances reduce the reliability (cp., Fisseni, 1997). The higher the within-group or error variances are, the lower the statistical power of study designs. Thus, potential effects, especially smaller ones, may not be detected. As has been already mentioned, adjusting is a useful means to increase the statistical power of study designs by reducing within-group or error variances (Lipsey, 1990). Children's scores on the multiple-choice tests (overall scales and subscales) were adjusted for reading comprehension and non-verbal intelligence in both the Pilot Study and Experiment 1; however, the high within-group or error variances in Experiment 1 might have still spoiled potential effects. As the results of Experiment 1 show, this was certainly not the case. The expected effects could be found (cp., results on the multimedia effect and the modality effect in Experiment 1). Therefore, the lower reliabilities of the subscales in Experiment 1 may be regarded as unproblematic.

With respect to the children's judgements, results show that reading time, testing time, text difficulty and the difficulty of the multiple-choice tests were appropriate.

5 Experiment 2

The main purpose of Experiment 2 was to determine whether aids for selection, organization and integration foster children's learning from science texts, with a special focus on the learning of text-only information, picture-only information and transfer information. Therefore, compared to Experiment 1, four further conditions providing either selection/organization aids or selection/organization + integration aids were realized in Experiment 2. These aids were provided for children who received text + pictures in order to determine whether children benefit from learning with additional aids and – if they do – to what amount.

A further aim of Experiment 2 was the replication of the findings of Experiment 1. Therefore, it was investigated whether pictures draw children's attention away from text or, in other words, whether a different amount of (split-)attention is given to the sources of information by exploring the multimedia and modality effects on text-only information, picture-only information as well as illustrated-text information (and transfer information). Thus, again, it was investigated whether the multimedia principle and the modality principle hold true for each source of information (including transfer information). Furthermore, the results of the "written text + pictures" condition were compared with the results of the "written text + pictures + selection/organization aids" condition as well as the "written text + pictures + selection/organization + integration aids" condition. The "spoken text + pictures" condition was used as a kind of control group for the "spoken text + pictures + selection/organization aids" condition as well as for the "spoken text + pictures + selection/organization + integration aids" condition.

5.1 Research Questions and Hypotheses

Aids for selection, organization and integration are assumed to be helpful for meaningful learning to occur (cp., Mayer, 2009). Having found in Experiment 1 that children in the "written text + pictures" condition were not able to pay attention to relevant portions of words (cp., "reversed multimedia effect" on text-only information in Experiment 1), it seemed to be important to promote the learning of relevant text-only information. Based on the first experiment's item analyses, for each learning unit, five text-only items with a medium to high difficulty level for learners were fostered by selection/organization aids in Experiment 2. The same procedure was applied to five picture-only items because of the general superficial processing of pictures (cp. Mokros & Tinker, 1987; Weidenmann, 1989). Thus, the first step of the CTML – selecting relevant words and images (Mayer, 2005c; 2009) – as well as the second step of the CTML – organizing relevant words and images – should be facilitated. Furthermore, in two conditions, children's attention was drawn to transfer information by means of aids for integration which were assumed to promote the learning of transfer information. Based on the first experiment's item analyses, for each learning unit, five transfer items with a medium to high difficulty level for learners were fostered by integration aids in Experiment 2[15]. Thus, the third step of the CTML – integrating the verbal and pictorial representations with each other and with relevant prior knowledge – should be facilitated as well.

With respect to the hypotheses, it has to be noted that different time limits had to be used for the learning phases in Experiment 1 and Experiment 2. Since children who received processing aids should have had enough time for working on these aids, a time limit of approximately 8 minutes, as in Experiment 1, would not have been sufficient in Experiment 2. Giving children more time in the learning phase might result in paying more attention to relevant portions of words and pictures and, thus, the reversed multimedia effect on text-only information which could be found in Experiment 1 might disappear in Experiment 2. In fact, following research reviews (e.g., Levie & Lentz, 1982), the pattern of results indicates that pictures do not have an impact on text-only information in general. Though, children who receive aids on text-only information should outperform children who do not receive any aids.

Thus, to examine whether additional aids for selection, organization and integration are helpful for the processing of multiple representations and whether the multimedia principle and the modality principle hold true for each source of information, the following eight experimental conditions were used: (1) a "written text" condition, (2) a "written text + pictures" condition, (3) a "written text + pictures" condition with selection/organization aids (4) a "written text + pictures" condition with selection/organization and integration aids (5) a "spoken text" condition (6) a "spoken text + pictures" condition, (7) a "spoken text + pictures" condition with selection/organization aids (8) a "spoken text + pictures" condition with selection/organization and integration aids. Taking the results of the above-mentioned studies into account, as well as potential expectations from the CTML or the ITPC, the following pattern of results was predicted:

[15] It has to be noted that the amount of tasks during the learning phases (Learning Unit 1: 13 tasks, Learning Unit 2: 14 tasks) differed from the amount of items (both learning unit: 15 items each). That was due to the fact that some items could be fostered by just one task because of similar foci (Learning Unit 1: 5 tasks concerning text-only items, 4 tasks concerning picture-only items and 4 tasks concerning transfer items; Learning Unit 2: 5 tasks concerning text-only items, 5 tasks concerning picture-only items and 4 tasks concerning transfer items).

Multimedia effect

H1: The “written text + pictures” condition will exceed the “written text” condition on overall learning scores (“overall multimedia effect”).

H1.1: The “written text + pictures” condition will outperform the “written text” condition on a picture-only information scale (“multimedia effect”).

H1.2: The “written text” condition will outperform the “written text + pictures” condition on a text-only information scale (“reversed multimedia effect”).

H1.3: Consequently, the “written text + pictures” condition will not outperform the “written text“ condition on transfer achievement (“no multimedia effect”), because it will not be possible to adequately build up referential connections between picture-only information and text-only information, which are important for answering the transfer questions.

H1.4: The “written text + pictures” condition will exceed the “written text” condition on illustrated-text information (“multimedia effect”).

Modality effect

According to Ginns (2005), the pace of presentation is a moderator for the occurrence of the modality effect. Since the learning phase is longer in Experiment 2, compared to Experiment 1, children who received written text plus pictures are rather provided with a self-paced presentation than with a system-paced presentation. Therefore, the modality effect is not likely to occur. More specifically:

H2: The “spoken text + pictures” condition will not differ from the “written text + pictures” condition on overall learning scores (“no overall modality effect”).

H2.1: The “spoken text + pictures” condition will not differ from the “written text + pictures” condition on a picture-only information scale (“no modality effect”).

H2.2: The “spoken text + pictures” condition will not differ from the “written text + pictures” condition on a text-only information scale (“no modality effect”).

H2.3: Consequently, the “spoken text + pictures” condition will not differ from the “written text + pictures” condition on transfer achievement (“no modality effect”).

H2.4: The “spoken text + pictures” condition will not differ from the “written text + pictures” condition on illustrated-text information (“no modality effect”).

Aids for selection/organization

H3: The “written text + pictures + selection/organization aids” condition will exceed the “written text + pictures” condition on overall learning scores (“overall selection/organization effect”).

H3.1: The “written text + pictures + selection/organization aids” condition will outperform the “written text + pictures” condition on a picture-only information scale (“selection/organization effect”).

H3.2: The “written text + pictures + selection/organization aids” condition will exceed the “written text + pictures” condition on a text-only information scale (“selection/organization effect”).

H3.3: Consequently, the “written text + pictures + selection/organization aids” condition will outperform the “written text + pictures” condition on transfer achievement (“selection/organization effect”), because it will be possible to adequately build up more referential connections between picture-only information and text-only information, which are important for answering the transfer questions.

H3.4: The “written text + pictures + selection/organization aids” condition will not exceed the “written text + pictures” condition on illustrated-text information (“no selection/organization effect”), because the learning of illustrated-text information was not promoted.

H3.5: The “spoken text + pictures + selection/organization aids” condition will exceed the “spoken text + pictures” condition on overall learning scores (“overall selection/organization effect”).

H3.6: The “spoken text + pictures + selection/organization aids” condition will outperform the “spoken text + pictures” condition on a picture-only information scale (“selection/organization effect”).

H3.7: The “spoken text + pictures + selection/organization aids” condition will exceed the “spoken text + pictures” condition on a text-only information scale (“selection/organization effect”).

H3.8: Consequently, the “spoken text + pictures + selection/organization aids” condition will outperform the “spoken text + pictures” condition on transfer achievement (“selection/organization effect”), because it will be possible to adequately build up more referential connections between picture-only information and text-only information, which are important for answering the transfer questions.

H3.9: The “spoken text + pictures + selection/organization aids” condition will not exceed the “spoken text + pictures” condition on illustrated-text information (“no selection/organization effect”), because the learning of illustrated-text information was not promoted.

Aids for selection/organization and integration

H4: The "written text + pictures + selection/organization + integration aids" condition will exceed the "written text + pictures" condition on overall learning scores ("overall selection/organization and integration effect").

H4.1: The "written text + pictures + selection/organization + integration aids" condition will outperform the "written text + pictures" condition on a picture-only information scale ("selection/organization and integration effect").

H4.2: The "written text + pictures + selection/organization + integration aids" condition will exceed the "written text + pictures" condition on a text-only information scale ("selection/organization and integration effect").

H4.3: The "written text + pictures + selection/organization + integration aids" condition will outperform the "written text + pictures" condition on transfer achievement ("selection/organization and integration effect"), because it will be possible to adequately build up more referential connections between picture-only information and text-only information, which are important for answering the transfer questions.

H4.4: The "written text + pictures + selection/organization + integration aids" condition will not exceed the "written text + pictures" condition on illustrated-text information ("no selection/organization and integration effect"), because the learning of illustrated-text information was not promoted.

H4.5: The "spoken text + pictures + selection/organization aids + integration aids" condition will exceed the "spoken text + pictures" condition on overall learning scores ("overall selection/organization and integration effect").

H4.6: The "spoken text + pictures + selection/organization aids + integration aids" condition will outperform the "spoken text + pictures" condition on a picture-only information scale ("selection/organization and integration effect").

H4.7: The "spoken text + pictures + selection/organization aids + integration aids" condition will exceed the "spoken text + pictures" condition on a text-only information scale ("selection/organization and integration effect").

H4.8: Consequently, the "spoken text + pictures + selection/organization aids + integration aids" condition will outperform the "spoken text + pictures" condition on transfer achievement ("selection/organization and integration effect"), because it will be possible to adequately build up more referential connections between picture-only information and text-only information, which are important for answering the transfer questions.

H4.9: The “spoken text + pictures + selection/organization aids + integration aids” condition will not exceed the “spoken text + pictures” condition on illustrated-text information (“no selection/organization and integration effect”), because the learning of illustrated-text information was not promoted.

5.2 Method

5.2.1 Participants and Design

Participants in the second experiment were 277 children from 4th grades of six German primary schools. The average age was 9.8 years (*SD* = .64), and there were 53.8 % girls and 46.2 % boys.

A 4x2 study design with two independent variables, namely *type of learning material* (text, text + pictures, text + pictures + selection/organization aids, text + pictures + selection/organization aids + integration aids) and *mode of text presentation* (written vs. spoken) was used. This resulted in eight experimental conditions: Children in the first condition received written text (see Appendix I and Appendix Q; n = 34), children in the second condition received written text plus pictures (see Appendix J and Appendix R; n = 35), children in the third condition received written text plus pictures with selection/organization aids (see Appendix K and Appendix S; n = 35), children in the fourth condition received written text plus pictures with selection/organization and integration aids (see Appendix L and Appendix T; n = 35), children in the fifth condition received spoken text (see Appendix M and Appendix U; n = 31), children in the sixth condition received spoken text plus pictures (see Appendix N and Appendix V; n = 34), children in the seventh condition received spoken text plus pictures with selection/organization aids (see Appendix O and Appendix W; n = 34) and children in the eighth condition received spoken text plus pictures with selection/organization and integration aids (see Appendix P and Appendix X; n = 33). Within each class, the teacher divided participants into eight groups, in which the distributions of Grade Point Average (GPA) and sex were roughly balanced. Then, the eight groups were randomly assigned to one of eight conditions. Six children neither worked on the first nor on the second learning unit. Thus, they could not be assigned to the above-mentioned conditions.

The dependent variables, as measured by criterion-referenced tests, were performance overall, performance on information presented in text only, performance on information presented in picture only, performance on information presented in both text and picture (illustrated-text information), and performance on transfer items. In addition, reading comprehension and non-verbal intelligence were recorded as control variables.

5.2.2 Materials

The materials used in the second experiment were identical to those of the first experiment. Thus, the learning units (Learning Unit 1 and Learning Unit 2) and their respective multiple-choice test (see Appendix Y and Appendix Z), a participant questionnaire (including items on the learner's prior knowledge), motivational judgements, cognitive load items, a distractor task, a text difficulty question, a question on the difficulty of the multiple-choice test and a question on reading time and testing time were implemented in Experiment 2. Additionally, aids for selection/organization and integration were provided as questions that had to be answered by children during the learning phase. For example, when receiving selection/organization aids, children were required to fill in blanks by writing words, to encircle important parts of the picture and so on. Integration aids were implemented in the same manner, intending to draw children's attention to to-be-integrated information from text and picture. Furthermore, reading comprehension (ELFE test; Lenhard & Schneider, 2006) and non-verbal intelligence (KFT intelligence test; Heller & Perleth, 2000) were assessed. In Chapter 2, a detailed description of all materials is given.

5.2.3 Procedure

Altogether, the study consisted of three phases taking place on three different days within a week, whereby each phase lasted for approximately two lessons (90 minutes). On the first day, all participants received the first learning unit. After an 18-minute learning phase in which participants were instructed to keep the most important information in mind from both the text paragraphs and the respective pictures (in the case of picture presentation), learning outcome was measured with a multiple-choice test (32 items, with a 20-min time limit). On the second day, participants went through the same procedure again with the second learning unit. On the third day, non-verbal intelligence and reading comprehension were assessed. Two months later, a follow-up test was conducted: Children received the corresponding multiple-choice test of each learning unit, again. In section 2.4, a more detailed description of the procedure is given.

It has to be noted that a time limit was set for working on the text paragraphs, their respective pictures and aids during the learning phase. Table 10 shows the time limits for both learning units. Since both the "written text" condition and the "spoken text" condition did not receive any pictures, children with these conditions were provided with the whole time for repeating the most important information in their mind. As soon as the time limit was over, children were required to turn over the page and to follow the instructions on the next page.

Table 10

Time Limits for Working on the Text Paragraphs, the Accompanying Pictures and the Respective Tasks During the Learning Phase – Learning Unit 1 & Learning Unit 2

	Learning Unit 1	Learning Unit 2
Text paragraph, accompanying picture and respective tasks	*Time limit*	*Time limit*
1. Text paragraph with respective tasks	50 seconds	1 minute and 5 seconds
1. Accompanying picture with respective tasks	20 seconds	---
1. Text paragraph and accompanying picture with respective tasks	1 minute and 10 seconds	---
2. Text paragraph with respective tasks	2 minutes	1 minute and 5 seconds
2. Accompanying picture with respective tasks	20 seconds	20 seconds
2. Text paragraph and accompanying picture with respective tasks	1 minute and 20 seconds	1 minute and 10 seconds
3. Text paragraph with respective tasks	1 minute and 20 seconds	1 minute and 20 seconds
3. Accompanying picture with respective tasks	1 minute	1 minute and 25 seconds
3. Text paragraph and accompanying picture with respective tasks	1 minute and 40 seconds	1 minute and 10 seconds
4. Text paragraph with respective tasks	1 minute	1 minute and 50 seconds
4. Accompanying picture with respective tasks	50 seconds	1 minute and 10 seconds
4. Text paragraph and accompanying picture with respective tasks	1 minute and 20 seconds	2 minutes
5. Text paragraph with respective tasks	1 minute and 30 seconds	1 minute and 10 seconds
5. Accompanying picture with respective tasks	1 minute	1 minute and 30 seconds
5. Text paragraph and accompanying picture with respective tasks	1 minute and 30 seconds	1 minute and 50 seconds
6. Text paragraph with respective tasks	---	1 minute and 20 seconds
6. Accompanying picture with respective tasks	---	---
6. Text paragraph and accompanying picture with respective tasks	---	---

5.3 Results

In a first step, the aforementioned hypotheses concerning the multimedia and modality effects as well as the selection/organization and integration aids will be addressed by analyzing the learning outcome of the eight experimental conditions. In a second step, internal consistencies for both multiple-choice tests and their respective subscales will be presented.

5.3.1 Multimedia effects, Modality effects and Aids for Selection/Organization and Integration

The analyses were based on the data of 226 participants: Fifty-one children had to be left out of the data analyses because they did not take part in the whole study.

In a first step, children's scores (relative frequencies of correct answers) on the multiple-choice tests (overall scales and subscales) were adjusted for reading comprehension and non-verbal intelligence. Although the eight conditions did not differ significantly on these variables, they account for a large amount of variance in the learning test scores (overall test scores of Learning Unit 1: $eta^2 = .30$; Learning Unit 1 two months later: $eta^2 = .23$; Learning Unit 2: $eta^2 = .19$; Learning Unit 2 two months later: $eta^2 = .15$). Thus, adjusting is a useful means to increase the statistical power of study designs by reducing within-group or error variance (Lipsey, 1990).

After that, a multivariate analysis of variance (MANOVA) was computed with the adjusted overall test scores of the multiple-choice tests of Learning Unit 1 and Learning Unit 2 (both directly after the learning phase and two months later) as dependent variables, and the type of learning material and mode of text presentation as factors (cp., Figure 7). This revealed a multivariate main effect for type of learning material, $F(12,651) = 2.56$, $p = .003$, *partial* $eta^2 = .05$. In univariate follow-up ANOVAs, this main effect was significant for Learning Unit 1 (*directly after the learning phase*: $M_{\text{text}} = .44$, $SD_{\text{text}} = .11$, $M_{\text{text + pictures}} = .53$, $SD_{\text{text + pictures}} = .15$, $M_{\text{text + pictures + selection/organization aids}} = .53$, $SD_{\text{text + pictures + selection/organization aids}} = .11$, $M_{\text{text + pictures + selection/organization aids + integration aids}} = .54$, $SD_{\text{text + pictures + selection/organization aids + integration aids}} = .13$, $F(3,218) = 7.34$, $p < .001$, *partial* $eta^2 = .09$; two months after the learning phase: $M_{\text{text}} = .40$, $SD_{\text{text}} = .12$, $M_{\text{text + pictures}} = .49$, $SD_{\text{text + pictures}} = .16$, $M_{\text{text + pictures + selection/organization aids}} = .50$, $SD_{\text{text + pictures + selection/organization aids}} = .13$, $M_{\text{text + pictures + selection/organization aids + integration aids}} = .47$, $SD_{\text{text + pictures + selection/organization aids + integration aids}} = .13$, $F(3,218) = 5.80$, $p = .001$, *partial* $eta^2 = .07$) as well as for Learning Unit 2 (*directly after the learning phase*: $M_{\text{text}} = .32$, $SD_{\text{text}} = .11$, $M_{\text{text + pictures}} = .41$, $SD_{\text{text + pictures}} = .18$, $M_{\text{text + pictures + selection/organization aids}} = .37$, $SD_{\text{text + pictures + selection/organization aids}} = .15$, $M_{\text{text + pictures + selection/organization aids + integration aids}} = .39$, $SD_{\text{text + pictures + selection/organization aids + integration aids}} =$

.14, $F(3,218) = 4.29$, $p = .006$, *partial eta²* = .06; two months after the learning phase: $M_{\text{text}} = .26$, $SD_{\text{text}} = .12$, $M_{\text{text + pictures}} = .34$, $SD_{\text{text + pictures}} = .19$, $M_{\text{text + pictures + selection/organization aids}} = .31$, $SD_{\text{text + pictures + selection/organization aids}} = .14$, $M_{\text{text + pictures + selection/organization aids + integration aids}} = .32$, $SD_{\text{text + pictures + selection/organization aids + integration aids}} = .18$, $F(3,218) = 2.72$, $p = .045$, *partial eta²* = .04).

In addition, neither a multivariate main effect for text presentation mode, $F(4,215) = 1.46$, $p = .215$, nor an interaction between the type of learning material and the text presentation mode was found, $F(12,651) = 1.13$, $p = .335$. More specifically, in univariate follow-up ANOVAs, there was no main effect for text presentation mode for Learning Unit 1 (*directly after the learning phase*: $M_{\text{written}} = .50$, $SD_{\text{written}} = .12$, $M_{\text{spoken}} = .52$, $SD_{\text{spoken}} = .14$, $F(1,218) > 1$; two months after the learning phase: $M_{\text{written}} = .46$, $SD_{\text{written}} = .15$, $M_{\text{spoken}} = .48$, $SD_{\text{spoken}} = .13$, $F(1,218) = 1.45$, $p = .231$) as well as for Learning Unit 2 (*directly after the learning phase*: $M_{\text{written}} = .36$, $SD_{\text{written}} = .16$, $M_{\text{spoken}} = .39$, $SD_{\text{spoken}} = .15$, $F(1,218) = 2.27$, $p = .134$; two months after the learning phase: $M_{\text{written}} = .31$, $SD_{\text{written}} = .16$, $M_{\text{spoken}} = .31$, $SD_{\text{spoken}} = .16$, $F(1,218) > 1$). With regard to the interaction between the type of learning material and the text presentation mode, univariate follow-up ANOVAs showed that there was no interaction for Learning Unit 1 (*directly after the learning phase*: $M_{\text{written text}} = .47$, $SD_{\text{written text}} = .11$, $M_{\text{written text + pictures}} = .53$, $SD_{\text{written text + pictures}} = .13$, $M_{\text{written text + pictures + selection/organization aids}} = .51$, $SD_{\text{written text + pictures + selection/organization aids}} = .11$, $M_{\text{written text + pictures + selection/organization aids + integration aids}} = .51$, $SD_{\text{written text + pictures + selection/organization aids + integration aids}} = .11$, $M_{\text{spoken text}} = .42$, $SD_{\text{spoken text}} = .10$, $M_{\text{spoken text + pictures}} = .54$, $SD_{\text{spoken text + pictures}} = .17$, $M_{\text{spoken text + pictures + selection/organization aids}} = .55$, $SD_{\text{spoken text + pictures + selection/organization aids}} = .11$, $M_{\text{spoken text + pictures + selection/organization aids + integration aids}} = .57$, $SD_{\text{spoken text + pictures + selection/organization aids + integration aids}} = .15$, $F(3,218) = 1.95$, $p = .122$; two months after the learning phase: $M_{\text{written text}} = .39$, $SD_{\text{written text}} = .15$, $M_{\text{written text + pictures}} = .48$, $SD_{\text{written text + pictures}} = .16$, $M_{\text{written text + pictures + selection/organization aids}} = .49$, $SD_{\text{written text + pictures + selection/organization aids}} = .14$, $M_{\text{written text + pictures + selection/organization aids + integration aids}} = .46$, $SD_{\text{written text + pictures + selection/organization aids + integration aids}} = .13$, $M_{\text{spoken text}} = .42$, $SD_{\text{spoken text}} = .07$, $M_{\text{spoken text + pictures}} = .50$, $SD_{\text{spoken text + pictures}} = .17$, $M_{\text{spoken text + pictures + selection/organization aids}} = .51$, $SD_{\text{spoken text + pictures + selection/organization aids}} = .13$, $M_{\text{spoken text + pictures + selection/organization aids + integration aids}} = .48$, $SD_{\text{spoken text + pictures + selection/organization aids + integration aids}} = .12$, $F(3,218) > 1$) as well as for Learning Unit 2 (*directly after the learning phase*: $M_{\text{written text}} = .31$, $SD_{\text{written text}} = .11$, $M_{\text{written text + pictures}} = .41$, $SD_{\text{written text + pictures}} = .19$, $M_{\text{written text + pictures + selection/organization aids}} = .34$, $SD_{\text{written text + pictures + selection/organization aids}} = .16$, $M_{\text{written text + pictures + selection/organization aids + integration aids}} = .37$, $SD_{\text{written text + pictures + selection/organization aids + integration aids}} = .15$, $M_{\text{spoken text}} = .32$, $SD_{\text{spoken text}} = .12$, $M_{\text{spoken text + pictures}} = .42$, $SD_{\text{spoken text + pictures}} = .18$, $M_{\text{spoken text + pictures + selection/organization aids}} = .41$, $SD_{\text{spoken text + pictures + selection/organization aids}} = .13$, $M_{\text{spoken text + pictures +}}$

$_{\text{selection/organization aids + integration aids}} = .41$, $SD_{\text{spoken text + pictures + selection/organization aids + integration aids}} = .12$, $F(3,218) > 1$; two months after the learning phase: $M_{\text{written text}} = .27$, $SD_{\text{written text}} = .11$, $M_{\text{written text + pictures}} = .34$, $SD_{\text{written text + pictures}} = .20$, $M_{\text{written text + pictures + selection/organization aids}} = .31$, $SD_{\text{written text + pictures + selection/organization aids}} = .13$, $M_{\text{written text + pictures + selection/organization aids + integration aids}} = .31$, $SD_{\text{written text + pictures + selection/organization aids + integration aids}} = .18$, $M_{\text{spoken text}} = .25$, $SD_{\text{spoken text}} = .12$, $M_{\text{spoken text + pictures}} = .34$, $SD_{\text{spoken text + pictures}} = .17$, $M_{\text{spoken text + pictures + selection/organization aids}} = .31$, $SD_{\text{spoken text + pictures + selection/organization aids}} = .15$, $M_{\text{spoken text + pictures + selection/organization aids + integration aids}} = .33$, $SD_{\text{spoken text + pictures + selection/organization aids + integration aids}} = .18$, $F(3,218) > 1$).

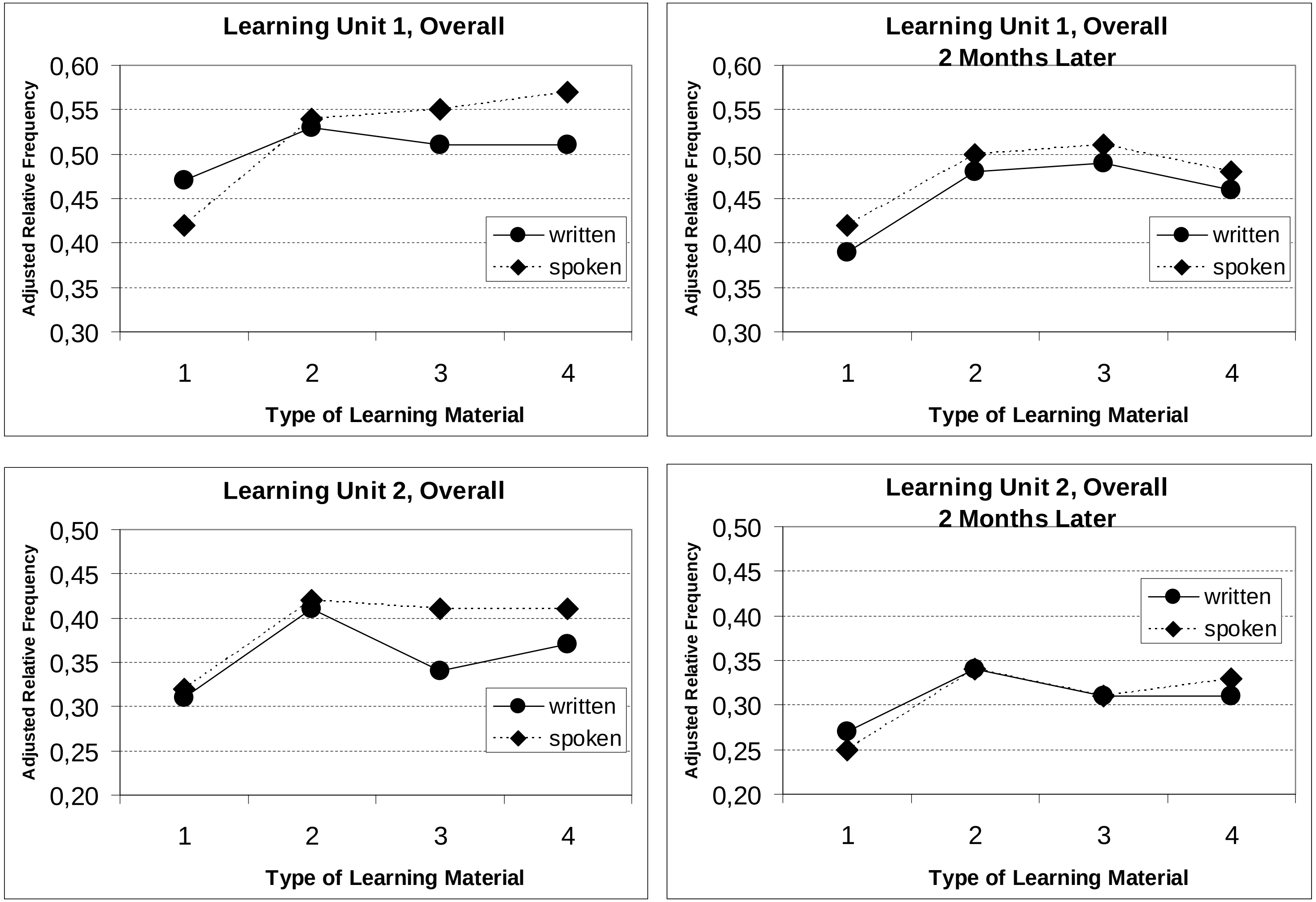


Figure 7. Learning Results (Overall) Directly After the Learning Phase and 2 Months Later, Depending on the Type of Learning Material (1 = Text, 2 = Text + Pictures, 3 = Text + Pictures + Selection/Organization Aids, 4 = Text + Pictures + Selection/Organization Aids + Integration Aids) and Mode of Text Presentation (Written, Spoken) for Learning Unit 1 and Learning Unit 2.

Furthermore, a multivariate analysis of variance (MANOVA) was computed with the adjusted subscales' scores of the multiple-choice test of Learning Unit 1 (both directly after the learning phase and two months later) as dependent variables, and the type of learning material and mode of text presentation as factors. This revealed a multivariate main effect for the type of learning material, $F(24,639) = 6.98$, $p < .001$, *partial* $eta^2 = .21$. Again, neither a multivariate main effect for text presentation mode, $F(8,211) = 1.01$, $p = .429$, nor an interaction between the type of learning material and the text presentation mode was found, $F(24,639) = 1.50$, $p = .059$. Finally, a multivariate analysis of variance (MANOVA) was computed with the adjusted subscales' scores of the multiple-choice test of Learning Unit 2 (both directly after the learning phase and two months later) as dependent variables, and the type of learning material and mode of text presentation as factors. This revealed a multivariate main effect for type of learning material, $F(24,639) = 2.35$, $p < .001$, *partial* $eta^2 = .08$. Again, neither a multivariate main effect for text presentation mode, $F(8,211) = 1.13$, $p = .342$, nor an interaction between the type of learning material and the text presentation mode was found, $F(24,639) < 1$, $p = .768$.

In order to investigate the role of information source, univariate ANOVAs with planned comparisons were computed for the subscales of the two learning tests. According to each hypothesis, one-tailed or two-tailed tests were conducted. The means and standard deviations for both learning units are shown in Tables 11, 12, 13, 14, 15 and 16.

5.3.1.1 Multimedia effects and Modality effects

The means and standard deviations for both learning units are shown in Table 11 and Table 12. With respect to Learning Unit 1, the pattern of results is depicted in Table 11.

Table 11

Adjusted Average Scores and Standard Deviations by Three Conditions on Different Sources of Information, Including the Number of Children – Learning Unit 1

	Directly after the learning phase		2 months later		Number of children
Source of information and condition	*M*	*SD*	*M*	*SD*	*N*
Overall scale					
Multimedia effect					
Written text	.47	.11	.39	.15	31
Written text + pictures	.53	.13	.48	.16	31
Modality effect					
Written text + pictures	.53	.13	.48	.16	31
Spoken text + pictures	.54	.17	.50	.17	28
Text-only subscale					
Multimedia effect					
Written text	.61	.17	.51	.24	31
Written text + pictures	.52	.21	.50	.26	31
Modality effect					
Written text + pictures	.52	.21	.50	.26	31
Spoken text + pictures	.56	.22	.53	.22	28
Picture-only subscale					
Multimedia effect					
Written text	.25	.21	.21	.20	31
Written text + pictures	.56	.25	.49	.28	31
Modality effect					
Written text + pictures	.56	.25	.49	.28	31
Spoken text + pictures	.63	.23	.51	.23	28
Illustrated-text subscale					
Multimedia effect					
Written text	.72	.17	.56	.18	31
Written text + pictures	.68	.20	.58	.17	31
Modality effect					
Written text + pictures	.68	.20	.58	.17	31
Spoken text + pictures	.61	.19	.58	.15	28
Transfer subscale					
Multimedia effect					
Written text	.29	.15	.28	.20	31
Written text + pictures	.38	.18	.38	.19	31
Modality effect					
Written text + pictures	.38	.18	.38	.19	31
Spoken text + pictures	.38	.18	.40	.24	28

Results of the *overall learning scores* of Learning Unit 1 were as follows: (1) Adding pictures to written text increased the learning of overall information (*directly after the learning phase*: $M_{\text{written text}} = .47$, $SD_{\text{written text}} = .11$, $M_{\text{written text + pictures}} = .53$, $SD_{\text{written text + pictures}} = .13$, $t(218) = 1.96$, $p = .026$ (one-tailed), $d = .51$; *two months later*: $M_{\text{written text}} = .39$, $SD_{\text{written text}} = .15$, $M_{\text{written text + pictures}} = .48$, $SD_{\text{written text + pictures}} = .16$, $t(218) = 2.65$, $p = .005$ (one-tailed), $d = .59$). (2) Learning with spoken instead of written text did not change the learning of overall information (*directly after the learning phase*: $M_{\text{written text + pictures}} = .53$, $SD_{\text{written text + pictures}} = .13$, to $M_{\text{spoken text + pictures}} = .54$, $SD_{\text{spoken text + pictures}} = .17$, $t(218) < 1$, *two months later*: $M_{\text{written text + pictures}} = .48$, $SD_{\text{written text + pictures}} = .16$, $M_{\text{spoken text + pictures}} = .50$, $SD_{\text{spoken text + pictures}} = .17$, $t(218) < 1$)[16]. G-Power (Faul et al., 2007) was used to calculate the statistical power for this comparison, given an error probability of $\alpha = .05$, a total sample size of n = 226 and a medium effect size of $f^2 = .15$ (numerator df = 1, number of predictors = 7). The resulting power of $1\text{-}\beta = .99$ indicated that a medium effect would have been detected with sufficient statistical power[17]. Thus, pictures led to a “multimedia effect” when added to written text. Furthermore, no “modality effect” could be found when presenting pictures with spoken instead of written text.

Results of *information presented in text only* were as follows: The univariate ANOVAs did not reveal statistically significant results. To say it in greater detail, (1) adding pictures to written text did not change the retention of pure text information (*directly after the learning phase*: $M_{\text{written text}} = .61$, $SD_{\text{written text}} = .17$, $M_{\text{written text + pictures}} = .52$, $SD_{\text{written text + pictures}} = .21$, $t(218) = 1.66$, $p = .051$ (one-tailed); *two months later*: $M_{\text{written text}} = .51$, $SD_{\text{written text}} = .24$, $M_{\text{written text + pictures}} = .50$, $SD_{\text{written text + pictures}} = .26$, $t(218) < 1$). (2) Learning with spoken instead of written text did not change the retention of text-only information (*directly after the learning phase*: $M_{\text{written text + pictures}} = .52$, $SD_{\text{written text + pictures}} = .21$, $M_{\text{spoken text + pictures}} = .56$, $SD_{\text{spoken text + pictures}} = .22$, $t(218) < 1$; *two months later*: $M_{\text{written text + pictures}} = .50$, $SD_{\text{written text + pictures}} = .26$, $M_{\text{spoken text + pictures}} = .53$, $SD_{\text{spoken text + pictures}} = .22$, $t(218) < 1$). Thus, no “reversed multimedia effect” appeared when adding pictures to written text. Additionally, presenting pictures with spoken instead of written text did not result in a “modality effect”.

Results of *information presented in picture only* were as follows: (1) Adding pictures to written text increased the learning of picture-only information (*directly after the learning phase*: $M_{\text{written text}} = .25$, $SD_{\text{written text}} = .21$, $M_{\text{written text + pictures}} = .56$, $SD_{\text{written text + pictures}} = .25$, $t(218) = 5.74$,

[16] Since the interaction of the *type of learning material* and the *mode of text presentation* was not significant, generally, further analyses should be avoided. However, in this case, the only reason for reporting the t-values was that the results should be presented clearly with regard to the multimedia and modality effects, implying an orientation on the results’ structure of Experiment 1.

[17] It has to be noted that this result is true for all comparisons.

p < .001 (one-tailed), d = 1.37; *two months later*: $M_{\text{written text}}$ = .21, $SD_{\text{written text}}$ = .20, $M_{\text{written text + pictures}}$ = .49, $SD_{\text{written text + pictures}}$ = .28, $t(218)$ = 4.37, p < .001 (one-tailed), d = 1.16). (2) Learning with spoken instead of written text did not change the learning of picture-only information (*directly after the learning phase*: $M_{\text{written text + pictures}}$ = .56, $SD_{\text{written text + pictures}}$ = .25, $M_{\text{spoken text + pictures}}$ = .63, $SD_{\text{spoken text + pictures}}$ = .23, $t(218)$ = 1.27, p = .207; *two months later*: $M_{\text{written text + pictures}}$ = .49, $SD_{\text{written text + pictures}}$ = .28, $M_{\text{spoken text + pictures}}$ = .51, $SD_{\text{spoken text + pictures}}$ = .23, $t(218)$ < 1). Thus, pictures induced a “multimedia effect” when added to written text. This positive impact of pictures could not be further enhanced by using spoken instead of written text (“no modality effect”).

Results of *illustrated-text information* were as follows: (1) Adding pictures to written text did not change the average performance score on illustrated-text information (*directly after the learning phase*: $M_{\text{written text}}$ = .72, $SD_{\text{written text}}$ = .17, $M_{\text{written text + pictures}}$ = .68, $SD_{\text{written text + pictures}}$ = .20, $t(218)$ = 1.10, p = .275; *two months later*: $M_{\text{written text}}$ = .56, $SD_{\text{written text}}$ = .18, $M_{\text{written text + pictures}}$ = .58, $SD_{\text{written text + pictures}}$ = .17, $t(218)$ < 1). (2) Learning with spoken instead of written text did not change the average performance score either (*directly after the learning phase*: $M_{\text{written text + pictures}}$ = .68, $SD_{\text{written text + pictures}}$ = .20, $M_{\text{spoken text + pictures}}$ = .61, $SD_{\text{spoken text + pictures}}$ = .19, $t(218)$ = 1.47, p = .142; *two months later*: $M_{\text{written text + pictures}}$ = .58, $SD_{\text{written text + pictures}}$ = .17, $M_{\text{spoken text + pictures}}$ = .58, $SD_{\text{spoken text + pictures}}$ = .15, $t(218)$ < 1). Thus, pictures did not have a positive impact when added to written text (“no multimedia effect”). Furthermore, no “modality effect” could be found when presenting pictures with spoken instead of written text.

Results of the *transfer subscale* were as follows: (1) Adding pictures to written text increased transfer achievement (*directly after the learning phase*: $M_{\text{written text}}$ = .29, $SD_{\text{written text}}$ = .15, $M_{\text{written text + pictures}}$ = .38, $SD_{\text{written text + pictures}}$ = .18, $t(218)$ = 2.32, p = .022, d = .57; *two months later*: $M_{\text{written text}}$ = .28, $SD_{\text{written text}}$ = .20, $M_{\text{written text + pictures}}$ = .38, $SD_{\text{written text + pictures}}$ = .19, $t(218)$ = 2.02, p = .044, d = .49). (2) Learning with spoken instead of written text did not change the transfer achievement (*directly after the learning phase*: $M_{\text{written text + pictures}}$ = .38, $SD_{\text{written text + pictures}}$ = .18, $M_{\text{spoken text + pictures}}$ = .38, $SD_{\text{spoken text + pictures}}$ = .18, $t(218)$ < 1; *two months later*: $M_{\text{written text + pictures}}$ = .38, $SD_{\text{written text + pictures}}$ = .19, $M_{\text{spoken text + pictures}}$ = .40, $SD_{\text{spoken text + pictures}}$ = .24, $t(218)$ < 1). Thus, presenting written text with pictures resulted in a “multimedia effect” on transfer achievement. Using spoken instead of written text did not further increase the learning results (“no modality effect”).

With respect to Learning Unit 2, a similar pattern of results could be found (Table 12).

Table 12

Adjusted Average Scores and Standard Deviations by Three Conditions on Different Sources of Information, Including the Number of Children – Learning Unit 2

	Directly after the learning phase		2 months later		Number of children
Source of information and condition	*M*	*SD*	*M*	*SD*	*N*
Overall scale					
Multimedia effect					
Written text	.31	.11	.27	.11	31
Written text + pictures	.41	.19	.34	.20	31
Modality effect					
Written text + pictures	.41	.19	.34	.20	31
Spoken text + pictures	.42	.18	.34	.17	28
Text-only subscale					
Multimedia effect					
Written text	.45	.20	.36	.17	31
Written text + pictures	.52	.20	.37	.25	31
Modality effect					
Written text + pictures	.52	.20	.37	.25	31
Spoken text + pictures	.47	.21	.42	.21	28
Picture-only subscale					
Multimedia effect					
Written text	.15	.14	.15	.18	31
Written text + pictures	.33	.22	.35	.25	31
Modality effect					
Written text + pictures	.33	.22	.35	.25	31
Spoken text + pictures	.40	.23	.33	.25	28
Illustrated-text subscale					
Multimedia effect					
Written text	.52	.16	.41	.21	31
Written text + pictures	.54	.28	.45	.28	31
Modality effect					
Written text + pictures	.54	.28	.45	.28	31
Spoken text + pictures	.56	.23	.39	.23	28
Transfer subscale					
Multimedia effect					
Written text	.15	.17	.14	.14	31
Written text + pictures	.24	.24	.19	.19	31
Modality effect					
Written text + pictures	.24	.24	.19	.19	31
Spoken text + pictures	.24	.21	.22	.16	28

Results of the *overall learning scores* of Learning Unit 2 were as follows: (1) Adding pictures to written text increased the learning of overall information (*directly after the learning phase*: $M_{\text{written text}} = .31$, $SD_{\text{written text}} = .11$, $M_{\text{written text + pictures}} = .41$, $SD_{\text{written text + pictures}} = .19$, $t(218) = 2.45$, $p = .008$ (one-tailed), $d = .60$; *two months later*: $M_{\text{written text}} = .27$, $SD_{\text{written text}} = .11$, $M_{\text{written text + pictures}} = .34$, $SD_{\text{written text + pictures}} = .20$, $t(218) = 1.81$, $p = .036$ (one-tailed), $d = .44$). (2) Learning with spoken instead of written text did not increase the learning of overall information (*directly after the learning phase*: $M_{\text{written text + pictures}} = .41$, $SD_{\text{written text + pictures}} = .19$, $M_{\text{spoken text + pictures}} = .42$, $SD_{\text{spoken text + pictures}} = .18$, $t(218) < 1$; *two months later*: $M_{\text{written text + pictures}} = .34$, $SD_{\text{written text + pictures}} = .20$, $M_{\text{spoken text + pictures}} = .34$, $SD_{\text{spoken text + pictures}} = .17$, $t(218) < 1$). To sum up, adding pictures to written text resulted in a “multimedia effect”; using spoken instead of written text had no additional positive impact on the learning of overall information (“no modality effect”).

Results of *information presented in text only* were as follows: The univariate ANOVAs did not reveal statistically significant results. To be more precise, (1) adding pictures to written text did not increase the retention of pure text information (*directly after the learning phase*: $M_{\text{written text}} = .45$, $SD_{\text{written text}} = .20$, $M_{\text{written text + pictures}} = .52$, $SD_{\text{written text + pictures}} = .20$, $t(218) = 1.32$, $p = .188$; *two months later*: $M_{\text{written text}} = .36$, $SD_{\text{written text}} = .17$, $M_{\text{written text + pictures}} = .37$, $SD_{\text{written text + pictures}} = .25$, $t(218) < 1$). (2) Learning with spoken instead of written text did not increase the retention of text-only information either (*directly after the learning phase*: $M_{\text{written text + pictures}} = .52$, $SD_{\text{written text + pictures}} = .20$, $M_{\text{spoken text + pictures}} = .47$, $SD_{\text{spoken text + pictures}} = .21$, $t(218) < 1$; *two months later*: $M_{\text{written text + pictures}} = .37$, $SD_{\text{written text + pictures}} = .25$, $M_{\text{spoken text + pictures}} = .42$, $SD_{\text{spoken text + pictures}} = .21$, $t(218) < 1$. To put it in a nutshell, pictures led to no “reversed multimedia effect” when added to written text. Furthermore, no “modality effect” could be found when presenting pictures with spoken instead of written text.

Results of *information presented in picture only* were as follows: (1) Adding pictures to written text increased the learning of picture-only information (*directly after the learning phase*: $M_{\text{written text}} = .15$, $SD_{\text{written text}} = .14$, $M_{\text{written text + pictures}} = .33$, $SD_{\text{written text + pictures}} = .22$, $t(218) = 3.91$, $p < .001$ (one-tailed), $d = .99$; *two months later*: $M_{\text{written text}} = .15$, $SD_{\text{written text}} = .18$, $M_{\text{written text + pictures}} = .35$, $SD_{\text{written text + pictures}} = .25$, $t(218) = 3.61$, $p < .001$ (one-tailed), $d = .91$). (2) Learning with spoken instead of written text did not further increase the learning of picture-only information (*directly after the learning phase*: $M_{\text{written text + pictures}} = .33$, $SD_{\text{written text + pictures}} = .22$, $M_{\text{spoken text + pictures}} = .40$, $SD_{\text{spoken text + pictures}} = .23$, $t(218) = 1.32$, $p = .187$; *two months later*: $M_{\text{written text + pictures}} = .35$, $SD_{\text{written text + pictures}} = .25$, $M_{\text{spoken text + pictures}} = .33$, $SD_{\text{spoken text + pictures}} = .25$, $t(218) < 1$). To summarize, pictures induced a “multimedia effect” when added to written text.

This positive impact of pictures could not be further enhanced by using spoken instead of written text (“no modality effect”).

Results of *illustrated-text information* were as follows: The univariate ANOVAs did not reveal statistically significant results. More precisely, (1) adding pictures to written text did not change the average performance score on illustrated-text information (*directly after the learning phase*: $M_{\text{written text}} = .52$, $SD_{\text{written text}} = .16$, $M_{\text{written text + pictures}} = .54$, $SD_{\text{written text + pictures}} = .28$, $t(218) < 1$; *two months later*: $M_{\text{written text}} = .41$, $SD_{\text{written text}} = .21$, $M_{\text{written text + pictures}} = .45$, $SD_{\text{written text + pictures}} = .28$, $t(218) < 1$). (2) Learning with spoken instead of written text did not change the average performance score either (*directly after the learning phase*: $M_{\text{written text + pictures}} = .54$, $SD_{\text{written text + pictures}} = .28$, $M_{\text{spoken text + pictures}} = .56$, $SD_{\text{spoken text + pictures}} = .23$, $t(218) < 1$; *two months later*: $M_{\text{written text + pictures}} = .45$, $SD_{\text{written text + pictures}} = .28$, $M_{\text{spoken text + pictures}} = .39$, $SD_{\text{spoken text + pictures}} = .23$, $t(218) < 1$). Thus, adding pictures to written text had no positive impact on the learning of illustrated-text information (“no multimedia effect”). Additionally, presenting pictures with spoken instead of written text did not induce a “modality effect” effect either.

Results of the *transfer subscale* were as follows: (1) Adding pictures to written text did not increase transfer achievement (*directly after the learning phase*: $M_{\text{written text}} = .15$, $SD_{\text{written text}} = .17$, $M_{\text{written text + pictures}} = .24$, $SD_{\text{written text + pictures}} = .24$, $t(218) = 1.87$, $p = .064$; *two months later*: $M_{\text{written text}} = .14$, $SD_{\text{written text}} = .14$, $M_{\text{written text + pictures}} = .19$, $SD_{\text{written text + pictures}} = .19$, $t(218) = 1.07$, $p = .286$. (2) Learning with spoken instead of written text did not change transfer achievement (*directly after the learning phase*: $M_{\text{written text + pictures}} = .24$, $SD_{\text{written text + pictures}} = .24$, $M_{\text{spoken text + pictures}} = .24$, $SD_{\text{spoken text + pictures}} = .21$, $t(218) < 1$; *two months later*: $M_{\text{written text + pictures}} = .19$, $SD_{\text{written text + pictures}} = .19$, $M_{\text{spoken text + pictures}} = .22$, $SD_{\text{spoken text + pictures}} = .16$, $t(218) < 1$). To put it in a nutshell, pictures induced no “multimedia effect” when added to written text. Presenting pictures with spoken instead of written text did not lead to a “modality effect”.

5.3.1.2 Aids for selection/organization

With regard to Learning Unit 1, the pattern of results is depicted in Table 13.

Table 13

Adjusted Average Scores and Standard Deviations by Four Conditions on Different Sources of Information, Including the Number of Children – Learning Unit 1

	Directly after the learning phase		2 months later		Number of children
Source of information and condition	*M*	*SD*	*M*	*SD*	*N*
Overall scale					
Selection/Organization effect					
Written text + pictures	.53	.13	.48	.16	31
Written text + pictures + sel./org. aids	.51	.11	.49	.14	31
Spoken text + pictures	.54	.17	.50	.17	28
Spoken text + pictures + sel./org. aids	.55	.11	.51	.13	29
Text-only subscale					
Selection/Organization effect					
Written text + pictures	.52	.21	.50	.26	31
…Written text + pictures + sel./org. aids	.54	.21	.52	.22	31
Spoken text + pictures	.56	.22	.53	.22	28
Spoken text + pictures + sel./org. aids	.65	.21	.53	.21	29
Picture-only subscale					
Selection/Organization effect					
Written text + pictures	.56	.25	.49	.28	31
Written text + pictures + sel./org. aids	.66	.25	.49	.30	31
Spoken text + pictures	.63	.23	.51	.23	28
Spoken text + pictures + sel./org. aids	.61	.21	.52	.26	29
Illustrated-text subscale					
Selection/Organization effect					
Written text + pictures	.68	.20	.58	.17	31
…Written text + pictures + sel./org. aids	.59	.13	.60	.12	31
Spoken text + pictures	.61	.19	.58	.15	28
Spoken text + pictures + sel./org. aids	.62	.14	.60	.16	29
Transfer subscale					
Selection/Organization effect					
Written text + pictures	.38	.18	.38	.19	31
Written text + pictures + sel./org. aids	.28	.12	.37	.17	31
Spoken text + pictures	.38	.18	.40	.24	28
Spoken text + pictures + sel./org. aids	.36	.14	.41	.18	29

Results of the *overall learning scores* of Learning Unit 1 were as follows: (1) Adding selection/organization aids to written text plus pictures did not increase the learning of overall information (*directly after the learning phase*: $M_{\text{written text + pictures}} = .53$, $SD_{\text{written text + pictures}} = .13$,

$M_{\text{written text + pictures + sel./org. aids}} = .51$, $SD_{\text{written text + pictures + sel./org. aids}} = .11$, $t(218) < 1$; *two months later*: $M_{\text{written text + pictures}} = .48$, $SD_{\text{written text + pictures}} = .16$, $M_{\text{written text + pictures + sel./org. aids}} = .49$, $SD_{\text{written text + pictures + sel./org. aids}} = .14$, $t(218) < 1$). G-Power (Faul et al., 2007) was used to calculate the statistical power for this comparison, given an error probability of $\alpha = .05$, a total sample size of n = 226 and a medium effect size of $f^2 = .15$ (numerator df = 1, number of predictors = 7). The resulting power of $1\text{-}\beta = .99$ indicated that a medium effect would have been detected with sufficient statistical power[18]. (2) Adding selection/organization aids to spoken text plus pictures did not increase the learning of overall information either (*directly after the learning phase*: $M_{\text{spoken text + pictures}} = .54$, $SD_{\text{spoken text + pictures}} = .17$, $M_{\text{spoken text + pictures + sel./org. aids}} = .55$, $SD_{\text{spoken text + pictures + sel./org. aids}} = .11$, $t(218) < 1$; *two months later*: $M_{\text{spoken text + pictures}} = .50$, $SD_{\text{spoken text + pictures}} = .17$, $M_{\text{spoken text + pictures + sel./org. aids}} = .51$, $SD_{\text{spoken text + pictures + sel./org. aids}} = .13$, $t(218) < 1$). Thus, providing selection/organization aids had no influence on the overall learning outcome ("no overall selection/organization effect").

Results of *information presented in text only* were as follows: The univariate ANOVAs did not reveal statistically significant results. (1) Adding selection/organization aids to written text plus pictures did not increase the learning of pure text information (*directly after the learning phase*: $M_{\text{written text + pictures}} = .52$, $SD_{\text{written text + pictures}} = .21$, $M_{\text{written text + pictures + sel./org. aids}} = .54$, $SD_{\text{written text + pictures + sel./org. aids}} = .21$, $t(218) < 1$; *two months later*: $M_{\text{written text + pictures}} = .50$, $SD_{\text{written text + pictures}} = .26$, $M_{\text{written text + pictures + sel./org. aids}} = .52$, $SD_{\text{written text + pictures + sel./org. aids}} = .22$, $t(218) < 1$). (2) Adding selection/organization aids to spoken text plus pictures increased the learning of pure text information *directly after the learning phase*, $M_{\text{spoken text + pictures}} = .56$, $SD_{\text{spoken text + pictures}} = .22$, $M_{\text{spoken text + pictures + sel./org. aids}} = .65$, $SD_{\text{spoken text + pictures + sel./org. aids}} = .21$, $t(218) = 1.74$, $p = .042$ (one-tailed), $d = 0.42$, but not *two months later*, $M_{\text{spoken text + pictures}} = .53$, $SD_{\text{spoken text + pictures}} = .22$, $M_{\text{spoken text + pictures + sel./org. aids}} = .53$, $SD_{\text{spoken text + pictures + sel./org. aids}} = .21$, $t(218) < 1$). To sum up, providing selection/organization aids had no influence on the learning of pure text information generally ("no selection/organization effect").

Results of *information presented in picture only* were as follows: (1) Adding selection/organization aids to written text plus pictures enhanced the learning of picture-only information *directly after the learning phase*, $M_{\text{written text + pictures}} = .56$, $SD_{\text{written text + pictures}} = .25$, $M_{\text{written text + pictures + sel./org. aids}} = .66$, $SD_{\text{written text + pictures + sel./org. aids}} = .25$, $t(218) = 1.89$, $p = .03$ (one-tailed), $d = 0.40$, but not *two months later*, $M_{\text{written text + pictures}} = .49$, $SD_{\text{written text + pictures}} = .28$, $M_{\text{written text + pictures + sel./org. aids}} = .49$, $SD_{\text{written text + pictures + sel./org. aids}} = .30$, $t(218) < 1$). (2) Adding

[18] It has to be noted that this result is true for all comparisons.

selection/organization aids to spoken text plus pictures did not improve further the learning of picture-only information (*directly after the learning phase*: $M_{\text{spoken text + pictures}} = .63$, $SD_{\text{spoken text + pictures}} = .23$, $M_{\text{spoken text + pictures + sel./org. aids}} = .61$, $SD_{\text{spoken text + pictures + sel./org. aids}} = .21$, $t(218) < 1$; *two months later*: $M_{\text{spoken text + pictures}} = .51$, $SD_{\text{spoken text + pictures}} = .23$, $M_{\text{spoken text + pictures + sel./org. aids}} = .52$, $SD_{\text{spoken text + pictures + sel./org. aids}} = .26$, $t(218) < 1$). Thus, altogether, providing selection/organization aids had no influence on the learning of picture-only information ("no selection/organization effect").

Results of *illustrated-text information* were as follows: (1) Adding selection/organization aids to written text plus pictures did not enhance the learning of illustrated-text information (*directly after the learning phase*: $M_{\text{written text + pictures}} = .68$, $SD_{\text{written text + pictures}} = .20$, $M_{\text{written text + pictures + sel./org. aids}} = .59$, $SD_{\text{written text + pictures + sel./org. aids}} = .13$, $t(218) = -1.92$, $p = .056$; *two months later*: $M_{\text{written text + pictures}} = .58$, $SD_{\text{written text + pictures}} = .17$, $M_{\text{written text + pictures + sel./org. aids}} = .60$, $SD_{\text{written text + pictures + sel./org. aids}} = .12$, $t(218) < 1$). (2) Adding selection/organization aids to spoken text plus pictures did not improve further the learning of illustrated-text information either (*directly after the learning phase*: $M_{\text{spoken text + pictures}} = .61$, $SD_{\text{spoken text + pictures}} = .19$, $M_{\text{spoken text + pictures + sel./org. aids}} = .62$, $SD_{\text{spoken text + pictures + sel./org. aids}} = .14$, $t(218) < 1$; *two months later*: $M_{\text{spoken text + pictures}} = .58$, $SD_{\text{spoken text + pictures}} = .15$, $M_{\text{spoken text + pictures + sel./org. aids}} = .60$, $SD_{\text{spoken text + pictures + sel./org. aids}} = .16$, $t(218) < 1$). Hence, adding selection/organization aids to the learning material had no influence on the learning of illustrated-text information ("no selection/organization effect").

Results of the *transfer subscale* were as follows: (1) Adding selection/organization aids to written text plus pictures reduced the performance on the transfer subscale *directly after the learning phase*, $M_{\text{written text + pictures}} = .38$, $SD_{\text{written text + pictures}} = .18$, $M_{\text{written text + pictures + sel./org. aids}} = .28$, $SD_{\text{written text + pictures + sel./org. aids}} = .12$, $t(218) = -2.42$, $p = .016$, $d = 0.65$. *Two months later*, this negative influence had gone, $M_{\text{written text + pictures}} = .38$, $SD_{\text{written text + pictures}} = .19$, $M_{\text{written text + pictures + sel./org. aids}} = .37$, $SD_{\text{written text + pictures + sel./org. aids}} = .17$, $t(218) < 1$. (2) Adding selection/organization aids to spoken text plus pictures did not increase the performance on the transfer subscale either (*directly after the learning phase*: $M_{\text{spoken text + pictures}} = .38$, $SD_{\text{spoken text + pictures}} = .18$, $M_{\text{spoken text + pictures + sel./org. aids}} = .36$, $SD_{\text{spoken text + pictures + sel./org. aids}} = .14$, $t(218) < 1$; *two months later*: $M_{\text{spoken text + pictures}} = .40$, $SD_{\text{spoken text + pictures}} = .24$, $M_{\text{spoken text + pictures + sel./org. aids}} = .41$, $SD_{\text{spoken text + pictures + sel./org. aids}} = .18$, $t(218) < 1$). Altogether, adding selection/organization aids to the learning material had no influence on the performance on the transfer subscale ("no selection/organization effect"); directly after the learning phase, seemingly a negative impact on the performance was found.

A similar pattern of results was found for Learning Unit 2 (cp., Table 14).

Table 14

Adjusted Average Scores and Standard Deviations by Four Conditions on Different Sources of Information, Including the Number of Children – Learning Unit 2

	Directly after the learning phase		2 months later		Number of children
Source of information and condition	*M*	*SD*	*M*	*SD*	*N*
Overall scale					
Selection/Organization effect					
Written text + pictures	.41	.19	.34	.20	31
Written text + pictures + sel./org. aids	.34	.16	.31	.13	31
Spoken text + pictures	.42	.18	.34	.17	28
Spoken text + pictures + sel./org. aids	.41	.13	.31	.15	29
Text-only subscale					
Selection/Organization effect					
Written text + pictures	.52	.20	.37	.25	31
…Written text + pictures + sel./org. aids	.46	.24	.36	.16	31
Spoken text + pictures	.47	.21	.42	.21	28
Spoken text + pictures + sel./org. aids	.54	.22	.38	.24	29
Picture-only subscale					
Selection/Organization effect					
Written text + pictures	.33	.22	.35	.25	31
Written text + pictures + sel./org. aids	.27	.19	.31	.20	31
Spoken text + pictures	.40	.23	.33	.25	28
Spoken text + pictures + sel./org. aids	.36	.17	.28	.21	29
Illustrated-text subscale					
Selection/Organization effect					
Written text + pictures	.54	.28	.45	.28	31
…Written text + pictures + sel./org. aids	.44	.21	.41	.20	31
Spoken text + pictures	.56	.23	.39	.23	28
Spoken text + pictures + sel./org. aids	.51	.20	.40	.20	29
Transfer subscale					
Selection/Organization effect					
Written text + pictures	.24	.24	.19	.19	31
Written text + pictures + sel./org. aids	.17	.20	.18	.22	31
Spoken text + pictures	.24	.21	.22	.16	28
Spoken text + pictures + sel./org. aids	.23	.18	.16	.17	29

Results of the *overall learning scores* of Learning Unit 2 were as follows: (1) Adding selection/organization aids to written text plus pictures did not increase the learning of overall information (*directly after the learning phase*: $M_{\text{written text + pictures}} = .41$, $SD_{\text{written text + pictures}} = .19$,

$M_{\text{written text + pictures + sel./org. aids}} = .34$, $SD_{\text{written text + pictures + sel./org. aids}} = .16$, $t(218) = -1.92$, $p = .057$; *two months later*: $M_{\text{written text + pictures}} = .34$, $SD_{\text{written text + pictures}} = .20$, $M_{\text{written text + pictures + sel./org. aids}} = .31$, $SD_{\text{written text + pictures + sel./org. aids}} = .13$, $t(218) < 1$). (2) Adding selection/organization aids to spoken text plus pictures did not increase the learning of overall information either (*directly after the learning phase*: $M_{\text{spoken text + pictures}} = .42$, $SD_{\text{spoken text + pictures}} = .18$, $M_{\text{spoken text + pictures + sel./org. aids}} = .41$, $SD_{\text{spoken text + pictures + sel./org. aids}} = .13$, $t(218) < 1$; *two months later*: $M_{\text{spoken text + pictures}} = .34$, $SD_{\text{spoken text + pictures}} = .17$, $M_{\text{spoken text + pictures + sel./org. aids}} = .31$, $SD_{\text{spoken text + pictures + sel./org. aids}} = .15$, $t(218) < 1$). Thus, adding selection/organization aids to the learning material had no influence on the overall learning outcome (“no overall selection/organization effect”).

Results of *information presented in text only* were as follows: The univariate ANOVAs did not reveal statistically significant results. More precisely, (1) adding selection/organization aids to written text plus pictures did not increase the learning of pure text information (*directly after the learning phase*: $M_{\text{written text + pictures}} = .52$, $SD_{\text{written text + pictures}} = .20$, $M_{\text{written text + pictures + sel./org. aids}} = .46$, $SD_{\text{written text + pictures + sel./org. aids}} = .24$, $t(218) = -1.12$, $p = .266$; *two months later*: $M_{\text{written text + pictures}} = .37$, $SD_{\text{written text + pictures}} = .25$, $M_{\text{written text + pictures + sel./org. aids}} = .36$, $SD_{\text{written text + pictures + sel./org. aids}} = .16$, $t(218) < 1$). (2) Adding selection/organization aids to spoken text plus pictures did not enhance the learning of pure text information either (*directly after the learning phase*: $M_{\text{spoken text + pictures}} = .47$, $SD_{\text{spoken text + pictures}} = .21$, $M_{\text{spoken text + pictures + sel./org. aids}} = .54$, $SD_{\text{spoken text + pictures + sel./org. aids}} = .22$, $t(218) = 1.20$, $p = .231$; *two months later*: $M_{\text{spoken text + pictures}} = .42$, $SD_{\text{spoken text + pictures}} = .21$, $M_{\text{spoken text + pictures + sel./org. aids}} = .38$, $SD_{\text{spoken text + pictures + sel./org. aids}} = .24$, $t(218) < 1$). In a nutshell, providing selection/organization aids had no influence on the learning of pure text information (“no selection/organization effect”).

Results of *information presented in picture only* were as follows: (1) Adding selection/organization aids to written text plus pictures did not change the learning of picture-only information (*directly after the learning phase*: $M_{\text{written text + pictures}} = .33$, $SD_{\text{written text + pictures}} = .22$, $M_{\text{written text + pictures + sel./org. aids}} = .27$, $SD_{\text{written text + pictures + sel./org. aids}} = .19$, $t(218) = -1.32$, $p = .189$; *two months later*: $M_{\text{written text + pictures}} = .35$, $SD_{\text{written text + pictures}} = .25$, $M_{\text{written text + pictures + sel./org. aids}} = .31$, $SD_{\text{written text + pictures + sel./org. aids}} = .20$, $t(218) < 1$). (2) Adding selection/organization aids to spoken text plus pictures did not change the learning of picture-only information either (*directly after the learning phase*: $M_{\text{spoken text + pictures}} = .40$, $SD_{\text{spoken text + pictures}} = .23$, $M_{\text{spoken text + pictures + sel./org. aids}} = .36$, $SD_{\text{spoken text + pictures + sel./org. aids}} = .17$, $t(218) < 1$; *two months later*: $M_{\text{spoken text + pictures}} = .33$, $SD_{\text{spoken text + pictures}} = .25$, $M_{\text{spoken text + pictures + sel./org. aids}} = .28$, $SD_{\text{spoken text + pictures + sel./org. aids}} = .21$, $t(218) < 1$). Thus, adding selection/organization aids to the learning material had no influence on the learning of picture-only information (“no selection/organization effect”).

Results of *illustrated-text information* were as follows: The univariate ANOVAs did not reveal statistically significant results. To be more specific, (1) adding selection/organization aids to written text plus pictures did not improve the learning of illustrated-text information (*directly after the learning phase*: $M_{\text{written text + pictures}} = .54$, $SD_{\text{written text + pictures}} = .28$, $M_{\text{written text + pictures + sel./org. aids}} = .44$, $SD_{\text{written text + pictures + sel./org. aids}} = .21$, $t(218) = -1.79$, $p = .074$; *two months later*: $M_{\text{written text + pictures}} = .45$, $SD_{\text{written text + pictures}} = .28$, $M_{\text{written text + pictures + sel./org. aids}} = .41$, $SD_{\text{written text + pictures + sel./org. aids}} = .20$, $t(218) < 1$). (2) Adding selection/organization aids to spoken text plus pictures did not improve the learning of illustrated-text information either (*directly after the learning phase*: $M_{\text{spoken text + pictures}} = .56$, $SD_{\text{spoken text + pictures}} = .23$, $M_{\text{spoken text + pictures + sel./org. aids}} = .51$, $SD_{\text{spoken text + pictures + sel./org. aids}} = .20$, $t(218) < 1$; *two months later*: $M_{\text{spoken text + pictures}} = .39$, $SD_{\text{spoken text + pictures}} = .23$, $M_{\text{spoken text + pictures + sel./org. aids}} = .40$, $SD_{\text{spoken text + pictures + sel./org. aids}} = .20$, $t(218) < 1$). Thus, providing selection/organization aids had no impact on the learning of illustrated-text information ("no selection/organization effect").

Results of the *transfer subscale* were as follows: (1) Adding selection/organization aids to written text plus pictures did not increase the performance on the transfer subscale (*directly after the learning phase*: $M_{\text{written text + pictures}} = .24$, $SD_{\text{written text + pictures}} = .24$, $M_{\text{written text + pictures + sel./org. aids}} = .17$, $SD_{\text{written text + pictures + sel./org. aids}} = .20$, $t(218) = -1.47$, $p = .143$; *two months later*: $M_{\text{written text + pictures}} = .19$, $SD_{\text{written text + pictures}} = .19$, $M_{\text{written text + pictures + sel./org. aids}} = .18$, $SD_{\text{written text + pictures + sel./org. aids}} = .22$, $t(218) < 1$). (2) Adding selection/organization aids to spoken text plus pictures did not increase the performance on the transfer subscale either (*directly after the learning phase*: $M_{\text{spoken text + pictures}} = .24$, $SD_{\text{spoken text + pictures}} = .21$, $M_{\text{spoken text + pictures + sel./org. aids}} = .23$, $SD_{\text{spoken text + pictures + sel./org. aids}} = .18$, $t(218) < 1$; *two months later*: $M_{\text{spoken text + pictures}} = .22$, $SD_{\text{spoken text + pictures}} = .16$, $M_{\text{spoken text + pictures + sel./org. aids}} = .16$, $SD_{\text{spoken text + pictures + sel./org. aids}} = .17$, $t(218) = -1.40$, $p = .164$). Thus, adding selection/organization aids to the learning material had no influence on the performance on the transfer subscale ("no selection/organization effect").

5.3.1.3 Aids for selection/organization and integration

With regard to Learning Unit 1, the pattern of results is depicted in Table 15.

Table 15

Adjusted Average Scores and Standard Deviations by Four Conditions on Different Sources of Information, Including the Number of Children – Learning Unit 1

	Directly after the learning phase		2 months later		Number of children
Source of information and condition	*M*	*SD*	*M*	*SD*	*N*
Overall scale					
Selection/Organization + Integration effect					
Written text + pictures	.53	.13	.48	.16	31
Written text + pictures + sel./org. + int. aids	.51	.11	.46	.13	26
Spoken text + pictures	.54	.17	.50	.17	28
Spoken text + pictures + sel./org. + int. aids	.57	.15	.48	.12	24
Text-only subscale					
Selection/Organization + Integration effect					
Written text + pictures	.52	.21	.50	.26	31
…Written text + pictures + sel./org. + int. aids	.62	.18	.52	.21	26
Spoken text + pictures	.56	.22	.53	.22	28
Spoken text + pictures + sel./org. + int. aids	.64	.20	.60	.16	24
Picture-only subscale					
Selection/Organization + Integration effect					
Written text + pictures	.56	.25	.49	.28	31
Written text + pictures + sel./org. + int. aids	.57	.17	.40	.26	26
Spoken text + pictures	.63	.23	.51	.23	28
Spoken text + pictures + sel./org. + int. aids	.64	.22	.36	.25	24
Illustrated-text subscale					
Selection/Organization + Integration effect					
Written text + pictures	.68	.20	.58	.17	31
…Written text + pictures + sel./org. + int. aids	.60	.17	.57	.14	26
Spoken text + pictures	.61	.19	.58	.15	28
Spoken text + pictures + sel./org. + int. aids	.67	.18	.56	.14	24
Transfer subscale					
Selection/Organization + Integration effect					
Written text + pictures	.38	.18	.38	.19	31
Written text + pictures + sel./org. + int. aids	.29	.12	.36	.18	26
Spoken text + pictures	.38	.18	.40	.24	28
Spoken text + pictures + sel./org. + int. aids	.35	.19	.41	.17	24

Results of the *overall learning scores* of Learning Unit 1 were as follows: (1) Adding selection/organization + integration aids to written text plus pictures did not enhance the learning of overall information (*directly after the learning phase*: $M_{\text{written text + pictures}}$ = .53, $SD_{\text{written text +}}$

$_{\text{pictures}}$ = .13, $M_{\text{written text + pictures + sel./org. aids + int. aids}}$ = .51, $SD_{\text{written text + pictures + sel./org. aids + int. aids}}$ = .11, *t*(218) < 1; *two months later*: $M_{\text{written text + pictures}}$ = .48, $SD_{\text{written text + pictures}}$ = .16, $M_{\text{written text + pictures + sel./org. aids + int. aids}}$ = .46, $SD_{\text{written text + pictures + sel./org. aids + int. aids}}$ = .13, *t*(218) < 1). G-Power (Faul et al., 2007) was used to calculate the statistical power for this comparison, given an error probability of α = .05, a total sample size of n = 226 and a medium effect size of f^2 = .15 (numerator df = 1, number of predictors = 7). The resulting power of 1-β = .99 indicated that a medium effect would have been detected with sufficient statistical power[19]. (2) Adding selection/organization + integration aids to spoken text plus pictures did not improve the learning of overall information either (*directly after the learning phase*: $M_{\text{spoken text + pictures}}$ = .54, $SD_{\text{spoken text + pictures}}$ = .17, $M_{\text{spoken text + pictures + sel./org. aids + int. aids}}$ = .57, $SD_{\text{spoken text + pictures + sel./org. aids + int. aids}}$ = .15, *t*(218) < 1; *two months later*: $M_{\text{spoken text + pictures}}$ = .50, $SD_{\text{spoken text + pictures}}$ = .17, $M_{\text{spoken text + pictures + sel./org. aids +int. aids}}$ = .48, $SD_{\text{spoken text + pictures + sel./org. aids + int. aids}}$ = .12, *t*(218) < 1). Thus, adding selection/organization + integration aids to the learning material had no impact on the overall learning outcome (“no overall selection/organization and integration effect”).

Results of *information presented in text only* were as follows: The univariate ANOVAs did not reveal statistically significant results. (1) Adding selection/organization + integration aids to written text plus pictures improved the learning of pure text information *directly after the learning phase*, $M_{\text{written text + pictures}}$ = .52, $SD_{\text{written text + pictures}}$ = .21, $M_{\text{written text + pictures + sel./org. aids + int. aids}}$ = .62, $SD_{\text{written text + pictures + sel./org. aids + int. aids}}$ = .18, *t*(218) = 1.87, *p* = .032 (one-tailed), *d* = 0.51, but *two months later*, this positive influence had disappeared, $M_{\text{written text + pictures}}$ = .50, $SD_{\text{written text + pictures}}$ = .26, $M_{\text{written text + pictures + sel./org. aids + int. aids}}$ = .52, $SD_{\text{written text + pictures + sel./org. aids + int. aids}}$ = .21, *t*(218) < 1. (2) Adding selection/organization + integration aids to spoken text plus pictures did not improve the learning of pure text information (*directly after the learning phase*: $M_{\text{spoken text + pictures}}$ = .56, $SD_{\text{spoken text + pictures}}$ = .22, $M_{\text{spoken text + pictures + sel./org. aids + int. aids}}$ = .64, $SD_{\text{spoken text + pictures + sel./org. aids + int. aids}}$ = .20, *t*(218) = 1.47, *p* = .143; *two months later*: $M_{\text{spoken text + pictures}}$ = .53, $SD_{\text{spoken text + pictures}}$ = .22, $M_{\text{spoken text + pictures + sel./org. aids +int. aids}}$ = .60, $SD_{\text{spoken text + pictures + sel./org. aids + int. aids}}$ = .16, *t*(218) = 1.17, *p* = .244). Excepting the first result, adding selection/organization + integration aids to the learning material had no influence on the learning of pure text information (“no selection/organization and integration effect”).

Results of *information presented in picture only* were as follows: (1) Adding selection/organization + integration aids to written text plus pictures did not increase the learning of picture-only information (*directly after the learning phase*: $M_{\text{written text + pictures}}$ = .56, $SD_{\text{written text}}$

[19] It has to be noted that this result is true for all comparisons.

$_{\text{+ pictures}}$ = .25, $M_{\text{written text + pictures + sel./org. aids + int. aids}}$ = .57, $SD_{\text{written text + pictures + sel./org. aids + int. aids}}$ = .17, $t(218) < 1$; *two months later*: $M_{\text{written text + pictures}}$ = .49, $SD_{\text{written text + pictures}}$ = .28, $M_{\text{written text + pictures + sel./org. aids + int. aids}}$ = .40, $SD_{\text{written text + pictures + sel./org. aids + int. aids}}$ = .26, $t(218) = -1.32$, $p = .187$). (2) Adding selection/organization + integration aids to spoken text plus pictures did not improve the learning of picture-only information either (*directly after the learning phase*: $M_{\text{spoken text + pictures}}$ = .63, $SD_{\text{spoken text + pictures}}$ = .23, $M_{\text{spoken text + pictures + sel./org. aids + int. aids}}$ = .64, $SD_{\text{spoken text + pictures + sel./org. aids + int. aids}}$ = .22, $t(218) < 1$; *two months later*: $M_{\text{spoken text + pictures}}$ = .51, $SD_{\text{spoken text + pictures}}$ = .23, $M_{\text{spoken text + pictures + sel./org. aids +int. aids}}$ = .36, $SD_{\text{spoken text + pictures + sel./org. aids + int. aids}}$ = .25, $t(218) = -2.14$, $p = .034$). Thus, adding selection/organization + integration aids to the learning material had no positive impact on the learning of picture-only information ("no selection/organization and integration effect").

Results of *illustrated-text information* were as follows: (1) Adding selection/organization + integration aids to written text plus pictures did not change the learning of illustrated-text information (*directly after the learning phase*: $M_{\text{written text + pictures}}$ = .68, $SD_{\text{written text + pictures}}$ = .20, $M_{\text{written text + pictures + sel./org. aids + int. aids}}$ = .60, $SD_{\text{written text + pictures + sel./org. aids + int. aids}}$ = .17, $t(218) = -1.63$, $p = .105$; *two months later*: $M_{\text{written text + pictures}}$ = .58, $SD_{\text{written text + pictures}}$ = .17, $M_{\text{written text + pictures + sel./org. aids + int. aids}}$ = .57, $SD_{\text{written text + pictures + sel./org. aids + int. aids}}$ = .14, $t(218) < 1$). (2) Adding selection/organization + integration aids to spoken text plus pictures did not change the learning of illustrated-text information either (*directly after the learning phase*: $M_{\text{spoken text + pictures}}$ = .61, $SD_{\text{spoken text + pictures}}$ = .19, $M_{\text{spoken text + pictures + sel./org. aids + int. aids}}$ = .67, $SD_{\text{spoken text + pictures + sel./org. aids + int. aids}}$ = .18, $t(218) = 1.17$, $p = .245$; *two months later*: $M_{\text{spoken text + pictures}}$ = .58, $SD_{\text{spoken text + pictures}}$ = .15, $M_{\text{spoken text + pictures + sel./org. aids +int. aids}}$ = .56, $SD_{\text{spoken text + pictures + sel./org. aids + int. aids}}$ = .14, $t(218) < 1$). Thus, adding selection/organization + integration aids to the learning material did not improve the learning of illustrated-text information ("no selection/organization and integration effect").

Results of the *transfer subscale* were as follows: (1) Adding selection/organization + integration aids to written text plus pictures reduced the performance on the transfer subscale *directly after the learning phase*, $M_{\text{written text + pictures}}$ = .38, $SD_{\text{written text + pictures}}$ = .18, $M_{\text{written text + pictures + sel./org. aids + int. aids}}$ = .29, $SD_{\text{written text + pictures + sel./org. aids + int. aids}}$ = .12, $t(218) = -2.04$, $p = .043$, $d = 0.58$. *Two months later*, this negative influence had gone, $M_{\text{written text + pictures}}$ = .38, $SD_{\text{written text + pictures}}$ = .19, $M_{\text{written text + pictures + sel./org. aids + int. aids}}$ = .36, $SD_{\text{written text + pictures + sel./org. aids + int. aids}}$ = .18, $t(218) < 1$. (2) Adding selection/organization + integration aids to spoken text plus pictures did not enhance the performance on the transfer subscale either (*directly after the learning phase*: $M_{\text{spoken text + pictures}}$ = .38, $SD_{\text{spoken text + pictures}}$ = .18, $M_{\text{spoken text + pictures + sel./org. aids + int.}}$

$_{\text{aids}}$ = .35, $SD_{\text{spoken text + pictures + sel./org. aids + int. aids}}$ = .19, $t(218) < 1$; *two months later*: $M_{\text{spoken text + pictures}}$ = .40, $SD_{\text{spoken text + pictures}}$ = .24, $M_{\text{spoken text + pictures + sel./org. aids +int. aids}}$ = .41, $SD_{\text{spoken text + pictures + sel./org. aids + int. aids}}$ = .17, $t(218) < 1$). To sum up, adding selection/organization + integration aids to the learning material had no positive impact on the performance on the transfer subscale ("no selection/organization and integration effect").

A similar pattern of results was found for Learning Unit 2 (cp., Table 16).

Table 16

Adjusted Average Scores and Standard Deviations by Four Conditions on Different Sources of Information, Including the Number of Children – Learning Unit 2

	Directly after the learning phase		2 months later		Number of children
Source of information and condition	*M*	*SD*	*M*	*SD*	*N*
Overall scale					
Selection/Organization + Integration effect					
Written text + pictures	.41	.19	.34	.20	31
Written text + pictures + sel./org. + int. aids	.37	.15	.31	.18	26
Spoken text + pictures	.42	.18	.34	.17	28
Spoken text + pictures + sel./org. + int. aids	.41	.12	.33	.18	24
Text-only subscale					
Selection/Organization + Integration effect					
Written text + pictures	.52	.20	.37	.25	31
…Written text + pictures + sel./org. + int. aids	.47	.20	.38	.23	26
Spoken text + pictures	.47	.21	.41	.21	28
Spoken text + pictures + sel./org. + int. aids	.51	.20	.43	.23	24
Picture-only subscale					
Selection/Organization + Integration effect					
Written text + pictures	.33	.22	.35	.25	31
Written text + pictures + sel./org. + int. aids	.30	.18	.29	.21	26
Spoken text + pictures	.40	.23	.33	.25	28
Spoken text + pictures + sel./org. + int. aids	.29	.15	.27	.24	24
Illustrated-text subscale					
Selection/Organization + Integration effect					
Written text + pictures	.54	.28	.45	.28	31
…Written text + pictures + sel./org. + int. aids	.49	.21	.41	.28	26
Spoken text + pictures	.56	.23	.39	.23	28
Spoken text + pictures + sel./org. + int. aids	.55	.19	.43	.25	24
Transfer subscale					
Selection/Organization + Integration effect					
Written text + pictures	.24	.24	.19	.19	31
Written text + pictures + sel./org. + int. aids	.23	.22	.17	.18	26
Spoken text + pictures	.24	.21	.22	.16	28
Spoken text + pictures + sel./org. + int. aids	.27	.16	.21	.16	24

Results of the *overall learning scores* of Learning Unit 2 were as follows: (1) Adding selection/organization + integration aids to written text plus pictures did not enhance the learning of overall information (*directly after the learning phase*: $M_{\text{written text + pictures}}$ = .41, $SD_{\text{written text +}}$

$_{\text{pictures}}$ = .19, $M_{\text{written text + pictures + sel./org. aids + int. aids}}$ = .37, $SD_{\text{written text + pictures + sel./org. aids + int. aids}}$ = .15, $t(218) < 1$; *two months later*: $M_{\text{written text + pictures}}$ = .34, $SD_{\text{written text + pictures}}$ = .20, $M_{\text{written text + pictures + sel./org. aids + int. aids}}$ = .31, $SD_{\text{written text + pictures + sel./org. aids + int. aids}}$ = .18, $t(218) < 1$). (2) Adding selection/organization + integration aids to spoken text plus pictures did not improve the learning of overall information either (*directly after the learning phase*: $M_{\text{spoken text + pictures}}$ = .42, $SD_{\text{spoken text + pictures}}$ = .18, $M_{\text{spoken text + pictures + sel./org. aids + int. aids}}$ = .41, $SD_{\text{spoken text + pictures + sel./org. aids + int. aids}}$ = .12, $t(218) < 1$; *two months later*: $M_{\text{spoken text + pictures}}$ = .34, $SD_{\text{spoken text + pictures}}$ = .17, $M_{\text{spoken text + pictures + sel./org. aids +int. aids}}$ = .33, $SD_{\text{spoken text + pictures + sel./org. aids + int. aids}}$ = .18, $t(218) < 1$). Thus, adding selection/organization + integration aids to the learning material did not influence the overall learning outcome (“no overall selection/organization and integration effect”).

Results of *information presented in text only* were as follows: The univariate ANOVAs did not reveal statistically significant results. More specifically, (1) adding selection/organization + integration aids to written text plus pictures did not improve the learning of pure text information (*directly after the learning phase*: $M_{\text{written text + pictures}}$ = .52, $SD_{\text{written text + pictures}}$ = .20, $M_{\text{written text + pictures + sel./org. aids + int. aids}}$ = .47, $SD_{\text{written text + pictures + sel./org. aids + int. aids}}$ = .20, $t(218) < 1$; *two months later*: $M_{\text{written text + pictures}}$ = .37, $SD_{\text{written text + pictures}}$ = .25, $M_{\text{written text + pictures + sel./org. aids + int. aids}}$ = .38, $SD_{\text{written text + pictures + sel./org. aids + int. aids}}$ = .23, $t(218) < 1$). (2) Adding selection/organization + integration aids to spoken text plus pictures did not increase the learning of pure text information either (*directly after the learning phase*: $M_{\text{spoken text + pictures}}$ = .47, $SD_{\text{spoken text + pictures}}$ = .21, $M_{\text{spoken text + pictures + sel./org. aids + int. aids}}$ = .51, $SD_{\text{spoken text + pictures + sel./org. aids + int. aids}}$ = .20, $t(218) < 1$; *two months later*: $M_{\text{spoken text + pictures}}$ = .41, $SD_{\text{spoken text + pictures}}$ = .21, $M_{\text{spoken text + pictures + sel./org. aids +int. aids}}$ = .43, $SD_{\text{spoken text + pictures + sel./org. aids + int. aids}}$ = .23, $t(218) < 1$). Thus, adding selection/organization + integration aids to the learning material had no impact on the learning of pure text information (“no selection/organization and integration effect”).

Results of *information presented in picture only* were as follows: (1) Adding selection/organization + integration aids to written text plus pictures did not increase the learning of picture-only information (*directly after the learning phase*: $M_{\text{written text + pictures}}$ = .33, $SD_{\text{written text + pictures}}$ = .22, $M_{\text{written text + pictures + sel./org. aids + int. aids}}$ = .30, $SD_{\text{written text + pictures + sel./org. aids + int. aids}}$ = .18, $t(218) < 1$; *two months later*: $M_{\text{written text + pictures}}$ = .35, $SD_{\text{written text + pictures}}$ = .25, $M_{\text{written text + pictures + sel./org. aids + int. aids}}$ = .29, $SD_{\text{written text + pictures + sel./org. aids + int. aids}}$ = .21, $t(218) = -1.12$, $p = .270$). (2) Adding selection/organization + integration aids to spoken text plus pictures did not increase the learning of picture-only information either (*directly after the learning phase*: $M_{\text{spoken text + pictures}}$ = .40, $SD_{\text{spoken text + pictures}}$ = .23, $M_{\text{spoken text + pictures + sel./org. aids + int. aids}}$ = .29, $SD_{\text{spoken text + pictures + sel./org. aids + int. aids}}$ = .15, $t(218) = -2.04$, $p = .042$, $d = 0.56$; *two months later*: $M_{\text{spoken text + pictures}}$ = .33,

$SD_{\text{spoken text + pictures}} = .25$, $M_{\text{spoken text + pictures + sel./org. aids +int. aids}} = .27$, $SD_{\text{spoken text + pictures + sel./org. aids + int. aids}} = .24$, $t(218) < 1$). Thus, adding selection/organization + integration aids to the learning material did not enhance the learning of picture-only information (“no selection/organization and integration effect”).

Results of *illustrated-text information* were as follows: The univariate ANOVAs did not reveal statistically significant results. To be more specific, (1) adding selection/organization + integration aids to written text plus pictures did not enhance the learning of illustrated-text information (*directly after the learning phase*: $M_{\text{written text + pictures}} = .54$, $SD_{\text{written text + pictures}} = .28$, $M_{\text{written text + pictures + sel./org. aids + int. aids}} = .49$, $SD_{\text{written text + pictures + sel./org. aids + int. aids}} = .21$, $t(218) < 1$; *two months later*: $M_{\text{written text + pictures}} = .45$, $SD_{\text{written text + pictures}} = .28$, $M_{\text{written text + pictures + sel./org. aids + int. aids}} = .41$, $SD_{\text{written text + pictures + sel./org. aids + int. aids}} = .28$, $t(218) < 1$). (2) Adding selection/organization + integration aids to spoken text plus pictures did not enhance the learning of illustrated-text information either (*directly after the learning phase*: $M_{\text{spoken text + pictures}} = .56$, $SD_{\text{spoken text + pictures}} = .23$, $M_{\text{spoken text + pictures + sel./org. aids + int. aids}} = .55$, $SD_{\text{spoken text + pictures + sel./org. aids + int. aids}} = .19$, $t(218) < 1$; *two months later*: $M_{\text{spoken text + pictures}} = .39$, $SD_{\text{spoken text + pictures}} = .23$, $M_{\text{spoken text + pictures + sel./org. aids +int. aids}} = .43$, $SD_{\text{spoken text + pictures + sel./org. aids + int. aids}} = .25$, $t(218) < 1$). Thus, adding selection/organization + integration aids to the learning material had no impact on the learning of illustrated-text information (“no selection/organization and integration effect”).

Results of the *transfer subscale* were as follows: (1) Adding selection/organization + integration aids to written text plus pictures did not enhance the performance on the transfer subscale (*directly after the learning phase*: $M_{\text{written text + pictures}} = .24$, $SD_{\text{written text + pictures}} = .24$, $M_{\text{written text + pictures + sel./org. aids + int. aids}} = .23$, $SD_{\text{written text + pictures + sel./org. aids + int. aids}} = .22$, $t(218) < 1$; *two months later*: $M_{\text{written text + pictures}} = .19$, $SD_{\text{written text + pictures}} = .19$, $M_{\text{written text + pictures + sel./org. aids + int. aids}} = .17$, $SD_{\text{written text + pictures + sel./org. aids + int. aids}} = .18$, $t(218) < 1$). (2) Adding selection/organization + integration aids to spoken text plus pictures did not increase the performance on the transfer subscale either (*directly after the learning phase*: $M_{\text{spoken text + pictures}} = .24$, $SD_{\text{spoken text + pictures}} = .21$, $M_{\text{spoken text + pictures + sel./org. aids + int. aids}} = .27$, $SD_{\text{spoken text + pictures + sel./org. aids + int. aids}} = .16$, $t(218) < 1$; *two months later*: $M_{\text{spoken text + pictures}} = .22$, $SD_{\text{spoken text + pictures}} = .16$, $M_{\text{spoken text + pictures + sel./org. aids +int. aids}} = .21$, $SD_{\text{spoken text + pictures + sel./org. aids + int. aids}} = .16$, $t(218) < 1$). Thus, adding selection/organization + integration aids to the learning material had no influence on transfer achievement (“no selection/organization and integration effect”).

5.3.2 Reliability analyses

All reliability analyses were based on the data of 257 children, each of them having worked on both learning units. However, children with missing data were automatically excluded from the analyses by SPSS. Reliability analyses for each multiple-choice test as well as for the respective subscales were conducted. Data on the internal consistencies (Cronbach's α) for the multiple-choice tests of both learning units and their respective subscales can be found in Table 17. As can be seen, the internal consistencies showed some unsatisfactory values for the subscales of the respective multiple-choice tests.

Table 17

Internal Consistencies for the Multiple-Choice Tests of Both Learning Units

	Internal consistencies				
Learning Unit and multiple-choice test	*Text-only subscale* (r_{tt})	*Picture-only subscale* (r_{tt})	*Illustrated-text subscale* (r_{tt})	*Transfer subscale* (r_{tt})	*Overall scale* (r_{tt})
Learning Unit 1 Multiple-choice test	.58 (8 items)	.68 (7 items)	.49 (8 items)	.54 (9 items)	.78 (32 items)
Learning Unit 2 Multiple-choice test	.61 (8 items)	.54 (8 items)	.56 (8 items)	.67 (8 items)	.83 (32 items)

Finally, it has to be noted that the mean difficulty of each subscale as well as of all subscales together (of the whole multiple-choice test) was appropriate for both learning units. For Learning Unit 1, the overall mean was M = .61, SD = .21 for the text-only subscale, M = .53, SD = .14 for the picture-only subscale[20], M = .65, SD = .25 for the illustrated-text subscale, M = .34, SD = .31 for the transfer subscale and M = .53, SD = .26 for all subscales together (for the whole multiple-choice test). For Learning Unit 2, the overall mean was M = .50, SD = .23 for the text-only subscale, M = .29, SD = .14 for the picture-only subscale[21], M = .52, SD = .19 for the illustrated-text subscale, M = .21, SD = .12 for the transfer subscale and M = .38, SD = .21 for all subscales together (for the whole multiple-choice test). To sum up, both multiple-choice tests as well as their respective subscales had a medium difficulty level for learners – except for the

[20] It has to be noted that the statistic specific values for the picture-only subscale were based on the data of all children. With regard to those children who actually received pictures, the overall mean was M = .63, SD = .16 for the picture-only subscale.

[21] With regard to those children who actually received pictures, the overall mean was M = .34, SD = .16 for the picture-only subscale.

picture-only subscale of Learning Unit 2 and the transfer subscales of both learning units. Again, the former result might be traced back to the superficial processing of pictures (cp., section 1.4; Mokros & Tinker, 1987; Weidenmann, 1989): More complex pictures might have been processed even more superficially. This might be a reason for why answering picture-only items was more difficult in Learning Unit 2 (M = .29) than in Learning Unit 1 (M = .53). As has been already mentioned in Experiment 1, the difficulty level of both transfer scales seems to be appropriate.

5.4 Discussion

The main purpose of Experiment 2 was to investigate whether aids for selection, organization and integration promote children's learning of text-only information, picture-only information, and transfer information. Furthermore, the findings of Experiment 1 should be replicated in Experiment 2. More specifically, again, pictures' potential of drawing children's attention away from text was investigated, respectively the amount of split-attention which was given to the different sources of information (text-only information, picture-only information, illustrated-text information, transfer information). Thus, a further purpose of Experiment 2 was to find out to which extent the multimedia and modality principles hold true for different sources of information. Following the order of the results' presentation, firstly, the results concerning the multimedia effect and modality effect will be discussed. Secondly, the effects of the aids for selection, organization and integration will be illuminated.

Multimedia effect

With respect to the multimedia effect, for Learning Unit 1, the "written text + pictures" condition exceeded the "written text" condition on overall learning scores ("overall multimedia effect"; H1 was confirmed), picture-only information ("multimedia effect"; H1.1 was confirmed), and transfer information ("multimedia effect"; H1.3 was not confirmed), whereas the two conditions did not differ on text-only information ("no reversed multimedia effect"; H1.2 was not confirmed), and illustrated-text information ("no multimedia effect"; H1.4 was not confirmed). Following Cohen's classification (cp., Cohen, 1988, pp. 285-287), the medium effect sizes on both times of measurement (directly after the learning phase and two months later) indicated that the multimedia effect was also practically important.

For Learning Unit 2, a similar pattern of results showed up: The "written text + pictures" condition exceeded the "written text" condition on overall learning scores ("overall multimedia effect"; H1 was confirmed), and picture-only information ("multimedia effect"; H1.1 was confirmed), whereas the two conditions did not differ on text-only information ("no reversed multimedia effect"; H1.2 was not confirmed), illustrated-text information ("no multimedia effect"; H1.4 was not confirmed), and transfer information ("no multimedia effect"; H1.3 was confirmed). As for Learning Unit 1, the effect sizes on both times of measurement (directly after the learning phase and two months later) were in the medium range – indicating that the multimedia effect was also practically important. In summary, the results are partly in line with the expectations.

For Learning Unit 1, again, the unexpected result on the illustrated-text information scale ("no multimedia effect"; H1.4 was not confirmed) might be due to the content of the first text. As discussed in Experiment 1 (cp., section 4.4), it might be possible that learners did not need the information in the picture as additional clarifier for the information in the text. However, the results which were obtained for Learning Unit 2 also showed a lack of a superiority of the "written text + pictures" condition. Even if the accompanying pictures of the second text clarify the structure of the heart as well as the process of blood circulation, the "written text + pictures" condition did not exceed the "written text" condition on the illustrated-text information scale. The reasons that were discussed in Experiment 1 may also apply for the results of Experiment 2 (cp., section 4.4).

Contrary to the expectations, the "written text" condition did not outperform the "written text + pictures" condition on a text-only information scale ("no reversed multimedia effect"; H1.2 was not confirmed). However, the results are in line with early studies in the field of multimedia learning (cp., Levie & Lentz, 1982) that show that pictures have no effect on *text-only information*. With respect to the comparison between Experiment 1 and 2, the different results on the text-only information scale might be due to the different amount of available learning time. Accordingly, when sufficient learning time is given, it might be possible that pictures still draw children's attention away from text, but due to the sufficient learning time, it might now be possible that children have enough time for reading the text. However, this raises the question of when learning time is sufficient for children, concerning a certain subject matter.

As expected, with respect to transfer information, the "written text + pictures" condition did not exceed the "written text" condition in Learning Unit 2. Contrary to the expectations, in Learning Unit 1, the "written text + pictures" condition outperformed the "written text" condition. One possible explanation might refer to the content of the learning material. Since the content of Learning Unit 1 was less complex than the content of Learning Unit 2 and, additionally, more learning time was provided in Experiment 2, it might be possible that these factors might have contributed to the multimedia effect on *both times of measurement* (directly after the learning phase *and* two months later) to occur.

Finally, it should be noted that the results of both learning units (Learning Unit 1 and Learning Unit 2) on (1) the text-only information scale ("no reversed multimedia effect") and (2) the picture-only information scale ("multimedia effect") no longer indicate a shift of attention from text to pictures (*shift-of-attention effect*; Brünken & Leutner, 2001) when *written text plus pictures are provided in a split-attention format*. Thus, the pattern of results of Experiment 1 could not be replicated in Experiment 2. This might be due to the longer learning time available in Experiment 2. Though, the longer learning time might not be the only explanation for the lacking "reversed multimedia effect" on text-only information. Besides the different arrangement of text paragraphs and their respective pictures, the time limits which have been set for working on the text paragraphs, their respective pictures and aids might have contributed to this result as well. The lacking "reversed multimedia effect" on text-only information might have been also caused by the arrangement of text and pictures resulting in a more structured/guided procedure. When, first, providing written text and the corresponding picture on separate sheets of paper and, second, on the same sheet of paper (in a split-attention format), it might be possible that pictures loose their potential of drawing children's attention away from text, because each source of information (text and the respective picture) can be processed individually at first.

Modality effect

With respect to the modality effect, for Learning Unit 1, the "spoken text + pictures" condition did not differ from the "written text + pictures" condition on overall learning scores ("no overall modality effect"; H2 was confirmed), text-only information ("no modality effect"; H2.2 was confirmed), picture-only information ("no modality effect"; H2.1 was confirmed), illustrated-text information ("no modality effect"; H2.4 was confirmed), and transfer information ("no modality effect"; H2.3 was confirmed).

For Learning Unit 2, a similar pattern of results showed up: Again, the "spoken text + pictures" condition did not differ from the "written text + pictures" condition on each source of information (including overall learning scores and transfer information). In summary, the results are in line with the expectations.

Aids for selection/organization

With respect to the aids for selection/organization, for Learning Unit 1, the "written text + pictures + selection/organization aids" condition did not exceed the "written text + pictures" condition on overall learning scores ("no overall selection/organization effect"; H3 was not confirmed), text-only information ("no selection/organization effect"; H3.2 was not confirmed), picture-only information ("no selection/organization effect"; altogether, H3.1 was not confirmed), illustrated-text information ("no selection/organization effect; H3.4 was confirmed), and transfer information ("no selection/organization effect"; H3.3 was not confirmed). A similar pattern of results showed up with respect to the comparison of "spoken text + pictures" and "spoken text + pictures + selection/organization aids": Children in the "spoken text + pictures + selection/organization aids" condition did not better on overall learning scores ("no overall selection/organization effect"; H3.5 was not confirmed), text-only information ("no selection/organization effect"; altogether, H3.7 was not confirmed), picture-only information ("no selection/organization effect"; H3.6 was not confirmed), illustrated-text information ("no selection/organization effect; H3.9 was confirmed), and transfer information ("no selection/organization effect"; H3.8 was not confirmed).

For Learning Unit 2, the following pattern of results was found: Again, the "written text + pictures + selection/organization aids" condition did not exceed the "written text + pictures" condition on overall learning scores ("no overall selection/organization effect"; H3 was not confirmed), text-only information ("no selection/organization effect"; H3.2 was not confirmed), picture-only information ("no selection/organization effect"; H3.1 was not confirmed), illustrated-text information ("no selection/organization effect; H3.4 was confirmed), and transfer information ("no selection/organization effect"; H.3.3 was not confirmed). A similar pattern of results showed up with respect to the comparison of "spoken text + pictures" and "spoken text + pictures + selection/organization aids": Again, children in the "spoken text + pictures + selection/organization aids" condition did not better on overall learning scores ("no overall selection/organization effect"; H3.5 was not confirmed), text-only information ("no selection/organization effect"; H3.7 was not confirmed), picture-only information ("no selection/organization effect"; H3.6 was not confirmed), illustrated-text information ("no selection/organization effect; H3.9 was confirmed), and transfer information ("no selection/organization effect"; H3.8 was not confirmed). In summary, the results are almost completely not in line with the expectations. Giving additional aids for selection/organization does not seem to promote learning outcome at all.

The unexpected results on overall learning scores, text-only information, picture-only information, and transfer information might have been caused by several aspects: (A) Although children were required to produce an external product (such as to put in the correct words in cloze tasks or to draw in missing information) when working on the selection/organization aids, most of them did not follow this request[22]. Children did not only seem to avoid behavioral activity but also cognitive activity. If they had engaged in the selection/organization aids, they should have exceeded those children who did not receive any instructional aids, because a deeper processing of text-only information and picture-only information would have been made

[22] As statistical analyses have shown, in average, children only worked on half of the selection/organisation aids in Learning Unit 1 (57.09 %). In Learning Unit 2, they worked on 73.15 % of the selection/organisation aids. Similar results were obtained with respect to the selection/organisation and integration aids: In average, children only worked on 35.40 % of the selection/organisation and integration aids in Learning Unit 1 and 68.67 % in Learning Unit 2.

possible. Since the performance on the transfer information scale depends on children's ability to integrate information from multiple representations, children who received the selection/organization aids should have also benefited from the aids on the transfer information scale. Being cognitively active during learning is absolutely necessary for meaningful learning to occur (*active processing assumption*; Mayer, 2005c; 2009). (B) Another explanation might refer to the time limits which were set for working on the text paragraphs, their respective pictures and aids. The time limits might have been too short so that children might not have been able to work on the aids in the required way. However, it would not have been possible to extend the time limits any more because those children who only received text should not get bored. (C) A further explanation might be that the arrangement of text paragraphs, pictures and aids overwhelmed the children with information (cp., Opfermann, 2008), and thus increased the extraneous cognitive load. Since the working memory capacity is limited (cp., CLT in section 1.2) children might have tried to reduce the extraneous cognitive load by ignoring the aids and engaging in text paragraphs and pictures. It might also be possible that children tried to avoid unnecessary search processes between (1) text paragraphs and aids, (2) pictures and aids, and (3) text paragraphs, pictures and aids. Working on the aids might have been regarded as "disturbing" for integrating multiple representations. (D) Finally, it might be possible that the aids provided a kind of "redundant information" which might have interfered with learning and therefore did not foster the learning outcome (cp., section 1.3.1; redundancy principle).

Aids for selection/organization and integration

With respect to the aids for selection/organization and integration, for Learning Unit 1, the "written text + pictures" condition with selection/organization + integration aids did not exceed the "written text + pictures" condition on overall learning scores ("no overall selection/organization and integration effect"; H4 was not confirmed), text-only information ("no selection/organization and integration effect"; altogether, H4.2 was not confirmed), picture-only information ("no selection/organization and integration effect"; H4.1 was not confirmed), illustrated-text information ("no selection/organization and integration effect"; H4.4 was confirmed), and transfer information ("no selection/organization and integration effect"; H4.3 was not confirmed). A similar pattern of results showed up with respect to the comparison of "spoken text + pictures" and "spoken text + pictures + selection/organization + integration aids": Children in the "spoken text + pictures + selection/organization + integration aids" condition did not better on overall learning scores ("no overall selection/organization and integration effect"; H4.5 was not confirmed), text-only information ("no selection/organization and integration effect";

H4.7 was not confirmed), picture-only information (“no selection/organization and integration effect”; H4.6 was not confirmed), illustrated-text information (“no selection/organization and integration effect; H4.9 was confirmed), and transfer information (“no selection/organization and integration effect”; H4.8 was not confirmed).

For Learning Unit 2, the following pattern of results was found: Again, the “written text + pictures” condition with selection/organization + integration aids did not exceed the “written text + pictures” condition on overall learning scores (“no overall selection/organization and integration effect”; H4 was not confirmed), text-only information (“no selection/organization and integration effect”; H4.2 was not confirmed), picture-only information (“no selection/organization and integration effect”; H4.1 was not confirmed), illustrated-text information (“no selection/organization and integration effect”; H4.4 was confirmed), and transfer information (“no selection/organization and integration effect”; H4.3 was not confirmed). A similar pattern of results showed up with respect to the comparison of “spoken text + pictures” and “spoken text + pictures + selection/organization + integration aids”: Children in the “spoken text + pictures + selection/organization + integration aids” condition did not better on overall learning scores (“no overall selection/organization and integration effect”; H4.5 was not confirmed), text-only information (“no selection/organization and integration effect”; H4.7 was not confirmed), picture-only information (“no selection/organization and integration effect”; H4.6 was not confirmed), illustrated-text information (“no selection/organization and integration effect; H4.9 was confirmed), and transfer information (“no selection/organization and integration effect”; H4.8 was not confirmed). In summary, the results are almost completely not in line with the expectations. Giving additional aids for selection/organization + integration does not seem to promote learning outcome at all. As has been already discussed for the selection/organization aids, several aspects might have contributed to the lacking usefulness of the aids.

Reliability Analyses

With regard to the reliability analyses, altogether, the internal consistencies for the subscales of the respective multiple-choice tests were unsatisfactory. Again, the resulting internal consistencies were worse than the ones in the Pilot Study, even though they received higher values compared to Experiment 1. As has been already discussed in section 4.4, different aspects might have contributed to this result. Although the learning phase of Experiment 2 was extended to 18 minutes and thus exceeded the learning time that was provided in the Pilot Study, the internal consistencies for the subscales of the respective multiple-choice tests did not reach the values that were obtained in the Pilot Study. Hence, the reduction of the internal consistencies might most likely be due to the “non-representativeness” of the 4th graders in the Pilot Study. The proportion of children who reported that they do not speak German at home was two to three times larger in the Pilot Study than in the following two experiments.

6 General Discussion

The general aim of this dissertation was to determine whether two well established principles, namely the multimedia principle and the modality principle, hold true for different sources of information with primary school children. By applying Peeck's procedure (1974) to the learning material, it was possible to investigate whether the multimedia effect as well as the modality effect show up for text-only information, picture-only information, illustrated-text information, and transfer information. In line with typical formats in schoolbooks, two learning units (Learning Unit 1 and Learning Unit 2) were constructed in such a way that the text paragraphs and their respective pictures were placed next to each other. This arrangement caused a typical split-attention situation. Based on this, the purpose of the two experiments (Experiment 1 and Experiment 2) conducted in this dissertation was to investigate, by means of the multimedia effect and the modality effect, whether children equally split their attention between the text paragraphs and the respective pictures. Previous research on both the multimedia effect and the modality effect indicates that children are not likely to split their attention equally between different sources of information. For example, with respect to the multimedia effect, reviews of research on early studies in the field of multimedia learning (e.g., Levie & Lentz, 1982) show that adding pictures to text does not enhance the learning outcome *of all sources of information*. In this context, the children's learning outcome on text-only information and picture-only information might give hints for a potential *shift of attention*. Additionally to these findings on the multimedia effect, Brünken and Leutner (2001) report that the modality effect showed up for verbal information whereas it could not be found for pictorial information. Following the authors, this pattern of results might indicate not only split attention between written text and pictures but also a shift of attention *from text to pictures*. Since children are especially expected to be influenced by pictures (cp., Goldstein & Underwood, 1981), this shift of attention might even be larger for younger or less competent children (cp., Goldsmith, 1984). Thus, the purpose of the two experiments (Experiment 1 and Experiment 2) was to determine, by means of the multimedia effect and the modality effect, whether pictures draw children's attention away from text. Or, in other words, the purpose of the two experiments (Experiment 1 and Experiment 2) was to investigate whether the multimedia effect and the modality effect show up for all sources of information (text-only information, picture-only information, illustrated-text information and transfer information).

A further aim of this dissertation (cp., Experiment 2) that had arisen from the results of Experiment 1 was to explore whether aids for selection, organization and integration improve the learning outcome on text-only information, picture-only information and transfer information. Following the research on coherence formation (e.g., Bodemer et al., 2005; Seufert, 2003; Seufert & Brünken, 2004), relevant elements *within* each single representation were promoted by selection/organization aids. Furthermore, for some children, relevant elements *between* different representations, that is between the text paragraphs and the respective picture (*global coherence formation*; Seufert & Brünken, 2004) were fostered by integration aids. Thus, children who were provided with aids for selection/organization received attentional guidance on a *surface structure level* (e.g., Seufert & Brünken, 2006), whereas children who were provided with aids for selection/organization and integration were supported on both a *surface structure level* and a *deep structure level* (Seufert & Brünken, 2004). Accordingly, the purpose of Experiment 2 was also to find out whether providing explicit aids (for selection, organization and integration; also cp. Mayer, 2009) increases the learning outcome.

Results of Experiment 1

As has been already discussed in section 4.4, the “classical“ multimedia effect (written text vs. written text plus pictures) could not be found for overall learning scores, illustrated-text information, and transfer information on both learning units (Learning Unit 1 and Learning Unit 2). This is in contrast to Mayer’s multimedia principle (2009); however, the results are in line with Segers et al. (2008), who could not find an overall multimedia effect for primary school children either. The results of both learning units (Learning Unit 1, Learning Unit 2) indicate that the typical split-attention format in schools did not lead to an overall multimedia effect and thus did not improve the children’s learning.

With respect to the lacking multimedia effect on illustrated-text information, the results of Experiment 1 are not consistent with Mayer’s (1989) arguments that pictures should especially facilitate learning when (1) a cause-and-effect system is described in the text and (2) the system is depicted in the pictures in an elucidating way. For Learning Unit 1, the lacking multimedia effect might be due to the content of the first text – the blood circulation system has not yet been described as a cause-and-effect system. But Learning Unit 2 comprised the description of the heart as well as the blood circulation system; thus, a multimedia effect should have shown up (for possible explanations of why it does not, see section 4.4).

The pattern of results on text-only information (“reversed multimedia effect”) and picture-only information (“multimedia effect”) indeed indicate a shift of attention from text to pictures (*shift-of-attention effect*; Brünken & Leutner, 2001) when *written text plus pictures are provided in a split-attention format*: The “written text + pictures” condition was superior to the “written text” condition on picture-only information (“multimedia effect”), whereas the “written text” condition outperformed the “written text + pictures” condition on text-only information (“reversed multimedia effect”). With respect to the results obtained for Learning Unit 2, children who received written text plus pictures certainly did not outperform children who were provided with written text on picture-only information, but this might be due to the general superficial processing of “more complex” pictures (cp., Mokros & Tinker, 1987; Weidenmann, 1989). Even if the “written text + pictures” condition was not significantly superior to the “written text” condition on picture-only information, both conditions differed descriptively in the intended way. Next to the multimedia effect on picture-only information, the reversed multimedia effect on text-only information might be regarded as an additional indicator for a potential *shift of attention from text to pictures*. The negative impact of pictures on text-only information is in line with previous studies (e.g., Brookshire et al., 2002; Bryant, Brown, Silberberg, & Elliott, 1981; Freisinger, 1976) which could already find a negative tendency of pictures on text-only information. Recently, Schnotz pointed out that “pictures are analyzed more intensively if the content is difficult and the learners’ prior knowledge is low” (Schnotz, 2005, p. 56). This statement is also in line with a potential *shift of attention from text to pictures* (Brünken & Leutner, 2001).

As has been already discussed in section 4.4, the “classical“ modality effect (written text plus pictures vs. spoken text plus pictures) was observed for overall learning scores, text-only information, picture-only information and transfer information on both learning units (Learning Unit 1 and Learning Unit 2). With respect to illustrated-text information, the modality effect did not appear for Learning Unit 1 (for possible reasons see section 4.4). The general pattern of results is in line with Ginns (2005), who identified two moderators of the modality effect (level of element interactivity and pacing of presentation). The materials of the learning units, especially of Learning Unit 2, had a high level of element interactivity and the children had to study under system-paced conditions on both learning units; thus, the modality effect was very likely to occur. Additionally, the modality effect was used as an indicator for a *general shift of attention from text to pictures*. However, contrary to expectations, children did not generally shift their attention from text to pictures (“*no general shift-of-attention effect*”), as indicated by the learning outcome on picture-only information.

To sum up, when providing *written text plus pictures in a split-attention format* (which is a typical form of learning at schools), pictures may indeed draw children’s attention away from the text: Apart from the split-attention effect, a potential *shift-of-attention effect* might reduce the learning outcome. That is, children's learning is not only made more difficult by the split-attention situation, but also by their shift of attention from text to pictures, which results in worse learning outcome on the information that is presented in the text. This reversed multimedia effect on text-only information could be compensated in Learning Unit 1 – in Learning Unit 2, it could even be "over-compensated" – by using spoken instead of written text. That is, by applying the modality principle, children could overcome the *shift-of-attention effect in split-attention formats*. Thus, accounting for the modality principle had a compensative positive impact on the learning of text-only information. Additionally, accounting for the modality principle seems to be a prerequisite for an overall multimedia effect to occur, as well as for a multimedia effect on transfer information. Following the CTML (Mayer, 2005c; Mayer, 2009), it might be possible that the lacking overall multimedia effect was due to the following theoretical explanation: The amount of the to-be-processed information might have exceeded the amount of information that can be processed in one channel (here: in the visual channel) at a time (limited capacity assumption; Mayer, 2005b) – in order to reduce the amount of information, children might have *shifted their attention from written text to pictures*. Using spoken text instead of written text freed some working memory capacity. This freed capacity might have been more important for Learning Unit 2 than for Learning Unit 1 as indicated by the larger modality effect for Learning Unit 2. Following the CLT (Chandler, 2004; Chandler & Sweller, 1991; Sweller, 1999; 2003), the absence of the overall multimedia effect is explained in a similar way: "Adding a heavy extraneous cognitive load to a heavy intrinsic cognitive load may exceed working memory capacity" (Sweller, 2005, p. 28). That is, it might be possible that presenting complex learning material (about the blood circulation system) in a split-attention format (by using *written text plus pictures*) caused cognitive overload. By applying the modality principle, extraneous cognitive load was reduced, the overload disappeared and a greater amount of free working memory capacity was left which might have permitted an increase in germane cognitive load. Furthermore, the differences between the learning units' effect sizes – the modality effect was always larger for Learning Unit 2 – might have resulted from the higher complexity of Learning Unit 2, thus yielding a higher intrinsic cognitive load. Thus, when applying the modality principle, the reduction of extraneous cognitive load (with a potential increase in germane cognitive load) was more essential for Learning Unit 2 than for Learning Unit 1, resulting in a larger modality effect for Learning Unit 2.

Finally, the risk of an additional *shift-of-attention effect* in split attention formats might be due to the following reasons: Firstly, pictures might be more attractive for children than written text (cp., Goldsmith, 1984), independent of reading comprehension. Secondly, children might not yet have been able to “read the information” in the pictures in an adequate way (cp., Weidenmann, 1994). Thus, they might have spent more time with trying to understand the pictures than reading the text, resulting in inferior learning outcome on text-only information.

Results of Experiment 2

As has already been discussed in section 5.4, the “classical“ multimedia effect (written text vs. written text plus pictures; Mayer, 2009) showed up for overall learning scores and picture-only information on both learning units (Learning Unit 1 and Learning Unit 2) and on both times of measurement. With respect to transfer information, the multimedia effect could only be found for Learning Unit 1. In contrast to Mayer’s multimedia principle (Mayer, 2009), the multimedia effect did not occur for text-only information and illustrated-text information on both learning units (Learning Unit 1 and Learning Unit 2) and on both times of measurement.

As with Experiment 1, the results of Experiment 2 on illustrated-text information (“no multimedia effect”) are not consistent with Mayer’s (1989) arguments that pictures should especially facilitate learning when (1) a cause-and-effect system is described in the text and (2) the system is depicted in the pictures in an elucidating way. Possible explanations for the lacking multimedia effect on illustrated-text information are given in section 4.4.

The patterns of results on text-only information (“no reversed multimedia effect”) and picture-only information (“multimedia effect”) do not any longer indicate a shift of attention from text to pictures (*shift-of-attention effect*; Brünken & Leutner, 2001) when *written text plus pictures are provided in a split-attention format.* The results of Experiment 1 could not be replicated in Experiment 2. However, when looking at the results of each source of information (text-only information, picture-only information, illustrated-text information), including transfer information, it can be seen that the multimedia effect only showed up for picture-only information and transfer information (at least partly). Thus, the “classical” overall multimedia effect was based on the multimedia effects for picture-only information and transfer information. The negative impact of pictures on text-only information that could be found in Experiment 1 no longer existed in Experiment 2. When providing more learning time (Experiment 1: about 8 minutes; Experiment 2: about 18 minutes), children seem to have had enough time for reading the text, and the pictures seem to have lost their detrimental impact on text-only information. As Weidenmann, Paechter, and Hartmannsgruber (1999) have already noted, the available learning time is a crucial factor for knowledge acquisition. However, as has been discussed in section 5.4, the learning time is one out of several reasons for the differences in the learning outcome on text-only information between Experiment 1 and Experiment 2. Due to the introduction of instructional aids (selection/organization and selection/organization and integration aids) several aspects (e.g., learning time, arrangement of text and pictures) have been varied between Experiment 1 and 2. Therefore, future research is needed for a clearer pattern of interpretations.

As expected, the modality effect (Mayer, 2009) did not occur for both learning units (Learning Unit 1 and Learning Unit 2) and both times of measurement. These results are in line with Ginns (2005), who emphasizes the role of pacing of presentation for a modality effect to occur in his meta-analysis (see also Tabbers, Martens, & van Merriënboer, 2001; 2004). In comparison to Experiment 1, children had more time for working on the learning materials in Experiment 2; therefore, in Experiment 2, the pacing of presentation might be regarded as "more self-paced" resulting in the absence of a modality effect.

Contrary to expectations, *no attentional-guidance effect* (that is, shifting the learner's attention to important parts of the learning material; Brünken et al., 2004) could be found. Providing children with additional learning aids does not necessarily seem to foster their learning outcome. More specifically, neither aids for selection/organization ("no selection/organization effect") nor aids for selection/organization and integration ("no selection/organization and integration effect) improved the children's learning outcome on both learning units (Learning Unit 1 and Learning Unit 2; directly after the learning phase and two months later). In section 5.4, potential explanations for this result have already been given.

In the following, the lacking influence of the additional learning aids is discussed in a broader way by focusing on further research contributions on attentional guidance in the field of multimedia learning. As several studies show, instructional aids are not always helpful for learners (e.g., Plötzner & Härder, 2001; Seufert, 2003). Following Brünken, Seufert, and Zander (2005), the effectiveness of instructional aids depends on whether their presentation results in germane cognitive load or causes additional extraneous cognitive load. Only the former is associated with higher learning outcome. Additionally, prior knowledge seems to be an important factor for the effectiveness of instructional aids. Although, intuitively, instructional aids seem to be especially helpful for learners with low prior knowledge, research indicates the opposite (Seufert, 2003; Seufert & Brünken, 2004). The results of this dissertation support these findings; learners with less prior knowledge do not seem to benefit from instructional aids. Furthermore, Seufert, Jänen, and Brünken (2007) report that the effectiveness of hyperlinks (an instructional aid) depends on the complexity of the learning task as well. That is, instructional aids seem only to be effective for less complex learning materials. Adding instructional aids to more complex learning materials (as, for example text, and pictures about the blood circulation system) might lead to an additional extraneous cognitive load, independent of whether the aids have been perceived as redundant to the learning material (*redundancy principle*; Mayer, 2009; Sweller, 2005b) or whether they have been perceived as "too far away" from the learning material (cp., *split-attention principle*; Ayres & Sweller, 2005).

To sum it up, children seem to overcome a potential *shift-of-attention effect* (Brünken & Leutner, 2001) when being provided with more learning time. Unfortunately, due to the introduction of instructional aids, the learning time is confounded with the arrangement of text and pictures; therefore, future research is needed for identifying conditions that may prevent a potential *shift-of-attention from written text to pictures in a split-attention format*. Despite this confusion, the available learning time seems to have a great impact on knowledge acquisition (cp., Weidenmann et al., 1999) and "qualify" instructional design principles in some way, as can be seen in the case of the modality principle. Presenting spoken text plus pictures is only more effective than presenting written text plus pictures when the presentation is system-paced (Ginns, 2005; Tabbers et al., 2004). Hence, it might be the case that the more time is available to the children, the better they get along with written text (and pictures) because they have enough time to process the text (and the pictures) and probably re-read important aspects. Thus, less learning time might be regarded as a kind of prerequisite for the modality principle to hold true; more learning time rather results in the disappearance of the modality effect. For an *attentional-guidance effect* (Brünken et al., 2004b) to occur, some boundary conditions should be taken into account: The instructional aids should be designed in such a way that germane cognitive load is fostered (Brünken et al., 2005), otherwise they will not be helpful for learning. Furthermore, learner characteristics (as prior knowledge; Seufert & Brünken, 2004) and characteristics of the learning material (as the complexity of the learning material; Seufert et al., 2007) may have a limiting influence on the *attentional-guidance effect*. Finally, it has to be noted that adding pictures to written expository text does not seem to foster all sources of information. While adding pictures to written expository text had a positive impact on the learning of picture-only information as well as on transfer achievement (referring to integrated knowledge from text and pictures), performance on text-only information and illustrated-text information did not benefit from additional pictures. Thus, the "classical" overall multimedia effect was mainly based on the results of the picture and the transfer scale. It seems that the "classical" overall multimedia effect results from the extra information in pictures, which go beyond pure textual information. Consequently, especially in light of the fact that there are a number of studies failing to show the multimedia effect (Opfermann, 2008; Segers et al., 2008), Peeck's (1994) suggestions concerning the differentiation of sources of information should be further considered within future research.

6.1 Theoretical Implications

Generally, the patterns of results of Experiment 1 and Experiment 2 are largely consistent with the predictions of both the CTML (Mayer, 2005c; Mayer, 2009) and the ITPC model (Schnotz, 2005) with the latter one being more elaborate. Only the ITPC model takes into account the possibility that adding pictures to text may result in lower learning outcome on text-only information (cp., Schnotz, Bannert, & Seufert, 2002). Following the ITPC model (Schnotz, 2005), it might be possible that – due to the "different routes for constructing mental representations" (Schnotz, 2005, p.63) in working memory – the route for picture processing takes the place of the route for text processing to some extent when *written text plus pictures are presented simultaneously* – provided that learners invest the same amount of working memory capacity (Schnotz, 2005) in the learning material. Thus, the less deep processing of text-only information results in lower learning outcome when compared with the learning outcome of children who received only written text. Therefore, it may be stated that the "reversed multimedia effect" on text-only information (Experiment 1) rather supports the ITPC model (Schnotz, 2005) than the CTML (Mayer, 2005c; Mayer, 2009). Hence, generally, the results may help to elaborate theories of multimedia learning.

Furthermore, with respect to Experiment 1, the classical multimedia effect (written text vs. written text plus pictures) did not hold true for split-attention learning formats which are typical in schoolbooks. Therefore, it might be possible that split-attention formats may prevent a multimedia effect. Thus, they may be considered as a kind of "boundary condition" for the multimedia effect to occur (cp., Mayer, 2009). However, future research is needed on this theoretical implication. Apart from the split-attention effect, research on multimedia learning should also take into account a *potential shift-of-attention effect*, especially when children participate in the study.

Last but not least, Peeck's procedure (1974, 1994) – which aims at dividing information into text-only information, picture-only information and illustrated-text information – should be applied in future studies on multimedia learning. As several studies show (e.g., De Westelinck et al., 2005; Segers et al., 2008), pictures do not automatically seem to improve learning when added to a text. Applying Peeck's procedure (1974) to the learning material allows a more elaborate analysis of the effect of pictures in and on texts. Thus, this procedure is also helpful when working with interpretational (or explanative) pictures that (are intended to) focus on the same essential elements of the learning content as the corresponding text segment (illustrated-text information; cp. section 1.4). If interpretational (or explanative) pictures really depict the same key elements as the corresponding text segments, the multimedia effect should show up on illustrated-text information. With respect to multimedia learning environments that do not clearly focus on illustrated-text information (even if they were intended to do), a more precise analysis of the pictures' impact on the learning outcome is possible, allowing potential explanations for a lacking "overall" multimedia effect (also cp. Levin & Mayer, 1993, for adequate measures of performance outcomes). Hence, Peeck's procedure (1974) which takes into account different sources of information should be regarded as a more adequate measurement of performance outcomes (Levin & Mayer, 1993) and thus should be used as a standard procedure in future studies on multimedia learning. Furthermore, the differentiation between different (re-)presentation formats – the format in which a stimulus is (re-)presented (verbal or pictorial/nonverbal; Mayer, 2009) – is important for an adequate measurement of the instructional design principles' impact on learning outcome because instructional design principles do not seem to influence "verbal form information" and "pictorial form information" in the same manner (e.g., Brünken & Leutner, 2001; Brünken, Steinbacher, Schnotz, & Leutner, 2001).

6.2 Practical Implications

Pictures do not always help primary school children in learning from expository text. Regarding the pattern of results of Experiment 1, the following recommendations for teachers might be given: (1) When *written text and pictures are provided in a split-attention format* (like in schoolbooks or on working sheets), teachers should read the text to their pupils in order to prevent a potential *shift-of attention from text to pictures*. That is, teachers should take advantage of the modality principle especially when pictorial material is added to written text. In this context, teachers should also consider the type of learning, respectively the type of retention that is required. The negative impact of pictures on information that is presented in text only seems to disappear when sufficient learning time is provided or when text and pictures are presented individually at first before they are presented together on one page (Experiment 2). Furthermore, teachers should renounce visual instructional aids when children have no or very little prior knowledge, because a positive impact on learning outcome is very questionable (cp., Seufert, 2003 for negative impacts of instructional aids). Additionally, teachers should keep in mind that instructional aids should be designed in a way that fosters germane – "good" – cognitive load and reduces extraneous cognitive load, which is "bad" for learning.

6.3 Future Directions

The *shift-of-attention effect* should be investigated in future studies in more detail, shedding more light on reasons (“why”), conditions (“when”) and learner characteristics (“for whom”). By doing so, future studies might also take into account the method of eye-tracking as a means of analyzing children’s division of visual attention. In order to explore the *shift-of-attention effect*, the multimedia and modality principles were used as an indirect basis for assessment in the present studies, rather than taking direct measures into account, such as eye-tracking (Schmidt-Weigand, 2006). Furthermore, future research should follow Peeck’s (1974, 1994) suggestions concerning the differentiation of sources of information when measuring learning outcome. Especially in light of the fact that there are several studies that fail to show the multimedia effect (e.g., Opfermann, 2008; Segers et al., 2008), the application of Peeck’s (1994) procedure seems to be promising for investigating the different effects of instructional design principles on (re-)presentation formats (verbal or pictorial/nonverbal; cp., Brünken & Leutner, 2001; Brünken et al., 2001). As this dissertation has shown, taking into account different sources of information (such as text-only information and picture-only information) leads to a more elaborate measurement of the effects of instructional design principles on the learning outcome. Furthermore, more attention should be paid to how the available learning time might moderate the effects of instructional design principles.

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Appendices

Appendix A:	Experiment 1: Learning Unit 1 – “written text” condition
Appendix B:	Experiment 1: Learning Unit 1 – “written text + pictures” condition
Appendix C:	Experiment 1: Learning Unit 1 – “spoken text” condition
Appendix D:	Experiment 1: Learning Unit 1 – “spoken text + pictures” condition
Appendix E:	Experiment 1: Learning Unit 2 – “written text” condition
Appendix F:	Experiment 1: Learning Unit 2 – “written text + pictures” condition
Appendix G:	Experiment 1: Learning Unit 2 – “spoken text” condition
Appendix H:	Experiment 1: Learning Unit 2 – “spoken text + pictures” condition
Appendix I:	Experiment 2: Learning Unit 1 – “written text” condition
Appendix J:	Experiment 2: Learning Unit 1 – “written text + pictures” condition
Appendix K:	Experiment 2: Learning Unit 1 – “written text + pictures + selection/organization aids” condition
Appendix L:	Experiment 2: Learning Unit 1 – “written text + pictures + selection/organization aids + integration aids” condition
Appendix M:	Experiment 2: Learning Unit 1 – “spoken text” condition
Appendix N:	Experiment 2: Learning Unit 1 – “spoken text + pictures” condition
Appendix O:	Experiment 2: Learning Unit 1 – “spoken text + pictures + selection/organization aids” condition
Appendix P:	Experiment 2: Learning Unit 1 – “spoken text + pictures + selection/organization aids + integration aids” condition
Appendix Q:	Experiment 2: Learning Unit 2 – “written text” condition
Appendix R:	Experiment 2: Learning Unit 2 – “written text + pictures” condition
Appendix S:	Experiment 2: Learning Unit 2 – “written text + pictures + selection/organization aids” condition
Appendix T:	Experiment 2: Learning Unit 2 – “written text + pictures + selection/organization aids + integration aids” condition
Appendix U:	Experiment 2: Learning Unit 2 – “spoken text” condition
Appendix V:	Experiment 2: Learning Unit 2 – “spoken text + pictures” condition

Appendix A

Experiment 1: Learning Unit 1 – “written text” condition

Unser Blutkreislauf (1)

Stopp!

Seite 1

Unser Blutkreislauf

Einleitung

Tom jubelt: „Ich bin ein Auto!“ „Unsinn“, ruft Nina, „du bist doch kein Auto!“ Tom grinst: „Doch, irgendwie schon. Ich habe einen Motor!“

Jedes Auto braucht einen Motor, um fahren zu können. Jeder Mensch braucht das Herz, um leben zu können. Das Herz ist unser Motor.

Seite 2

Das Herz

Das Herz, dein Motor, ist ungefähr so groß wie deine Faust. Das Herz pumpt das Blut bis in die kleinsten Teile deines Körpers. Das ist deshalb so wichtig, weil im Blut viele Stoffe sind, die dein Körper an allen Stellen braucht. Das Blut fließt in kleinen Rohren, die wir Blutgefäße oder Adern nennen. Wichtig ist, dass das Blut innerhalb der Adern immer in die gleiche Richtung fließt. Bei den Adern gibt es die Arterien und die Venen. Arterien führen vom Herz weg. Venen führen zum Herz hin. Die Adern sind unterschiedlich dünn. Sie sind überall in deinem Körper, wie ein Netz. Wenn du deine Hand auf den Tisch legst und dir deinen Handrücken anschaust, siehst du deine Adern grün schimmern.

Seite 3

Der Blutkreislauf

Jetzt geht's los. Du weißt, dass das Herz Blut durch deinen Körper pumpt. Dabei pumpt das Herz das Blut immer zuerst in die Lunge und dann in den Körper.

Aber warum kommt das Blut zuerst in die Lunge?

Du atmest, damit Sauerstoff in deine Lunge kommt. Sauerstoff ist wichtig, damit dein Körper richtig arbeiten kann. Um den Sauerstoff auftanken zu können, muss das Blut nun zuerst zur Lunge fließen. Der Weg des Blutes in die Lunge heißt kleiner Lungenkreislauf.

Seite 4

Und wie kommt der Sauerstoff in deinen ganzen Körper?

Nach dem Lungenkreislauf fließt das Blut nun voll beladen mit Sauerstoff in deinen Körper. Das Blut gibt den Sauerstoff nach und nach an deinen Körper ab. So kommt der Sauerstoff überall dort hin, wo dein Körper ihn braucht. Dieser Weg des Blutes durch den Körper heißt großer Körperkreislauf.

Seite 5

Wenn das Blut den Sauerstoff abgegeben hat, fließt es wieder in den kleinen Lungenkreislauf. Nun beginnt alles wieder von vorne: Im Lungenkreislauf tankt das Blut Sauerstoff auf. Dann kommt es wieder in den großen Körperkreislauf und verteilt den Sauerstoff. Dann kommt es wieder in den Lungenkreislauf, dann wieder in den Körperkreislauf…

Blut mit viel Sauerstoff wird rot gemalt. Blut mit wenig Sauerstoff wird blau gemalt.

Das Wort Kreislauf meint also, dass dein Blut wie im Kreis vom Herz weggepumpt wird und zum Herz zurück fließt. Der kleine Lungenkreislauf und der große Körperkreislauf bilden zusammen unseren Blutkreislauf.

Appendix B

Experiment 1: Learning Unit 1 – “written text + pictures” condition

Unser Blutkreislauf (1)

Stopp!

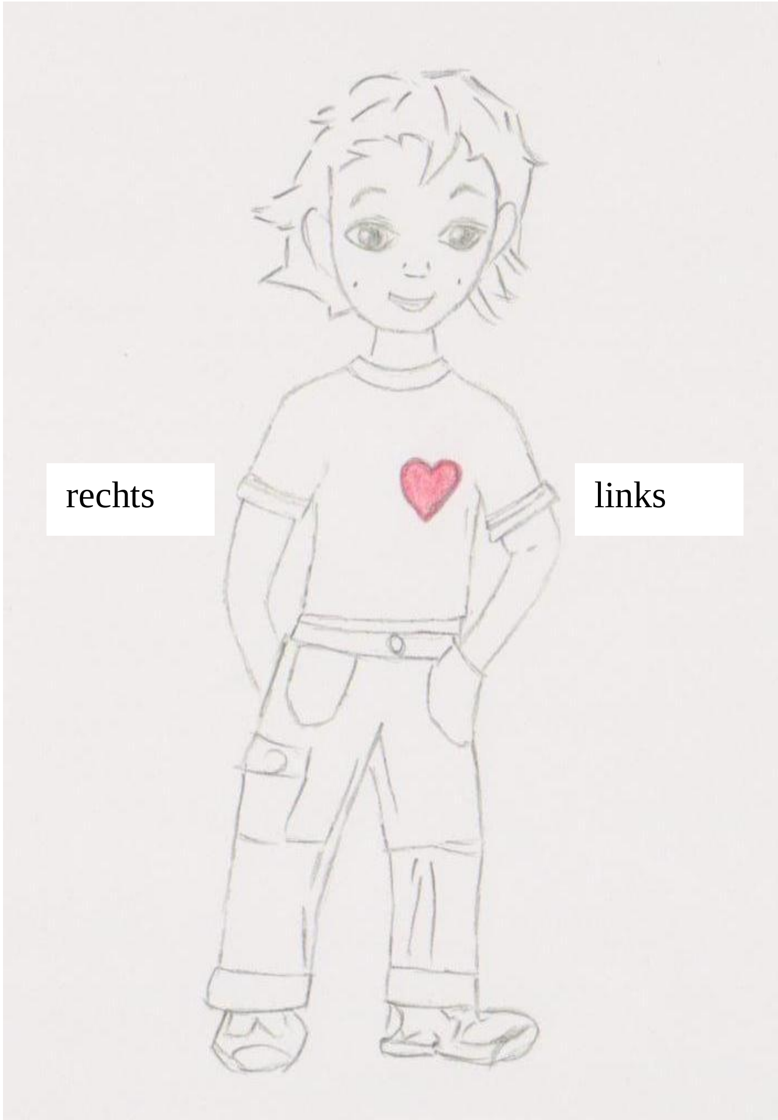
Seite 1

Unser Blutkreislauf

Einleitung

Tom jubelt: „Ich bin ein Auto!“ „Unsinn“, ruft Nina, „du bist doch kein Auto!“ Tom grinst: „Doch, irgendwie schon. Ich habe einen Motor!“

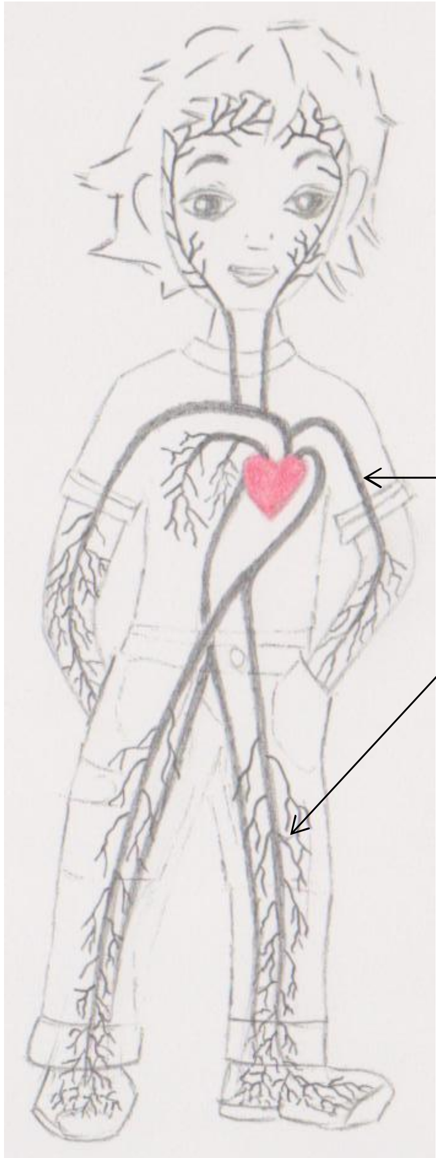
Jedes Auto braucht einen Motor, um fahren zu können. Jeder Mensch braucht das Herz, um leben zu können. Das Herz ist unser Motor.



Seite 2

Das Herz

Das Herz, dein Motor, ist ungefähr so groß wie deine Faust. Das Herz pumpt das Blut bis in die kleinsten Teile deines Körpers. Das ist deshalb so wichtig, weil im Blut viele Stoffe sind, die dein Körper an allen Stellen braucht. Das Blut fließt in kleinen Rohren, die wir Blutgefäße oder Adern nennen. Wichtig ist, dass das Blut innerhalb der Adern immer in die gleiche Richtung fließt. Bei den Adern gibt es die Arterien und die Venen. Arterien führen vom Herz weg. Venen führen zum Herz hin. Die Adern sind unterschiedlich dünn. Sie sind überall in deinem Körper, wie ein Netz. Wenn du deine Hand auf den Tisch legst und dir deinen Handrücken anschaust, siehst du deine Adern grün schimmern.



Blutgefäße oder Adern,
in denen Blut fließt

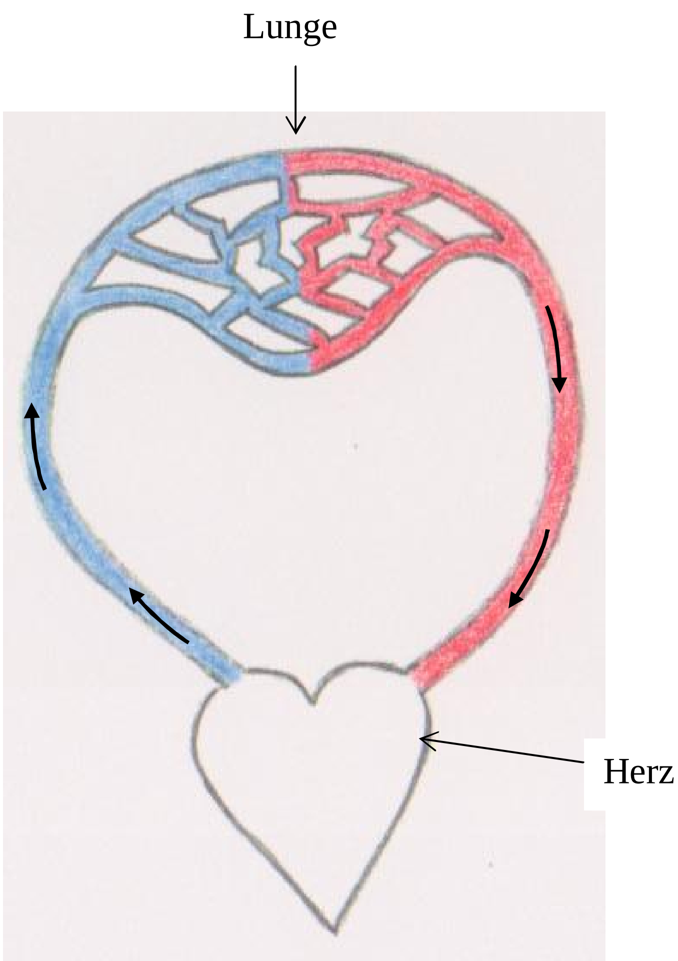
Seite 3

Der Blutkreislauf

Jetzt geht's los. Du weißt, dass das Herz Blut durch deinen Körper pumpt. Dabei pumpt das Herz das Blut immer zuerst in die Lunge und dann in den Körper.

<u>Aber warum kommt das Blut zuerst in die Lunge?</u>

Du atmest, damit Sauerstoff in deine Lunge kommt. Sauerstoff ist wichtig, damit dein Körper richtig arbeiten kann. Um den Sauerstoff auftanken zu können, muss das Blut nun zuerst zur Lunge fließen. Der Weg des Blutes in die Lunge heißt kleiner Lungenkreislauf.



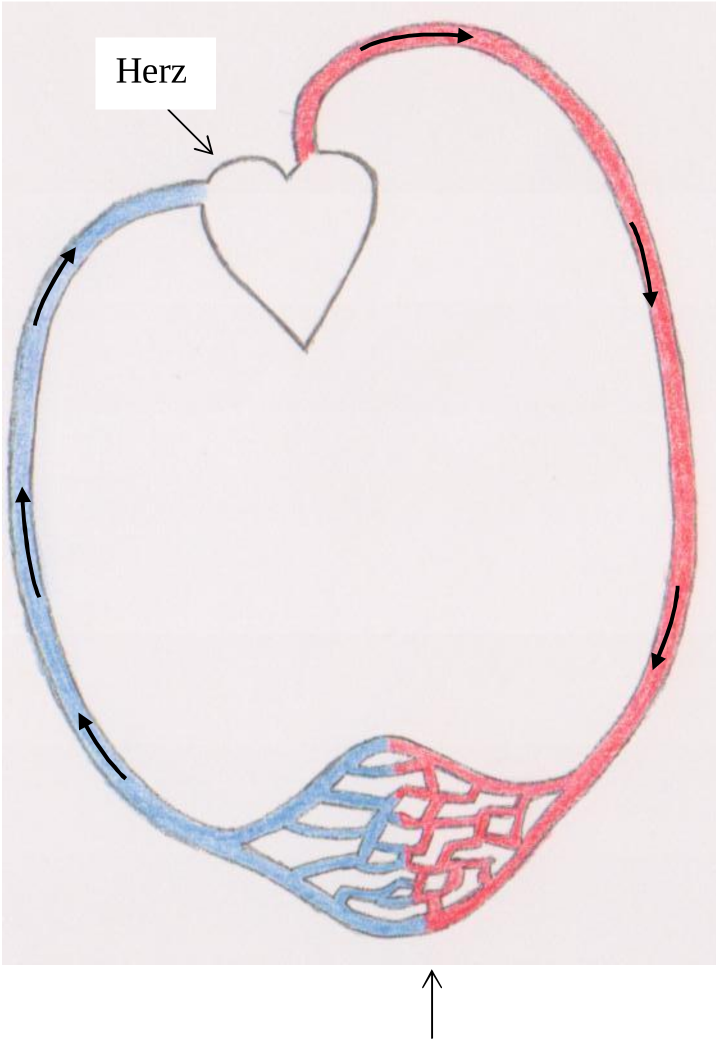
rot = Blut mit viel Sauerstoff

blau = Blut mit wenig Sauerstoff

Seite 4

Und wie kommt der Sauerstoff in deinen ganzen Körper?

Nach dem Lungenkreislauf fließt das Blut nun voll beladen mit Sauerstoff in deinen Körper. Das Blut gibt den Sauerstoff nach und nach an deinen Körper ab. So kommt der Sauerstoff überall dort hin, wo dein Körper ihn braucht. Dieser Weg des Blutes durch den Körper heißt großer Körperkreislauf.



rot = Blut mit viel Sauerstoff

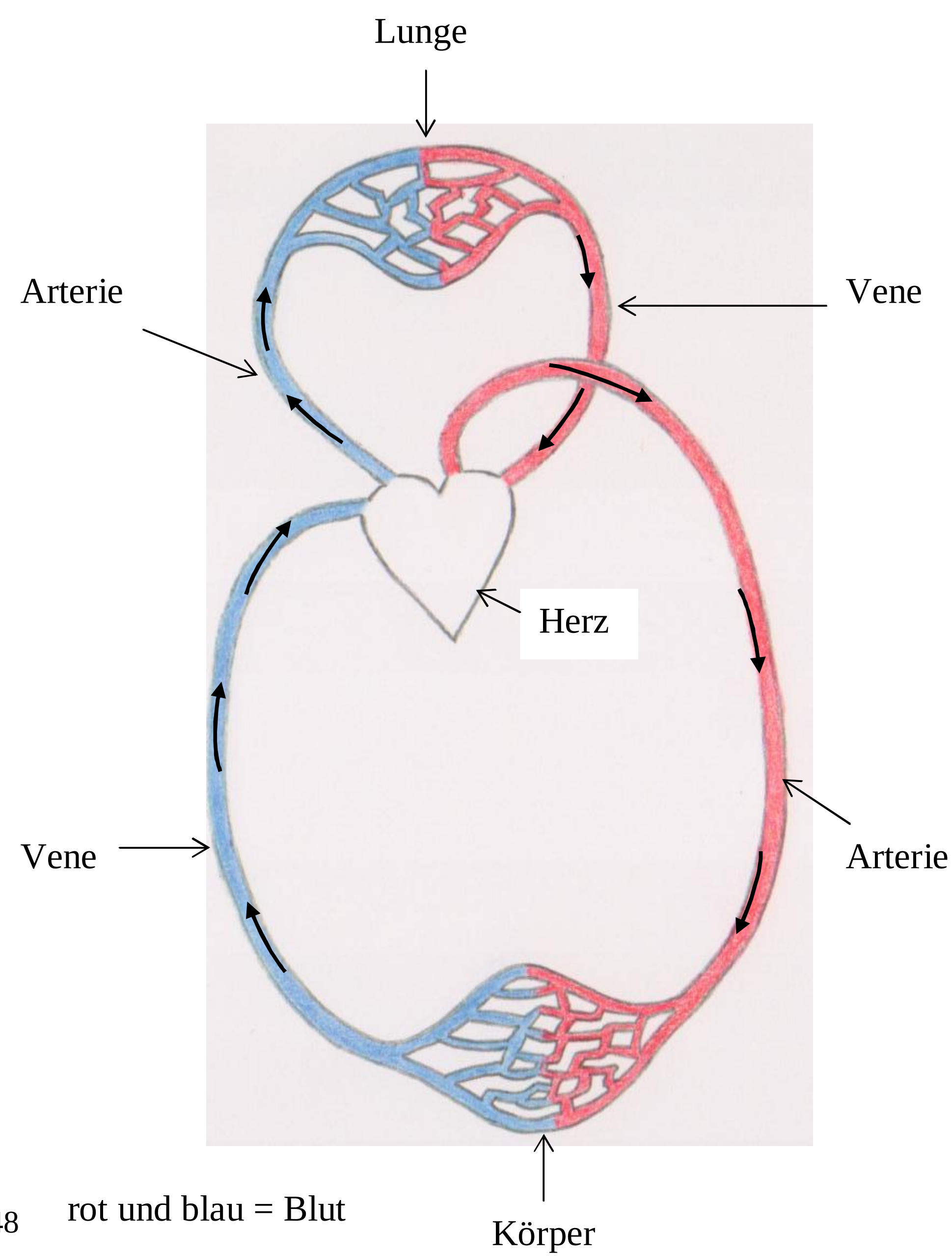
blau = Blut mit wenig Sauerstoff

Seite 5

Wenn das Blut den Sauerstoff abgegeben hat, fließt es wieder in den kleinen Lungenkreislauf. Nun beginnt alles wieder von vorne: Im Lungenkreislauf tankt das Blut Sauerstoff auf. Dann kommt es wieder in den großen Körperkreislauf und verteilt den Sauerstoff. Dann kommt es wieder in den Lungenkreislauf, dann wieder in den Körperkreislauf…

Blut mit viel Sauerstoff wird rot gemalt. Blut mit wenig Sauerstoff wird blau gemalt.

Das Wort Kreislauf meint also, dass dein Blut wie im Kreis vom Herz weggepumpt wird und zum Herz zurück fließt. Der kleine Lungenkreislauf und der große Körperkreislauf bilden zusammen unseren Blutkreislauf.



Appendix C

Experiment 1: Learning Unit 1 – "spoken text" condition

The text used in the "written text" condition (Experiment 1: Learning Unit 1 – "written text" condition) was spoken.

Appendix D

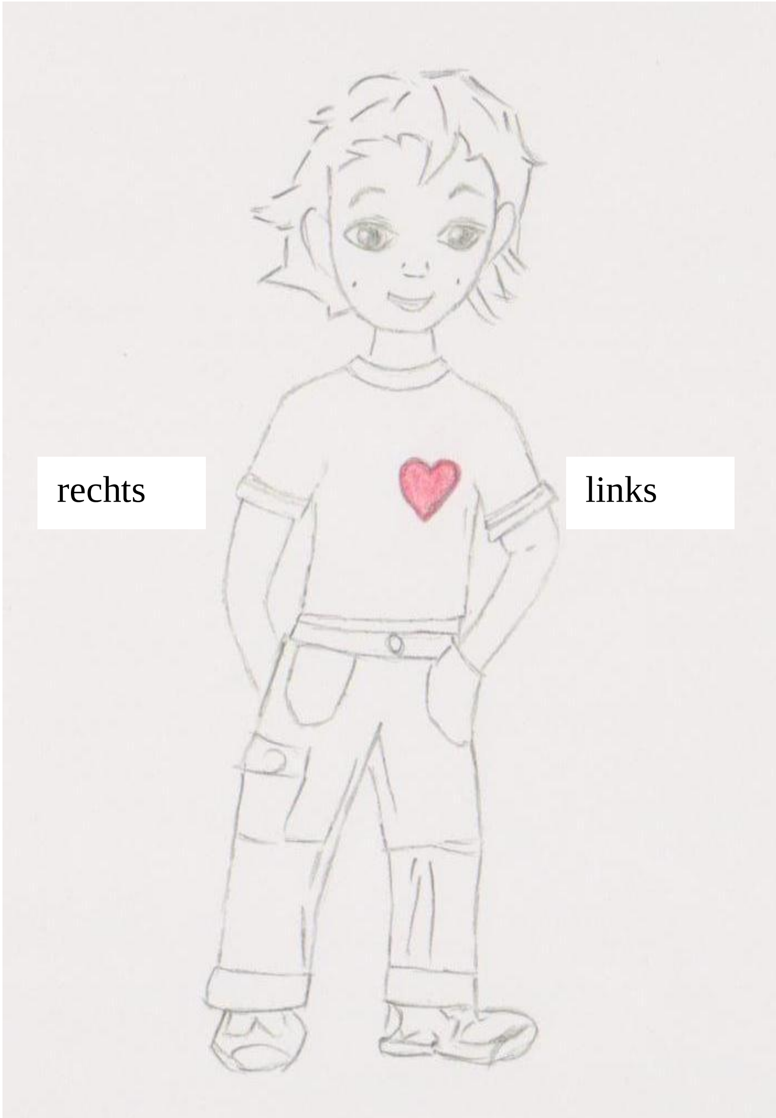
Experiment 1: Learning Unit 1 – "spoken text + pictures" condition

The text used in the "written text + pictures" condition (Experiment 1: Learning Unit 1 – "written text + pictures" condition) was spoken.

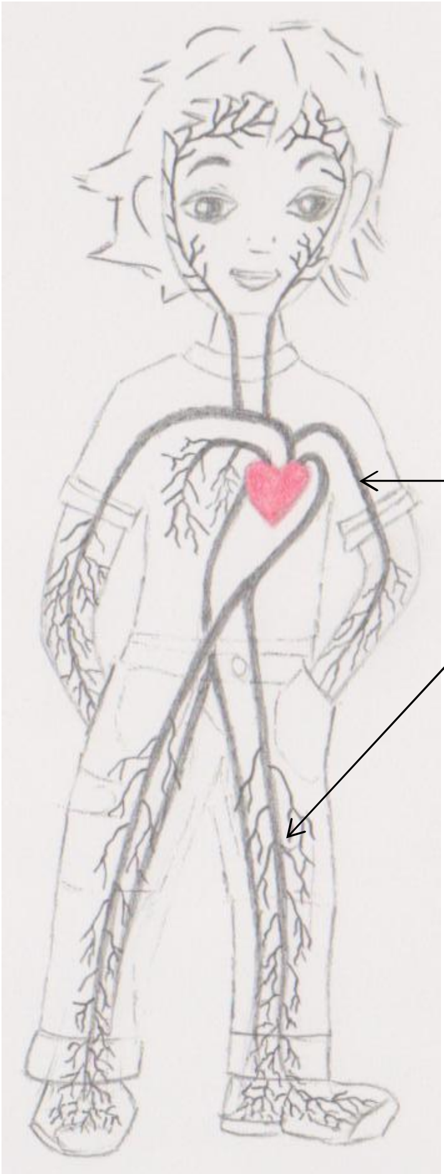
Unser Blutkreislauf (1)

Stopp!

Seite 1

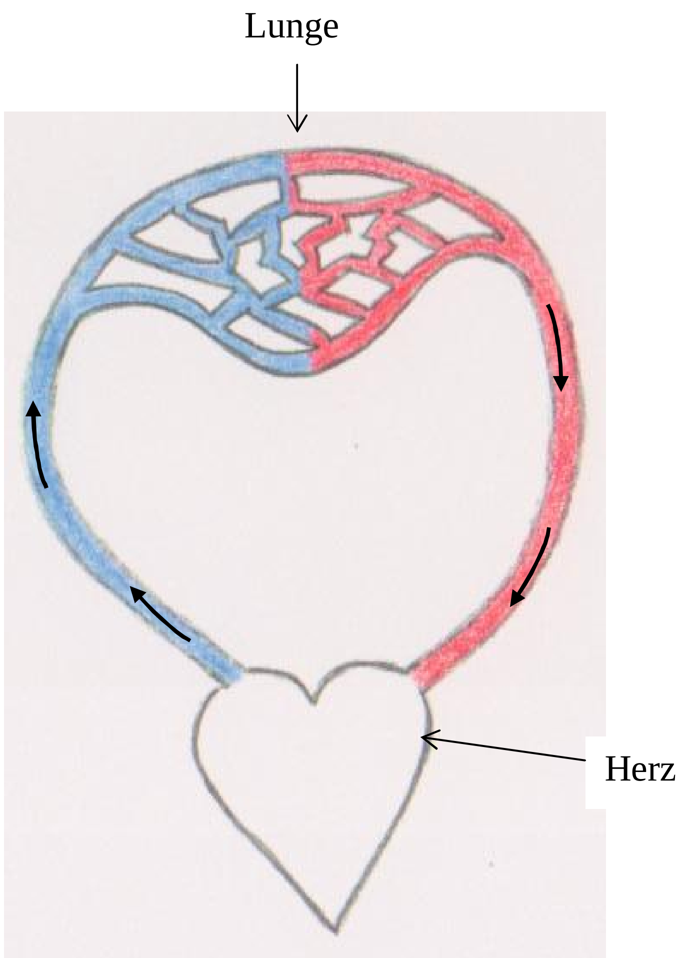


Seite 2



Blutgefäße oder
Adern,
in denen Blut fließt

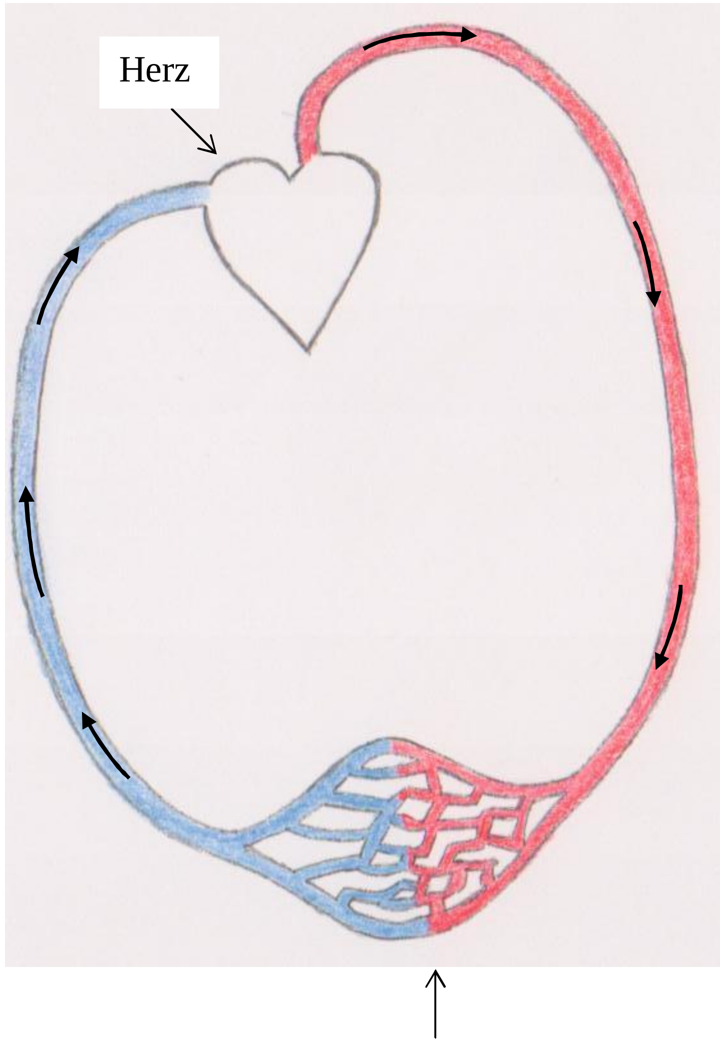
Seite 3



rot = Blut mit viel Sauerstoff

blau = Blut mit wenig Sauerstoff

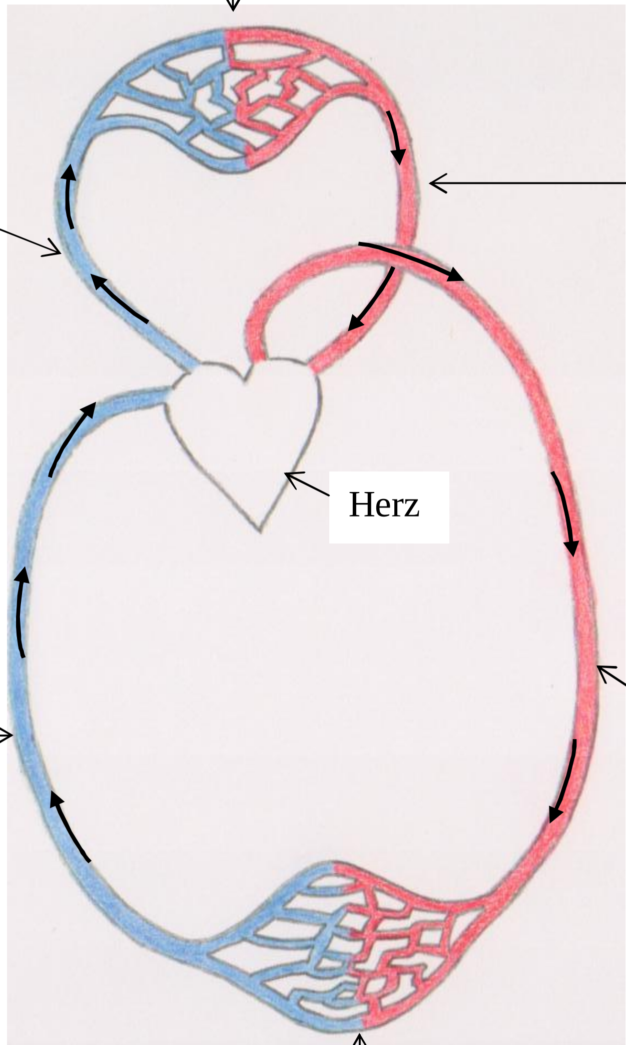
Seite 4



rot = Blut mit viel Sauerstoff

blau = Blut mit wenig Sauerstoff

Seite 5



rot und blau = Blut

Appendix E

Experiment 1: Learning Unit 2 – "written text" condition

Unser Blutkreislauf (2)

Stopp!

Seite 1

Unser Blutkreislauf 2

Einleitung

Nina singt: „Lungenkreislauf, Körperkreislauf, Lungenkreislauf, Körperkreislauf…“ Tom klatscht dazu in die Hände und ruft: „Hey, Sauerstoff tanken und verteilen, das sind die beiden Sachen, die das Blut in den Kreisläufen macht.“

OK, das ist klar! Im kleinen Lungenkreislauf tankt das Blut den Sauerstoff auf. Und im großen Körperkreislauf verteilt es den Sauerstoff. Aber wie funktionieren der Lungenkreislauf, der Körperkreislauf und das Herz zusammen? Das lernst du heute.

Seite 2

Das Herz

Wenn du an ein Herz denkst, stellst du es dir bestimmt wie ein Lebkuchenherz vor. Aber eigentlich sieht das Herz in deinem Körper nicht so aus. Dicke Rohre laufen in das Herz hinein und aus dem Herz heraus. Diese Rohre heißen Blutgefäße oder Adern. Erinnerst du dich? Sie sind überall in deinem Körper, wie ein Netz.

Das Herz ist innen hohl. Deshalb kann das Blut hinein und heraus fließen. Das Herz hilft dem Blut dabei, indem es sich immer wieder zusammenzieht und ausdehnt. So pumpt das Herz das Blut voran. Du kannst das Pumpen als deinen Herzschlag fühlen.

Seite 3

Wie sieht das Herz innen aus?

Das Herz wird durch eine Wand in zwei Hälften geteilt: in die schwächere (rechte) und in die stärkere (linke) Herzhälfte.

Jede Herzhälfte besteht aus zwei Teilen: einem kleinen Vorhof und einer größeren Herzkammer. Der Vorhof liegt über der Herzkammer und ist mit dieser verbunden.

In den Vorhof hinein läuft eine Vene. Das ist eine Ader, die das Blut zum Herz hin bringt. Von der Herzkammer heraus läuft eine Arterie. Das ist eine Ader, die das Blut vom Herz weg bringt.

Seite 4

Jetzt lernst du, wie der Lungenkreislauf, der Körperkreislauf und das Herz zusammen funktionieren.

Der kleine Lungenkreislauf

Im kleinen Lungenkreislauf tankt das Blut Sauerstoff auf. Der kleine Lungenkreislauf startet immer in der schwächeren Herzhälfte. Diesen Weg nimmt das Blut genau: Das Blut fließt innerhalb des Herzens vom Vorhof in die Herzkammer. Von dort gelangt es nun in die Lunge. Von der Lunge fließt das Blut in den Vorhof der stärkeren Herzhälfte. In der stärkeren Herzhälfte endet der kleine Lungenkreislauf.

Seite 5

Der große Körperkreislauf

Im großen Körperkreislauf wird der Sauerstoff überall in deinem Körper verteilt. Der große Körperkreislauf startet immer in der stärkeren Herzhälfte. Diesen Weg nimmt das Blut genau: Das Blut fließt innerhalb des Herzens vom Vorhof in die Herzkammer. Von dort gelangt es nun in deinen Körper. Wenn das Blut durch deinen Körper geflossen ist, kommt es in den Vorhof der schwächeren Herzhälfte zurück. In der schwächeren Herzhälfte endet der große Körperkreislauf.

Seite 6

Nun beginnt alles wieder von vorne: Das Blut kommt wieder in den Lungenkreislauf, dann in den Körperkreislauf, dann wieder in den Lungenkreislauf…

Nun weißt du, dass unser Blutkreislauf aus dem kleinen Lungenkreislauf und dem großen Körperkreislauf besteht.

Appendix F

Experiment 1: Learning Unit 2 – “written text + pictures” condition

Unser Blutkreislauf (2)

Stopp!

Seite 1

Unser Blutkreislauf

Einleitung

Nina singt: „Lungenkreislauf, Körperkreislauf, Lungenkreislauf, Körperkreislauf…“ Tom klatscht dazu in die Hände und ruft: „Hey, Sauerstoff tanken und verteilen, das sind die beiden Sachen, die das Blut in den Kreisläufen macht.“

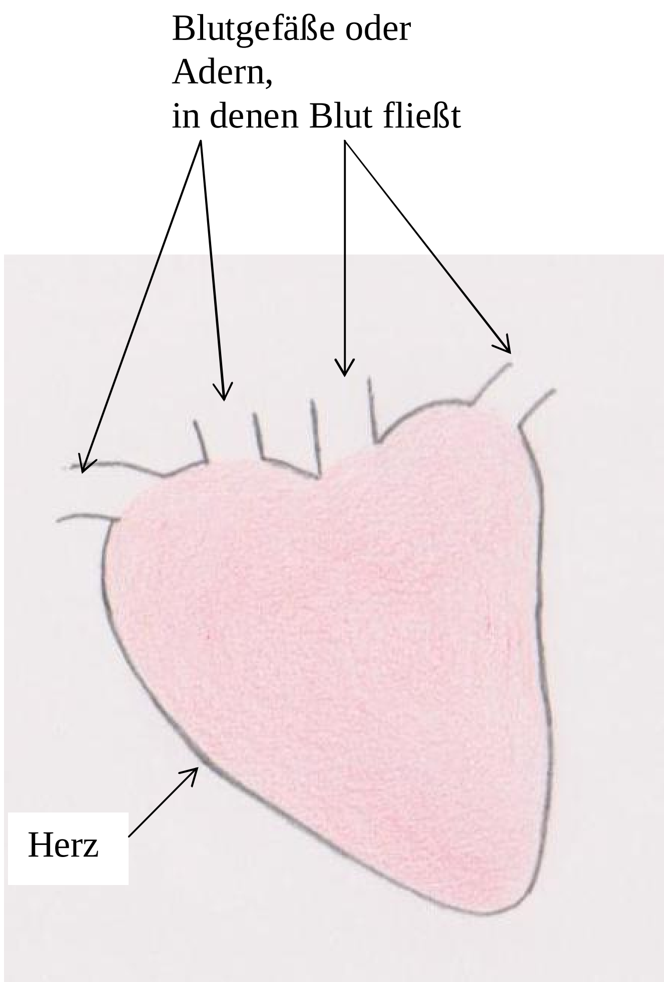
OK, das ist klar! Im kleinen Lungenkreislauf tankt das Blut den Sauerstoff auf. Und im großen Körperkreislauf verteilt es den Sauerstoff. Aber wie funktionieren der Lungenkreislauf, der Körperkreislauf und das Herz zusammen? Das lernst du heute.

Seite 2

Das Herz

Wenn du an ein Herz denkst, stellst du es dir bestimmt wie ein Lebkuchenherz vor. Aber eigentlich sieht das Herz in deinem Körper nicht so aus. Dicke Rohre laufen in das Herz hinein und aus dem Herz heraus. Diese Rohre heißen Blutgefäße oder Adern. Erinnerst du dich? Sie sind überall in deinem Körper, wie ein Netz.

Das Herz ist innen hohl. Deshalb kann das Blut hinein und heraus fließen. Das Herz hilft dem Blut dabei, indem es sich immer wieder zusammenzieht und ausdehnt. So pumpt das Herz das Blut voran. Du kannst das Pumpen als deinen Herzschlag fühlen.



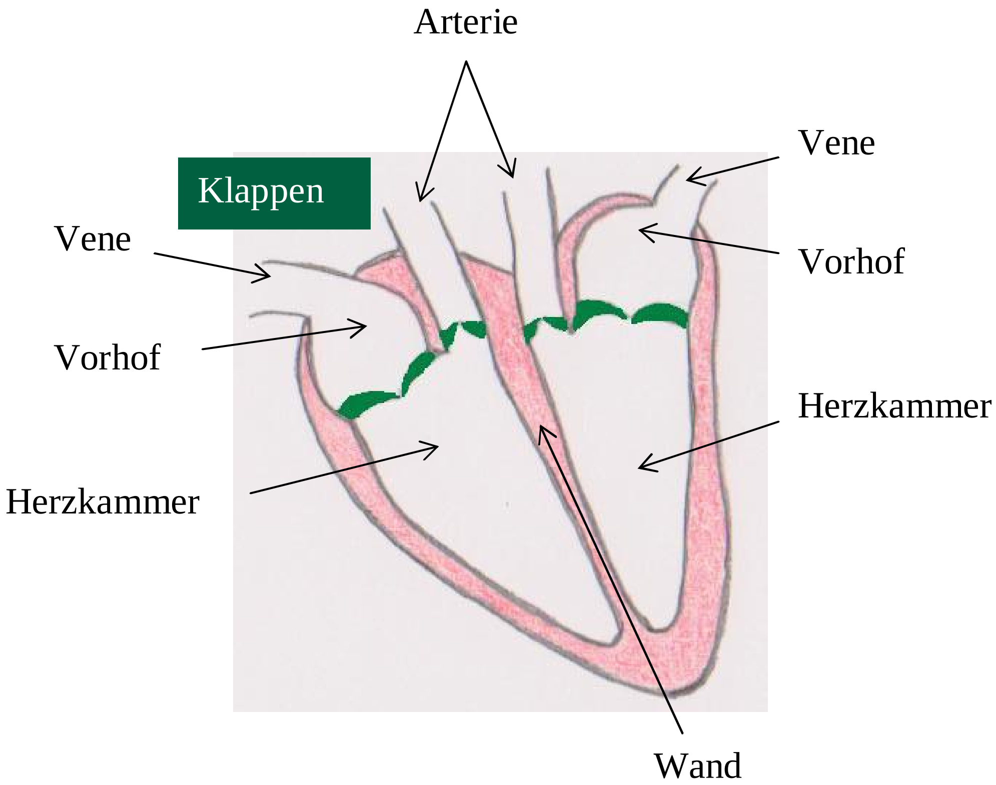
Seite 3

Wie sieht das Herz innen aus?

Das Herz wird durch eine Wand in zwei Hälften geteilt: in die schwächere und in die stärkere Herzhälfte.

Jede Herzhälfte besteht aus zwei Teilen: einem kleinen Vorhof und einer größeren Herzkammer. Der Vorhof liegt über der Herzkammer und ist mit dieser verbunden.

In den Vorhof hinein läuft eine Vene. Das ist eine Ader, die das Blut zum Herz hin bringt. Von der Herzkammer heraus läuft eine Arterie. Das ist eine Ader, die das Blut vom Herz weg bringt.



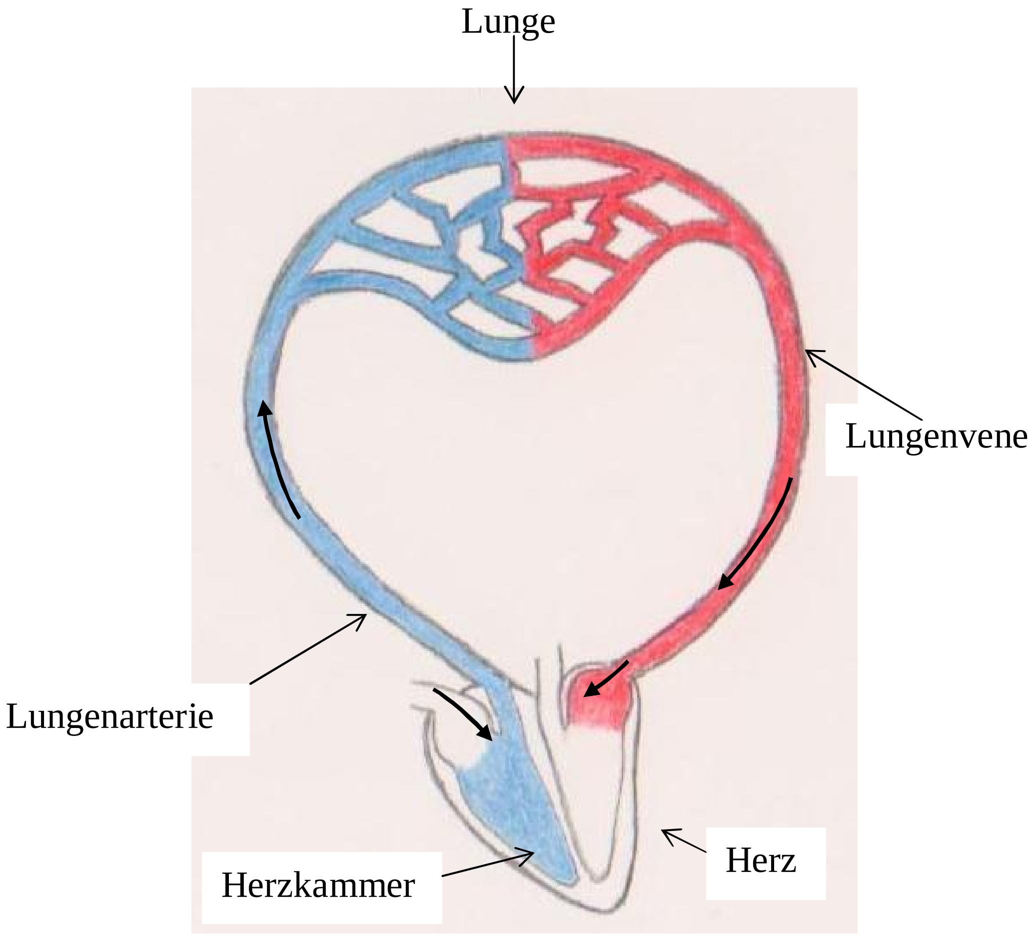
Seite 4

Jetzt lernst du, wie der Lungenkreislauf, der Körperkreislauf und das Herz zusammen funktionieren.

Der kleine Lungenkreislauf

Im kleinen Lungenkreislauf tankt das Blut Sauerstoff auf. Der kleine Lungenkreislauf startet immer in der schwächeren Herzhälfte. Diesen Weg nimmt das Blut: Das Blut fließt innerhalb des Herzens vom Vorhof in die Herzkammer. Von dort gelangt es nun in die Lunge. Von der Lunge fließt das Blut in den Vorhof der stärkeren Herzhälfte. In der stärkeren Herzhälfte endet der kleine Lungenkreislauf.

Der kleine Lungenkreislauf



rot = Blut mit viel Sauerstoff

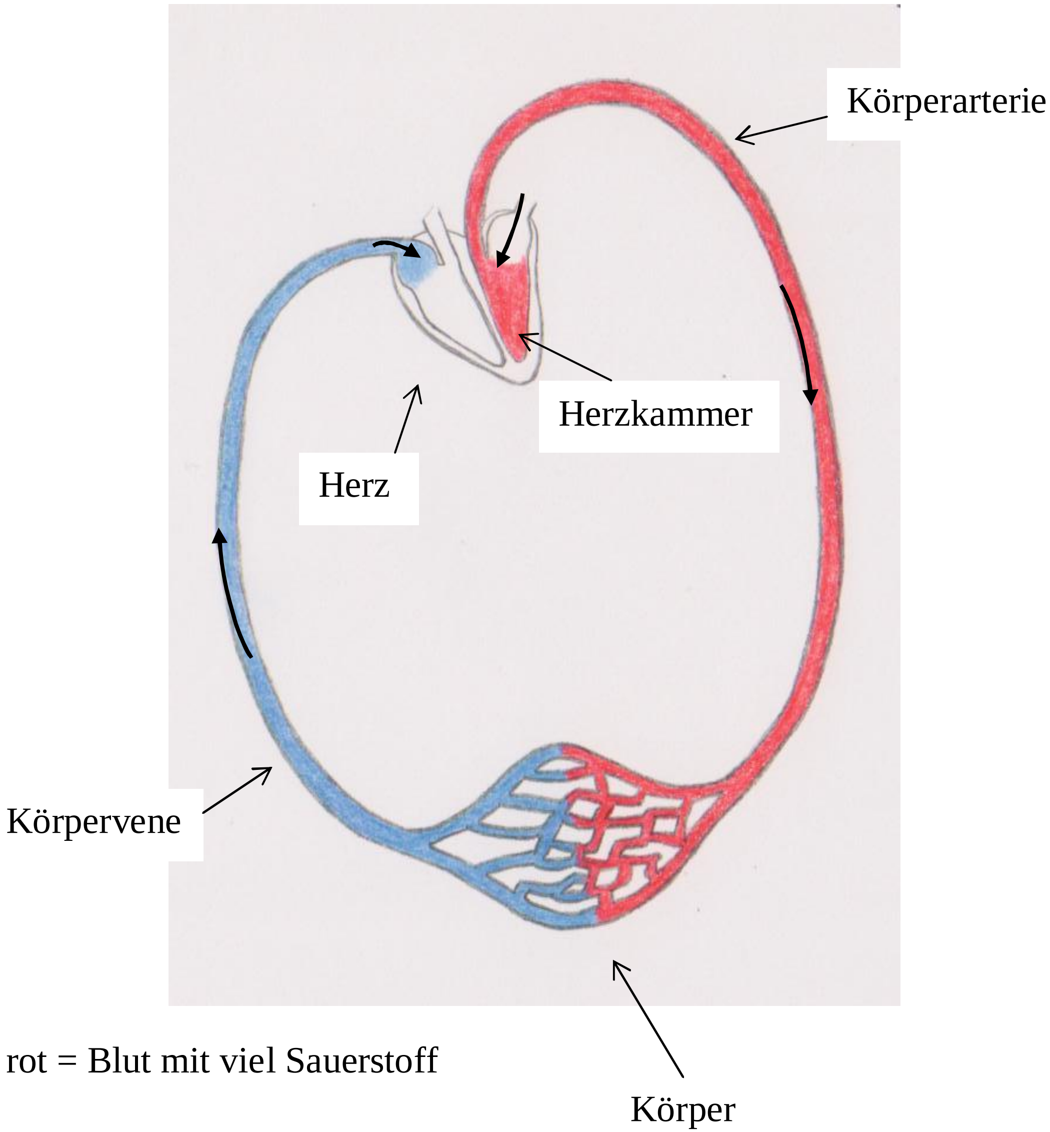
blau = Blut mit wenig Sauerstoff

Seite 5

Der große Körperkreislauf

Der große Körperkreislauf

Im großen Körperkreislauf wird der Sauerstoff überall in deinem Körper verteilt. Der große Körperkreislauf startet immer in der stärkeren Herzhälfte. Diesen Weg nimmt das Blut: Das Blut fließt innerhalb des Herzens vom Vorhof in die Herzkammer. Von dort gelangt es nun in deinen Körper. Wenn das Blut durch deinen Körper geflossen ist, kommt es in den Vorhof der schwächeren Herzhälfte zurück. In der schwächeren Herzhälfte endet der große Körperkreislauf.



rot = Blut mit viel Sauerstoff

blau = Blut mit wenig Sauerstoff

Seite 6

Nun beginnt alles wieder von vorne: Das Blut kommt wieder in den Lungenkreislauf, dann in den Körperkreislauf, dann wieder in den Lungenkreislauf…

Nun weißt du, dass unser Blutkreislauf aus dem kleinen Lungenkreislauf und dem großen Körperkreislauf besteht.

Appendix G

Experiment 1: Learning Unit 2 – "spoken text" condition

The text used in the "written text" condition (Experiment 1: Learning Unit 2 – "written text" condition) was spoken.

Appendix H

Experiment 1: Learning Unit 2 – “spoken text + pictures” condition

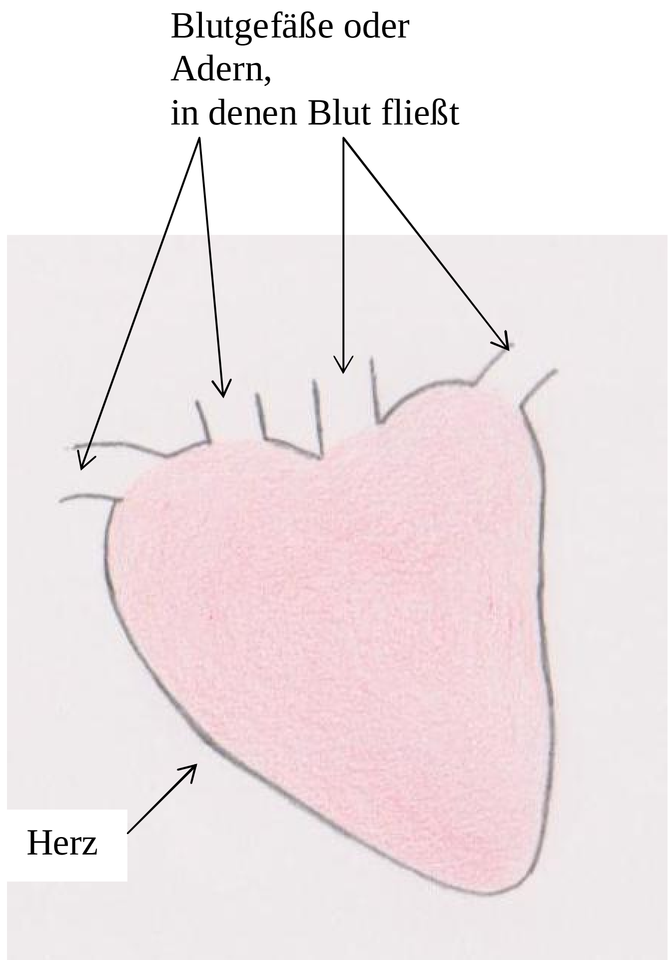
The text used in the “written text + pictures” condition (Experiment 1: Learning Unit 2 – “written text + pictures” condition) was spoken.

Unser Blutkreislauf (2)

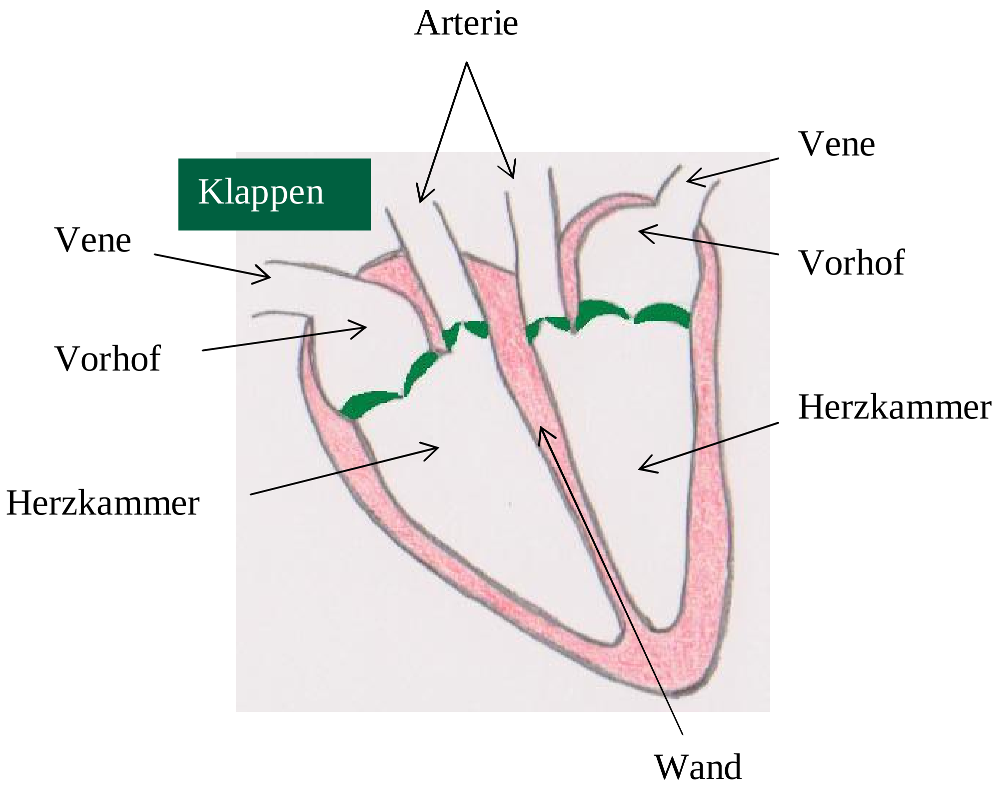
Stopp!

Seite 1

Seite 2

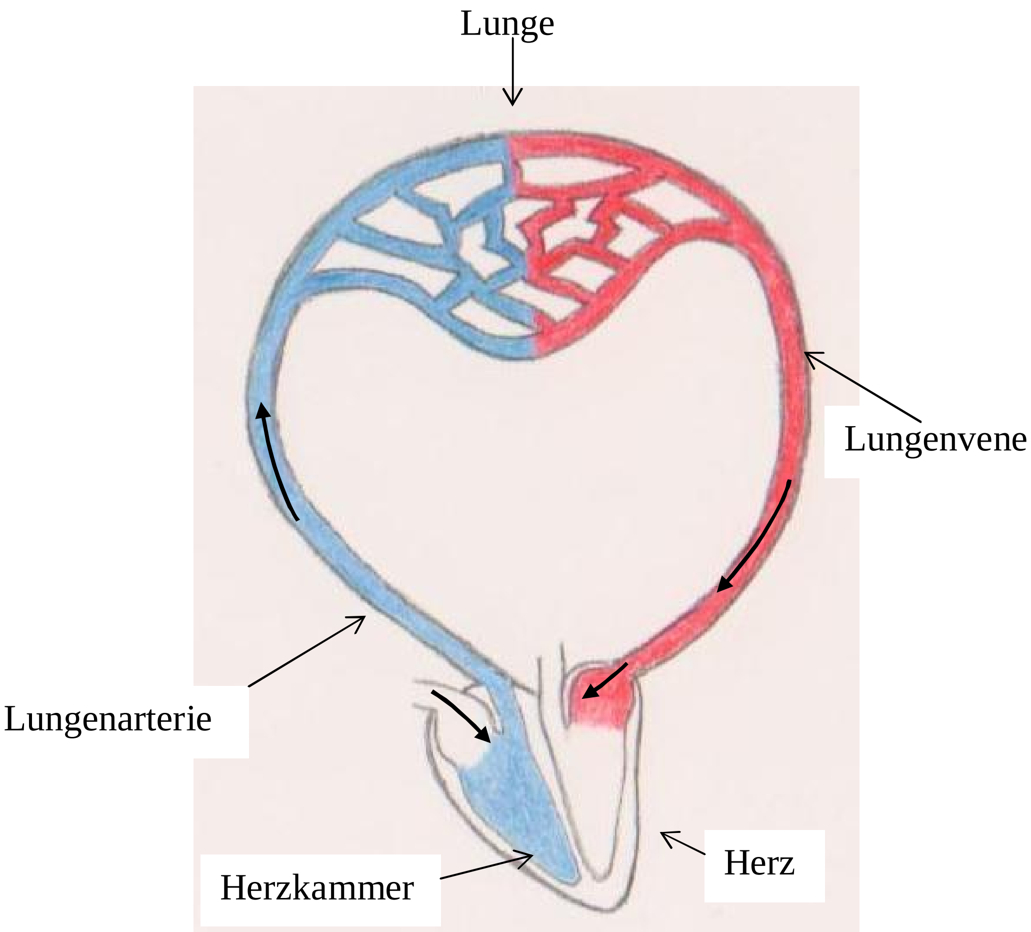


Seite 3


Arterie
Vene
Klappen
Vene
Vorhof
Vorhof
Herzkammer
Herzkammer
Wand

Seite 4

Der kleine Lungenkreislauf

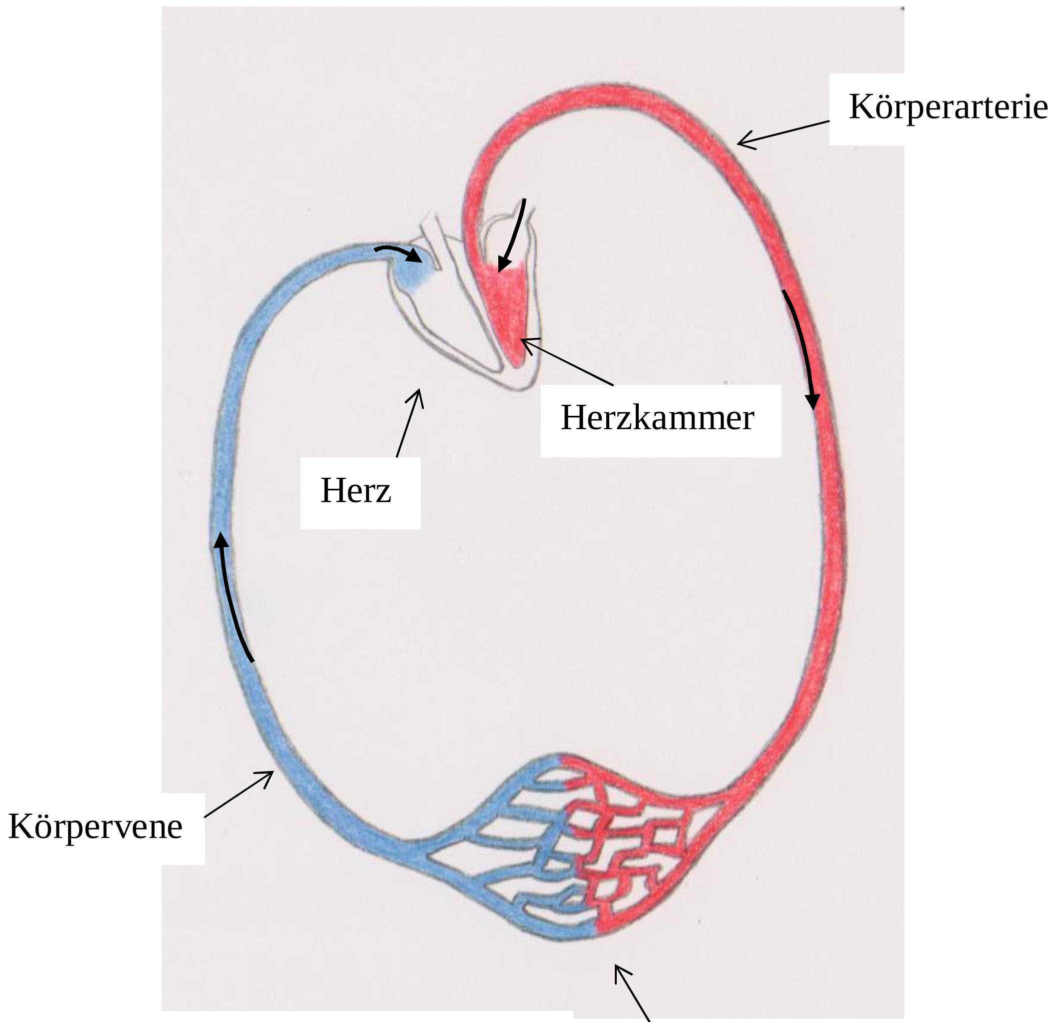


rot = Blut mit viel Sauerstoff

blau = Blut mit wenig Sauerstoff

<u>Seite 5</u>

Der große Körperkreislauf



rot = Blut mit viel Sauerstoff

blau = Blut mit wenig Sauerstoff

Seite 6

Appendix I

Experiment 2: Learning Unit 1 – “written text” condition

Unser Blutkreislauf (1)

Stopp!

Aufgabe 1

Merke dir das Wichtigste vom Text!

Seite 1

Unser Blutkreislauf

Einleitung

Tom jubelt: „Ich bin ein Auto!“ „Unsinn“, ruft Nina, „du bist doch kein Auto!“ Tom grinst: „Doch, irgendwie schon. Ich habe einen Motor!“

Jedes Auto braucht einen Motor, um fahren zu können. Jeder Mensch braucht das Herz, um leben zu können. Das Herz ist unser Motor.

STOPP!

Aufgabe 2

Merke dir das Wichtigste vom Text!

Seite 2

Das Herz

Das Herz, dein Motor, ist ungefähr so groß wie deine Faust. Das Herz pumpt das Blut bis in die kleinsten Teile deines Körpers. Das ist deshalb so wichtig, weil im Blut viele Stoffe sind, die dein Körper an allen Stellen braucht. Das Blut fließt in kleinen Rohren, die wir Blutgefäße oder Adern nennen. Wichtig ist, dass das Blut innerhalb der Adern immer in die gleiche Richtung fließt. Bei den Adern gibt es die Arterien und die Venen. Arterien führen vom Herz weg. Venen führen zum Herz hin. Die Adern sind unterschiedlich dünn. Sie sind überall in deinem Körper, wie ein Netz. Wenn du deine Hand auf den Tisch legst und dir deinen Handrücken anschaust, siehst du deine Adern grün schimmern.

STOPP!

Aufgabe 3

Merke dir das Wichtigste vom Text!

Seite 3

Der Blutkreislauf

Jetzt geht’s los. Du weißt, dass das Herz Blut durch deinen Körper pumpt. Dabei pumpt das Herz das Blut immer zuerst in die Lunge und dann in den Körper.

Aber warum kommt das Blut zuerst in die Lunge?

Du atmest, damit Sauerstoff in deine Lunge kommt. Sauerstoff ist wichtig, damit dein Körper richtig arbeiten kann. Um den Sauerstoff auftanken zu können, muss das Blut nun zuerst zur Lunge fließen. Der Weg des Blutes in die Lunge heißt kleiner Lungenkreislauf.

STOPP!

<u>Aufgabe 4</u>

Merke dir das Wichtigste vom Text!

Seite 4

<u>Und wie kommt der Sauerstoff in deinen ganzen Körper?</u>

Nach dem Lungenkreislauf fließt das Blut nun voll beladen mit Sauerstoff in deinen Körper. Das Blut gibt den Sauerstoff nach und nach an deinen Körper ab. So kommt der Sauerstoff überall dort hin, wo dein Körper ihn braucht. Dieser Weg des Blutes durch den Körper heißt großer Körperkreislauf.

STOPP!

Aufgabe 5

Merke dir das Wichtigste vom Text!

Seite 5

Wenn das Blut den Sauerstoff abgegeben hat, fließt es wieder in den kleinen Lungenkreislauf. Nun beginnt alles wieder von vorne: Im Lungenkreislauf tankt das Blut Sauerstoff auf. Dann kommt es wieder in den großen Körperkreislauf und verteilt den Sauerstoff. Dann kommt es wieder in den Lungenkreislauf, dann wieder in den Körperkreislauf…

Blut mit viel Sauerstoff wird rot gemalt. Blut mit wenig Sauerstoff wird blau gemalt.

Das Wort Kreislauf meint also, dass dein Blut wie im Kreis vom Herz weggepumpt wird und zum Herz zurück fließt. Der kleine Lungenkreislauf und der große Körperkreislauf bilden zusammen unseren Blutkreislauf.

STOPP!

Appendix J

Experiment 2: Learning Unit 1 – “written text + pictures” condition

Unser Blutkreislauf (1)

Stopp!

Aufgabe 1

Merke dir das Wichtigste vom Text!

Seite 1

Unser Blutkreislauf

Einleitung

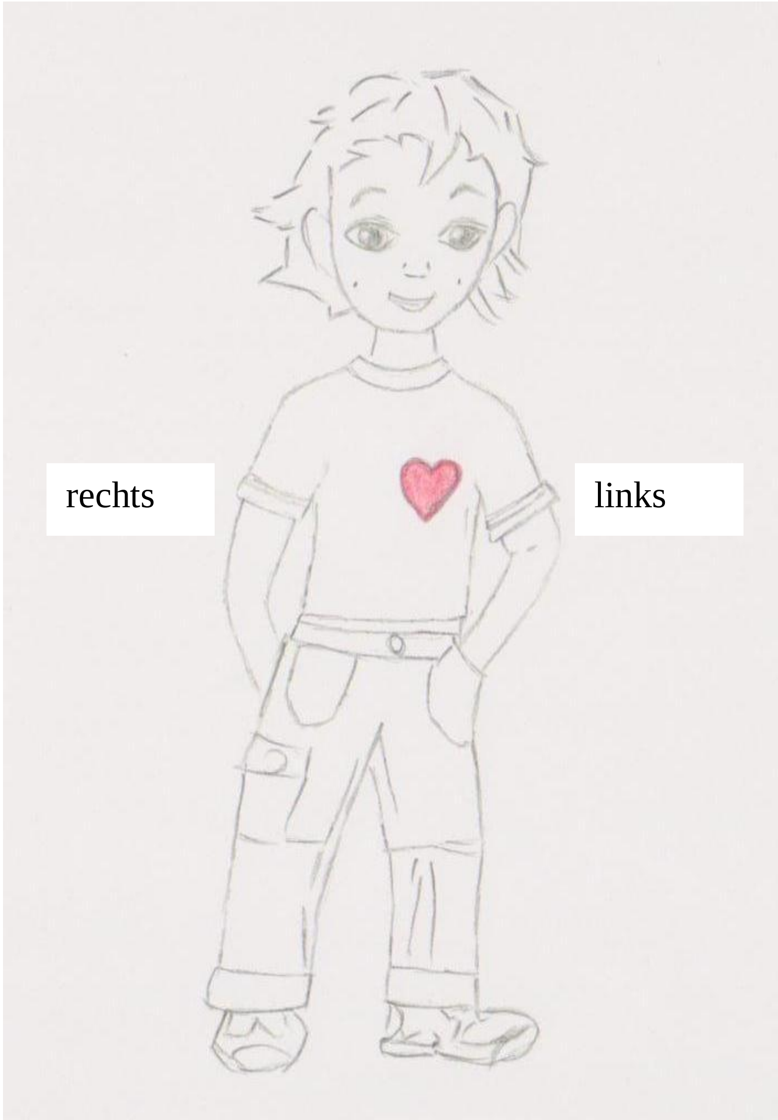
Tom jubelt: „Ich bin ein Auto!“ „Unsinn“, ruft Nina, „du bist doch kein Auto!“ Tom grinst: „Doch, irgendwie schon. Ich habe einen Motor!“

Jedes Auto braucht einen Motor, um fahren zu können. Jeder Mensch braucht das Herz, um leben zu können. Das Herz ist unser Motor.

STOPP!

Aufgabe 2

Merke dir das Wichtigste vom Bild!



STOPP!

Aufgabe 3

Findest du Sachen, die im Text und im Bild vorkommen? Blättere auf die nächste Seite und suche danach.

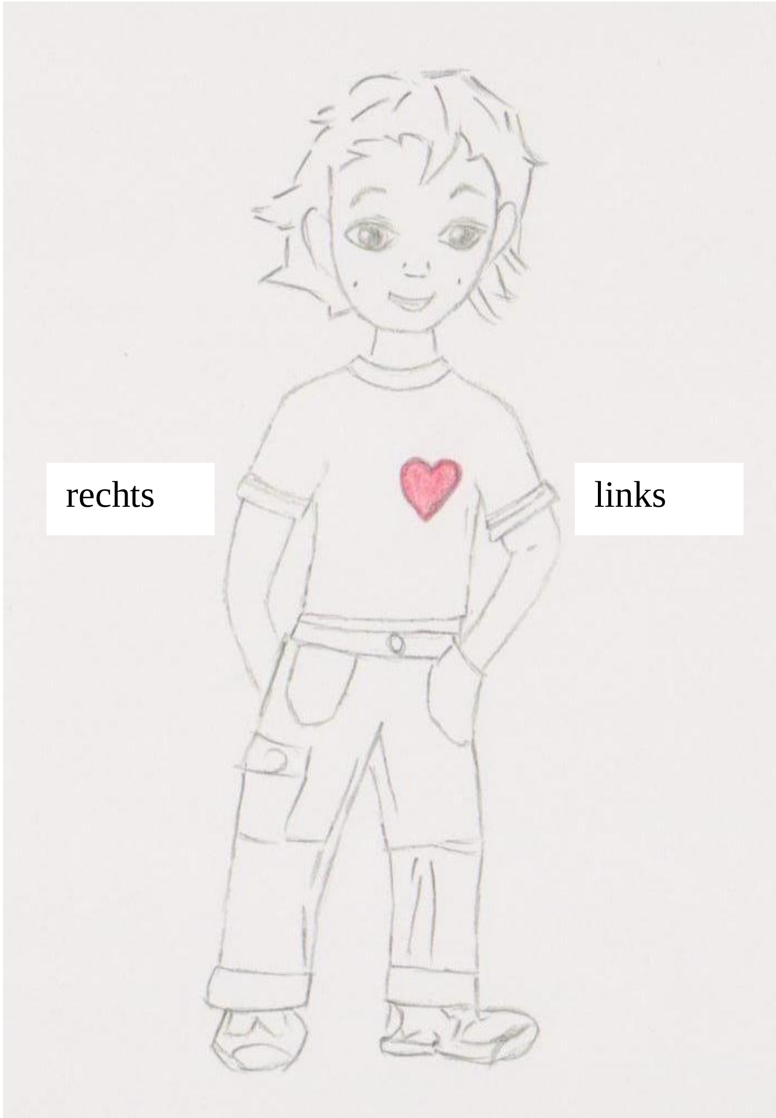
Seite 1

Unser Blutkreislauf

Einleitung

Tom jubelt: „Ich bin ein Auto!“ „Unsinn“, ruft Nina, „du bist doch kein Auto!“ Tom grinst: „Doch, irgendwie schon. Ich habe einen Motor!“

Jedes Auto braucht einen Motor, um fahren zu können. Jeder Mensch braucht das Herz, um leben zu können. Das Herz ist unser Motor.



STOPP!

Aufgabe 4

Merke dir das Wichtigste vom Text!

Seite 2

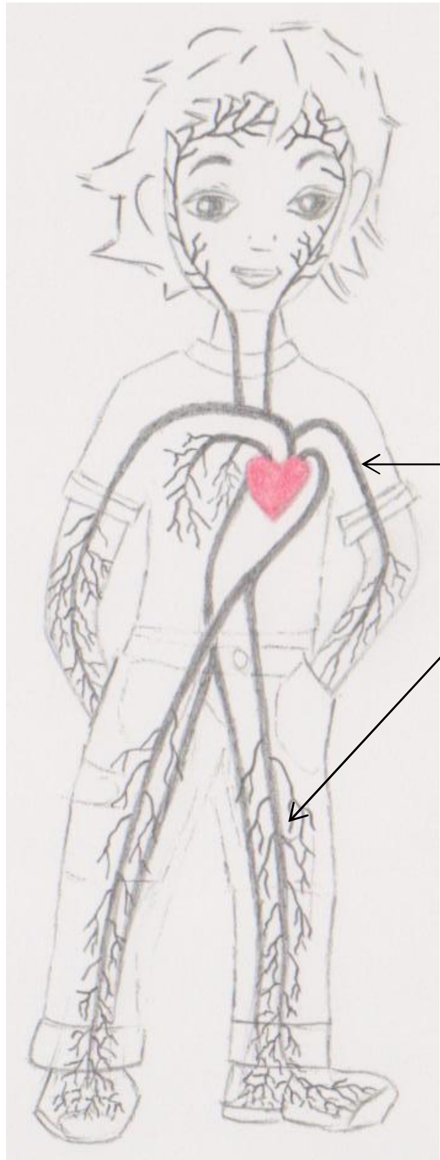
Das Herz

Das Herz, dein Motor, ist ungefähr so groß wie deine Faust. Das Herz pumpt das Blut bis in die kleinsten Teile deines Körpers. Das ist deshalb so wichtig, weil im Blut viele Stoffe sind, die dein Körper an allen Stellen braucht. Das Blut fließt in kleinen Rohren, die wir Blutgefäße oder Adern nennen. Wichtig ist, dass das Blut innerhalb der Adern immer in die gleiche Richtung fließt. Bei den Adern gibt es die Arterien und die Venen. Arterien führen vom Herz weg. Venen führen zum Herz hin. Die Adern sind unterschiedlich dünn. Sie sind überall in deinem Körper, wie ein Netz. Wenn du deine Hand auf den Tisch legst und dir deinen Handrücken anschaust, siehst du deine Adern grün schimmern.

STOPP!

Aufgabe 5

Merke dir das Wichtigste vom Bild!



Blutgefäße oder
Adern,
in denen Blut fließt

STOPP!

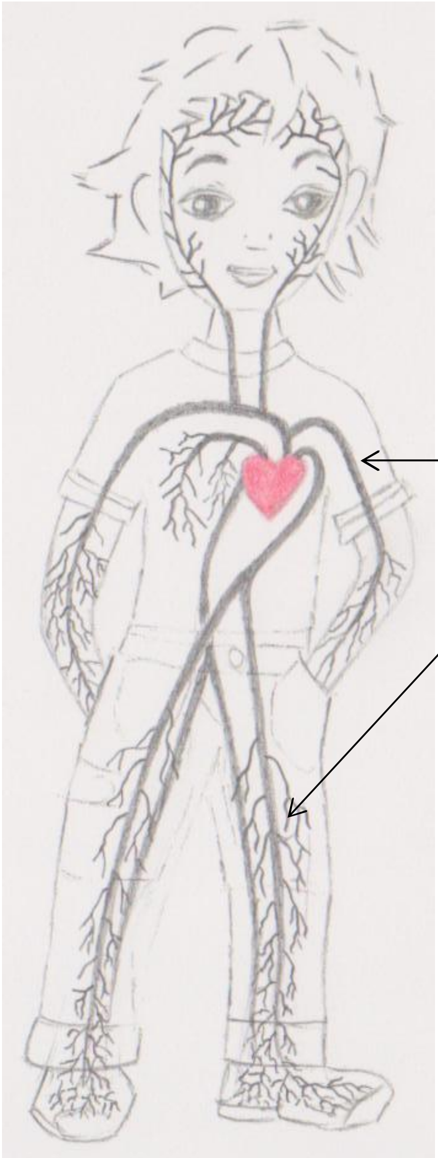
Aufgabe 6

Findest du Sachen, die im Text und im Bild vorkommen? Blättere auf die nächste Seite und suche danach.

Seite 2

Das Herz

Das Herz, dein Motor, ist ungefähr so groß wie deine Faust. Das Herz pumpt das Blut bis in die kleinsten Teile deines Körpers. Das ist deshalb so wichtig, weil im Blut viele Stoffe sind, die dein Körper an allen Stellen braucht. Das Blut fließt in kleinen Rohren, die wir Blutgefäße oder Adern nennen. Wichtig ist, dass das Blut innerhalb der Adern immer in die gleiche Richtung fließt. Bei den Adern gibt es die Arterien und die Venen. Arterien führen vom Herz weg. Venen führen zum Herz hin. Die Adern sind unterschiedlich dünn. Sie sind überall in deinem Körper, wie ein Netz. Wenn du deine Hand auf den Tisch legst und dir deinen Handrücken anschaust, siehst du deine Adern grün schimmern.



Blutgefäße oder
Adern,
in denen Blut fließt

STOPP!

Aufgabe 7

Merke dir das Wichtigste vom Text!

Seite 3

Der Blutkreislauf

Jetzt geht’s los. Du weißt, dass das Herz Blut durch deinen Körper pumpt. Dabei pumpt das Herz das Blut immer zuerst in die Lunge und dann in den Körper.

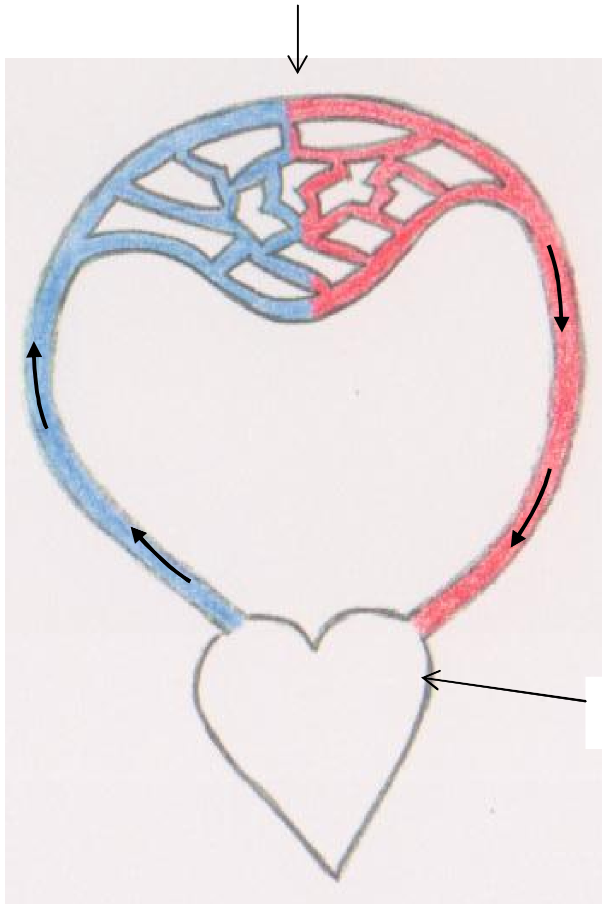
Aber warum kommt das Blut zuerst in die Lunge?

Du atmest, damit Sauerstoff in deine Lunge kommt. Sauerstoff ist wichtig, damit dein Körper richtig arbeiten kann. Um den Sauerstoff auftanken zu können, muss das Blut nun zuerst zur Lunge fließen. Der Weg des Blutes in die Lunge heißt kleiner Lungenkreislauf.

STOPP!

Aufgabe 8

Merke dir das Wichtigste vom Bild!



rot = Blut mit viel Sauerstoff

blau = Blut mit wenig Sauerstoff

STOPP!

Aufgabe 9

Findest du Sachen, die im Text und im Bild vorkommen? Blättere auf die nächste Seite und suche danach.

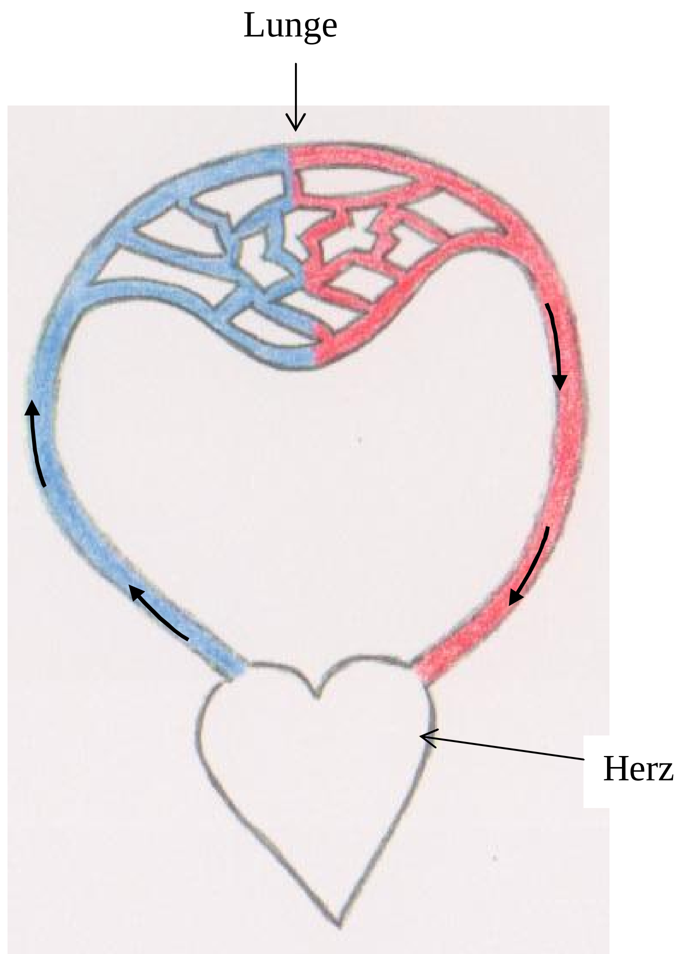
Seite 3

Der Blutkreislauf

Jetzt geht's los. Du weißt, dass das Herz Blut durch deinen Körper pumpt. Dabei pumpt das Herz das Blut immer zuerst in die Lunge und dann in den Körper.

<u>Aber warum kommt das Blut zuerst in die Lunge?</u>

Du atmest, damit Sauerstoff in deine Lunge kommt. Sauerstoff ist wichtig, damit dein Körper richtig arbeiten kann. Um den Sauerstoff auftanken zu können, muss das Blut nun zuerst zur Lunge fließen. Der Weg des Blutes in die Lunge heißt kleiner Lungenkreislauf.



rot = Blut mit viel Sauerstoff

blau = Blut mit wenig Sauerstoff

STOPP!

Aufgabe 10

Merke dir das Wichtigste vom Text!

Seite 4

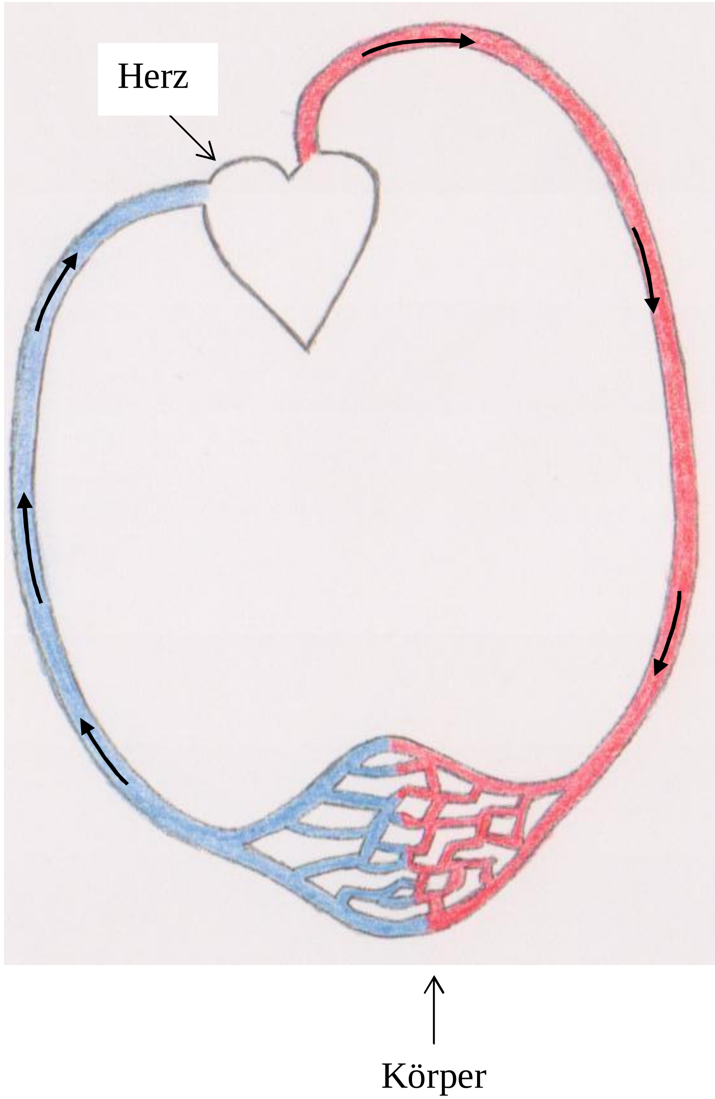
Und wie kommt der Sauerstoff in deinen ganzen Körper?

Nach dem Lungenkreislauf fließt das Blut nun voll beladen mit Sauerstoff in deinen Körper. Das Blut gibt den Sauerstoff nach und nach an deinen Körper ab. So kommt der Sauerstoff überall dort hin, wo dein Körper ihn braucht. Dieser Weg des Blutes durch den Körper heißt großer Körperkreislauf.

STOPP!

Aufgabe 11

Merke dir das Wichtigste vom Bild!



rot = Blut mit viel Sauerstoff

blau = Blut mit wenig Sauerstoff

STOPP!

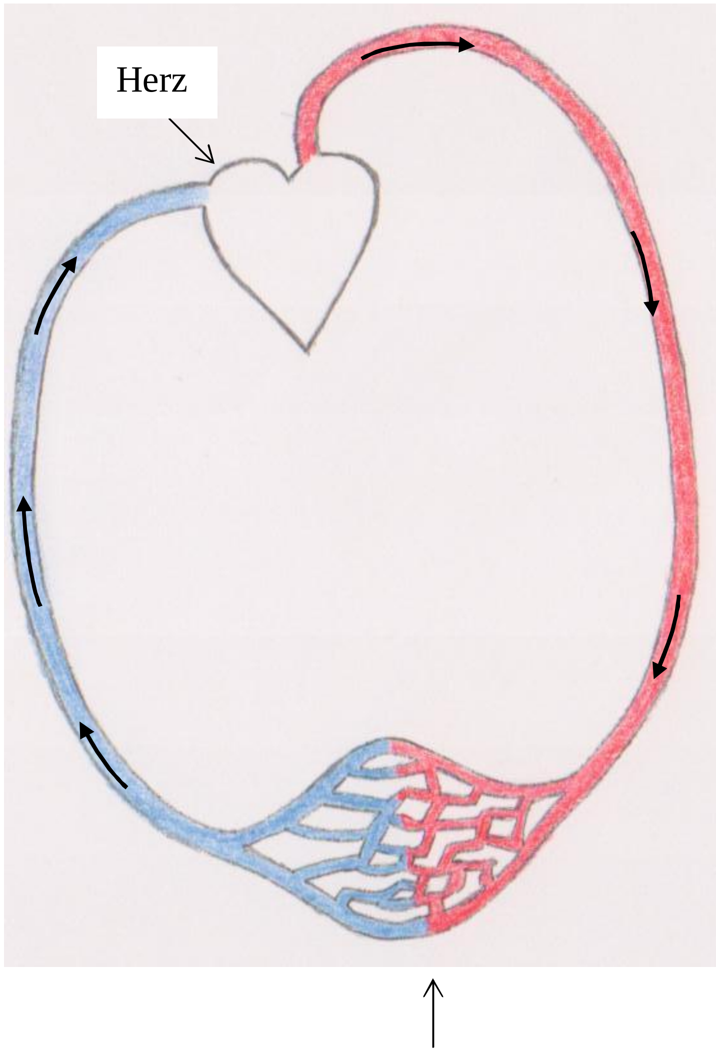
Aufgabe 12

Findest du Sachen, die im Text und im Bild vorkommen? Blättere auf die nächste Seite und suche danach.

Seite 4

Und wie kommt der Sauerstoff in deinen ganzen Körper?

Nach dem Lungenkreislauf fließt das Blut nun voll beladen mit Sauerstoff in deinen Körper. Das Blut gibt den Sauerstoff nach und nach an deinen Körper ab. So kommt der Sauerstoff überall dort hin, wo dein Körper ihn braucht. Dieser Weg des Blutes durch den Körper heißt großer Körperkreislauf.



Körper

rot = Blut mit viel Sauerstoff

blau = Blut mit wenig Sauerstoff

STOPP!

Aufgabe 13

Merke dir das Wichtigste vom Text!

Seite 5

Wenn das Blut den Sauerstoff abgegeben hat, fließt es wieder in den kleinen Lungenkreislauf. Nun beginnt alles wieder von vorne: Im Lungenkreislauf tankt das Blut Sauerstoff auf. Dann kommt es wieder in den großen Körperkreislauf und verteilt den Sauerstoff. Dann kommt es wieder in den Lungenkreislauf, dann wieder in den Körperkreislauf…

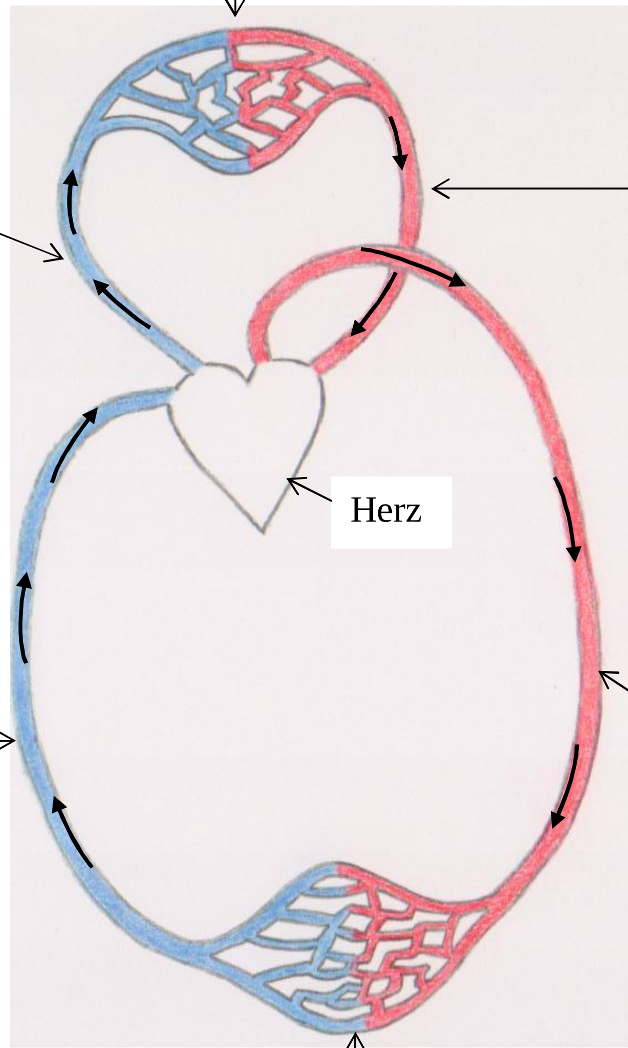
Blut mit viel Sauerstoff wird rot gemalt. Blut mit wenig Sauerstoff wird blau gemalt.

Das Wort Kreislauf meint also, dass dein Blut wie im Kreis vom Herz weggepumpt wird und zum Herz zurück fließt. Der kleine Lungenkreislauf und der große Körperkreislauf bilden zusammen unseren Blutkreislauf.

STOPP!

Aufgabe 14

Merke dir das Wichtigste vom Bild!



rot und blau = Blut

STOPP!

Aufgabe 15

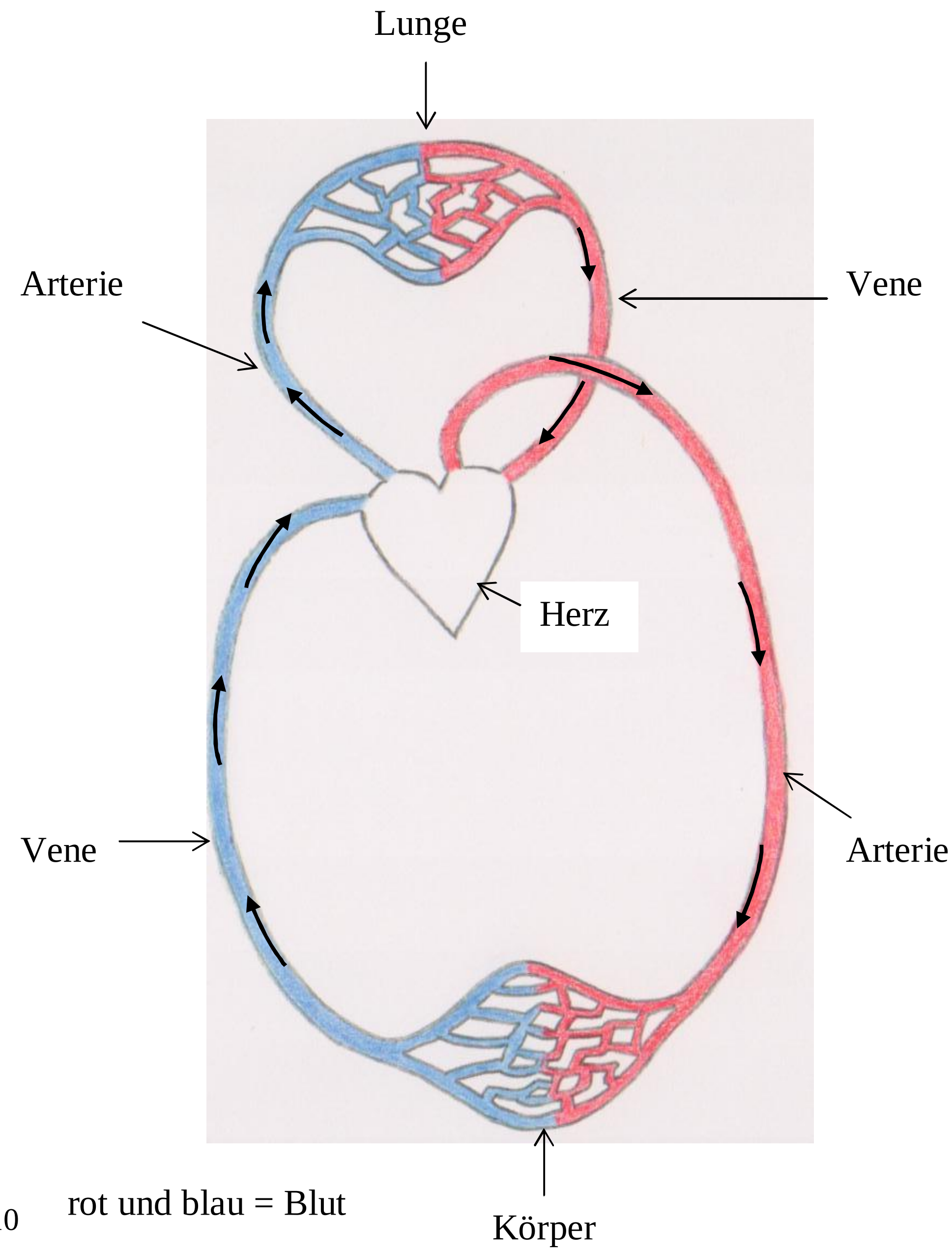
Findest du Sachen, die im Text und im Bild vorkommen? Blättere auf die nächste Seite und suche danach.

Seite 5

Wenn das Blut den Sauerstoff abgegeben hat, fließt es wieder in den kleinen Lungenkreislauf. Nun beginnt alles wieder von vorne: Im Lungenkreislauf tankt das Blut Sauerstoff auf. Dann kommt es wieder in den großen Körperkreislauf und verteilt den Sauerstoff. Dann kommt es wieder in den Lungenkreislauf, dann wieder in den Körperkreislauf…

Blut mit viel Sauerstoff wird rot gemalt. Blut mit wenig Sauerstoff wird blau gemalt.

Das Wort Kreislauf meint also, dass dein Blut wie im Kreis vom Herz weggepumpt wird und zum Herz zurück fließt. Der kleine Lungenkreislauf und der große Körperkreislauf bilden zusammen unseren Blutkreislauf.



STOPP!

Appendix K

Experiment 2: Learning Unit 1 – “written text + pictures + selection/organization aids” condition

Unser Blutkreislauf (1)

Stopp!

Aufgabe 1

Merke dir das Wichtigste vom Text

Seite 1

Unser Blutkreislauf

Einleitung

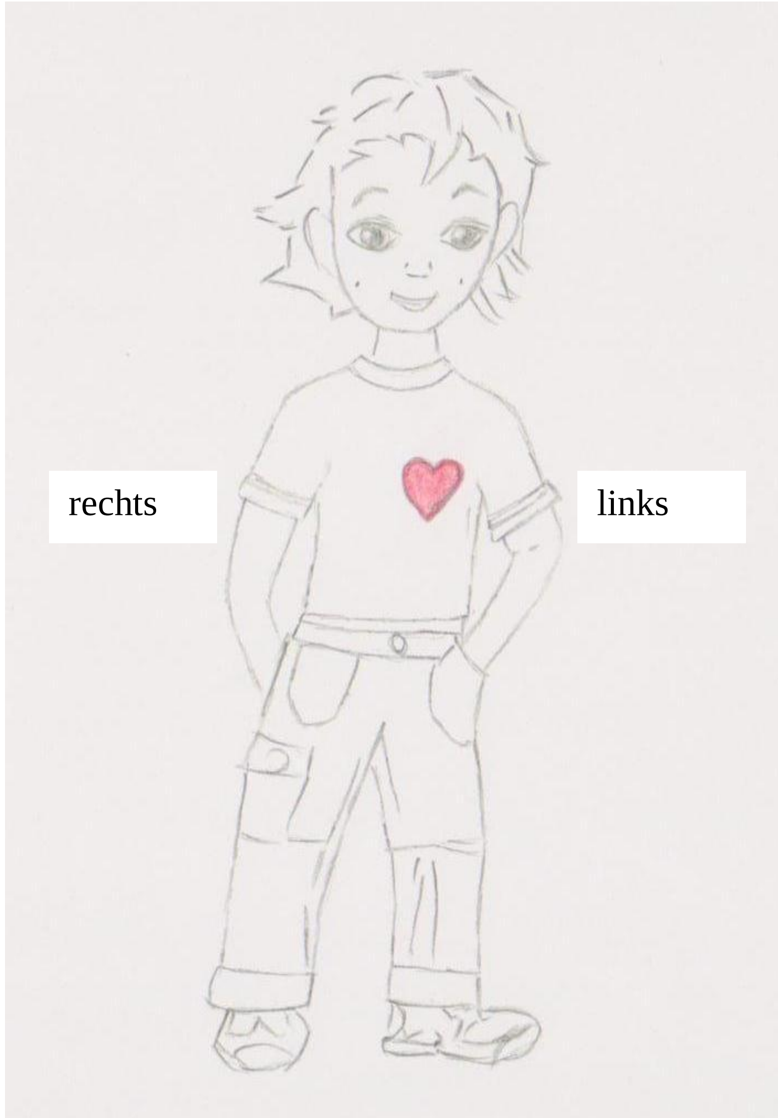
Tom jubelt: „Ich bin ein Auto!“ „Unsinn“, ruft Nina, „du bist doch kein Auto!“ Tom grinst: „Doch, irgendwie schon. Ich habe einen Motor!“

Jedes Auto braucht einen Motor, um fahren zu können. Jeder Mensch braucht das Herz, um leben zu können. Das Herz ist unser Motor.

STOPP!

Aufgabe 2

Merke dir das Wichtigste vom Bild!



STOPP!

Aufgabe 3

Findest du Sachen, die im Text und im Bild vorkommen? Blättere auf die nächste Seite und suche danach.

Seite 1

Unser Blutkreislauf

Einleitung

Tom jubelt: „Ich bin ein Auto!“ „Unsinn“, ruft Nina, „du bist doch kein Auto!“ Tom grinst: „Doch, irgendwie schon. Ich habe einen Motor!“

Jedes Auto braucht einen Motor, um fahren zu können. Jeder Mensch braucht das Herz, um leben zu können. Das Herz ist unser Motor.

STOPP!

Aufgabe 4

Merke dir das Wichtigste vom Text!

Aufgabe 5

Kreise das richtige Wort ein!

Im Blut sind viele Stoffe, die dein Körper an vielen / allen Stellen braucht.

Aufgabe 6

Ergänze den folgenden Satz!

Das Blut fließt innerhalb der Adern immer in ____.

Seite 2

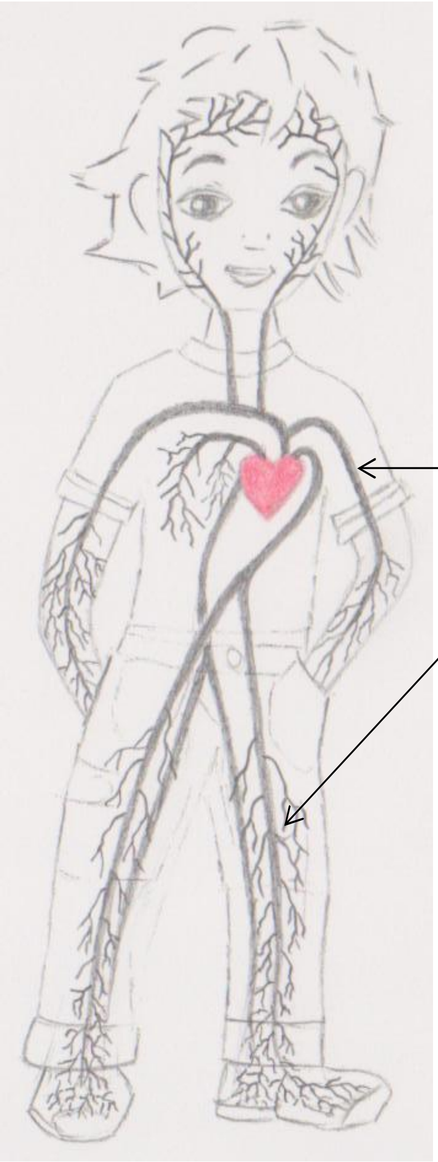
Das Herz

Das Herz, dein Motor, ist ungefähr so groß wie deine Faust. Das Herz pumpt das Blut bis in die kleinsten Teile deines Körpers. Das ist deshalb so wichtig, weil im Blut viele Stoffe sind, die dein Körper an allen Stellen braucht. Das Blut fließt in kleinen Rohren, die wir Blutgefäße oder Adern nennen. Wichtig ist, dass das Blut innerhalb der Adern immer in die gleiche Richtung fließt. Bei den Adern gibt es die Arterien und die Venen. Arterien führen vom Herz weg. Venen führen zum Herz hin. Die Adern sind unterschiedlich dünn. Sie sind überall in deinem Körper, wie ein Netz. Wenn du deine Hand auf den Tisch legst und dir deinen Handrücken anschaust, siehst du deine Adern grün schimmern.

STOPP!

Aufgabe 7

Merke dir das Wichtigste vom Bild!



Blutgefäße oder
Adern,
in denen Blut fließt

STOPP!

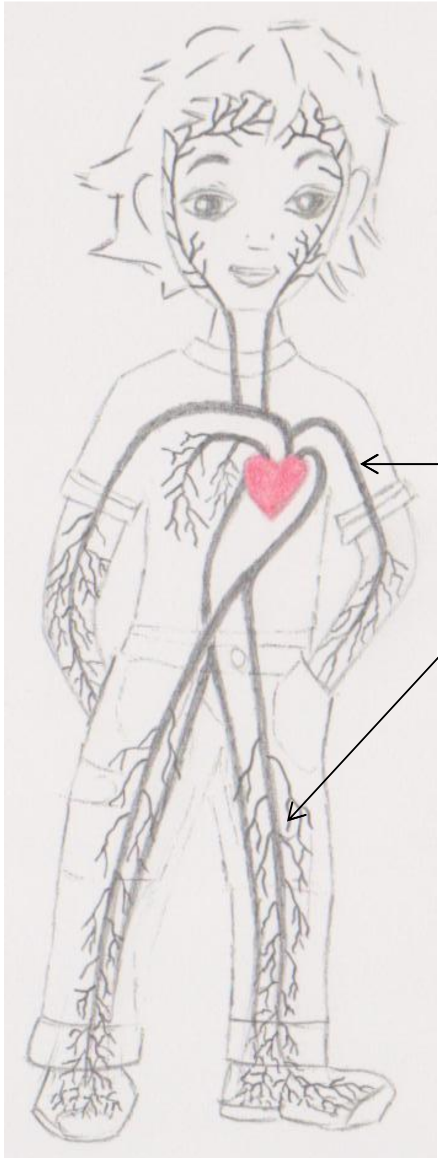
Aufgabe 8

Findest du Sachen, die im Text und im Bild vorkommen? Blättere auf die nächste Seite und suche danach.

Seite 2

Das Herz

Das Herz, dein Motor, ist ungefähr so groß wie deine Faust. Das Herz pumpt das Blut bis in die kleinsten Teile deines Körpers. Das ist deshalb so wichtig, weil im Blut viele Stoffe sind, die dein Körper an allen Stellen braucht. Das Blut fließt in kleinen Rohren, die wir Blutgefäße oder Adern nennen. Wichtig ist, dass das Blut innerhalb der Adern immer in die gleiche Richtung fließt. Bei den Adern gibt es die Arterien und die Venen. Arterien führen vom Herz weg. Venen führen zum Herz hin. Die Adern sind unterschiedlich dünn. Sie sind überall in deinem Körper, wie ein Netz. Wenn du deine Hand auf den Tisch legst und dir deinen Handrücken anschaust, siehst du deine Adern grün schimmern.



Blutgefäße oder Adern,
in denen Blut fließt

STOPP!

Aufgabe 9

Merke dir das Wichtigste vom Text!

Aufgabe 10

Schreibe die zwei richtigen Wörter in die Lücken!

Der Weg des Blutes in die Lunge heißt _____________ _______________________.

Seite 3

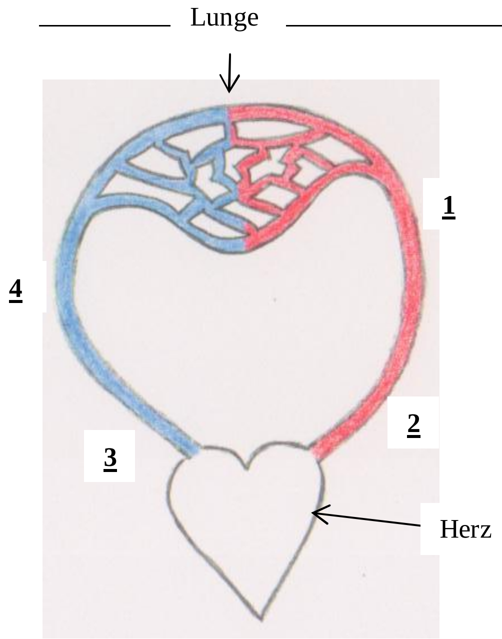
Der Blutkreislauf

Jetzt geht's los. Du weißt, dass das Herz Blut durch deinen Körper pumpt. Dabei pumpt das Herz das Blut immer zuerst in die Lunge und dann in den Körper.

Aber warum kommt das Blut zuerst in die Lunge?

Du atmest, damit Sauerstoff in deine Lunge kommt. Sauerstoff ist wichtig, damit dein Körper richtig arbeiten kann. Um den Sauerstoff auftanken zu können, muss das Blut nun zuerst zur Lunge fließen. Der Weg des Blutes in die Lunge heißt kleiner Lungenkreislauf.

STOPP!

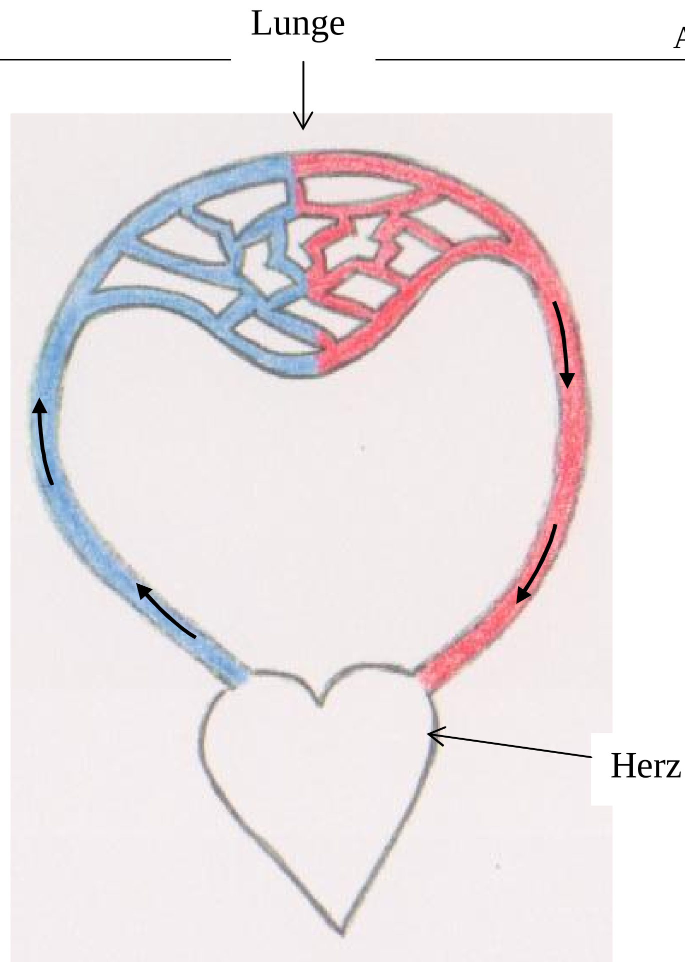


rot = Blut mit viel Sauerstoff

blau = Blut mit wenig Sauerstoff

Aufgabe 11

Zeichne die vier Pfeile bei den Zahlen 1, 2, 3 und 4 ein. Vergleiche deine Pfeile mit den schwarzen Pfeilen im großen Bild. Lege nun deinen Finger auf den ersten Pfeil und fahre den Weg der Pfeile mit deinem Finger nach. Merke dir, dass die Pfeile im **Lungenkreislauf** im **Uhrzeigersinn** laufen!



rot = Blut mit viel Sauerstoff

blau = Blut mit wenig Sauerstoff

Aufgabe 12

Merke dir das Wichtigste vom großen Bild!

STOPP!

Aufgabe 13

Findest du Sachen, die im Text und im Bild vorkommen? Blättere auf die nächste Seite und suche danach.

<u>Seite 3</u>

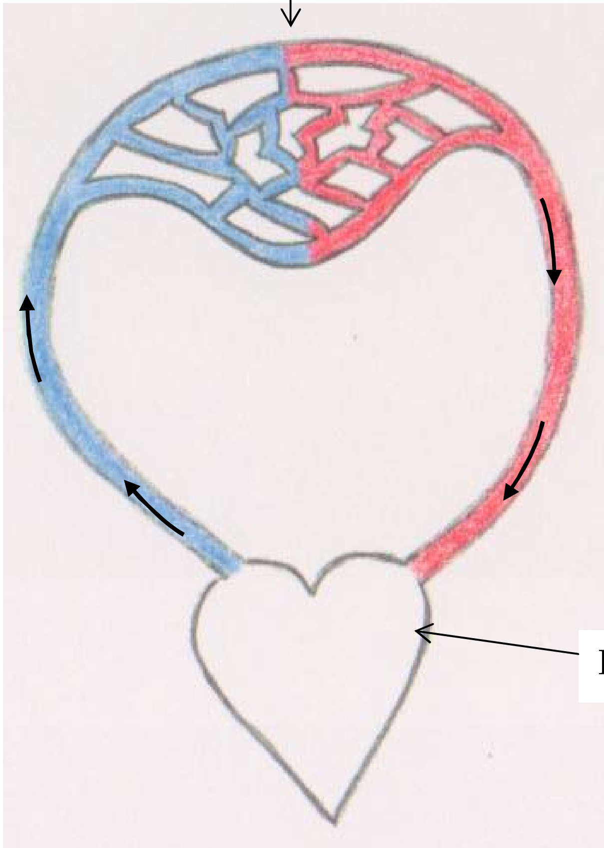
<u>Der Blutkreislauf</u>

Jetzt geht's los. Du weißt, dass das Herz Blut durch deinen Körper pumpt. Dabei pumpt das Herz das Blut immer zuerst in die Lunge und dann in den Körper.

<u>Aber warum kommt das Blut zuerst in die Lunge?</u>

Du atmest, damit Sauerstoff in deine Lunge kommt. Sauerstoff ist wichtig, damit dein Körper richtig arbeiten kann. Um den Sauerstoff auftanken zu können, muss das Blut nun zuerst zur Lunge fließen. Der Weg des Blutes in die Lunge heißt kleiner Lungenkreislauf.

Lunge



Herz

rot = Blut mit viel Sauerstoff

blau = Blut mit wenig Sauerstoff

STOPP!

Aufgabe 14

Merke dir das Wichtigste vom Text!

Aufgabe 15

Merke dir besonders die fett geschriebenen Wörter im folgenden Satz!

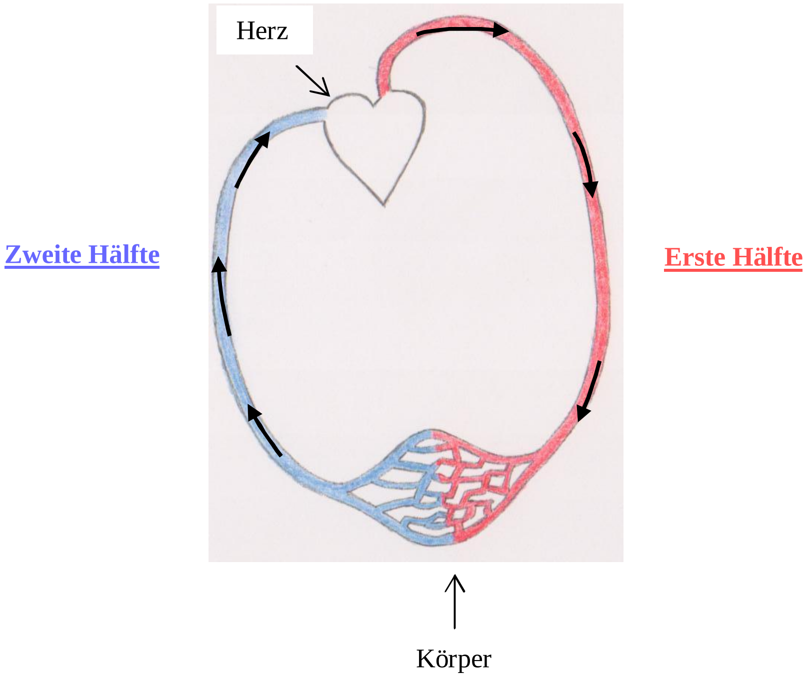
Der Weg des Blutes durch den Körper heißt **großer Körperkreislauf**.

Seite 4

Und wie kommt der Sauerstoff in deinen ganzen Körper?

Nach dem Lungenkreislauf fließt das Blut nun voll beladen mit Sauerstoff in deinen Körper. Das Blut gibt den Sauerstoff nach und nach an deinen Körper ab. So kommt der Sauerstoff überall dort hin, wo dein Körper ihn braucht. Dieser Weg des Blutes durch den Körper heißt großer Körperkreislauf.

STOPP!



rot = Blut mit viel Sauerstoff

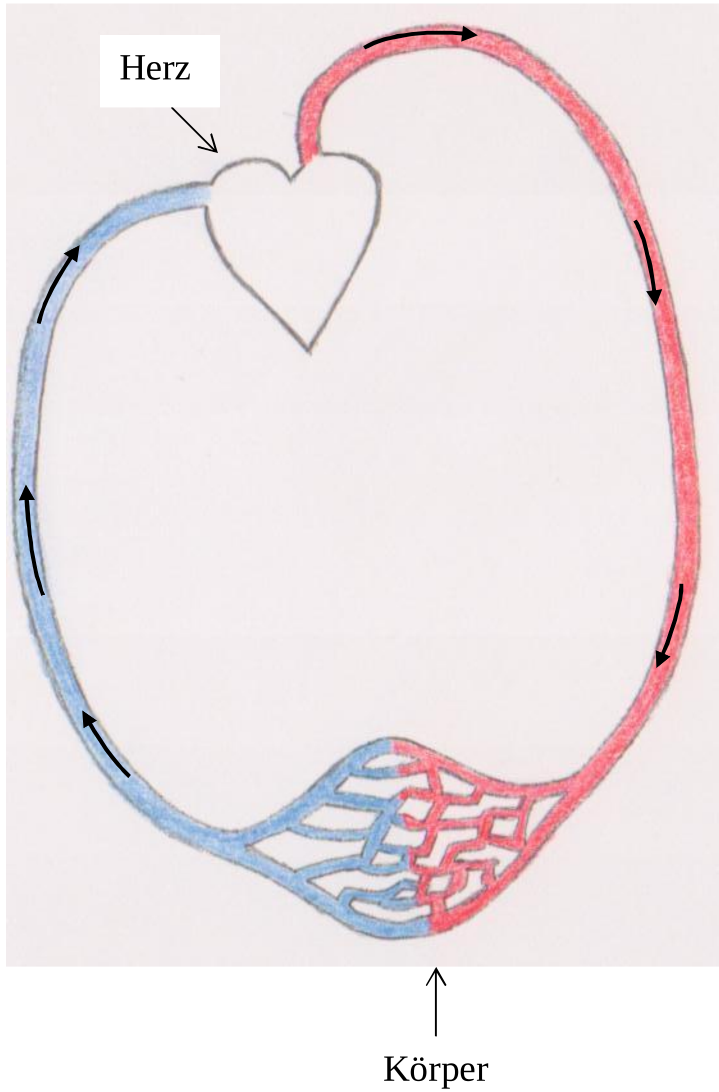
blau = Blut mit wenig Sauerstoff

Aufgabe 16

Wir haben gesehen, dass die Pfeile in den Kreisläufen immer im Uhrzeigersinn laufen. Schaue dir das obere Bild an! Im **Körperkreislauf** wird die erste Hälfte rot gemalt. Die zweite Hälfte wird blau gemalt. Merke dir das gut!

Aufgabe 17

Merke dir das Wichtigste vom großen Bild!



rot = Blut mit viel Sauerstoff

blau = Blut mit wenig Sauerstoff

STOPP!

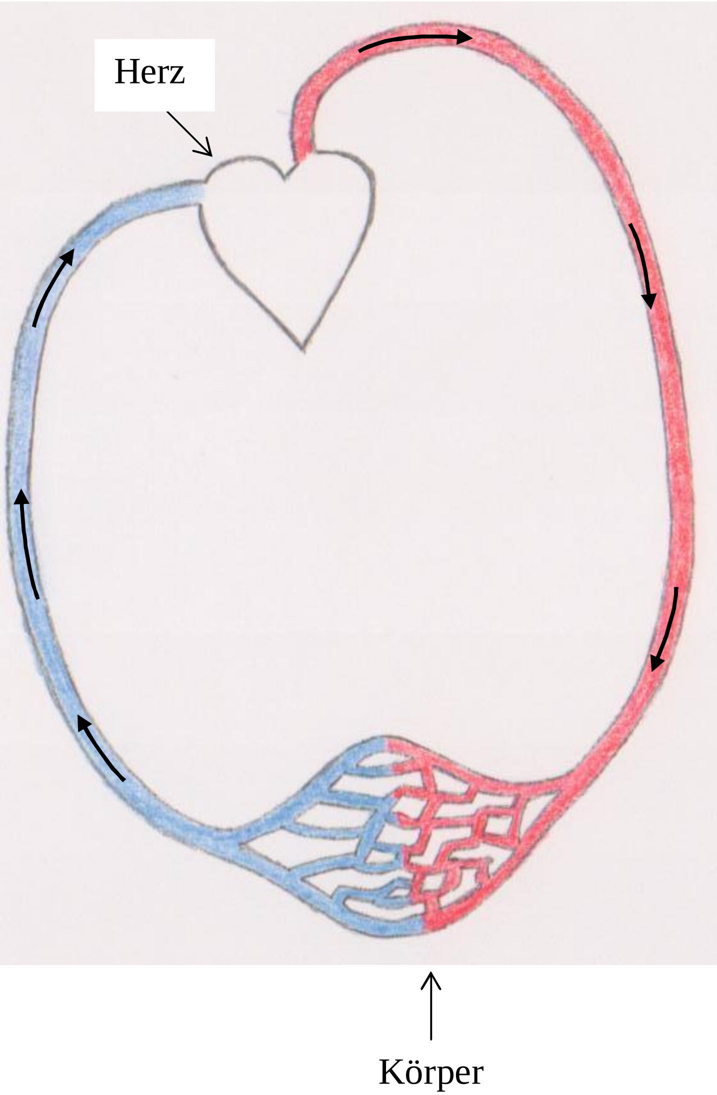
Aufgabe 18

Findest du Sachen, die im Text und im Bild vorkommen? Blättere auf die nächste Seite und suche danach.

Seite 4

Und wie kommt der Sauerstoff in deinen ganzen Körper?

Nach dem Lungenkreislauf fließt das Blut nun voll beladen mit Sauerstoff in deinen Körper. Das Blut gibt den Sauerstoff nach und nach an deinen Körper ab. So kommt der Sauerstoff überall dort hin, wo dein Körper ihn braucht. Dieser Weg des Blutes durch den Körper heißt großer Körperkreislauf.



rot = Blut mit viel Sauerstoff

blau = Blut mit wenig Sauerstoff

STOPP!

Aufgabe 19

Merke dir das Wichtigste vom Text!

Aufgabe 20

Schreibe das richtige Wie-Wort beim Lungenkreislauf und beim Körperkreislauf hin!

Wie-Wörter: großer, schwacher, kleiner, starker

__________________________ Lungenkreislauf

__________________________ Körperkreislauf

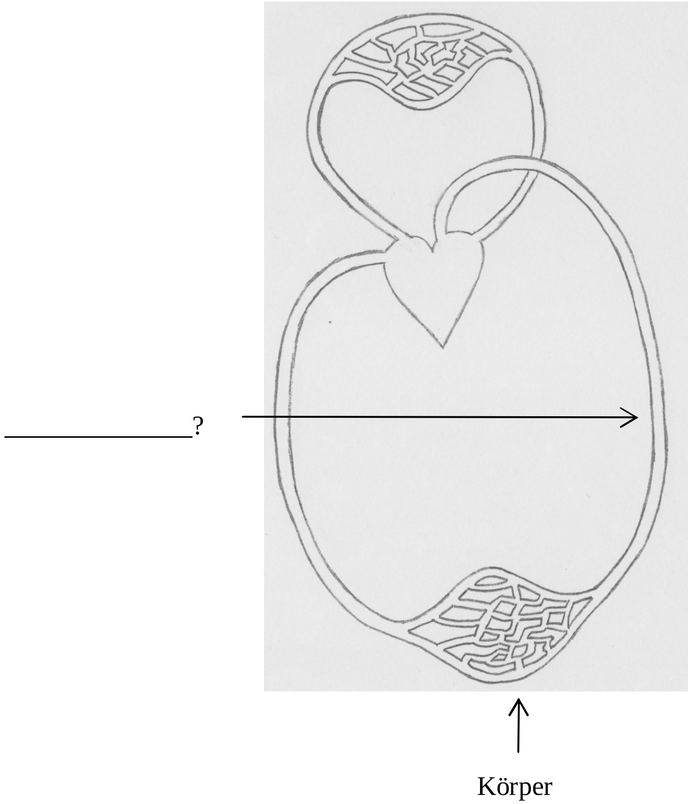
Seite 5

Wenn das Blut den Sauerstoff abgegeben hat, fließt es wieder in den kleinen Lungenkreislauf. Nun beginnt alles wieder von vorne: Im Lungenkreislauf tankt das Blut Sauerstoff auf. Dann kommt es wieder in den großen Körperkreislauf und verteilt den Sauerstoff. Dann kommt es wieder in den Lungenkreislauf, dann wieder in den Körperkreislauf…

Blut mit viel Sauerstoff wird rot gemalt. Blut mit wenig Sauerstoff wird blau gemalt.

Das Wort Kreislauf meint also, dass dein Blut wie im Kreis vom Herz weggepumpt wird und zum Herz zurück fließt. Der kleine Lungenkreislauf und der große Körperkreislauf bilden zusammen unseren Blutkreislauf.

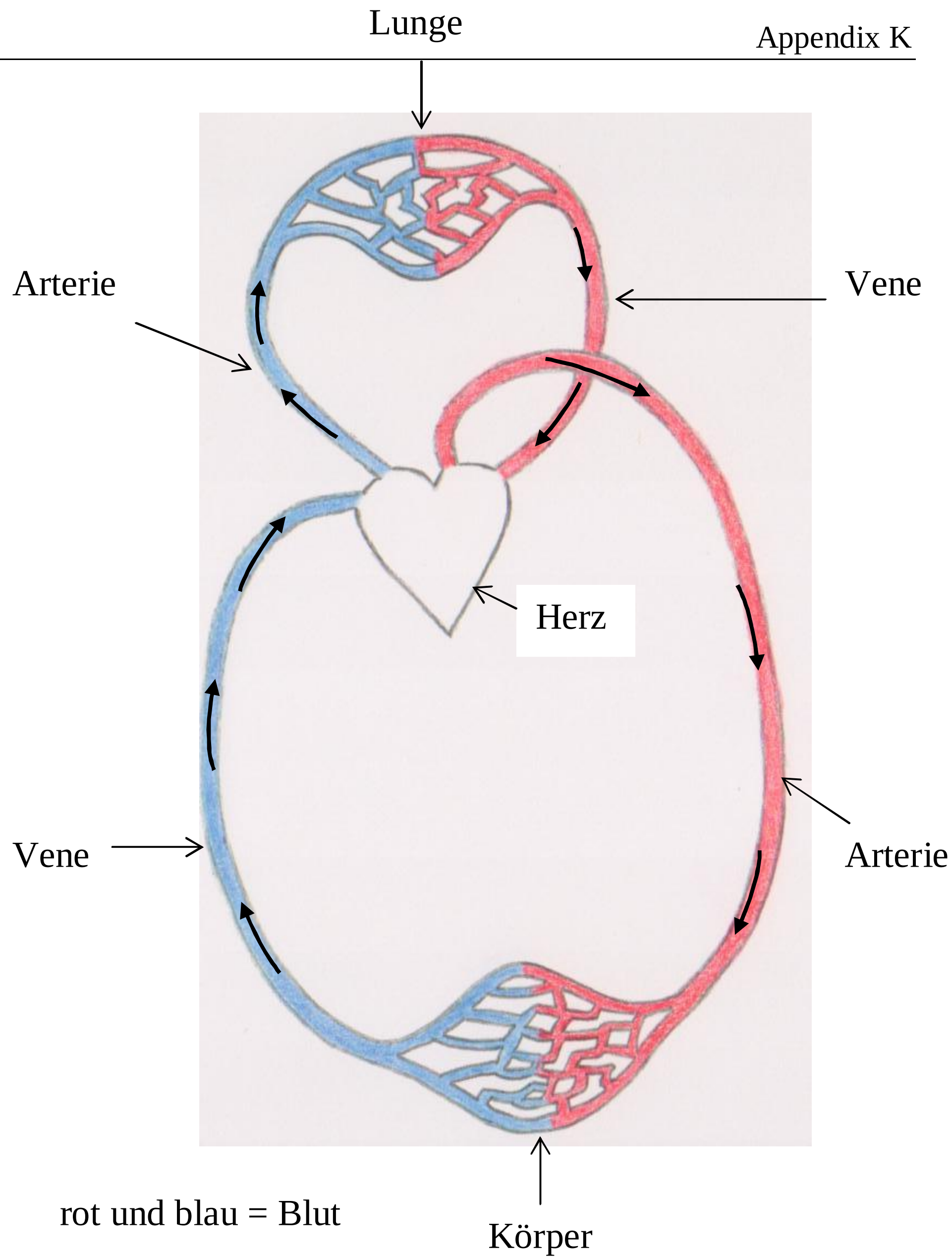
STOPP!

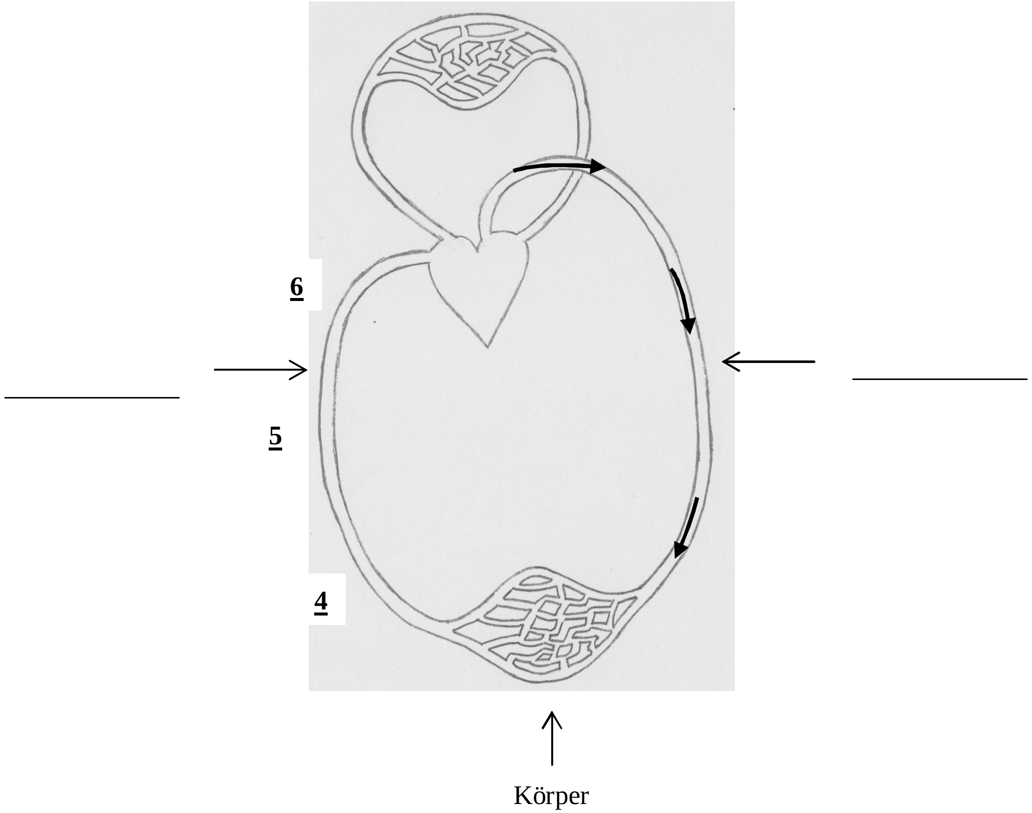


<u>Aufgabe 21</u>

Schreibe das richtige Wort an den oberen Pfeil!

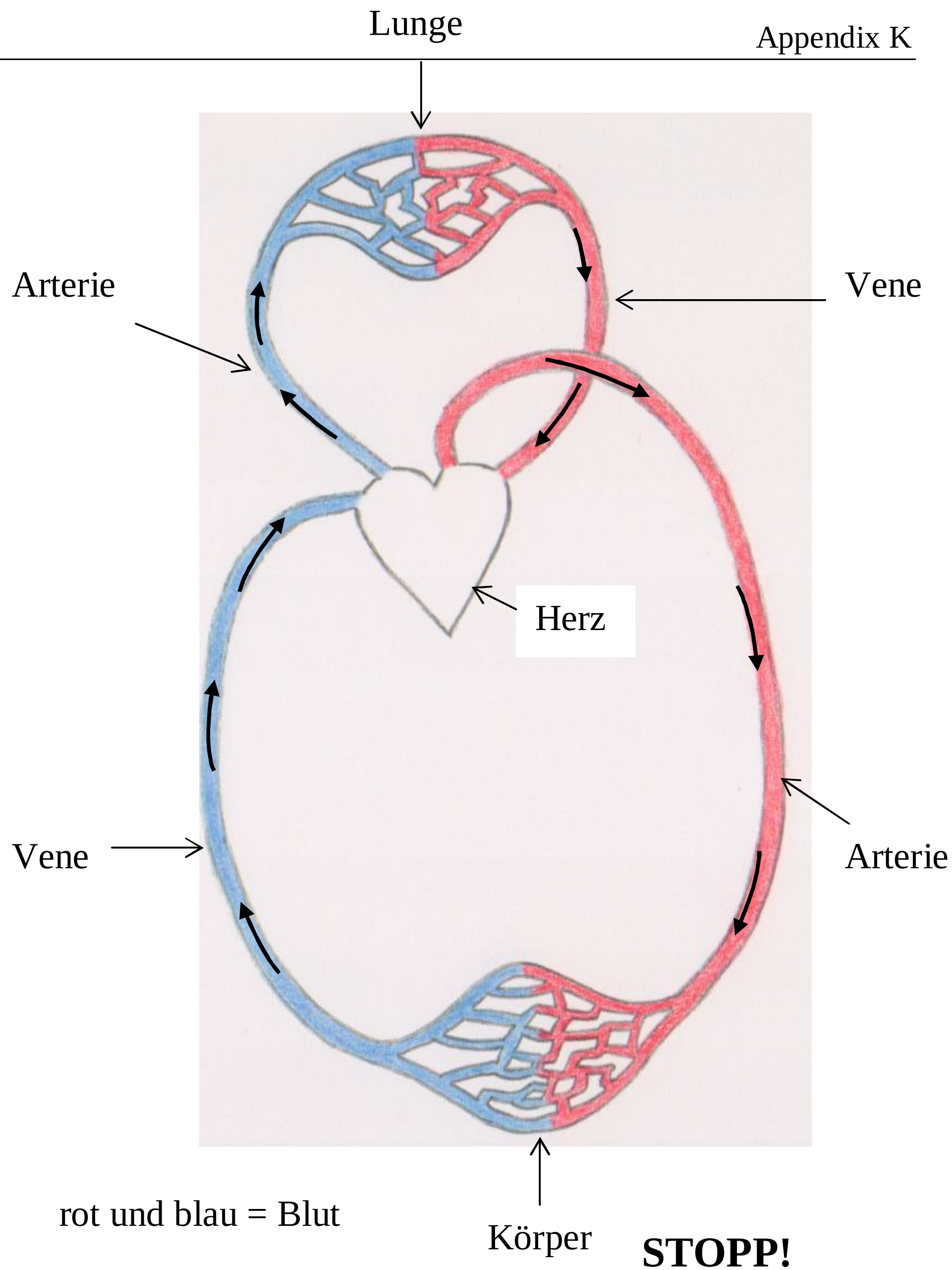
Merke dir gut, wie die Ader heißt!





<u>Aufgabe 22</u>

Schreibe zuerst das Wort „Vene“ an die richtige Stelle! Zeichne dann die drei Pfeile bei den Zahlen 4, 5 und 6 ein. Vergleiche deine Pfeile mit den schwarzen Pfeilen im großen Bild!



rot und blau = Blut

STOPP!

<u>Aufgabe 23</u>

Merke dir das Wichtigste vom großen Bild!

Aufgabe 24

Findest du Sachen, die im Text und im Bild vorkommen? Blättere auf die nächste Seite und suche danach.

<u>Seite 5</u>

Wenn das Blut den Sauerstoff abgegeben hat, fließt es wieder in den kleinen Lungenkreislauf. Nun beginnt alles wieder von vorne: Im Lungenkreislauf tankt das Blut Sauerstoff auf. Dann kommt es wieder in den großen Körperkreislauf und verteilt den Sauerstoff. Dann kommt es wieder in den Lungenkreislauf, dann wieder in den Körperkreislauf…

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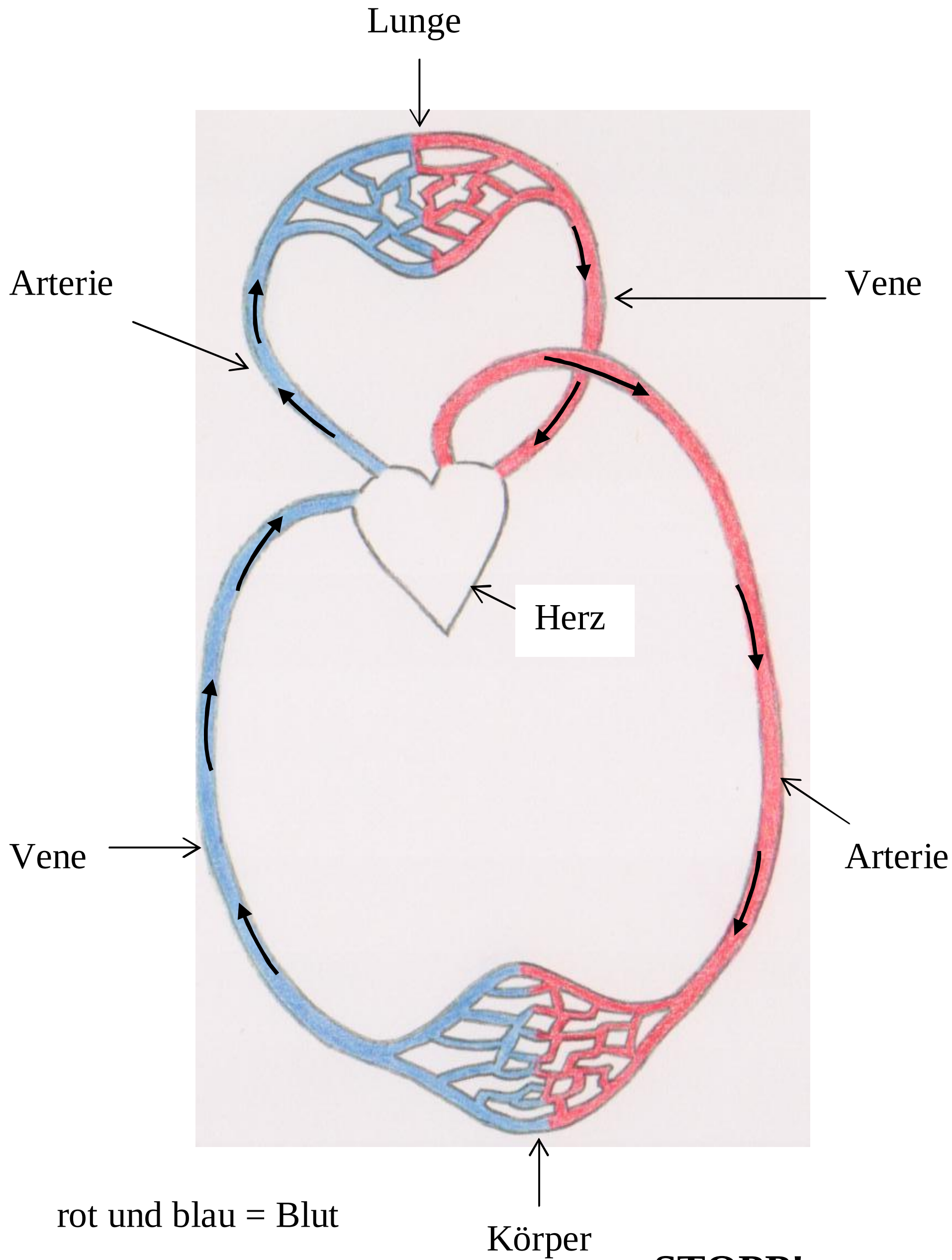
Das Wort Kreislauf meint also, dass dein Blut wie im Kreis vom Herz weggepumpt wird und zum Herz zurück fließt. Der kleine Lungenkreislauf und der große Körperkreislauf bilden zusammen unseren Blutkreislauf.



STOPP!

Appendix L

Experiment 2: Learning Unit 1 – "written text + pictures + selection/organization aids + integration aids" condition

Unser Blutkreislauf (1)

Stopp!

Aufgabe 1

Merke dir das Wichtigste vom Text!

Seite 1

Unser Blutkreislauf

Einleitung

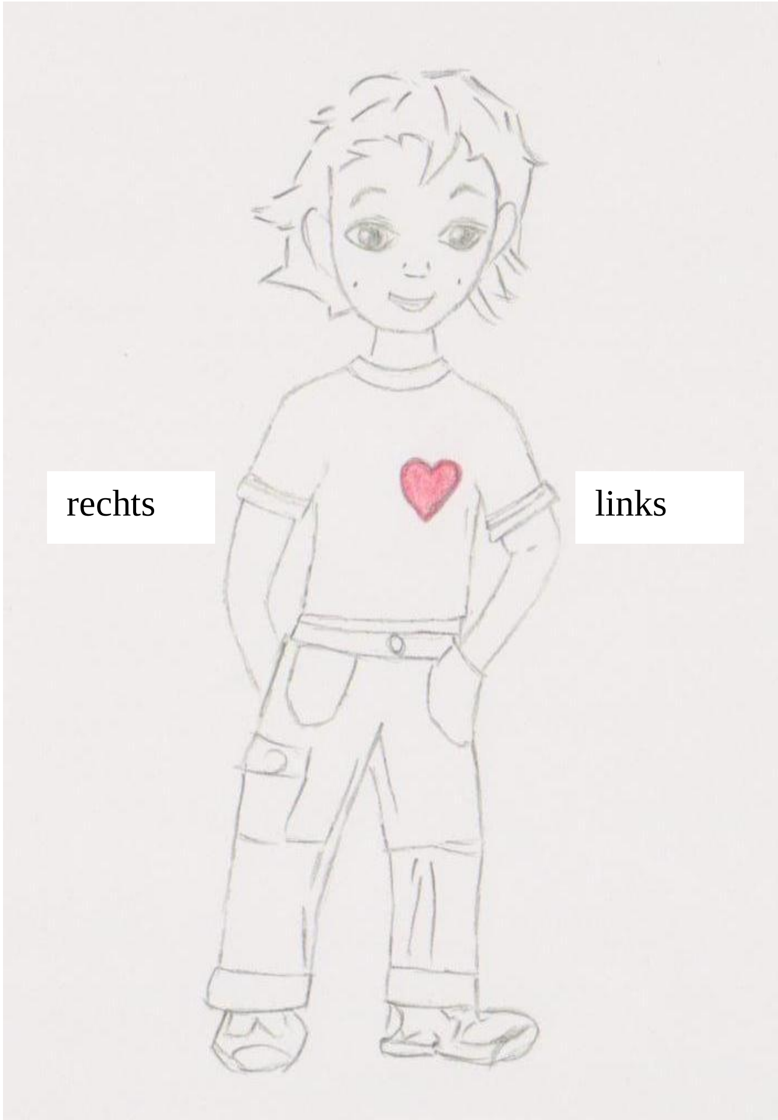
Tom jubelt: „Ich bin ein Auto!“ „Unsinn“, ruft Nina, „du bist doch kein Auto!“ Tom grinst: „Doch, irgendwie schon. Ich habe einen Motor!“

Jedes Auto braucht einen Motor, um fahren zu können. Jeder Mensch braucht das Herz, um leben zu können. Das Herz ist unser Motor.

STOPP!

Aufgabe 2

Merke dir das Wichtigste vom Bild!



STOPP!

Aufgabe 3

Findest du Sachen, die im Text und im Bild vorkommen? Blättere auf die nächste Seite und suche danach.

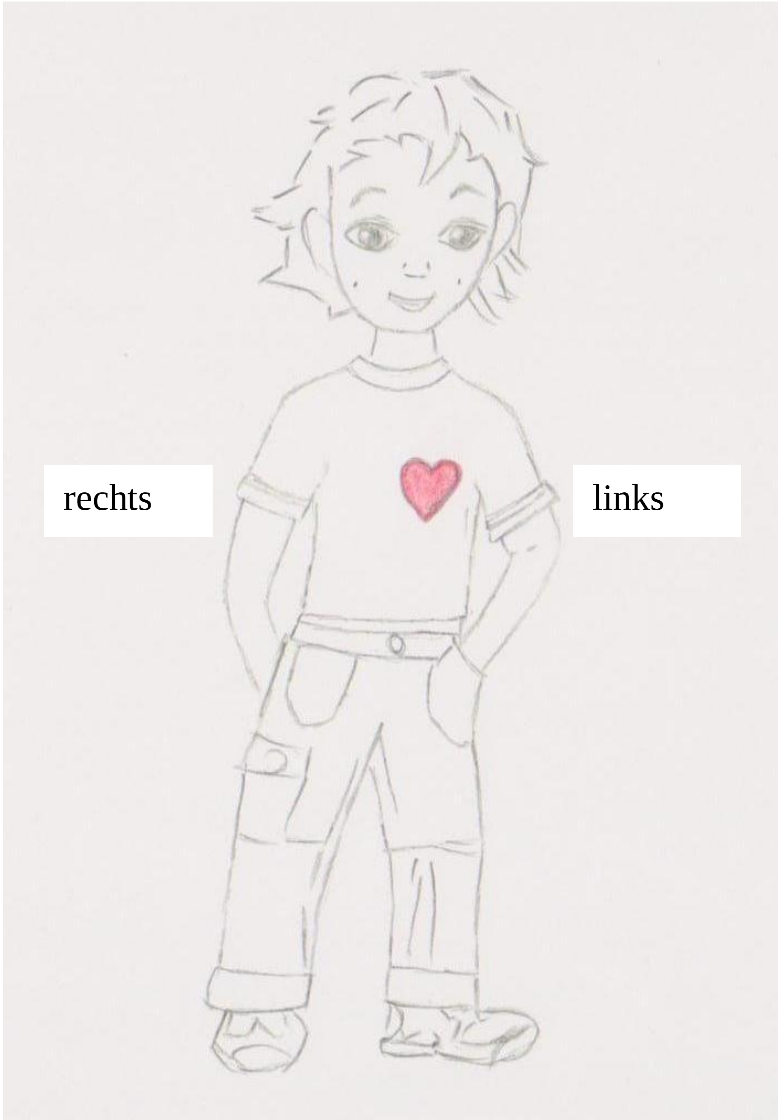
Seite 1

Unser Blutkreislauf

Einleitung

Tom jubelt: „Ich bin ein Auto!“ „Unsinn“, ruft Nina, „du bist doch kein Auto!“ Tom grinst: „Doch, irgendwie schon. Ich habe einen Motor!“

Jedes Auto braucht einen Motor, um fahren zu können. Jeder Mensch braucht das Herz, um leben zu können. Das Herz ist unser Motor.



STOPP!

Aufgabe 4

Merke dir das Wichtigste vom Text!

Aufgabe 5

Kreise das richtige Wort ein!

Im Blut sind viele Stoffe, die dein Körper an vielen / allen Stellen braucht.

Aufgabe 6

Ergänze den folgenden Satz!

Das Blut fließt innerhalb der Adern immer in ____.

Seite 2

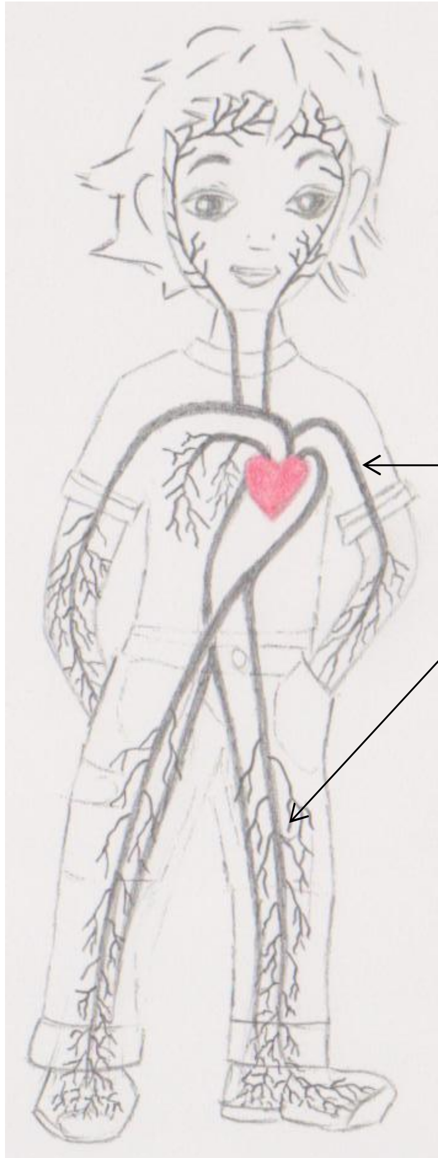
Das Herz

Das Herz, dein Motor, ist ungefähr so groß wie deine Faust. Das Herz pumpt das Blut bis in die kleinsten Teile deines Körpers. Das ist deshalb so wichtig, weil im Blut viele Stoffe sind, die dein Körper an allen Stellen braucht. Das Blut fließt in kleinen Rohren, die wir Blutgefäße oder Adern nennen. Wichtig ist, dass das Blut innerhalb der Adern immer in die gleiche Richtung fließt. Bei den Adern gibt es die Arterien und die Venen. Arterien führen vom Herz weg. Venen führen zum Herz hin. Die Adern sind unterschiedlich dünn. Sie sind überall in deinem Körper, wie ein Netz. Wenn du deine Hand auf den Tisch legst und dir deinen Handrücken anschaust, siehst du deine Adern grün schimmern.

STOPP!

Aufgabe 7

Merke dir das Wichtigste vom Bild!



STOPP!

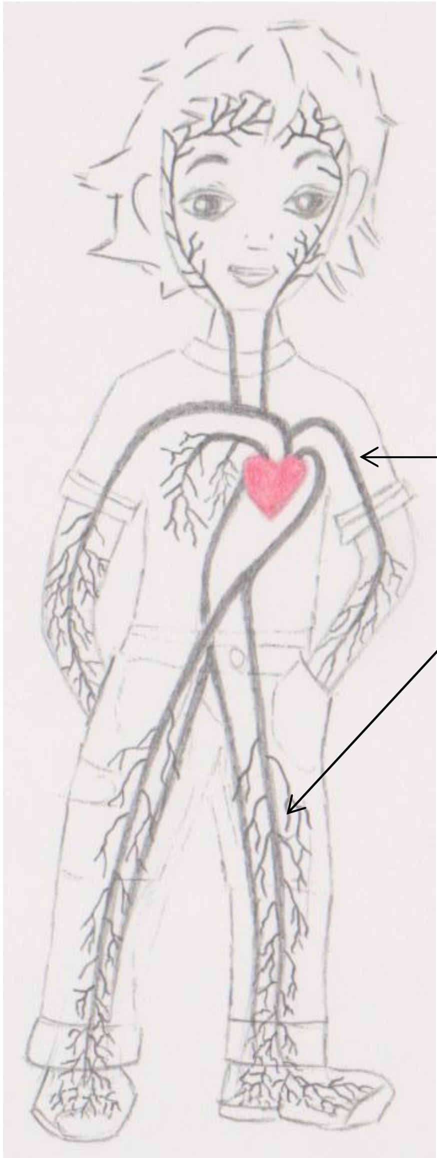
Aufgabe 8

Findest du Sachen, die im Text und im Bild vorkommen? Blättere auf die nächste Seite und suche danach.

Seite 2

Das Herz

Das Herz, dein Motor, ist ungefähr so groß wie deine Faust. Das Herz pumpt das Blut bis in die kleinsten Teile deines Körpers. Das ist deshalb so wichtig, weil im Blut viele Stoffe sind, die dein Körper an allen Stellen braucht. Das Blut fließt in kleinen Rohren, die wir Blutgefäße oder Adern nennen. Wichtig ist, dass das Blut innerhalb der Adern immer in die gleiche Richtung fließt. Bei den Adern gibt es die Arterien und die Venen. Arterien führen vom Herz weg. Venen führen zum Herz hin. Die Adern sind unterschiedlich dünn. Sie sind überall in deinem Körper, wie ein Netz. Wenn du deine Hand auf den Tisch legst und dir deinen Handrücken anschaust, siehst du deine Adern grün schimmern.



STOPP!

<u>Aufgabe 9</u>

Merke dir das Wichtigste vom Text!

<u>Aufgabe 10</u>

Schreibe die zwei richtigen Wörter in die Lücken!

Der Weg des Blutes in die Lunge heißt

______________ _________________________.

<u>Seite 3</u>

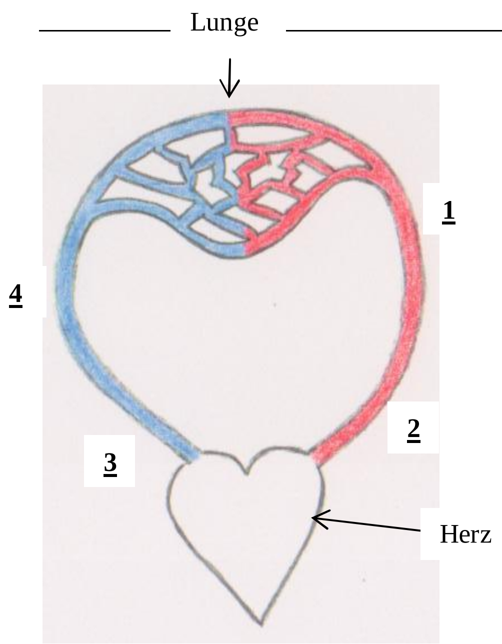
<u>Der Blutkreislauf</u>

Jetzt geht’s los. Du weißt, dass das Herz Blut durch deinen Körper pumpt. Dabei pumpt das Herz das Blut immer zuerst in die Lunge und dann in den Körper.

<u>Aber warum kommt das Blut zuerst in die Lunge?</u>

Du atmest, damit Sauerstoff in deine Lunge kommt. Sauerstoff ist wichtig, damit dein Körper richtig arbeiten kann. Um den Sauerstoff auftanken zu können, muss das Blut nun zuerst zur Lunge fließen. Der Weg des Blutes in die Lunge heißt kleiner Lungenkreislauf.

STOPP!

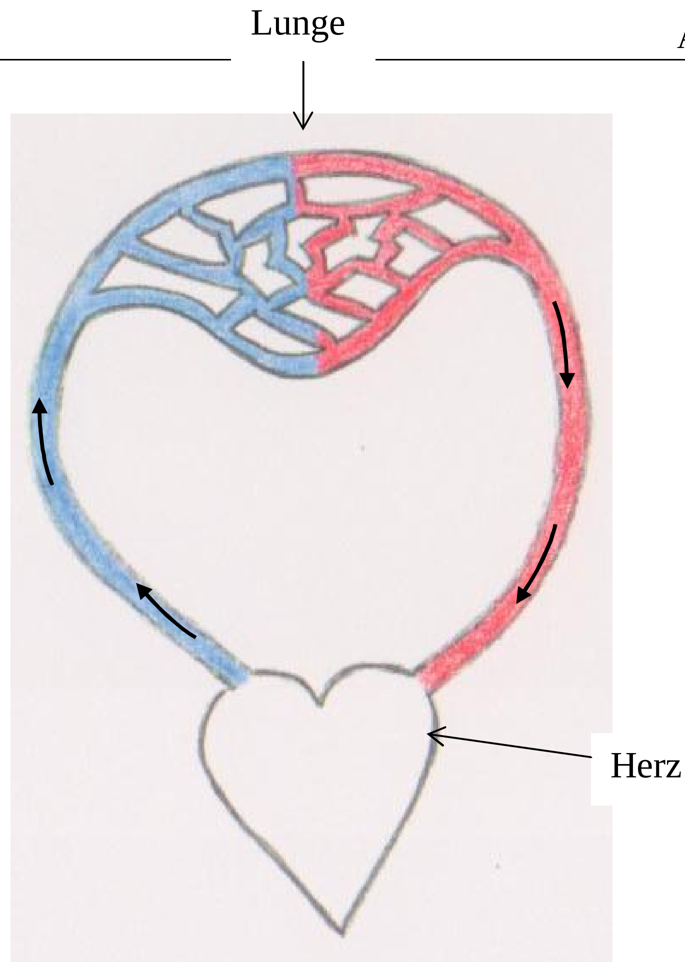


rot = Blut mit viel Sauerstoff

blau = Blut mit wenig Sauerstoff

Aufgabe 11

Zeichne die vier Pfeile bei den Zahlen 1, 2, 3 und 4 ein. Vergleiche deine Pfeile mit den schwarzen Pfeilen im großen Bild. Lege nun deinen Finger auf den ersten Pfeil und fahre den Weg der Pfeile mit deinem Finger nach. Merke dir, dass die Pfeile im **Lungenkreislauf** im **Uhrzeigersinn** laufen!



rot = Blut mit viel Sauerstoff

blau = Blut mit wenig Sauerstoff

Aufgabe 12

Merke dir das Wichtigste vom großen Bild!

STOPP!

Aufgabe 13

Findest du Sachen, die im Text und im Bild vorkommen? Bearbeite zuerst die Aufgaben und suche dann nach diesen Sachen. Blättere jetzt auf die nächste Seite.

Seite 3

Der Blutkreislauf

Jetzt geht's los. Du weißt, dass das Herz Blut durch deinen Körper pumpt. Dabei pumpt das Herz das Blut immer zuerst in die Lunge und dann in den Körper.

Aber warum kommt das Blut zuerst in die Lunge?

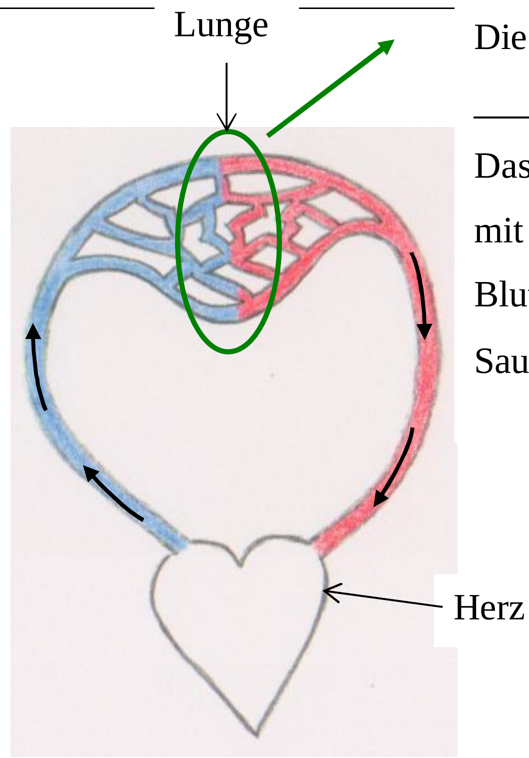
Du atmest, damit Sauerstoff in deine Lunge kommt. Sauerstoff ist wichtig, damit dein Körper richtig arbeiten kann. Um den Sauerstoff auftanken zu können, muss das Blut nun zuerst zur Lunge fließen. Der Weg des Blutes in die Lunge heißt kleiner Lungenkreislauf.

Aufgabe 14

Ergänze den Satz!

Die Lunge nimmt ____________________ auf.

Das sehe ich daran, dass Blut mit ________ Sauerstoff zu Blut mit ________ Sauerstoff wird.



rot = Blut mit viel Sauerstoff

blau = Blut mit wenig Sauerstoff

Aufgabe 15

Ergänze!

In der Lunge ist immer Blut mit wenig ________________ und Blut mit viel ________________.

STOPP!

Aufgabe 16

Merke dir das Wichtigste vom Text!

Aufgabe 17

Merke dir besonders die fett geschriebenen Wörter im folgenden Satz!

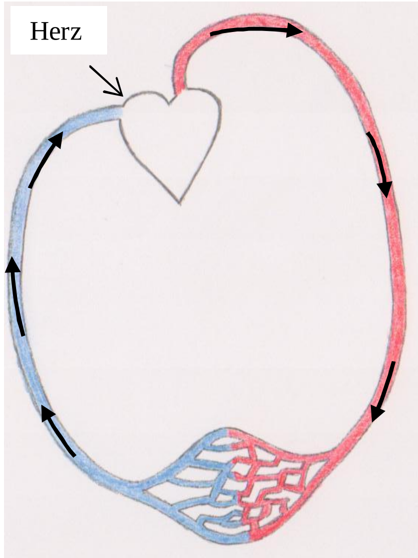
Der Weg des Blutes durch den Körper heißt **großer Körperkreislauf**.

Seite 4

Und wie kommt der Sauerstoff in deinen ganzen Körper?

Nach dem Lungenkreislauf fließt das Blut nun voll beladen mit Sauerstoff in deinen Körper. Das Blut gibt den Sauerstoff nach und nach an deinen Körper ab. So kommt der Sauerstoff überall dort hin, wo dein Körper ihn braucht. Dieser Weg des Blutes durch den Körper heißt großer Körperkreislauf.

STOPP!



<u>Zweite Hälfte</u>

<u>Erste Hälfte</u>

Körper

rot = Blut mit viel Sauerstoff

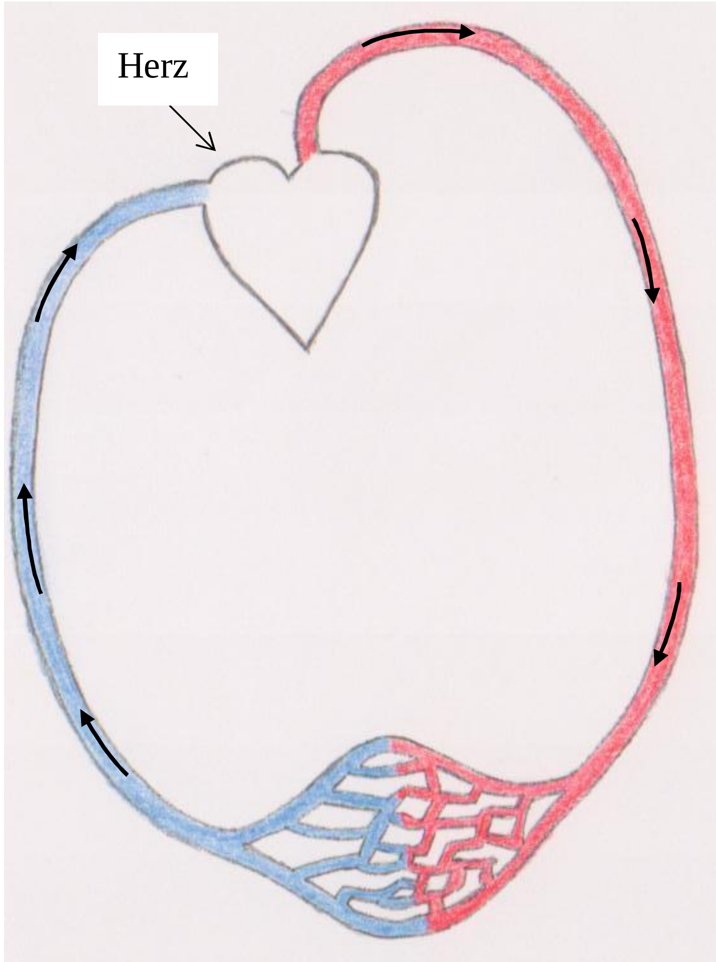
blau = Blut mit wenig Sauerstoff

Aufgabe 19

Wir haben gesehen, dass die Pfeile in den Kreisläufen immer im Uhrzeigersinn laufen. Schaue dir das obere Bild an! Im **Körperkreislauf** wird die erste Hälfte rot gemalt. Die zweite Hälfte wird blau gemalt. Merke dir das gut!

Aufgabe 20

Merke dir das Wichtigste vom großen Bild!



Körper

rot = Blut mit viel Sauerstoff

blau = Blut mit wenig Sauerstoff

STOPP!

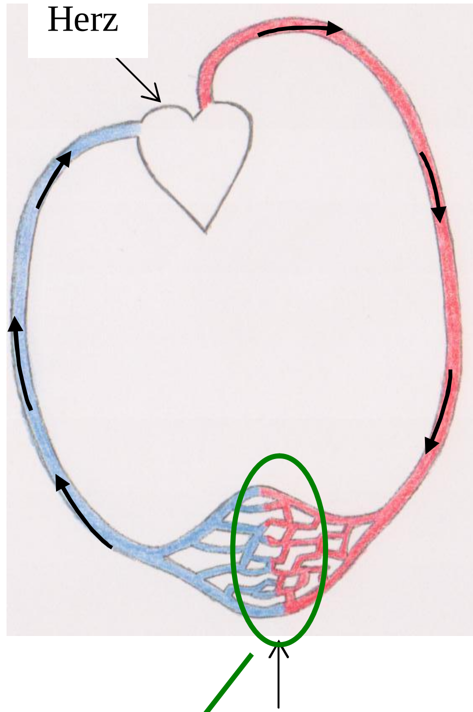
Aufgabe 21

Findest du Sachen, die im Text und im Bild vorkommen? Bearbeite zuerst die Aufgaben und suche dann nach diesen Sachen. Blättere jetzt auf die nächste Seite.

Seite 4

Und wie kommt der Sauerstoff in deinen ganzen Körper?

Nach dem Lungenkreislauf fließt das Blut nun voll beladen mit Sauerstoff in deinen Körper. Das Blut gibt den Sauerstoff nach und nach an deinen Körper ab. So kommt der Sauerstoff überall dort hin, wo dein Körper ihn braucht. Dieser Weg des Blutes durch den Körper heißt großer Körperkreislauf.



rot = Blut mit viel Sauerstoff

blau = Blut mit wenig Sauerstoff

Aufgabe 22

Ergänze den Satz!

Der ________________________ wird an den Körper abgegeben.

Das sehe ich daran, dass Blut mit ________ Sauerstoff zu Blut mit ________ Sauerstoff wird.

STOPP!

Aufgabe 23

Merke dir das Wichtigste vom Text!

Aufgabe 24

Schreibe das richtige Wie-Wort beim Lungenkreislauf und beim Körperkreislauf hin!

Wie-Wörter: großer, schwacher, kleiner, starker

_________________________ Lungenkreislauf

_________________________ Körperkreislauf

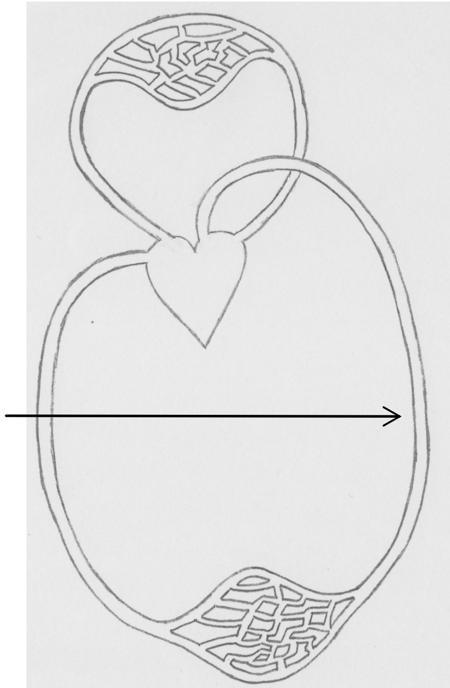
Seite 5

Wenn das Blut den Sauerstoff abgegeben hat, fließt es wieder in den kleinen Lungenkreislauf. Nun beginnt alles wieder von vorne: Im Lungenkreislauf tankt das Blut Sauerstoff auf. Dann kommt es wieder in den großen Körperkreislauf und verteilt den Sauerstoff. Dann kommt es wieder in den Lungenkreislauf, dann wieder in den Körperkreislauf…

Blut mit viel Sauerstoff wird rot gemalt. Blut mit wenig Sauerstoff wird blau gemalt.

Das Wort Kreislauf meint also, dass dein Blut wie im Kreis vom Herz weggepumpt wird und zum Herz zurück fließt. Der kleine Lungenkreislauf und der große Körperkreislauf bilden zusammen unseren Blutkreislauf.

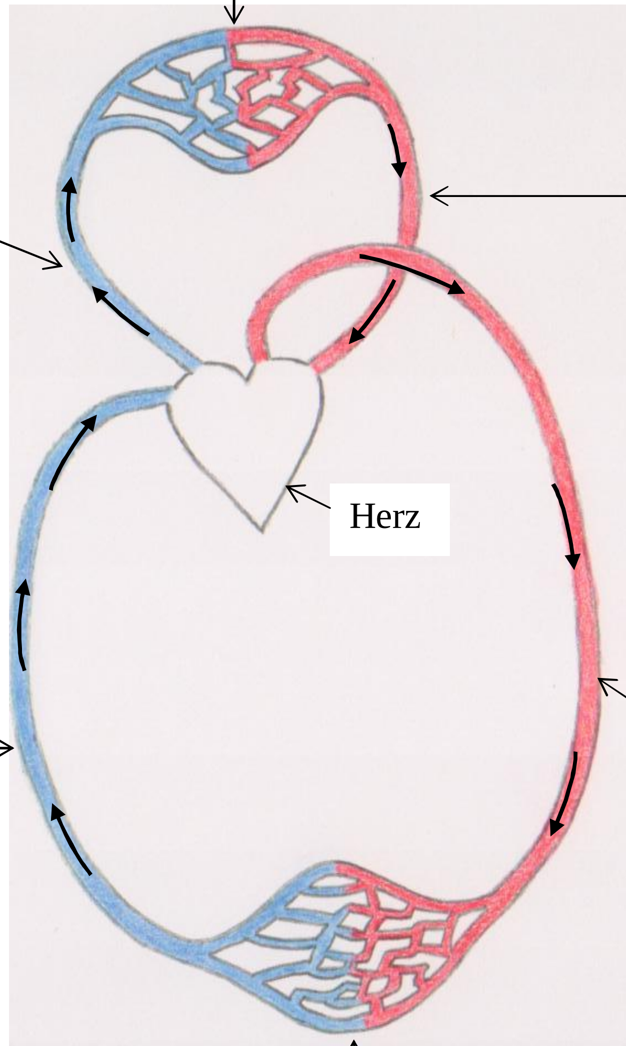
STOPP!



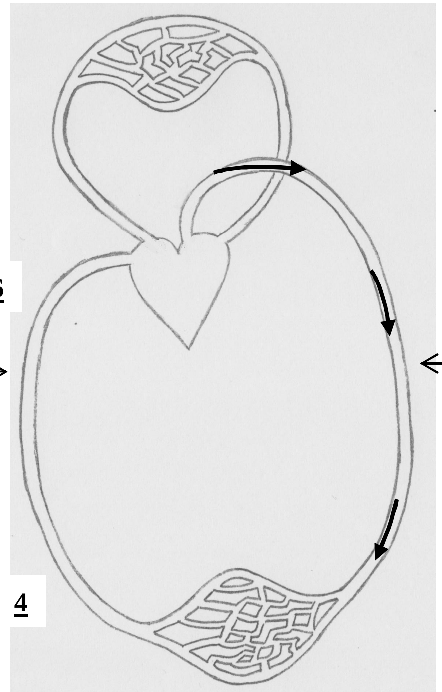
<u>Aufgabe 25</u>

Schreibe das richtige Wort an den oberen Pfeil!

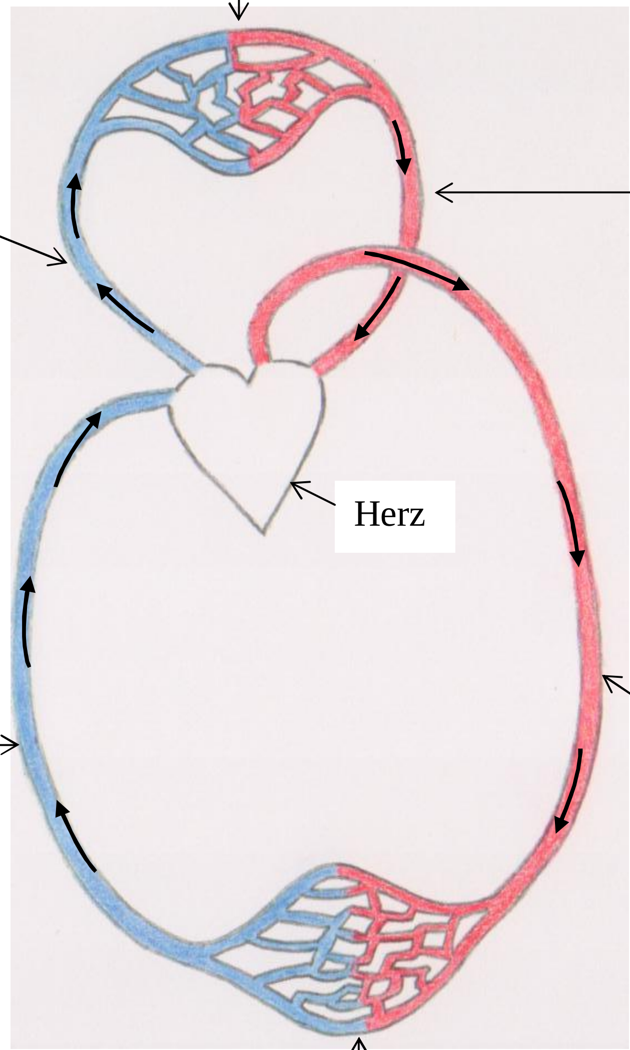
Merke dir gut, wie die Ader heißt!



rot und blau = Blut



Lunge



rot und blau = Blut

STOPP!

Aufgabe 26

Schreibe zuerst das Wort „Vene“ an die richtige Stelle! Zeichne dann die drei Pfeile bei den Zahlen 4, 5 und 6 ein. Vergleiche deine Pfeile mit den schwarzen Pfeilen im großen Bild!

Aufgabe 27

Merke dir das Wichtigste vom großen Bild!

Aufgabe 28

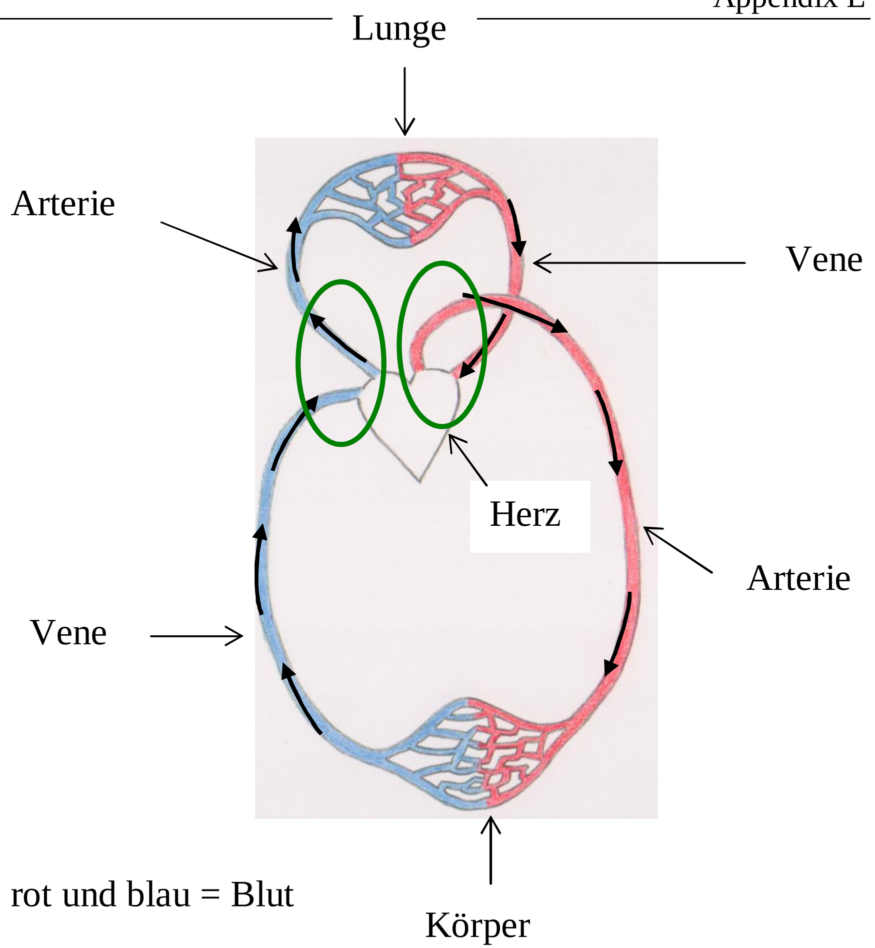
Findest du Sachen, die im Text und im Bild vorkommen? Bearbeite zuerst die Aufgaben und suche dann nach diesen Sachen. Blättere jetzt auf die nächste Seite.

Seite 5

Wenn das Blut den Sauerstoff abgegeben hat, fließt es wieder in den kleinen Lungenkreislauf. Nun beginnt alles wieder von vorne: Im Lungenkreislauf tankt das Blut Sauerstoff auf. Dann kommt es wieder in den großen Körperkreislauf und verteilt den Sauerstoff. Dann kommt es wieder in den Lungenkreislauf, dann wieder in den Körperkreislauf…

Blut mit viel Sauerstoff wird rot gemalt. Blut mit wenig Sauerstoff wird blau gemalt.

Das Wort Kreislauf meint also, dass dein Blut wie im Kreis vom Herz weggepumpt wird und zum Herz zurück fließt. Der kleine Lungenkreislauf und der große Körperkreislauf bilden zusammen unseren Blutkreislauf.



<u>Aufgabe 31</u>

Wie du siehst, sind der Lungenkreislauf und der Körperkreislauf durch das Herz miteinander verbunden. Ergänze den folgenden Satz!

Vom Lungen___________________________ kommt das Blut in den Körperkreislauf und dann wieder in den ______________________________________. Fahre den Weg mit deinem Finger nach!

STOPP!

Appendix M

Experiment 2: Learning Unit 1 – “spoken text” condition

The text used in the “written text” condition (Experiment 2: Learning Unit 1 – “written text” condition) was spoken.

Appendix N

Experiment 2: Learning Unit 1 – "spoken text + pictures" condition

The text used in the "written text + pictures" condition (Experiment 2: Learning Unit 1 – "written text + pictures" condition) was spoken.

Unser Blutkreislauf (1)

Stopp!

Aufgabe 1

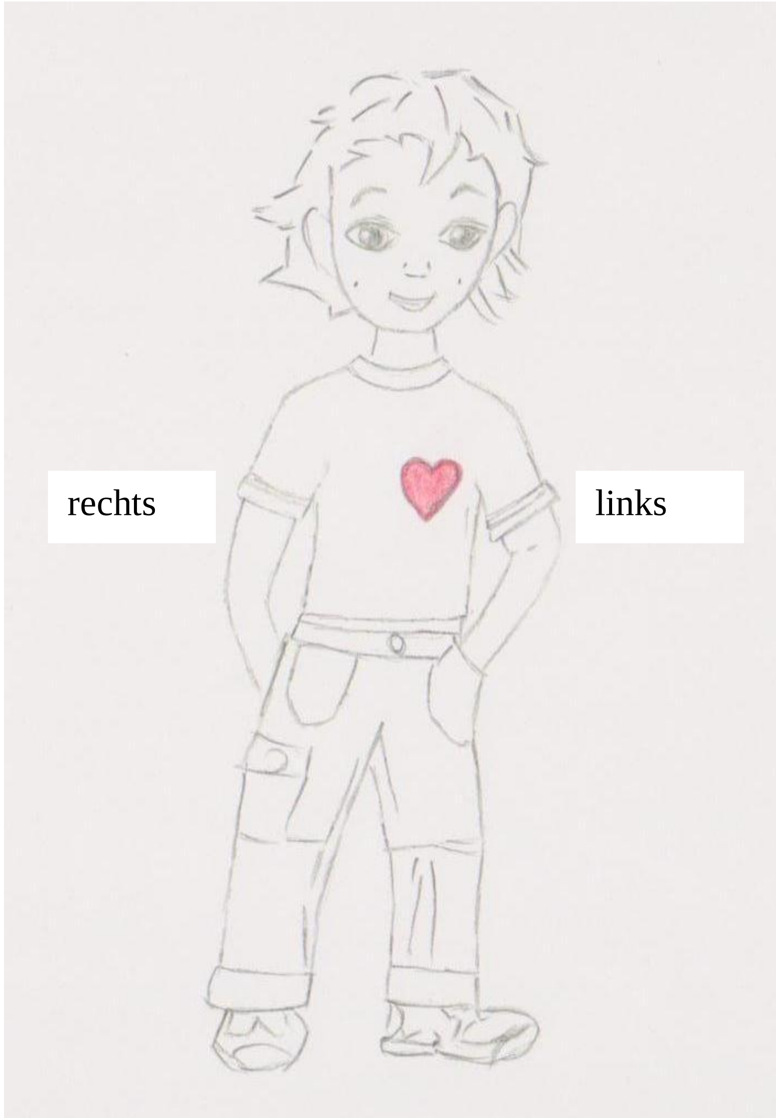
Seite 1

Merke dir das Wichtigste vom Text!

STOPP!

Aufgabe 2

Merke dir das Wichtigste vom Bild!

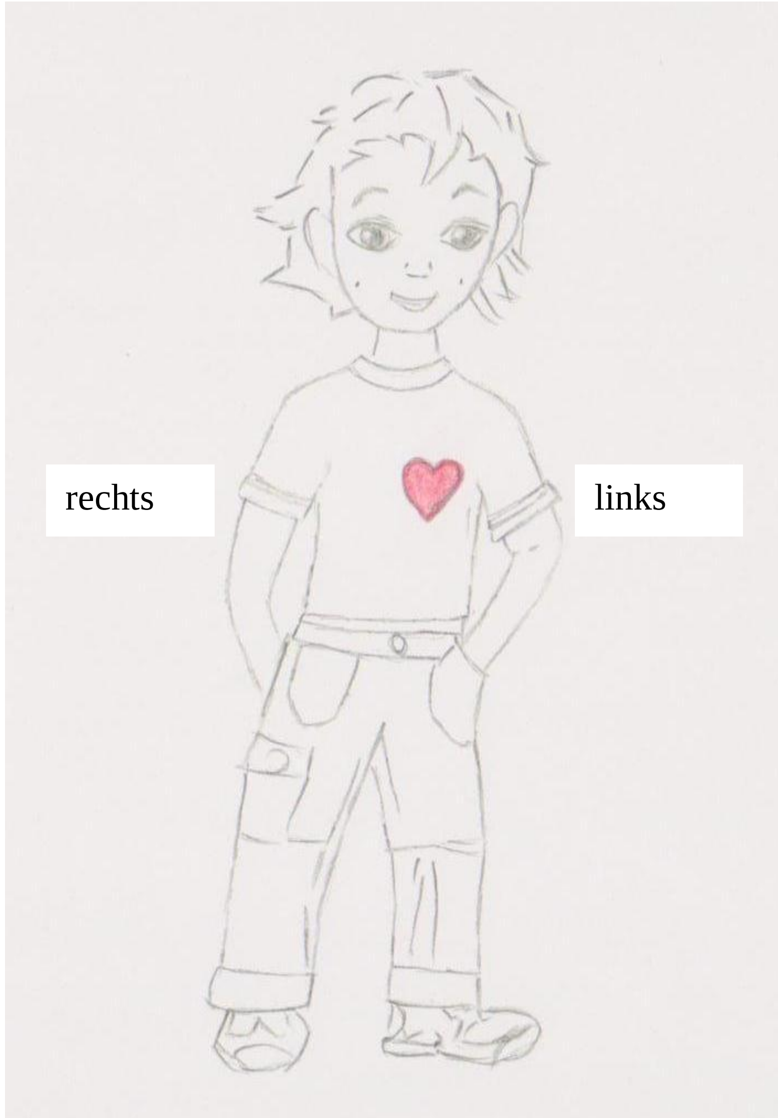


STOPP!

Aufgabe 3

Findest du Sachen, die im Text und im Bild vorkommen? Blättere auf die nächste Seite und suche danach.

Seite 1



STOPP!

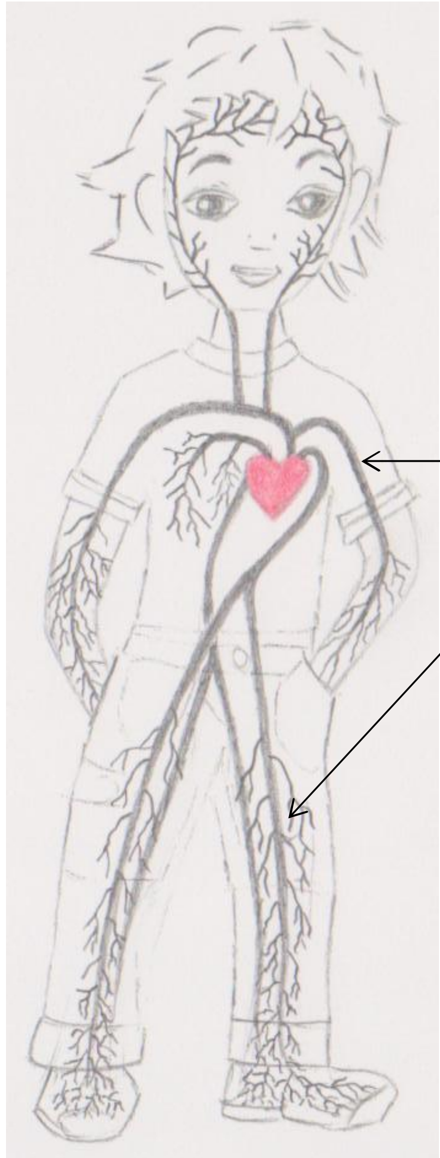
Aufgabe 4 **Seite 2**

Merke dir das Wichtigste vom Text!

STOPP!

Aufgabe 5

Merke dir das Wichtigste vom Bild!



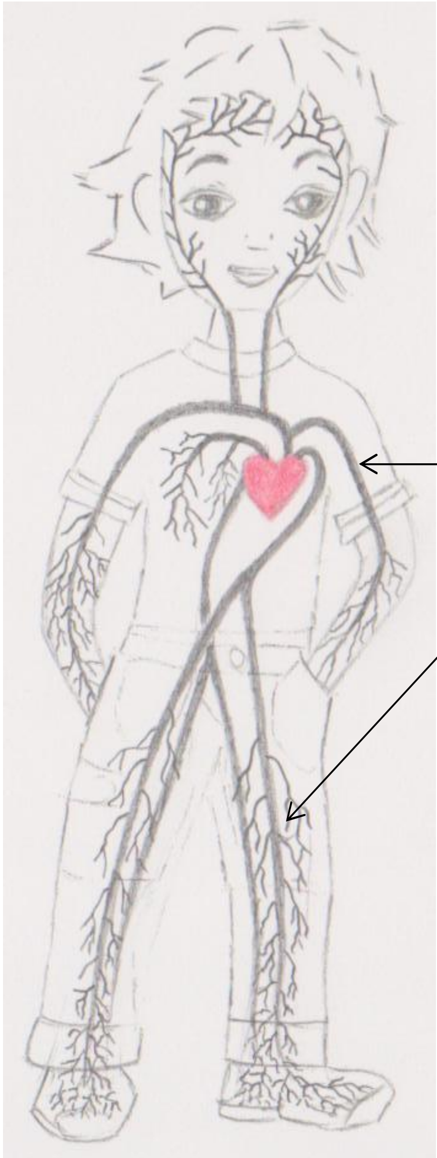
Blutgefäße oder
Adern,
in denen Blut fließt

STOPP!

Aufgabe 6

Findest du Sachen, die im Text und im Bild vorkommen? Blättere auf die nächste Seite und suche danach.

Seite 2



Blutgefäße oder
Adern,
in denen Blut fließt

STOPP!

Aufgabe 7

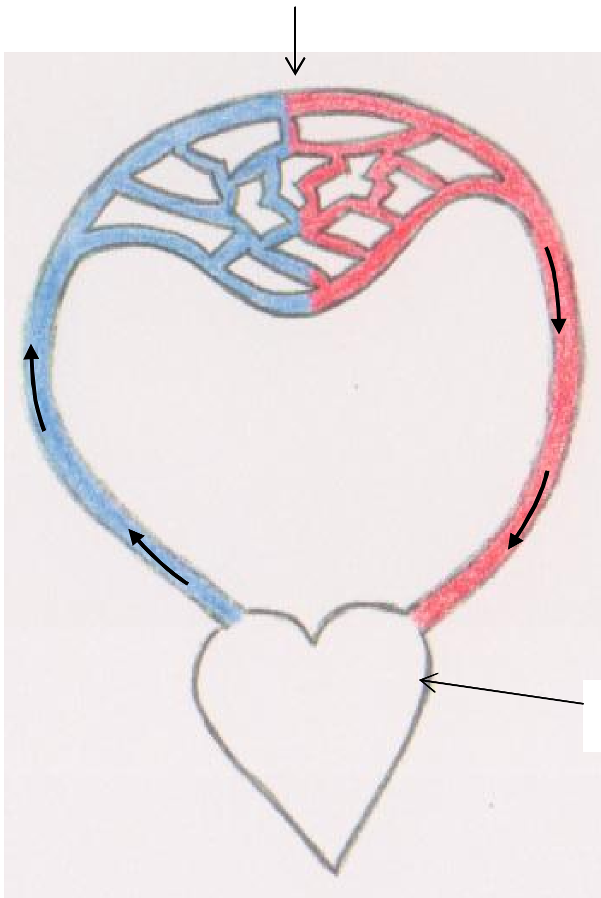
Seite 3

Merke dir das Wichtigste vom Text!

STOPP!

Aufgabe 8

Merke dir das Wichtigste vom Bild!



rot = Blut mit viel Sauerstoff

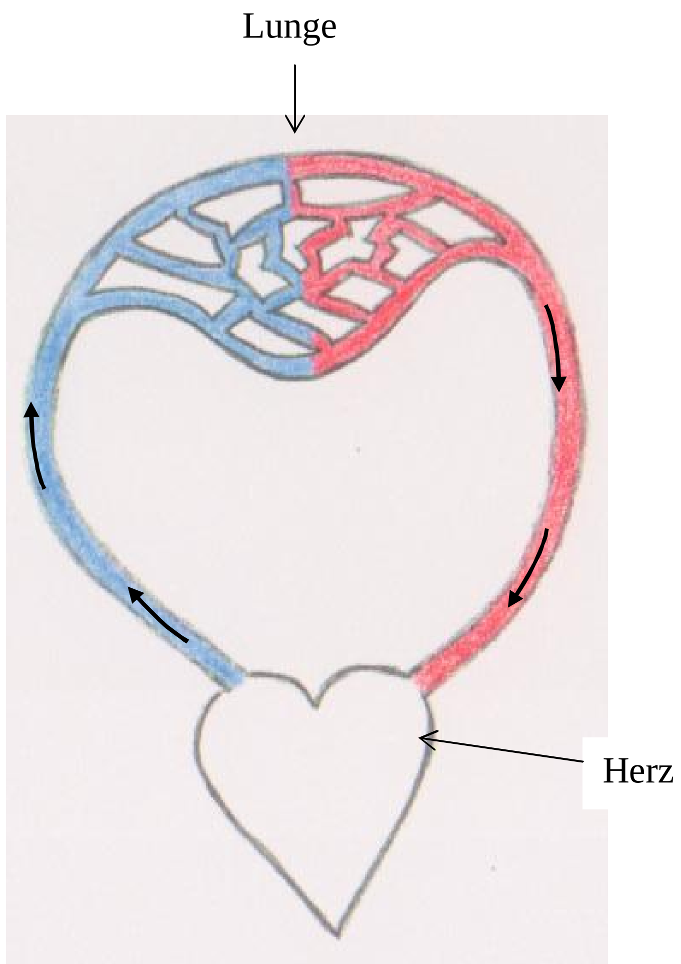
blau = Blut mit wenig Sauerstoff

STOPP!

Aufgabe 9

Findest du Sachen, die im Text und im Bild vorkommen? Blättere auf die nächste Seite und suche danach.

Seite 3



rot = Blut mit viel Sauerstoff

blau = Blut mit wenig Sauerstoff

STOPP!

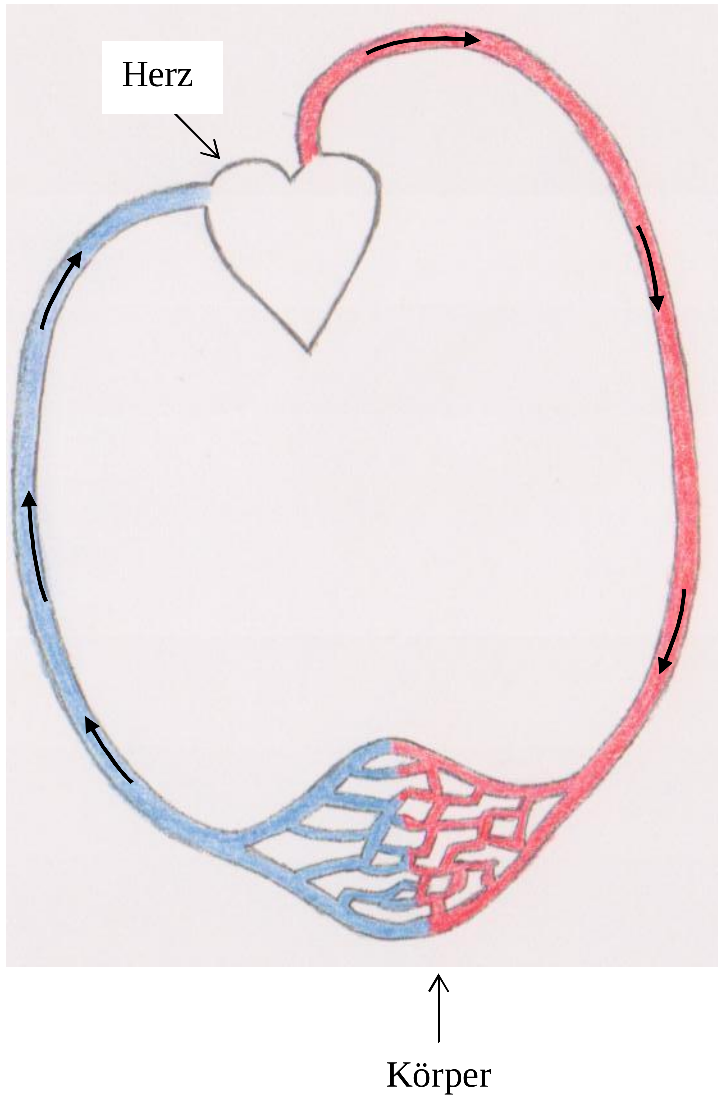
Aufgabe 10 **Seite 4**

Merke dir das Wichtigste vom Text!

STOPP!

Aufgabe 11

Merke dir das Wichtigste vom Bild!



rot = Blut mit viel Sauerstoff

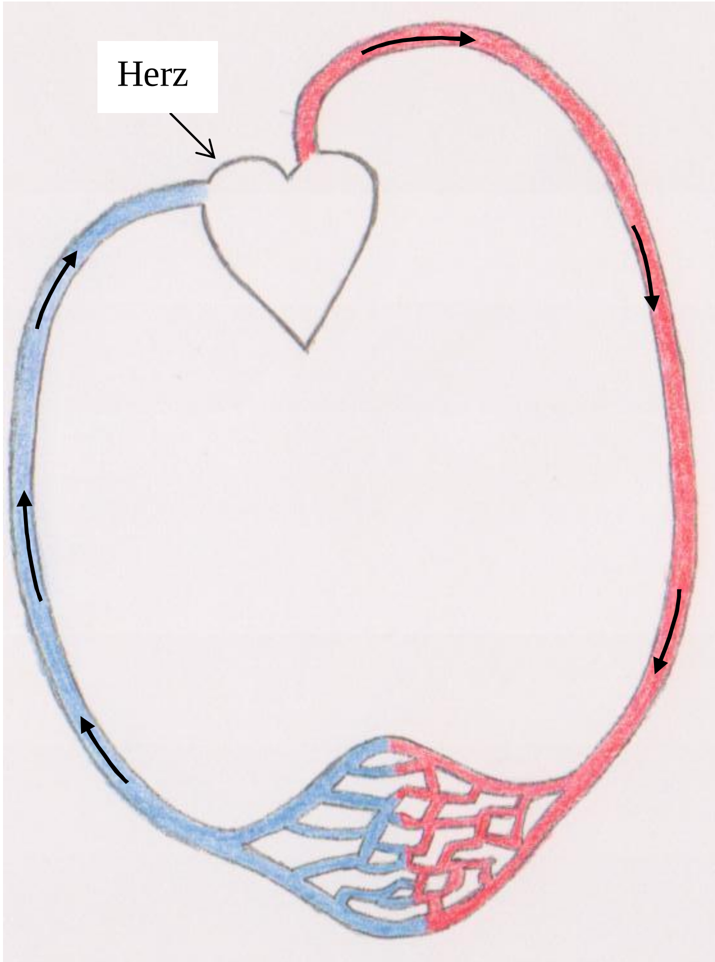
blau = Blut mit wenig Sauerstoff

STOPP!

Aufgabe 12

Findest du Sachen, die im Text und im Bild vorkommen? Blättere auf die nächste Seite und suche danach.

Seite 4



Körper

rot = Blut mit viel Sauerstoff

blau = Blut mit wenig Sauerstoff

STOPP!

Aufgabe 13

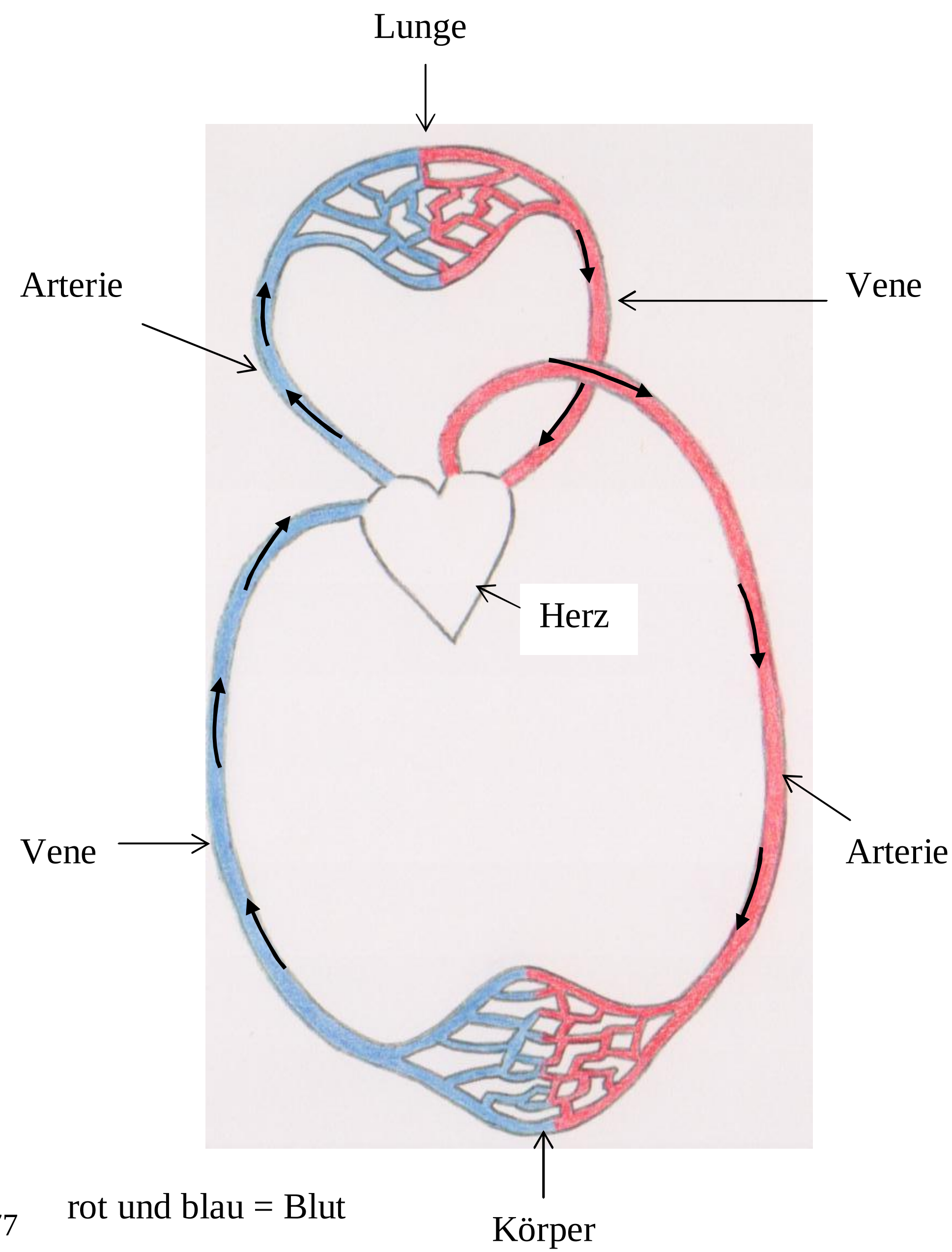
Seite 5

Merke dir das Wichtigste vom Text!

STOPP!

Aufgabe 14

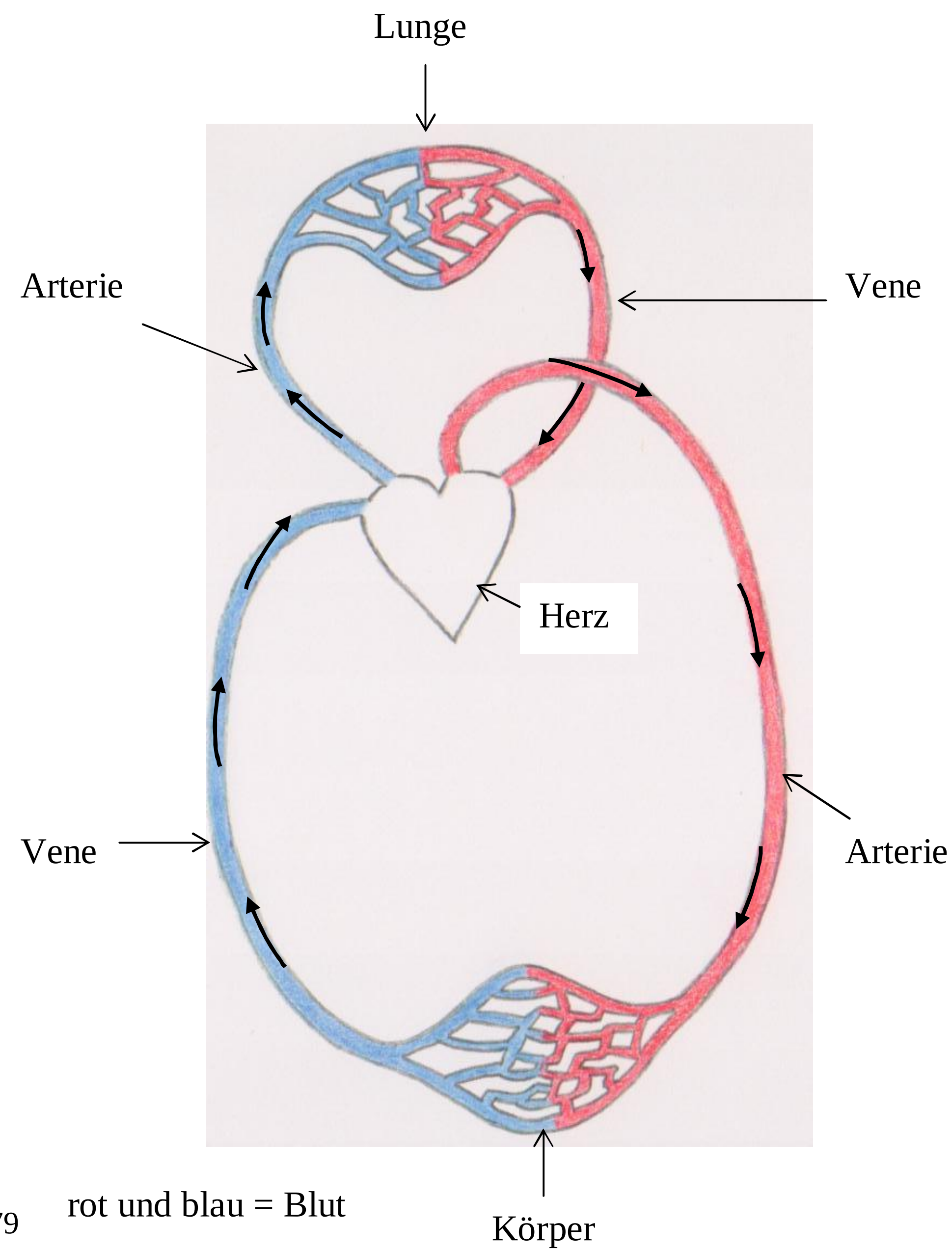
Merke dir das Wichtigste vom Bild!



STOPP!

Aufgabe 15

Findest du Sachen, die im Text und im Bild vorkommen? Blättere auf die nächste Seite und suche danach.



rot und blau = Blut

STOPP!

Appendix O

Experiment 2: Learning Unit 1 – "spoken text + pictures + selection/organization aids" condition

The text used in the "written text + pictures + selection/organization aids" condition (Experiment 2: Learning Unit 1 – "written text + pictures + selection/organization aids" condition) was spoken.

Unser Blutkreislauf (1)

Stopp!

Aufgabe 1

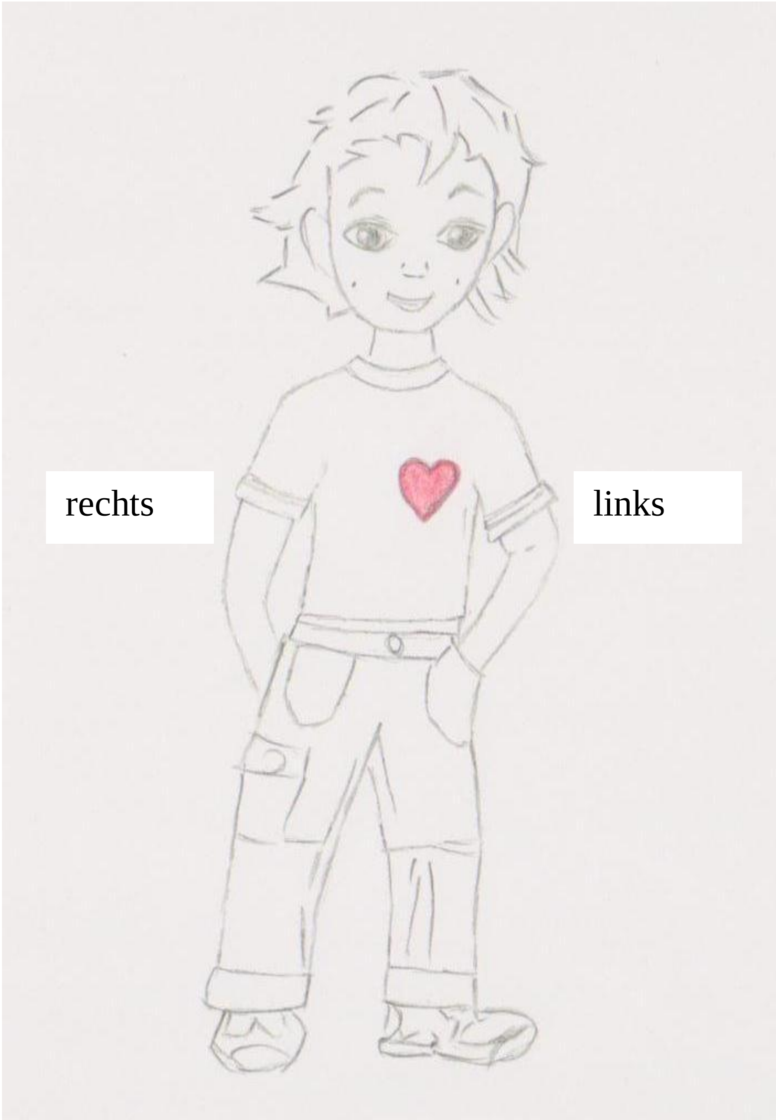
Seite 1

Merke dir das Wichtigste vom Text!

STOPP!

Aufgabe 2

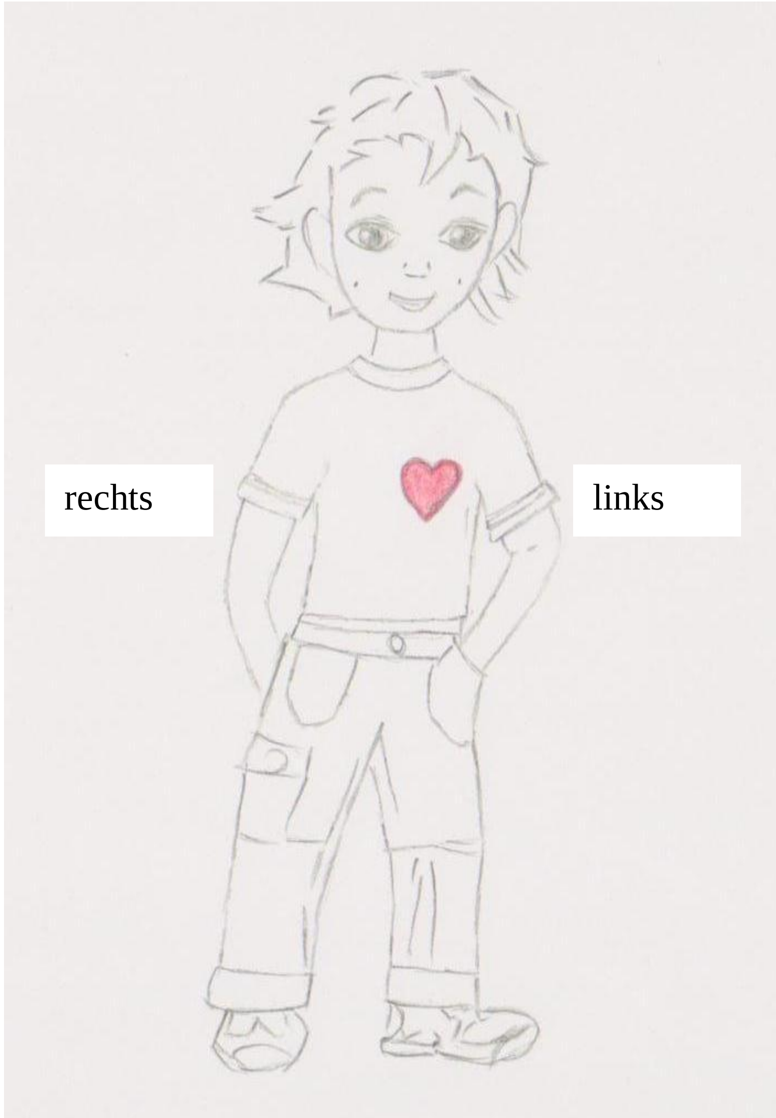
Merke dir das Wichtigste vom Bild!



STOPP!

Aufgabe 3

Findest du Sachen, die im Text und im Bild vorkommen? Blättere auf die nächste Seite und suche danach.



STOPP!

Aufgabe 4 **Seite 2**

Merke dir das Wichtigste vom Text!

Aufgabe 5

Kreise das richtige Wort ein!

Im Blut sind viele Stoffe, die dein Körper an vielen / allen Stellen braucht.

Aufgabe 6

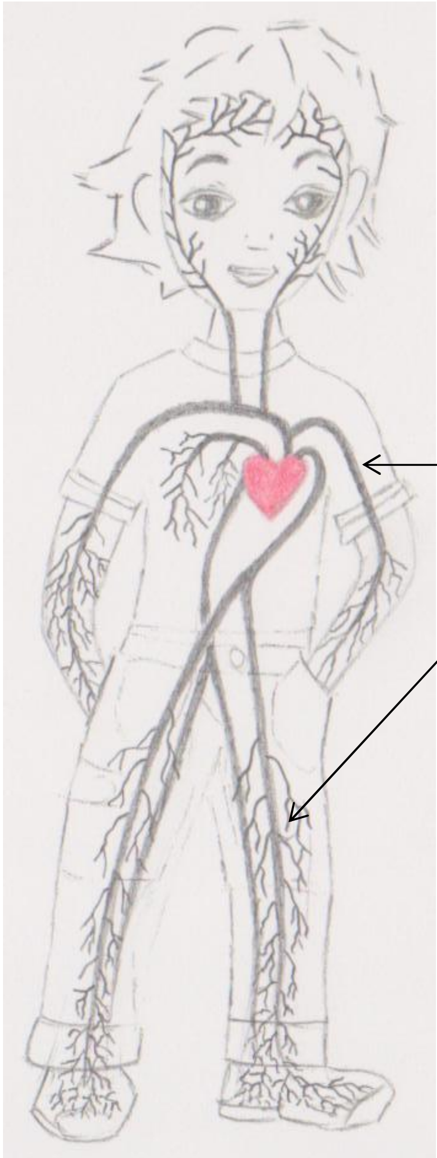
Ergänze den folgenden Satz!

Das Blut fließt innerhalb der Adern immer in ____.

STOPP!

Aufgabe 7

Merke dir das Wichtigste vom Bild!

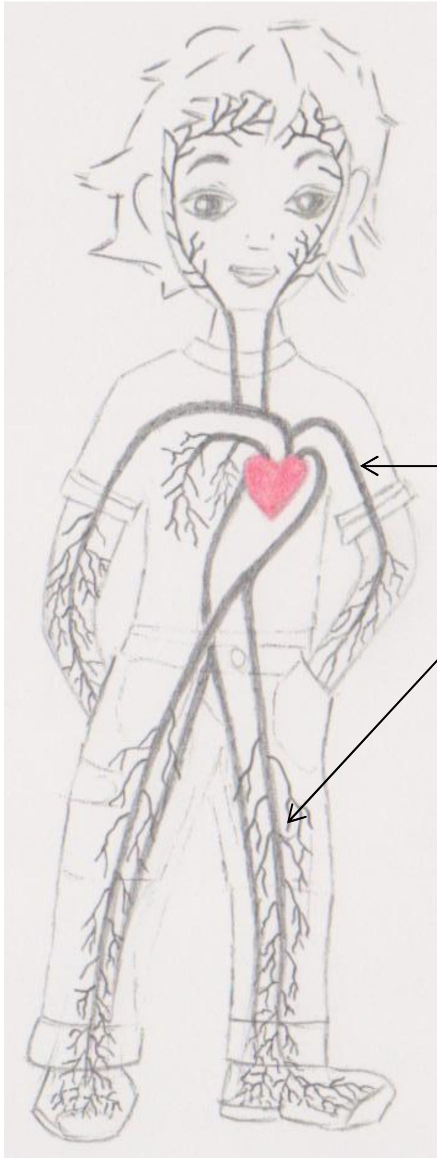


STOPP!

Aufgabe 8

Findest du Sachen, die im Text und im Bild vorkommen? Blättere auf die nächste Seite und suche danach.

Seite 2



STOPP!

Aufgabe 9

Seite 3

Merke dir das Wichtigste vom Text!

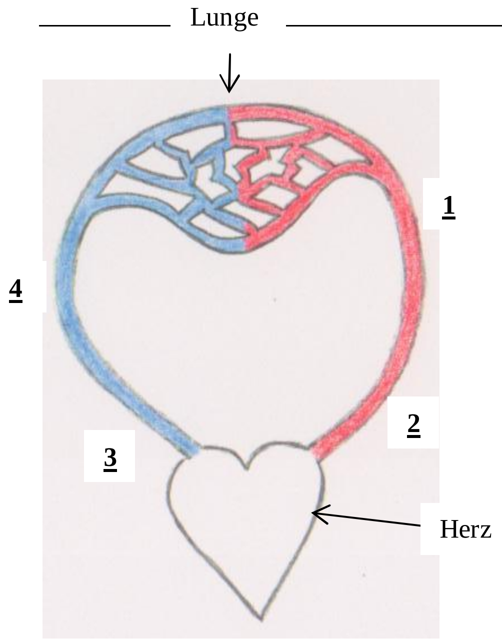
Aufgabe 10

Schreibe die zwei richtigen Wörter in die Lücken!

Der Weg des Blutes in die Lunge heißt

______________ _________________________.

STOPP!

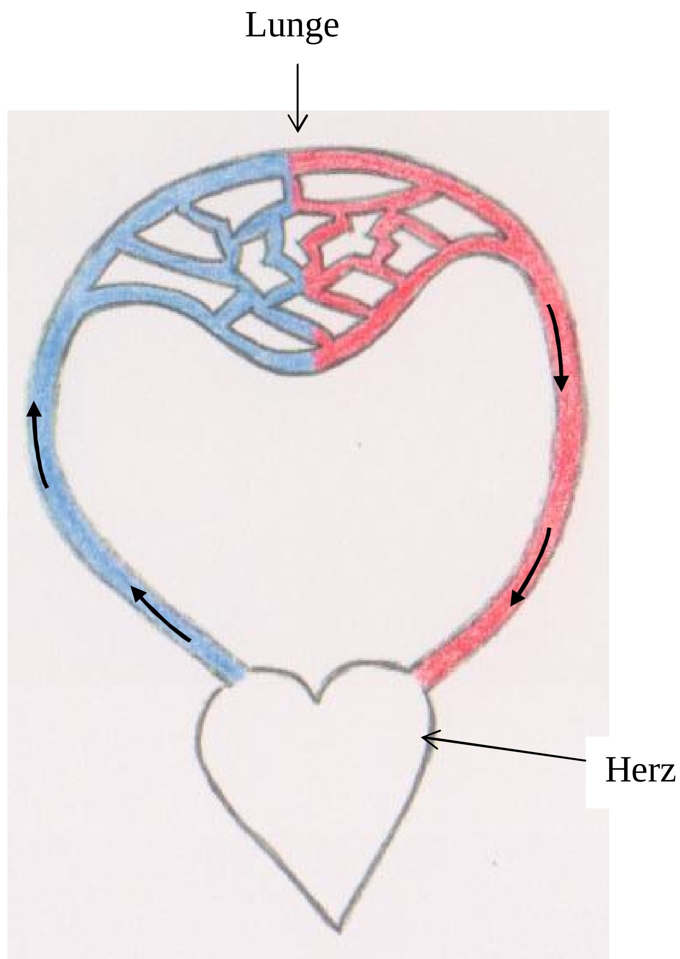


rot = Blut mit viel Sauerstoff

blau = Blut mit wenig Sauerstoff

Aufgabe 11

Zeichne die vier Pfeile bei den Zahlen 1, 2, 3 und 4 ein. Vergleiche deine Pfeile mit den schwarzen Pfeilen im großen Bild. Lege nun deinen Finger auf den ersten Pfeil und fahre den Weg der Pfeile mit deinem Finger nach. Merke dir, dass die Pfeile im **Lungenkreislauf** im **Uhrzeigersinn** laufen!



rot = Blut mit viel Sauerstoff

blau = Blut mit wenig Sauerstoff

Aufgabe 12

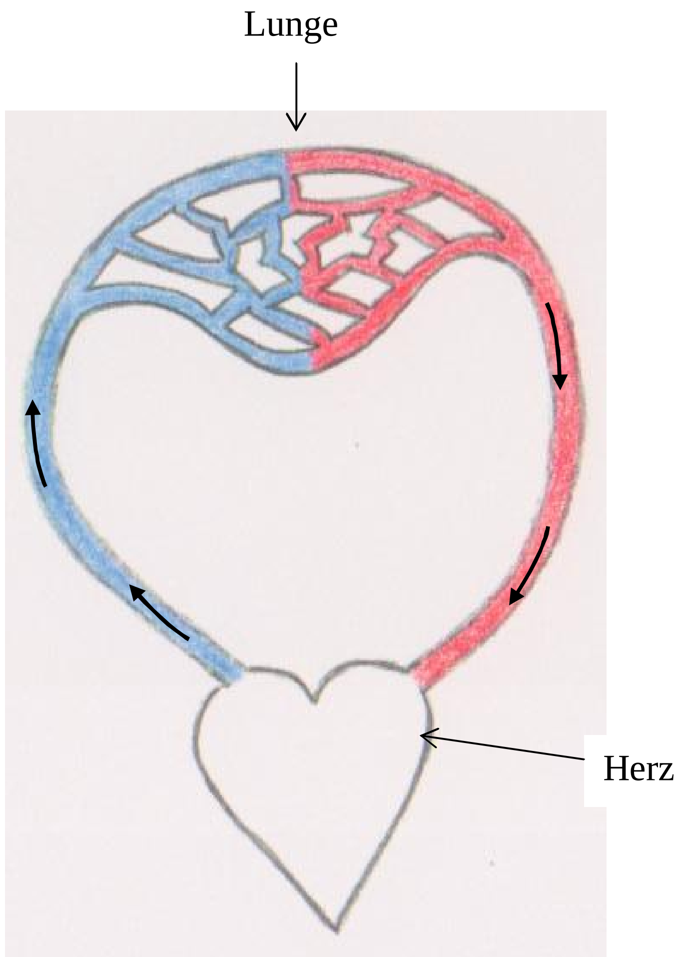
Merke dir das Wichtigste von dem Bild!

STOPP!

Aufgabe 13

Findest du Sachen, die im Text und im Bild vorkommen? Blättere auf die nächste Seite und suche danach.

Seite 3



rot = Blut mit viel Sauerstoff

blau = Blut mit wenig Sauerstoff

STOPP!

Aufgabe 14

Seite 4

Merke dir das Wichtigste vom Text!

Aufgabe 15

Merke dir besonders die fett geschriebenen Wörter im folgenden Satz!

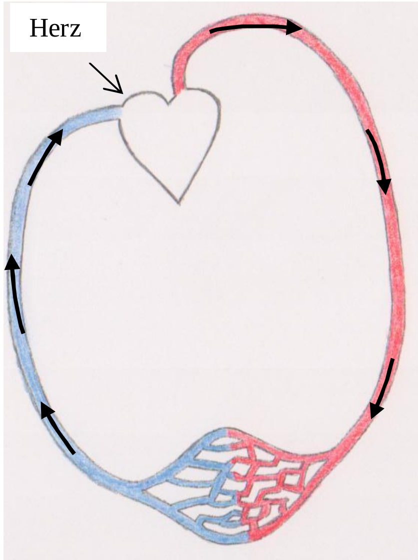
Der Weg des Blutes durch den Körper heißt **großer Körperkreislauf**.

STOPP!

Aufgabe 17

Merke dir das Wichtigste vom großen Bild!

Zweite Hälfte



Erste Hälfte

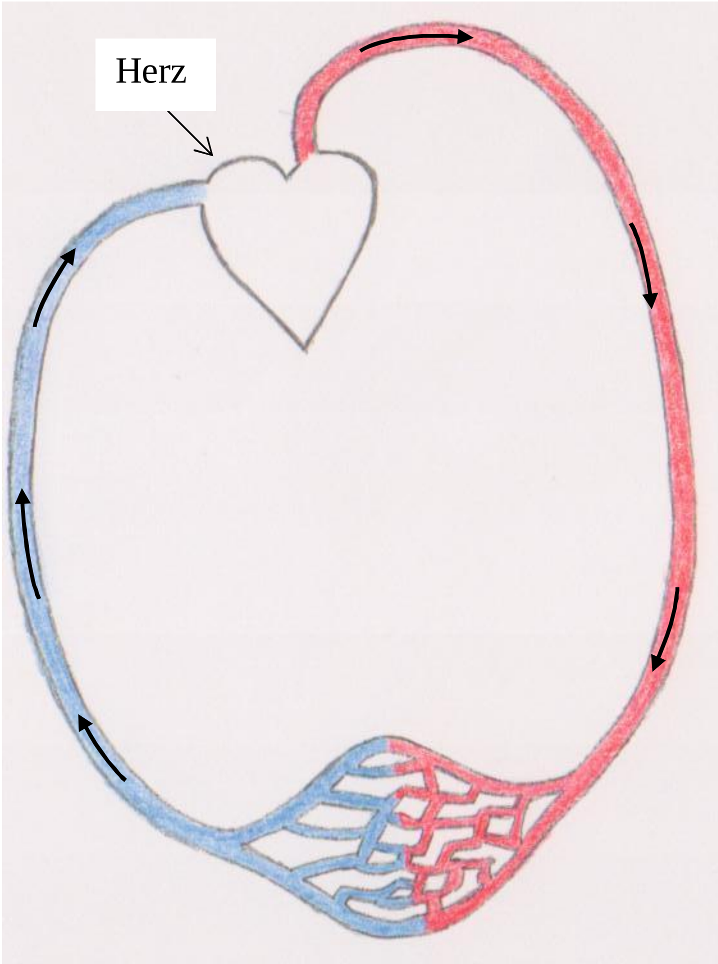
Körper

rot = Blut mit viel Sauerstoff

blau = Blut mit wenig Sauerstoff

Aufgabe 16

Wir haben gesehen, dass die Pfeile in den Kreisläufen immer im Uhrzeigersinn laufen. Schaue dir das obere Bild an! Im **Körperkreislauf** wird die erste Hälfte rot gemalt. Die zweite Hälfte wird blau gemalt. Merke dir das gut!



Körper

rot = Blut mit viel Sauerstoff

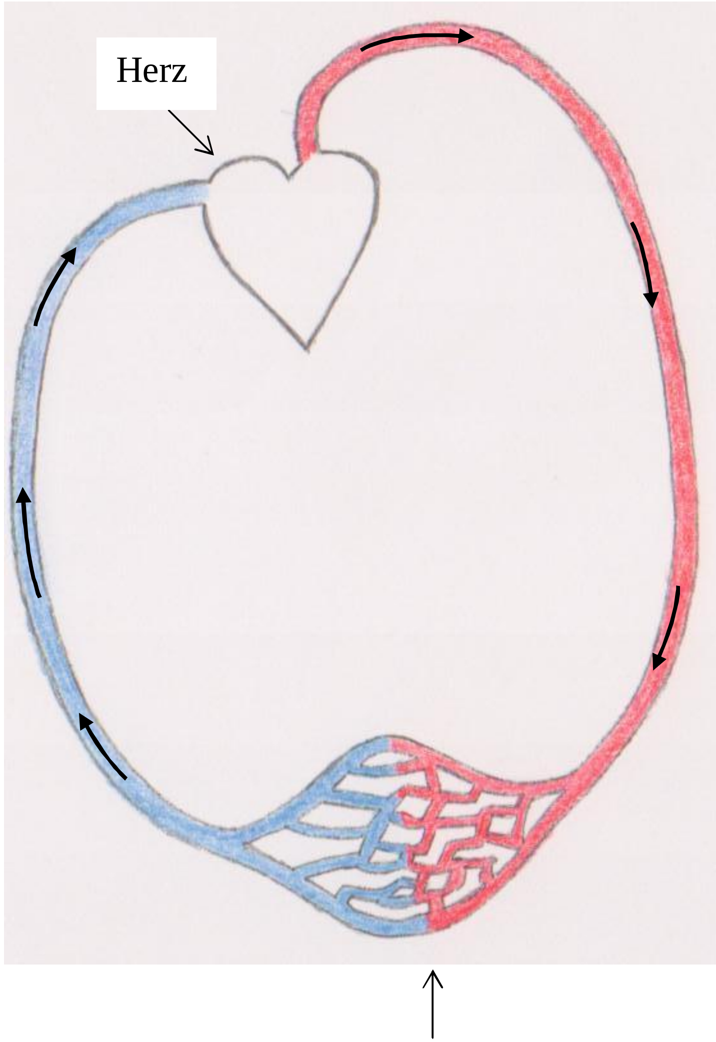
blau = Blut mit wenig Sauerstoff

STOPP!

Aufgabe 18

Findest du Sachen, die im Text und im Bild vorkommen? Blättere auf die nächste Seite und suche danach.

Seite 4



rot = Blut mit viel Sauerstoff

blau = Blut mit wenig Sauerstoff

STOPP!

Aufgabe 19 **Seite 5**

Merke dir das Wichtigste vom Text!

Aufgabe 20

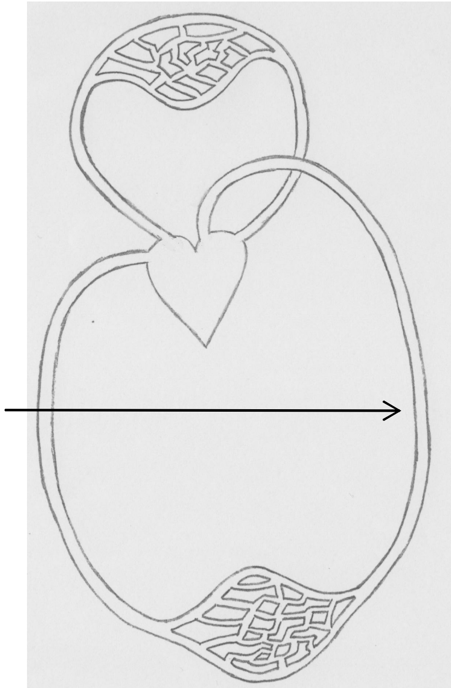
Schreibe das richtige Wie-Wort beim Lungenkreislauf und beim Körperkreislauf hin!

Wie-Wörter: großer, schwacher, kleiner, starker

___________________________ Lungenkreislauf

___________________________ Körperkreislauf

STOPP!



____________?

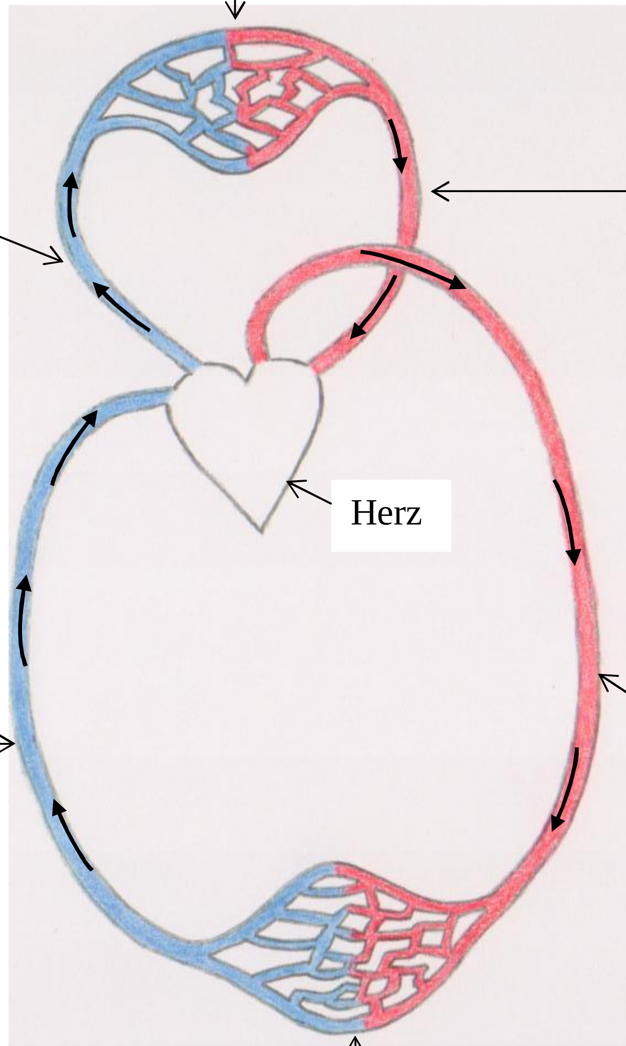
Körper

<u>Aufgabe 21</u>

Schreibe das richtige Wort an den oberen Pfeil!

Merke dir gut, wie die Ader heißt!

Lunge



Arterie

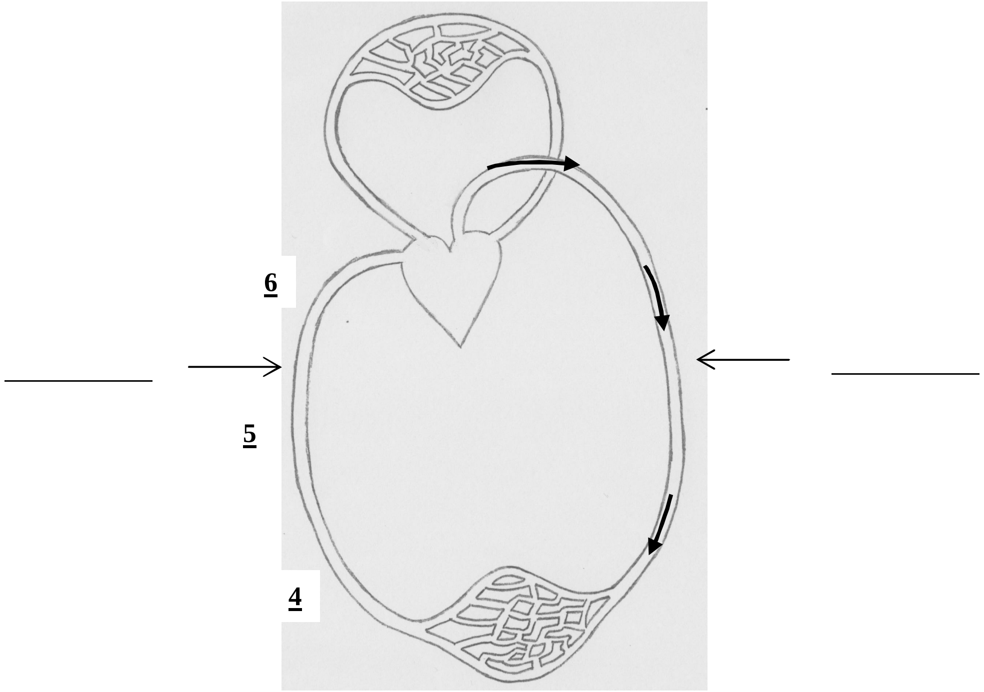
Vene

Vene

Arterie

rot und blau = Blut

Körper



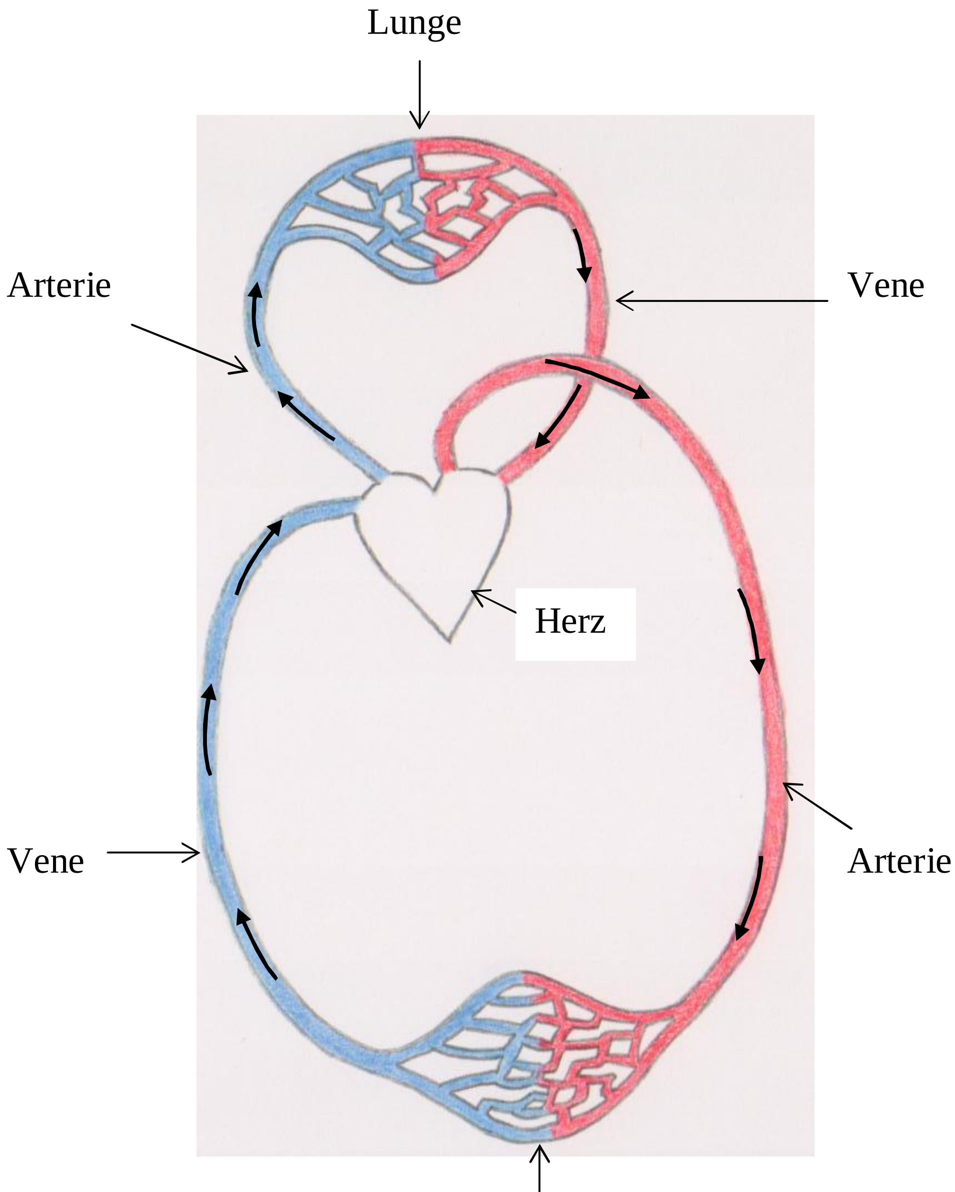
Körper

Aufgabe 22

Schreibe zuerst das Wort „Vene“ an die richtige Stelle! Zeichne dann die drei Pfeile bei den Zahlen 4, 5 und 6 ein. Vergleiche deine Pfeile mit den schwarzen Pfeilen im großen Bild!

Aufgabe 23

Merke dir das Wichtigste vom großen Bild!



rot und blau = Blut

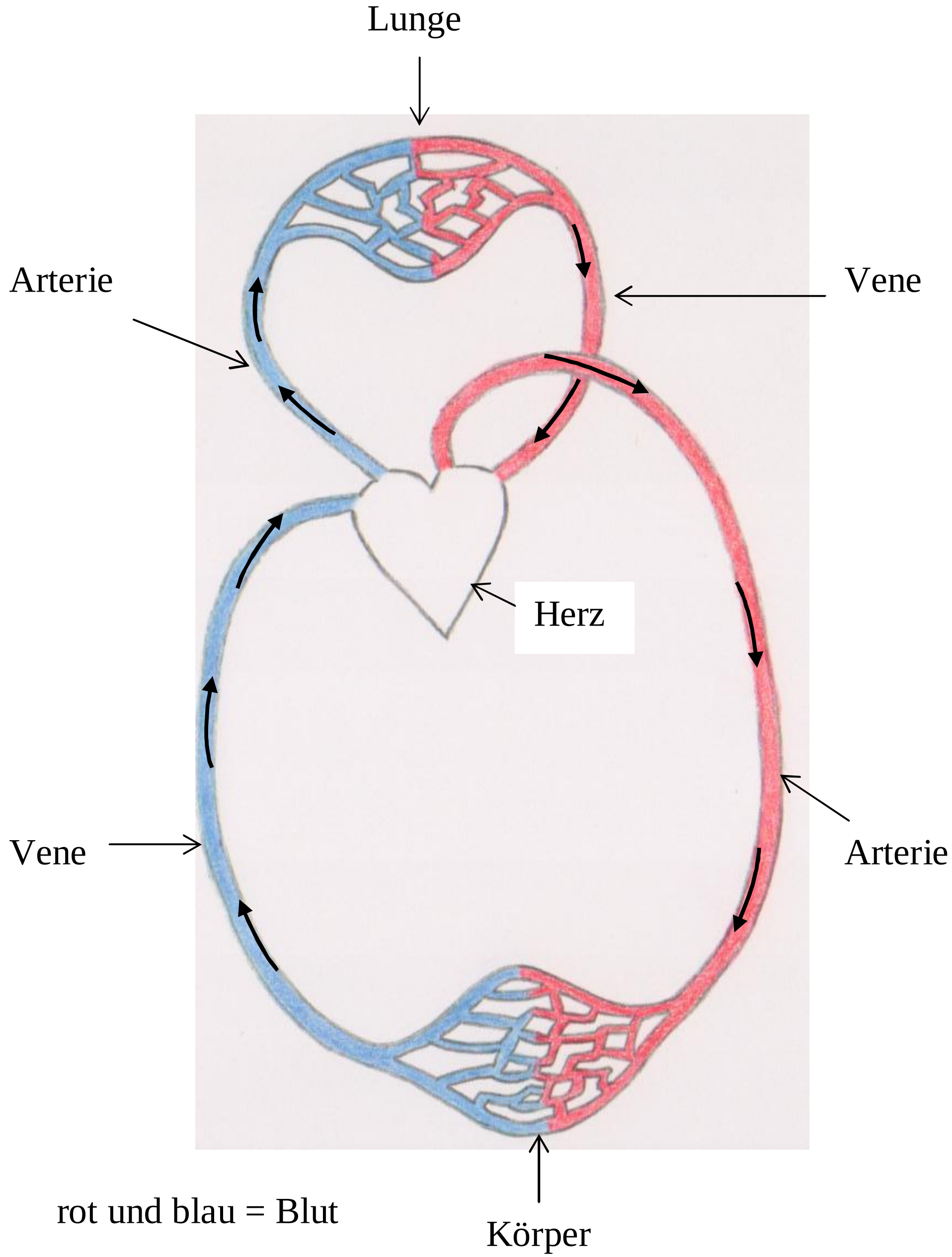
Körper

STOPP!

Aufgabe 24

Findest du Sachen, die im Text und im Bild vorkommen? Blättere auf die nächste Seite und suche danach.

Seite 5



rot und blau = Blut

STOPP!

Appendix P

Experiment 2: Learning Unit 1 – "spoken text + pictures + selection/organization aids + integration aids" condition

The text used in the "written text + pictures + selection/organization aids + integration aids" condition (Experiment 2: Learning Unit 1 – "written text + pictures + selection/organization aids + integration aids" condition) was spoken.

Unser Blutkreislauf (1)

Stopp!

Aufgabe 1

Seite 1

Merke dir das Wichtigste vom Text!

STOPP!

Aufgabe 2

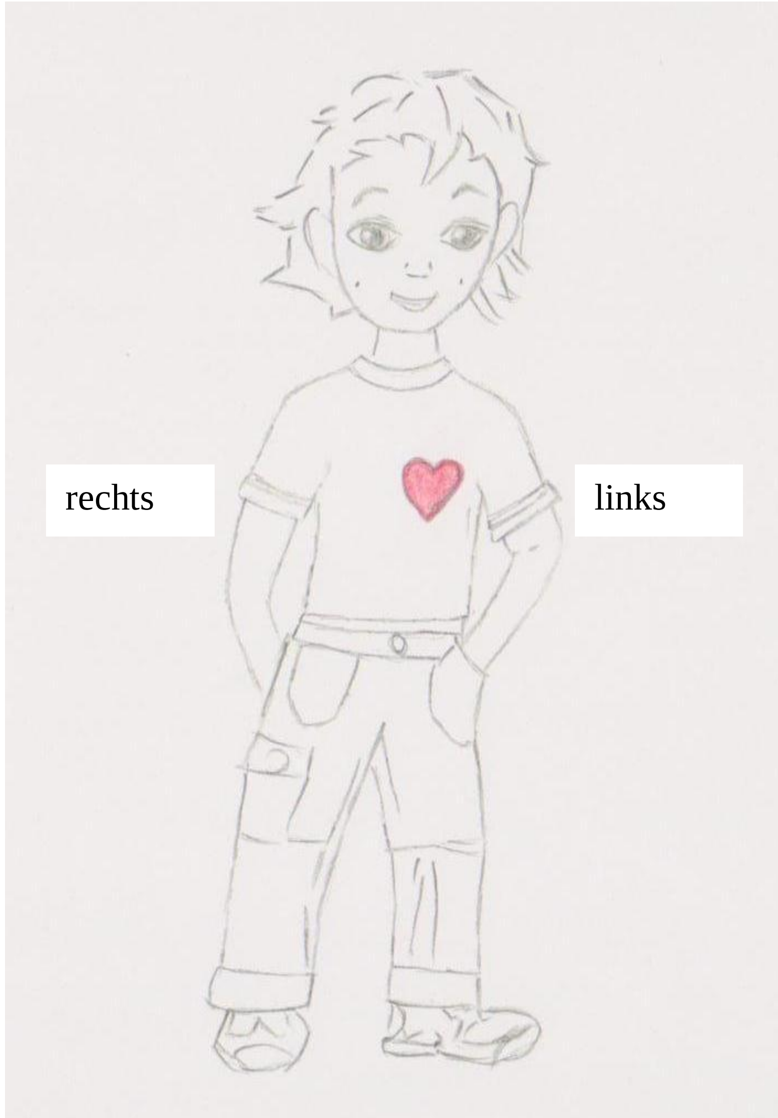
Merke dir das Wichtigste vom Bild!

STOPP!

Aufgabe 3

Findest du Sachen, die im Text und im Bild vorkommen? Blättere auf die nächste Seite und suche danach.

Seite 1



STOPP!

Aufgabe 4

Seite 2

Merke dir das Wichtigste vom Text!

Aufgabe 5

Kreise das richtige Wort ein!

Im Blut sind viele Stoffe, die dein Körper an vielen / allen Stellen braucht.

Aufgabe 6

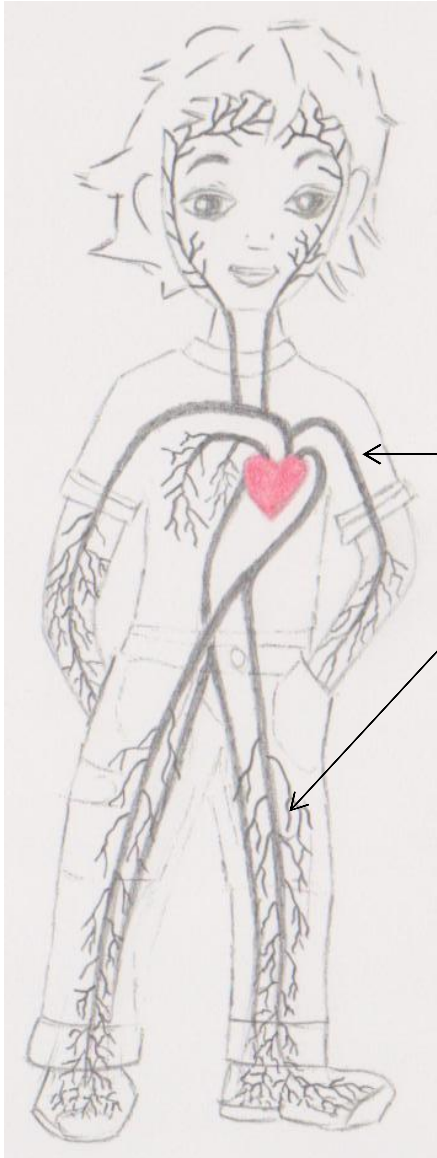
Ergänze den folgenden Satz!

Das Blut fließt innerhalb der Adern immer in ____.

STOPP!

Aufgabe 7

Merke dir das Wichtigste vom Bild!

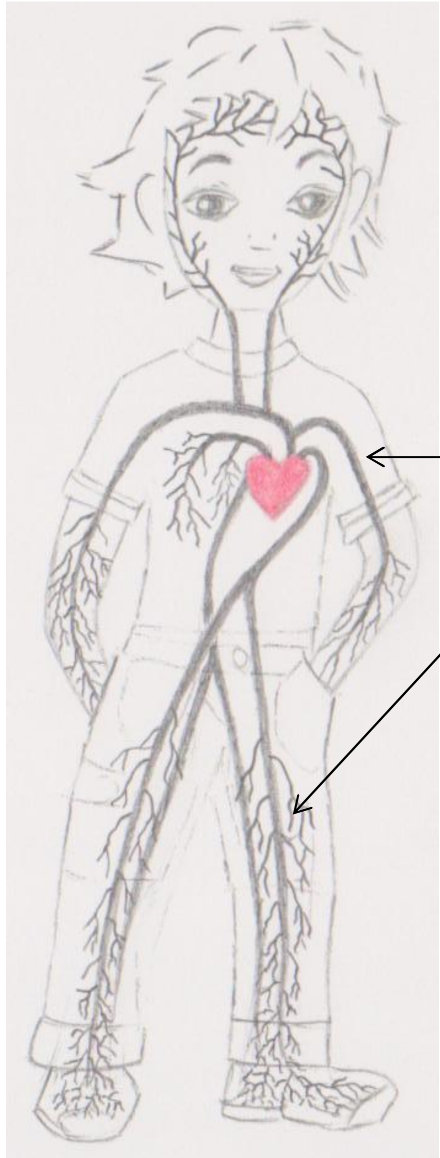


STOPP!

Aufgabe 8

Findest du Sachen, die im Text und im Bild vorkommen? Blättere auf die nächste Seite und suche danach.

Seite 2



Blutgefäße oder
Adern,
in denen Blut fließt

STOPP!

Aufgabe 9

Seite 3

Merke dir das Wichtigste vom Text!

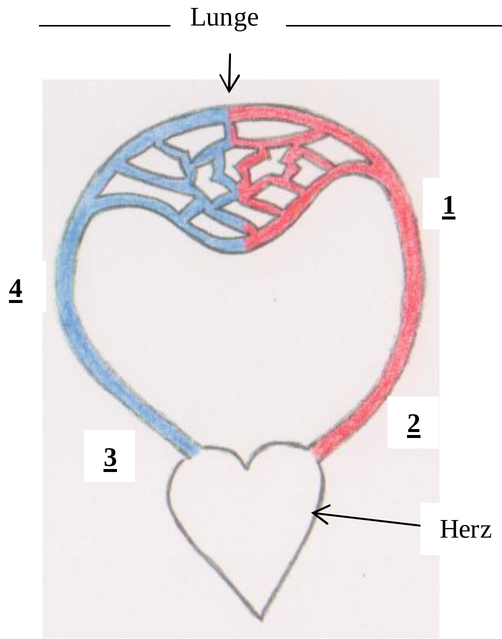
Aufgabe 10

Schreibe die zwei richtigen Wörter in die Lücken!

Der Weg des Blutes in die Lunge heißt

______________ _________________________.

STOPP!

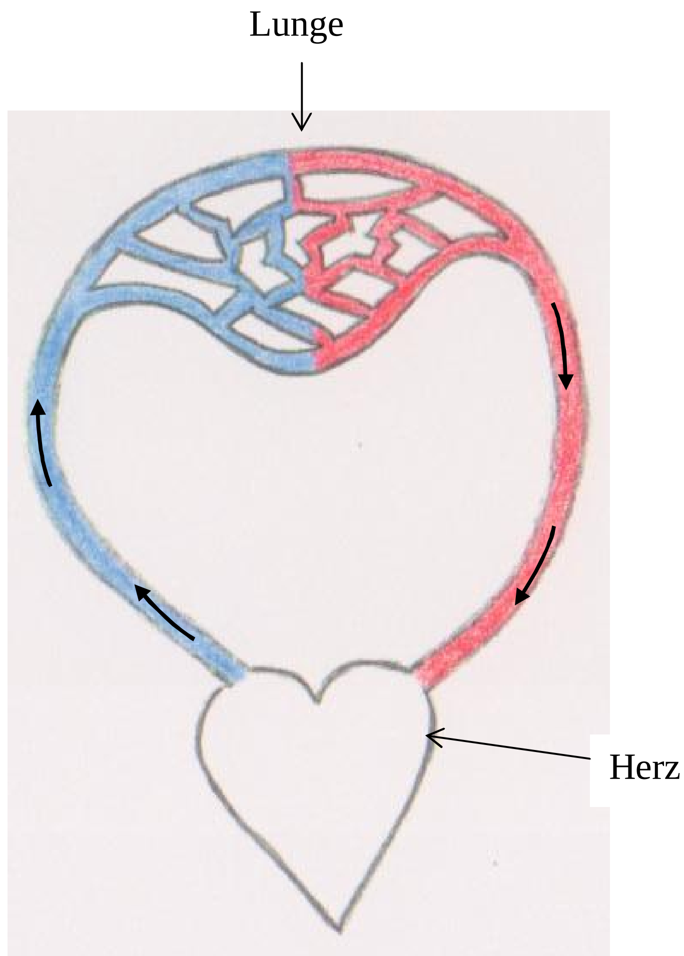


rot = Blut mit viel Sauerstoff

blau = Blut mit wenig Sauerstoff

<u>Aufgabe 11</u>

Zeichne die vier Pfeile bei den Zahlen 1, 2, 3 und 4 ein. Vergleiche deine Pfeile mit den schwarzen Pfeilen im großen Bild. Lege nun deinen Finger auf den ersten Pfeil und fahre den Weg der Pfeile mit deinem Finger nach. Merke dir, dass die Pfeile im **Lungenkreislauf** im **Uhrzeigersinn** laufen!



rot = Blut mit viel Sauerstoff

blau = Blut mit wenig Sauerstoff

<u>Aufgabe 12</u>

Merke dir das Wichtigste vom großen Bild!

STOPP!

Aufgabe 13

Findest du Sachen, die im Text und im Bild vorkommen? Bearbeite zuerst die Aufgaben und suche dann nach diesen Sachen. Blättere jetzt auf die nächste Seite.

Seite 3

Aufgabe 14

Ergänze den Satz!

Die Lunge nimmt

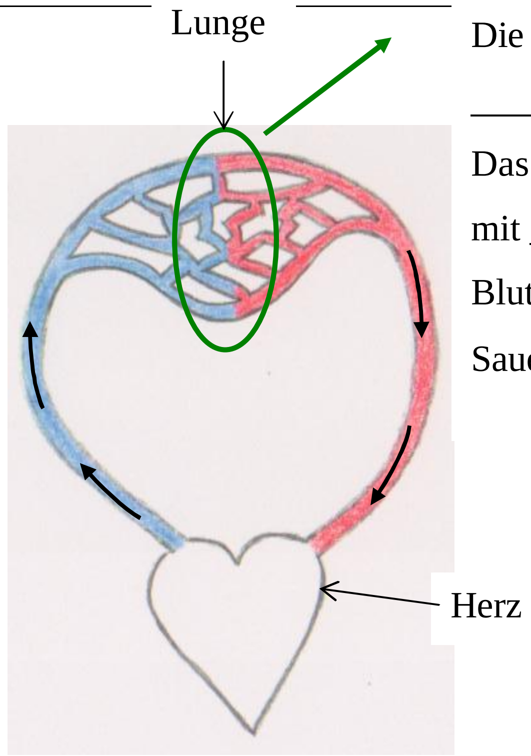
______________________ auf.

Das sehe ich daran, dass Blut

mit _________ Sauerstoff zu

Blut mit _________

Sauerstoff wird.



rot = Blut mit viel Sauerstoff

blau = Blut mit wenig Sauerstoff

Aufgabe 15

Ergänze!

In der Lunge ist immer Blut mit wenig _________________

und Blut mit viel _________________.

STOPP!

Aufgabe 16

Seite 4

Merke dir das Wichtigste vom Text!

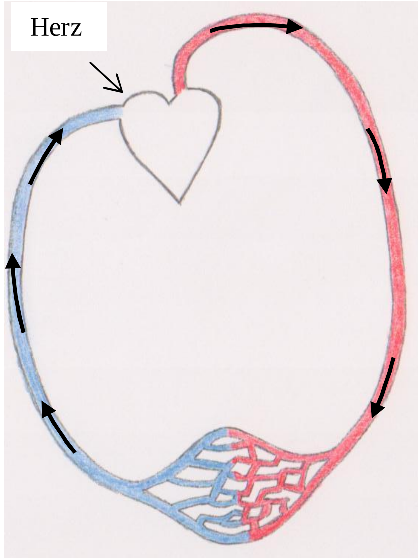
Aufgabe 17

Merke dir besonders die fett geschriebenen Wörter im folgenden Satz!

Der Weg des Blutes durch den Körper heißt **großer Körperkreislauf**.

STOPP!

Zweite Hälfte



Erste Hälfte

Körper

rot = Blut mit viel Sauerstoff

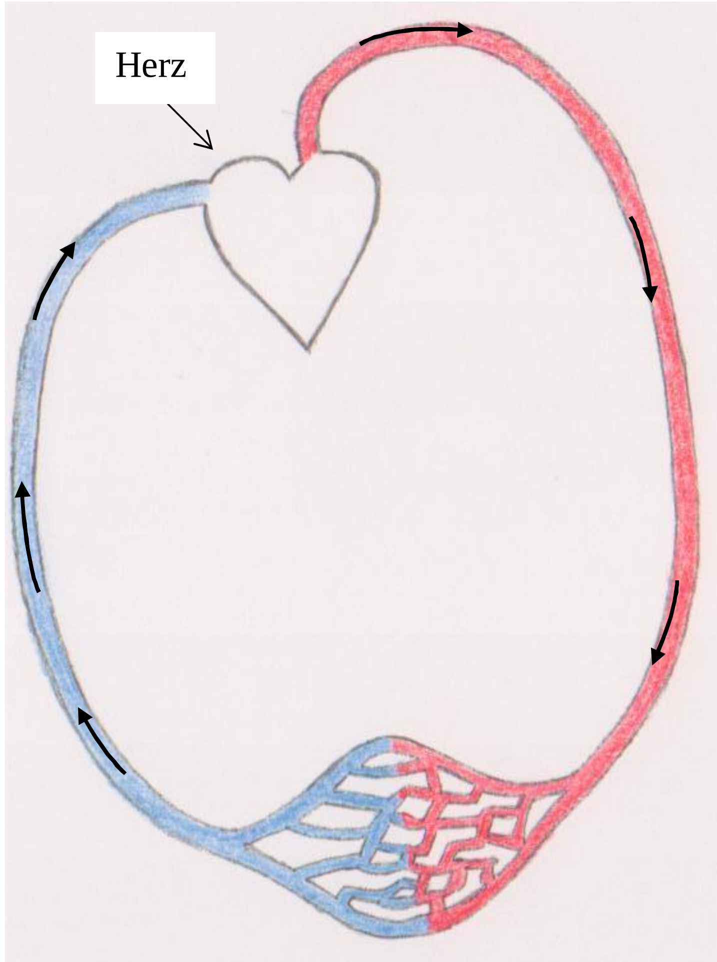
blau = Blut mit wenig Sauerstoff

Aufgabe 18

Wir haben gesehen, dass die Pfeile in den Kreisläufen immer im Uhrzeigersinn laufen. Schaue dir das obere Bild an! Im **Körperkreislauf** wird die erste Hälfte rot gemalt. Die zweite Hälfte wird blau gemalt. Merke dir das gut!

Aufgabe 19

Merke dir das Wichtigste vom großen Bild!



Körper

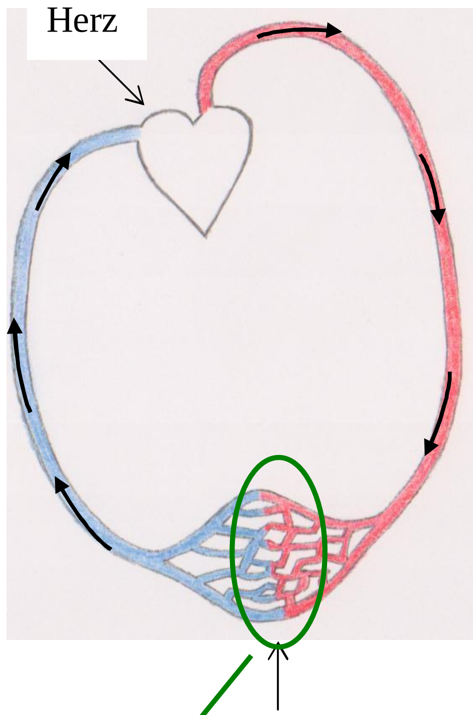
rot = Blut mit viel Sauerstoff

blau = Blut mit wenig Sauerstoff

STOPP!

Aufgabe 20

Findest du Sachen, die im Text und im Bild vorkommen? Bearbeite zuerst die Aufgaben und suche dann nach diesen Sachen. Blättere jetzt auf die nächste Seite.



Körper

rot = Blut mit viel Sauerstoff

blau = Blut mit wenig Sauerstoff

Aufgabe 21

Ergänze den Satz!

Der ________________________ wird an den Körper abgegeben.

Das sehe ich daran, dass Blut mit ________ Sauerstoff zu Blut

mit ________ Sauerstoff wird.

STOPP!

Aufgabe 22 **Seite 5**

Merke dir das Wichtigste vom Text!

Aufgabe 23

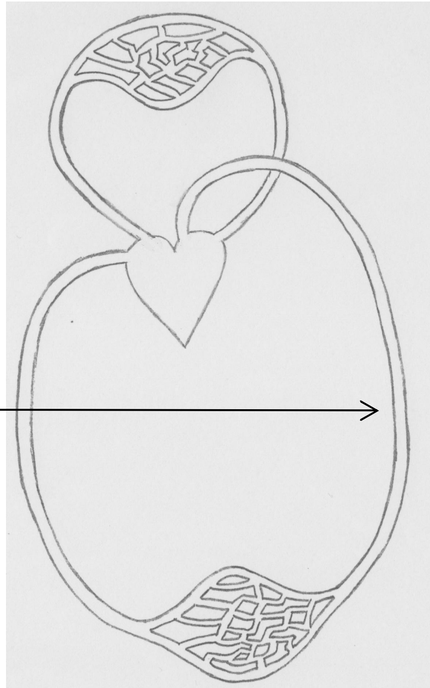
Schreibe das richtige Wie-Wort beim Lungenkreislauf und beim Körperkreislauf hin!

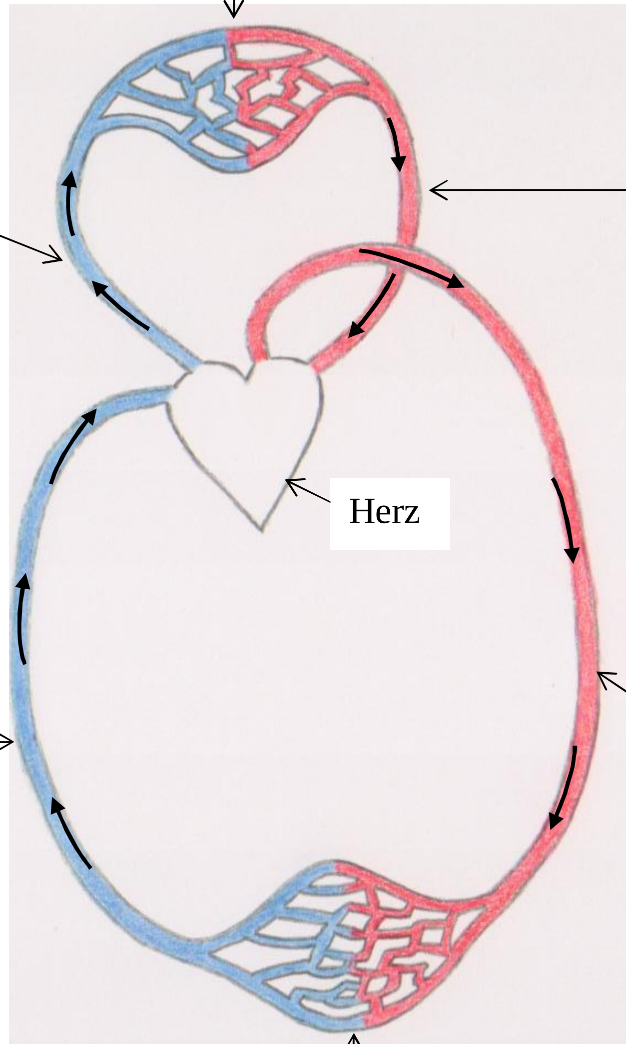
Wie-Wörter: großer, schwacher, kleiner, starker

__________________________ Lungenkreislauf

__________________________ Körperkreislauf

STOPP!



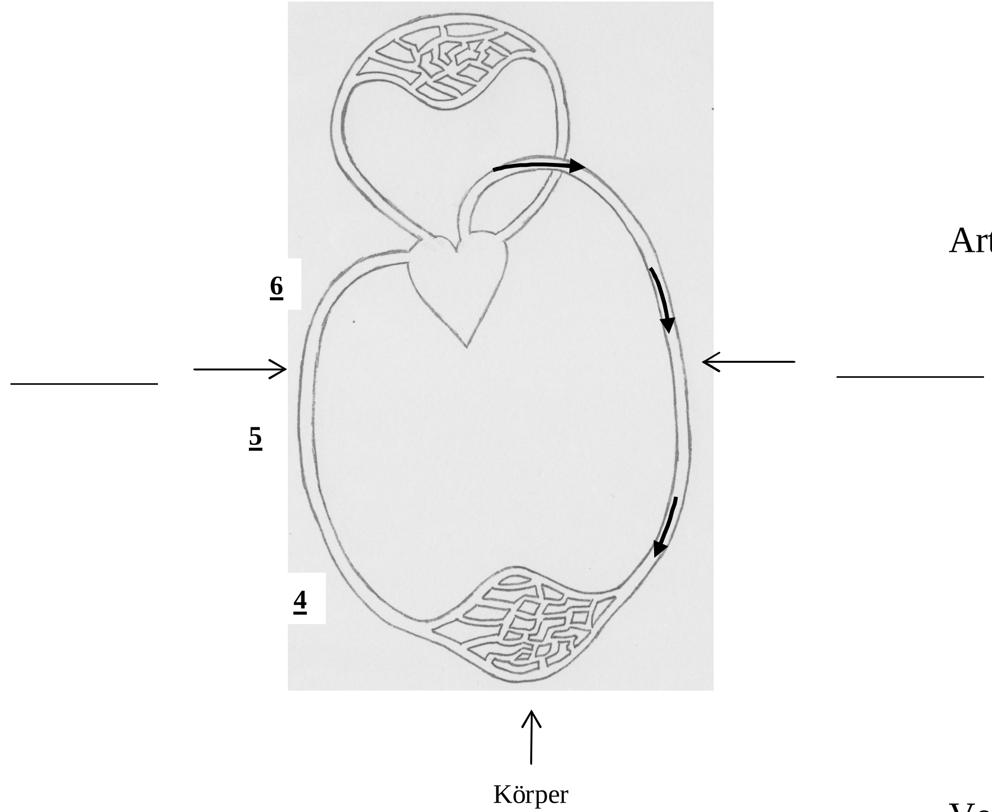


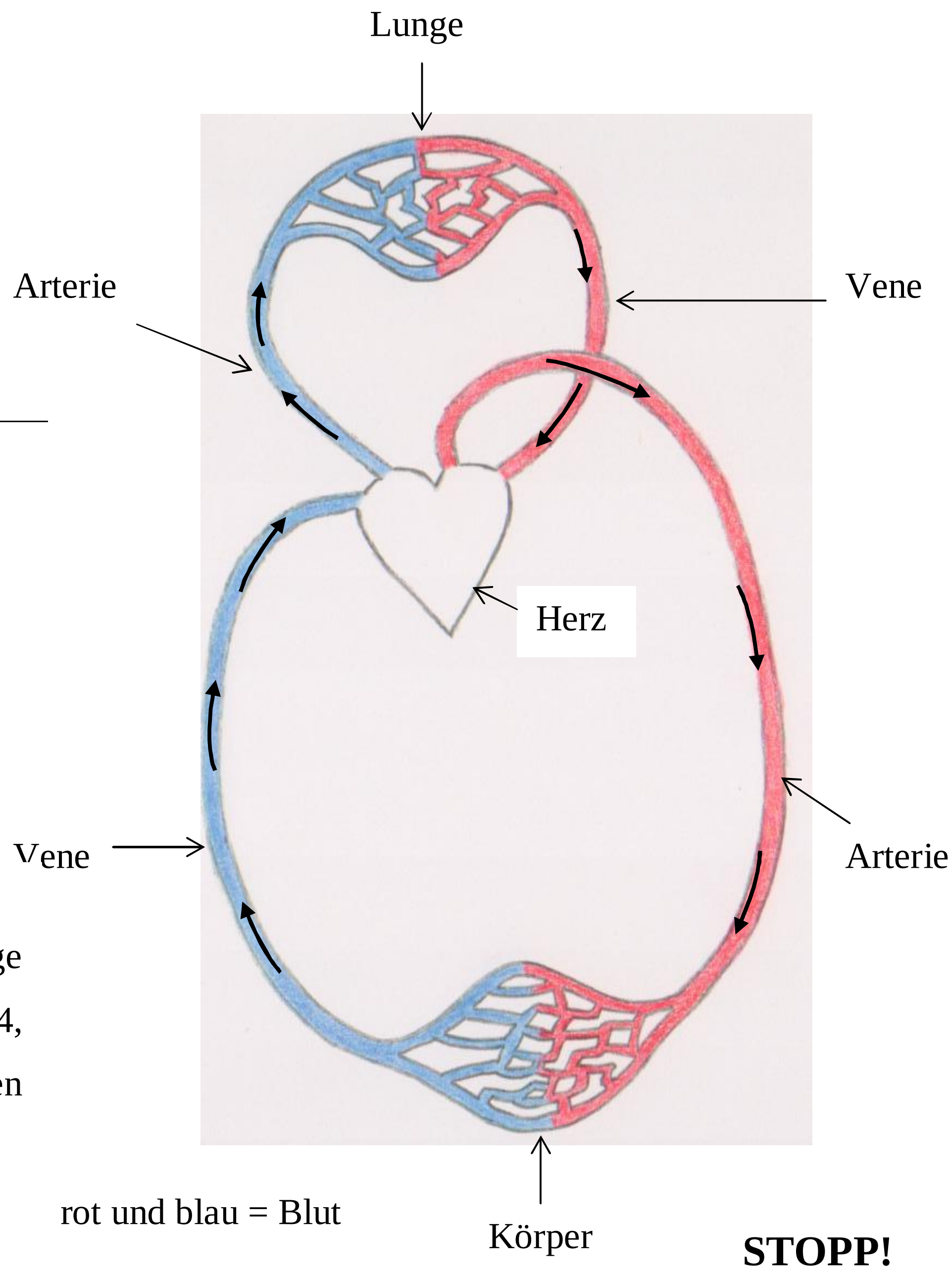
rot und blau = Blut

Aufgabe 24

Schreibe das richtige Wort an den oberen Pfeil!

Merke dir gut, wie die Ader heißt!





rot und blau = Blut

Aufgabe 25

Schreibe zuerst das Wort „Vene“ an die richtige Stelle! Zeichne dann die drei Pfeile bei den Zahlen 4, 5 und 6 ein. Vergleiche deine Pfeile mit den schwarzen Pfeilen im großen Bild!

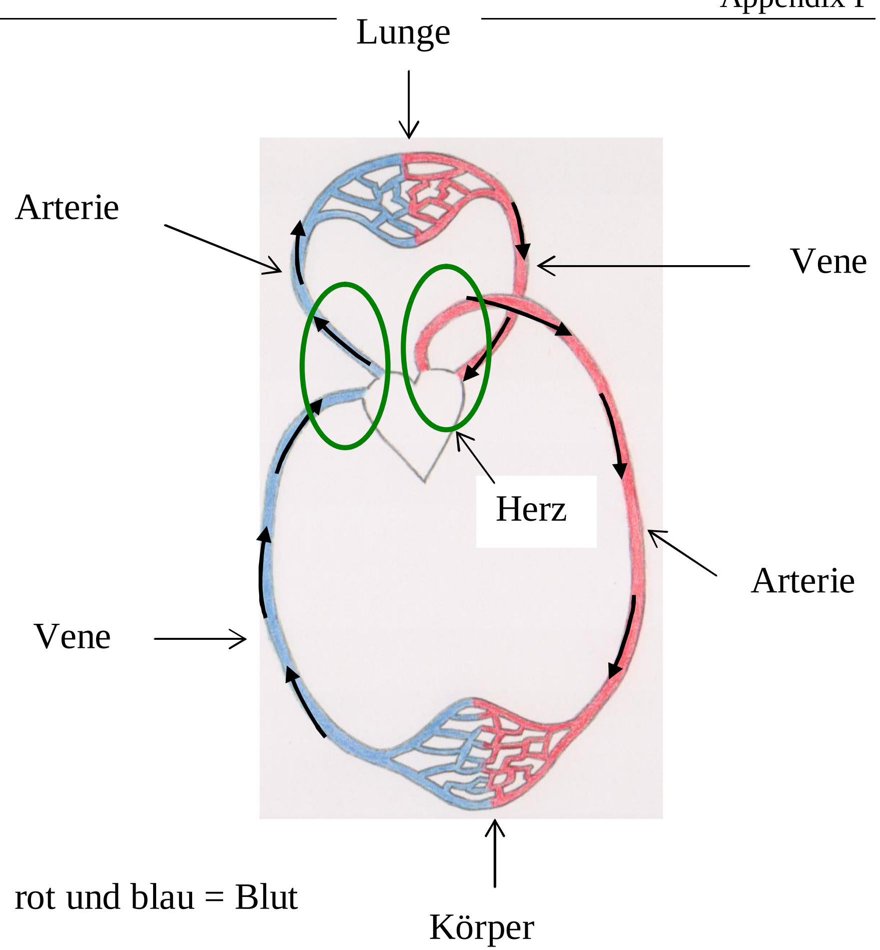
STOPP!

Aufgabe 26

Merke dir das Wichtigste vom großen Bild!

Aufgabe 27

Findest du Sachen, die im Text und im Bild vorkommen? Bearbeite zuerst die Aufgaben und suche dann nach diesen Sachen. Blättere jetzt auf die nächste Seite.



Aufgabe 31

Wie du siehst, sind der Lungenkreislauf und der Körperkreislauf durch das Herz miteinander verbunden. Ergänze den folgenden Satz!

Vom Lungen_____________________________ kommt das Blut in den Körperkreislauf und dann wieder in den ____. Fahre den Weg mit deinem Finger nach!

STOPP!

Appendix Q

Experiment 2: Learning Unit 2 – "written text" condition

Unser Blutkreislauf (2)

Stopp!

Aufgabe 1

Merke dir das Wichtigste vom Text!

Seite 1

Unser Blutkreislauf

Einleitung

Nina singt: „Lungenkreislauf, Körperkreislauf, Lungenkreislauf, Körperkreislauf…“ Tom klatscht dazu in die Hände und ruft: „Hey, Sauerstoff tanken und verteilen, das sind die beiden Sachen, die das Blut in den Kreisläufen macht.“

OK, das ist klar! Im kleinen Lungenkreislauf tankt das Blut den Sauerstoff auf. Und im großen Körperkreislauf verteilt es den Sauerstoff. Aber wie funktionieren der Lungenkreislauf, der Körperkreislauf und das Herz zusammen? Das lernst du heute.

STOPP!

Aufgabe 2

Merke dir das Wichtigste vom Text!

Seite 2

Das Herz

Wenn du an ein Herz denkst, stellst du es dir bestimmt wie ein Lebkuchenherz vor. Aber eigentlich sieht das Herz in deinem Körper nicht so aus. Dicke Rohre laufen in das Herz hinein und aus dem Herz heraus. Diese Rohre heißen Blutgefäße oder Adern. Erinnerst du dich? Sie sind überall in deinem Körper, wie ein Netz.

Das Herz ist innen hohl. Deshalb kann das Blut hinein und heraus fließen. Das Herz hilft dem Blut dabei, indem es sich immer wieder zusammenzieht und ausdehnt. So pumpt das Herz das Blut voran. Du kannst das Pumpen als deinen Herzschlag fühlen.

STOPP!

Aufgabe 3

Merke dir das Wichtigste vom Text!

Seite 3

Wie sieht das Herz innen aus?

Das Herz wird durch eine Wand in zwei Hälften geteilt: in die schwächere und in die stärkere Herzhälfte.

Jede Herzhälfte besteht aus zwei Teilen: einem kleinen Vorhof und einer größeren Herzkammer. Der Vorhof liegt über der Herzkammer und ist mit dieser verbunden.

In den Vorhof hinein läuft eine Vene. Das ist eine Ader, die das Blut zum Herz hin bringt. Von der Herzkammer heraus läuft eine Arterie. Das ist eine Ader, die das Blut vom Herz weg bringt.

STOPP!

Aufgabe 4

Merke dir das Wichtigste vom Text!

Seite 4

Jetzt lernst du, wie der Lungenkreislauf, der Körperkreislauf und das Herz zusammen funktionieren.

Der kleine Lungenkreislauf

Im kleinen Lungenkreislauf tankt das Blut Sauerstoff auf. Der kleine Lungenkreislauf startet immer in der schwächeren Herzhälfte. Diesen Weg nimmt das Blut: Das Blut fließt innerhalb des Herzens vom Vorhof in die Herzkammer. Von dort gelangt es nun in die Lunge. Von der Lunge fließt das Blut in den Vorhof der stärkeren Herzhälfte. In der stärkeren Herzhälfte endet der kleine Lungenkreislauf.

STOPP!

Aufgabe 5

Merke dir das Wichtigste vom Text!

Seite 5

Der große Körperkreislauf

Im großen Körperkreislauf wird der Sauerstoff überall in deinem Körper verteilt. Der große Körperkreislauf startet immer in der stärkeren Herzhälfte. Diesen Weg nimmt das Blut: Das Blut fließt innerhalb des Herzens vom Vorhof in die Herzkammer. Von dort gelangt es nun in deinen Körper. Wenn das Blut durch deinen Körper geflossen ist, kommt es in den Vorhof der schwächeren Herzhälfte zurück. In der schwächeren Herzhälfte endet der große Körperkreislauf.

STOPP!

Aufgabe 6

Merke dir das Wichtigste vom Text!

Seite 6

Nun beginnt alles wieder von vorne: Das Blut kommt wieder in den Lungenkreislauf, dann in den Körperkreislauf, dann wieder in den Lungenkreislauf…

Nun weißt du, dass unser Blutkreislauf aus dem kleinen Lungenkreislauf und dem großen Körperkreislauf besteht.

STOPP!

Appendix R

Experiment 2: Learning Unit 2 – “written text + pictures” condition

Unser Blutkreislauf (2)

Stopp!

Aufgabe 1

Merke dir das Wichtigste vom Text!

Seite 1

Unser Blutkreislauf

Einleitung

Nina singt: „Lungenkreislauf, Körperkreislauf, Lungenkreislauf, Körperkreislauf…“ Tom klatscht dazu in die Hände und ruft: „Hey, Sauerstoff tanken und verteilen, das sind die beiden Sachen, die das Blut in den Kreisläufen macht.“

OK, das ist klar! Im kleinen Lungenkreislauf tankt das Blut den Sauerstoff auf. Und im großen Körperkreislauf verteilt es den Sauerstoff. Aber wie funktionieren der Lungenkreislauf, der Körperkreislauf und das Herz zusammen? Das lernst du heute.

STOPP!

Aufgabe 2

Merke dir das Wichtigste vom Text!

Seite 2

Das Herz

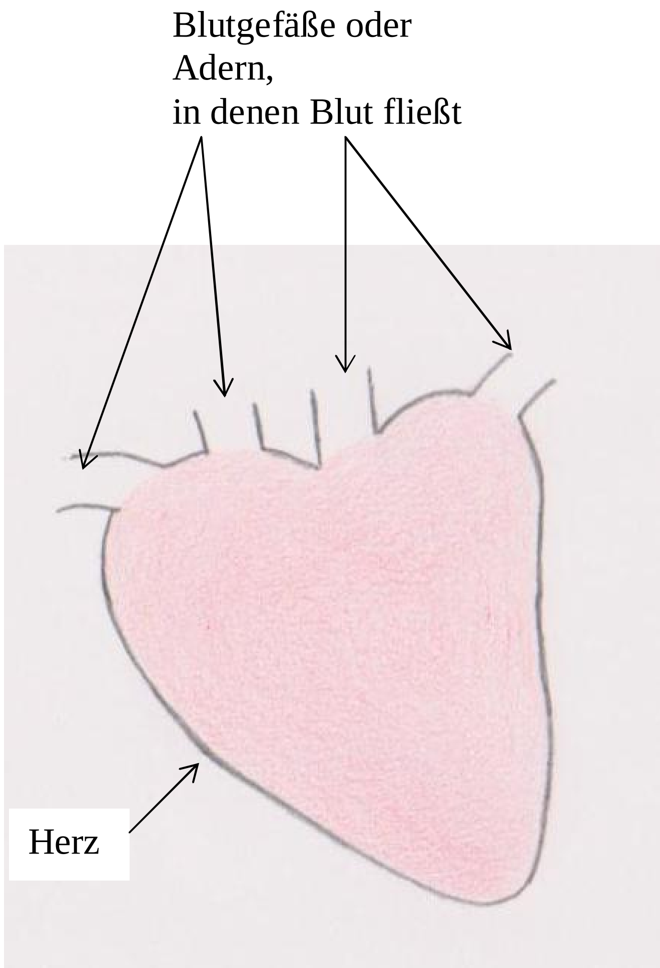
Wenn du an ein Herz denkst, stellst du es dir bestimmt wie ein Lebkuchenherz vor. Aber eigentlich sieht das Herz in deinem Körper nicht so aus. Dicke Rohre laufen in das Herz hinein und aus dem Herz heraus. Diese Rohre heißen Blutgefäße oder Adern. Erinnerst du dich? Sie sind überall in deinem Körper, wie ein Netz.

Das Herz ist innen hohl. Deshalb kann das Blut hinein und heraus fließen. Das Herz hilft dem Blut dabei, indem es sich immer wieder zusammenzieht und ausdehnt. So pumpt das Herz das Blut voran. Du kannst das Pumpen als deinen Herzschlag fühlen.

STOPP!

Aufgabe 3

Merke dir das Wichtigste vom Bild!



STOPP!

Aufgabe 4

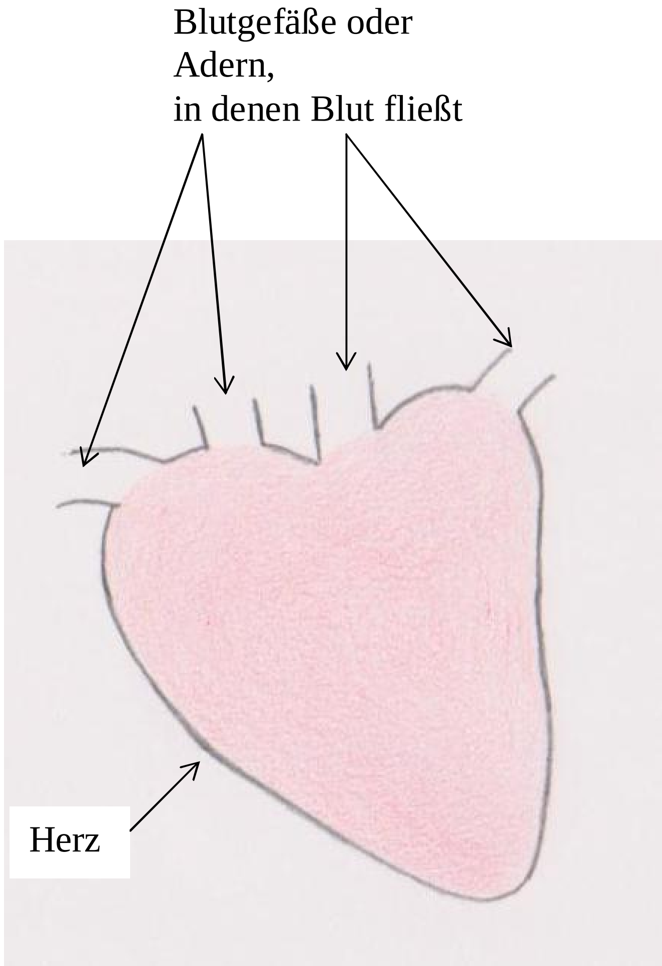
Findest du Sachen, die im Text und im Bild vorkommen? Blättere auf die nächste Seite und suche danach.

Seite 2

Das Herz

Wenn du an ein Herz denkst, stellst du es dir bestimmt wie ein Lebkuchenherz vor. Aber eigentlich sieht das Herz in deinem Körper nicht so aus. Dicke Rohre laufen in das Herz hinein und aus dem Herz heraus. Diese Rohre heißen Blutgefäße oder Adern. Erinnerst du dich? Sie sind überall in deinem Körper, wie ein Netz.

Das Herz ist innen hohl. Deshalb kann das Blut hinein und heraus fließen. Das Herz hilft dem Blut dabei, indem es sich immer wieder zusammenzieht und ausdehnt. So pumpt das Herz das Blut voran. Du kannst das Pumpen als deinen Herzschlag fühlen.



STOPP!

Aufgabe 5

Merke dir das Wichtigste vom Text!

Seite 3

Wie sieht das Herz innen aus?

Das Herz wird durch eine Wand in zwei Hälften geteilt: in die schwächere und in die stärkere Herzhälfte.

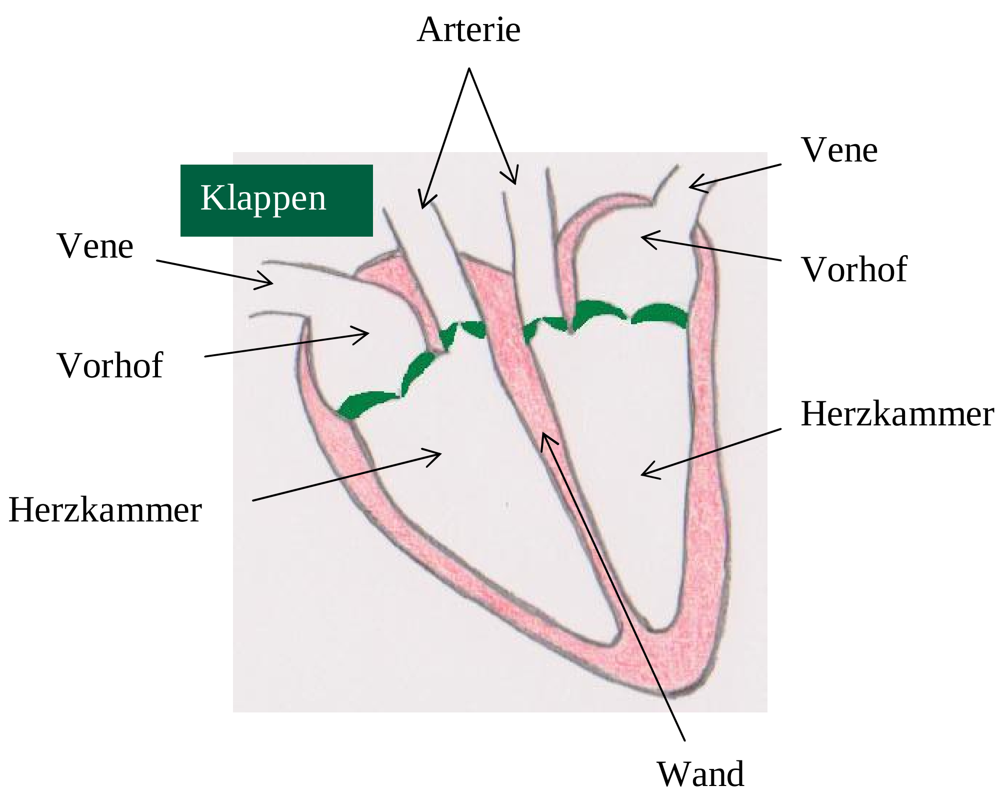
Jede Herzhälfte besteht aus zwei Teilen: einem kleinen Vorhof und einer größeren Herzkammer. Der Vorhof liegt über der Herzkammer und ist mit dieser verbunden.

In den Vorhof hinein läuft eine Vene. Das ist eine Ader, die das Blut zum Herz hin bringt. Von der Herzkammer heraus läuft eine Arterie. Das ist eine Ader, die das Blut vom Herz weg bringt.

STOPP!

Aufgabe 6

Merke dir das Wichtigste vom Bild!



STOPP!

Aufgabe 7

Findest du Sachen, die im Text und im Bild vorkommen? Blättere auf die nächste Seite und suche danach.

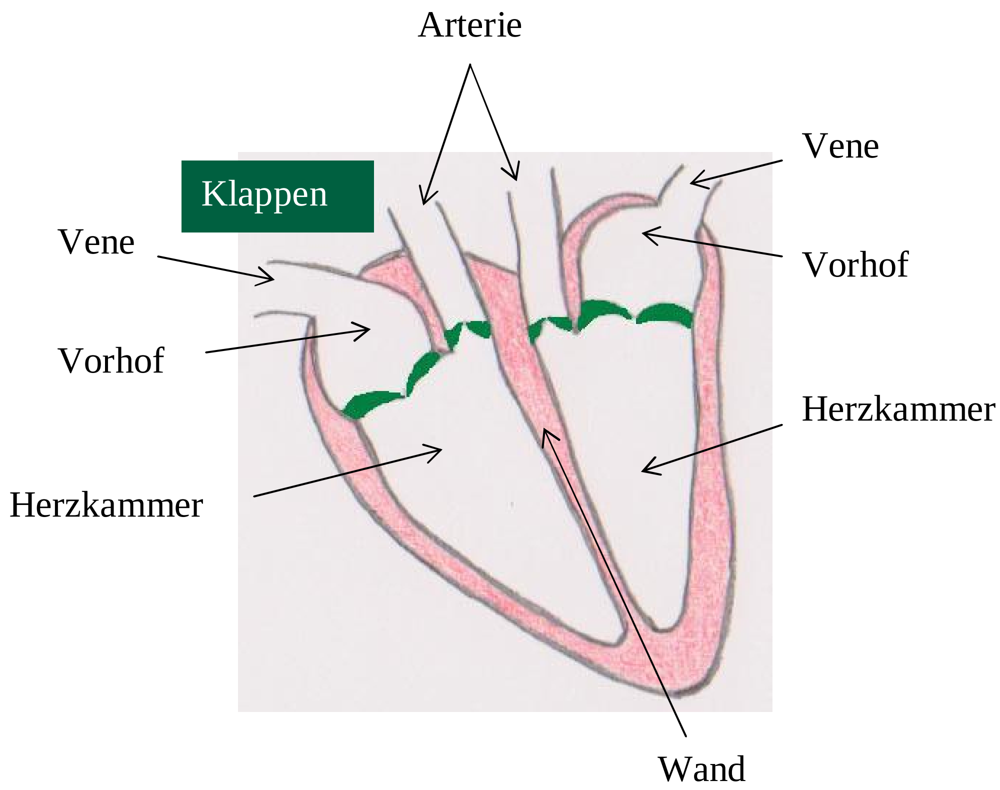
<u>Seite 3</u>

<u>Wie sieht das Herz innen aus?</u>

Das Herz wird durch eine Wand in zwei Hälften geteilt: in die schwächere und in die stärkere Herzhälfte.

Jede Herzhälfte besteht aus zwei Teilen: einem kleinen Vorhof und einer größeren Herzkammer. Der Vorhof liegt über der Herzkammer und ist mit dieser verbunden.

In den Vorhof hinein läuft eine Vene. Das ist eine Ader, die das Blut zum Herz hin bringt. Von der Herzkammer heraus läuft eine Arterie. Das ist eine Ader, die das Blut vom Herz weg bringt.



STOPP!

Aufgabe 8

Merke dir das Wichtigste vom Text!

Seite 4

Jetzt lernst du, wie der Lungenkreislauf, der Körperkreislauf und das Herz zusammen funktionieren.

Der kleine Lungenkreislauf

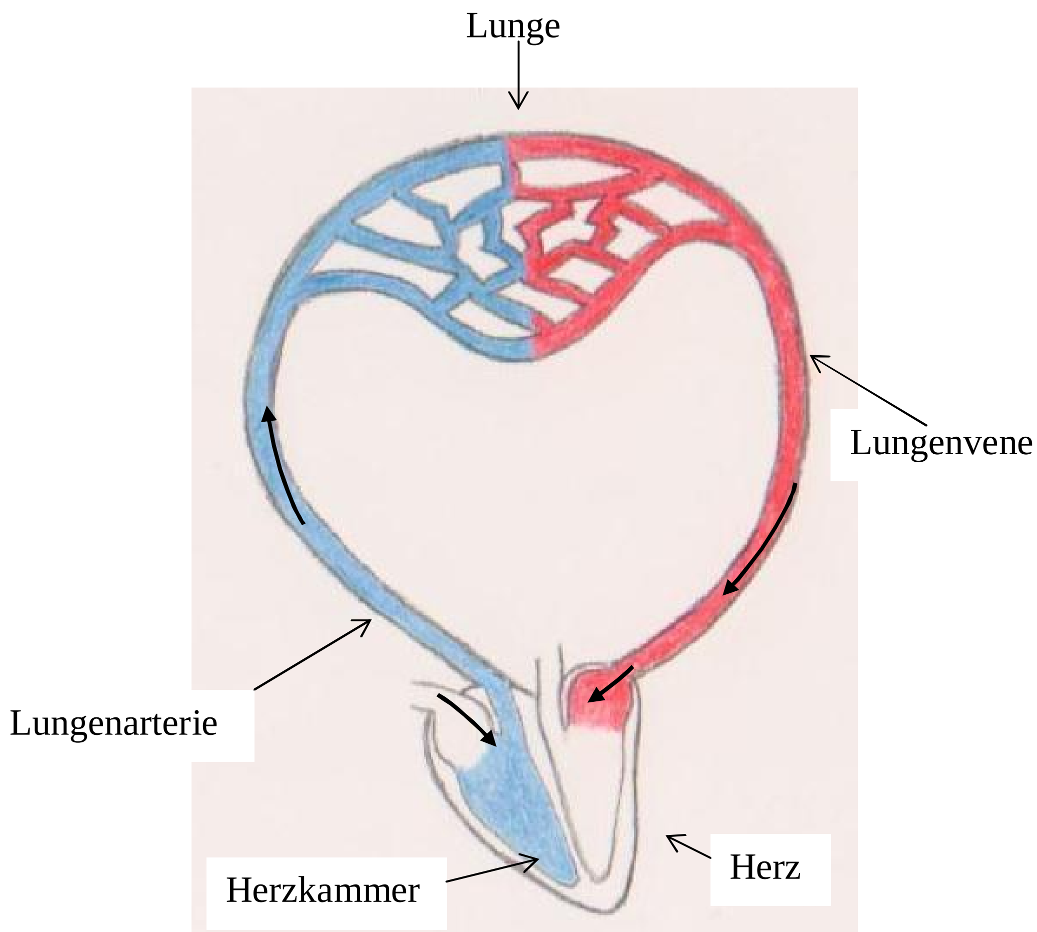
Im kleinen Lungenkreislauf tankt das Blut Sauerstoff auf. Der kleine Lungenkreislauf startet immer in der schwächeren Herzhälfte. Diesen Weg nimmt das Blut: Das Blut fließt innerhalb des Herzens vom Vorhof in die Herzkammer. Von dort gelangt es nun in die Lunge. Von der Lunge fließt das Blut in den Vorhof der stärkeren Herzhälfte. In der stärkeren Herzhälfte endet der kleine Lungenkreislauf.

STOPP!

Aufgabe 9

Merke dir das Wichtigste vom Bild!

Der kleine Lungenkreislauf



rot = Blut mit viel Sauerstoff

blau = Blut mit wenig Sauerstoff

STOPP!

Aufgabe 10

Findest du Sachen, die im Text und im Bild vorkommen? Blättere auf die nächste Seite und suche danach.

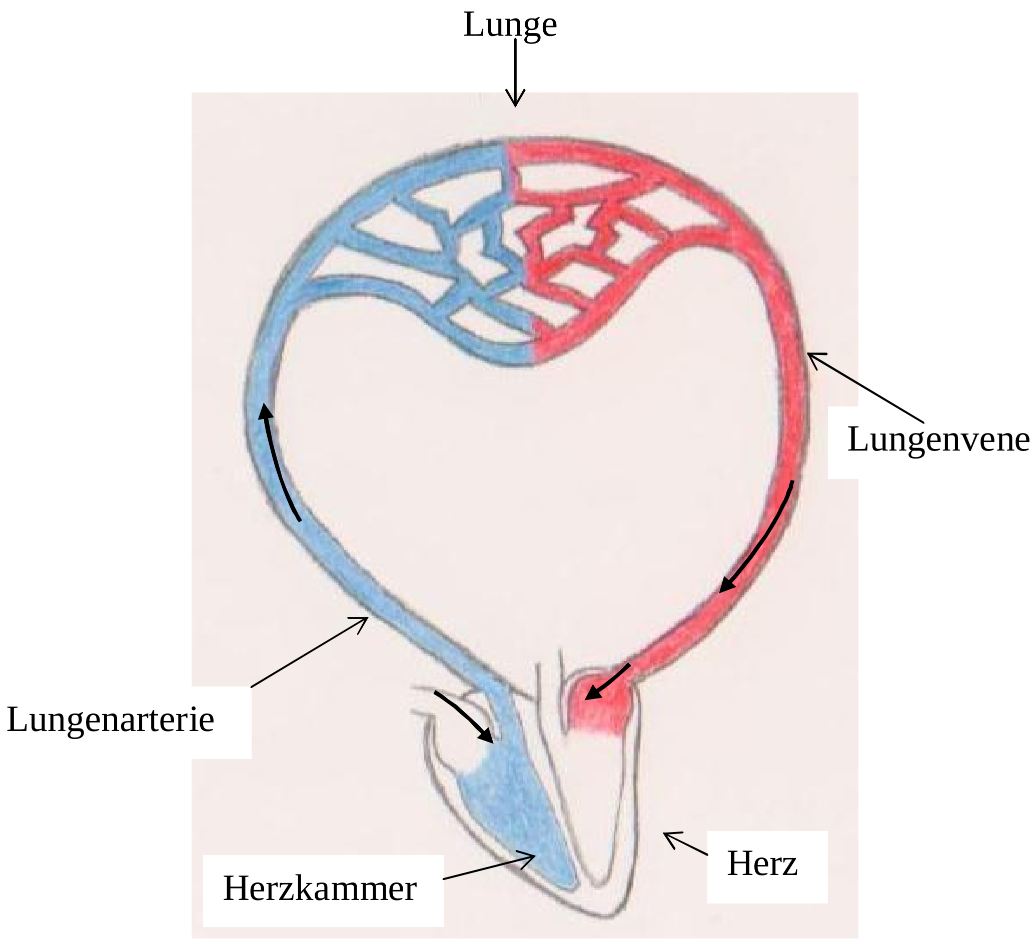
Seite 4

Jetzt lernst du, wie der Lungenkreislauf, der Körperkreislauf und das Herz zusammen funktionieren.

Der kleine Lungenkreislauf

Im kleinen Lungenkreislauf tankt das Blut Sauerstoff auf. Der kleine Lungenkreislauf startet immer in der schwächeren Herzhälfte. Diesen Weg nimmt das Blut: Das Blut fließt innerhalb des Herzens vom Vorhof in die Herzkammer. Von dort gelangt es nun in die Lunge. Von der Lunge fließt das Blut in den Vorhof der stärkeren Herzhälfte. In der stärkeren Herzhälfte endet der kleine Lungenkreislauf.

Der kleine Lungenkreislauf



rot = Blut mit viel Sauerstoff

blau = Blut mit wenig Sauerstoff

STOPP!

Aufgabe 11

Merke dir das Wichtigste vom Text!

Seite 5

Der große Körperkreislauf

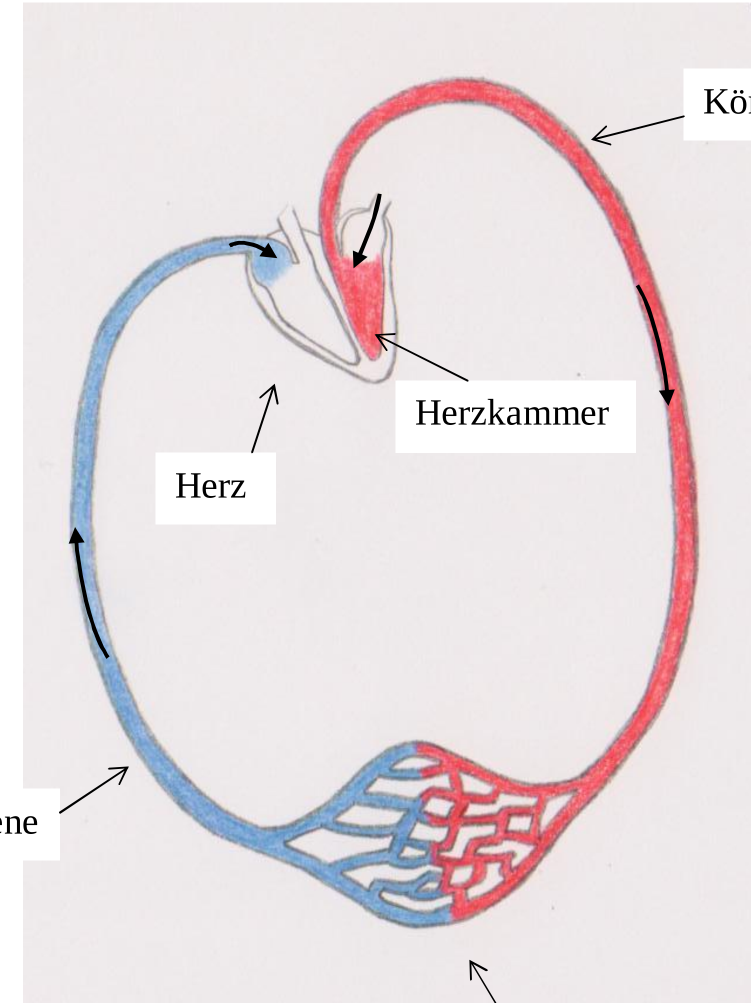
Im großen Körperkreislauf wird der Sauerstoff überall in deinem Körper verteilt. Der große Körperkreislauf startet immer in der stärkeren Herzhälfte. Diesen Weg nimmt das Blut: Das Blut fließt innerhalb des Herzens vom Vorhof in die Herzkammer. Von dort gelangt es nun in deinen Körper. Wenn das Blut durch deinen Körper geflossen ist, kommt es in den Vorhof der schwächeren Herzhälfte zurück. In der schwächeren Herzhälfte endet der große Körperkreislauf.

STOPP!

Aufgabe 12

Der große Körperkreislauf

Merke dir das Wichtigste vom Bild!



rot = Blut mit viel Sauerstoff

blau = Blut mit wenig Sauerstoff

STOPP!

Aufgabe 13

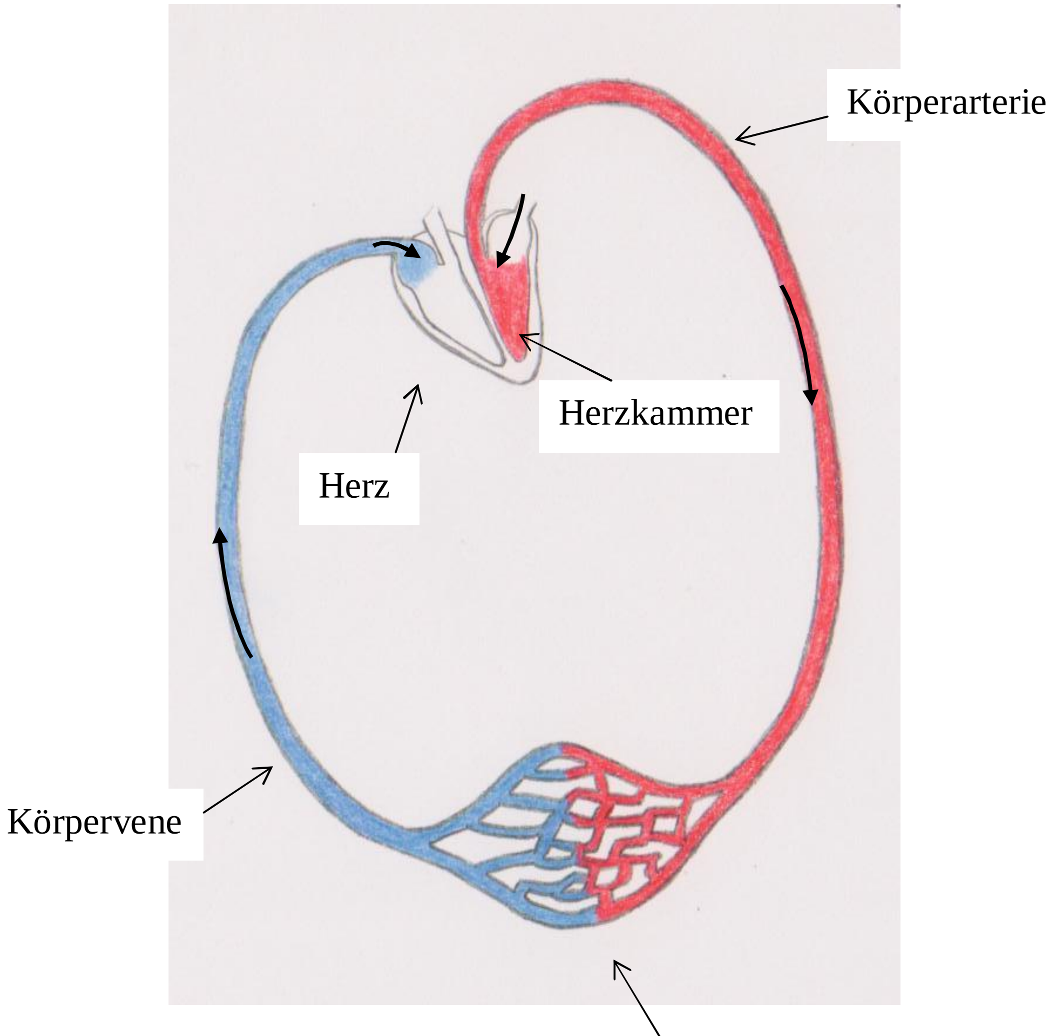
Findest du Sachen, die im Text und im Bild vorkommen? Blättere auf die nächste Seite und suche danach.

Seite 5

Der große Körperkreislauf

Im großen Körperkreislauf wird der Sauerstoff überall in deinem Körper verteilt. Der große Körperkreislauf startet immer in der stärkeren Herzhälfte. Diesen Weg nimmt das Blut: Das Blut fließt innerhalb des Herzens vom Vorhof in die Herzkammer. Von dort gelangt es nun in deinen Körper. Wenn das Blut durch deinen Körper geflossen ist, kommt es in den Vorhof der schwächeren Herzhälfte zurück. In der schwächeren Herzhälfte endet der große Körperkreislauf.

Der große Körperkreislauf



rot = Blut mit viel Sauerstoff

blau = Blut mit wenig Sauerstoff

STOPP!

Aufgabe 14

Merke dir das Wichtigste vom Text!

Seite 6

Nun beginnt alles wieder von vorne: Das Blut kommt wieder in den Lungenkreislauf, dann in den Körperkreislauf, dann wieder in den Lungenkreislauf…

Nun weißt du, dass unser Blutkreislauf aus dem kleinen Lungenkreislauf und dem großen Körperkreislauf besteht.

STOPP!

Appendix S

Experiment 2: Learning Unit 2 – “written text + pictures + selection/organization aids” condition

Unser Blutkreislauf (2)

Stopp!

Aufgabe 1

Merke dir das Wichtigste vom Text!

Seite 1

Unser Blutkreislauf

Einleitung

Nina singt: „Lungenkreislauf, Körperkreislauf, Lungenkreislauf, Körperkreislauf…“ Tom klatscht dazu in die Hände und ruft: „Hey, Sauerstoff tanken und verteilen, das sind die beiden Sachen, die das Blut in den Kreisläufen macht.“

OK, das ist klar! Im kleinen Lungenkreislauf tankt das Blut den Sauerstoff auf. Und im großen Körperkreislauf verteilt es den Sauerstoff. Aber wie funktionieren der Lungenkreislauf, der Körperkreislauf und das Herz zusammen? Das lernst du heute.

STOPP!

Aufgabe 2

Merke dir das Wichtigste vom Text!

Seite 2

Das Herz

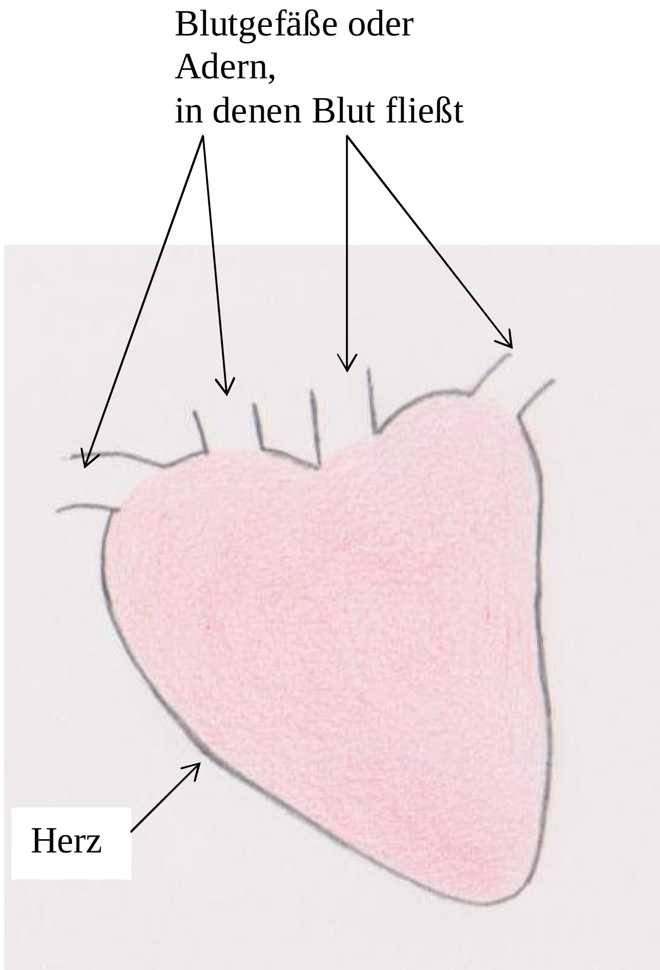
Wenn du an ein Herz denkst, stellst du es dir bestimmt wie ein Lebkuchenherz vor. Aber eigentlich sieht das Herz in deinem Körper nicht so aus. Dicke Rohre laufen in das Herz hinein und aus dem Herz heraus. Diese Rohre heißen Blutgefäße oder Adern. Erinnerst du dich? Sie sind überall in deinem Körper, wie ein Netz.

Das Herz ist innen hohl. Deshalb kann das Blut hinein und heraus fließen. Das Herz hilft dem Blut dabei, indem es sich immer wieder zusammenzieht und ausdehnt. So pumpt das Herz das Blut voran. Du kannst das Pumpen als deinen Herzschlag fühlen.

STOPP!

<u>Aufgabe 3</u>

Merke dir das Wichtigste vom Bild!



STOPP!

Aufgabe 4

Findest du Sachen, die im Text und im Bild vorkommen? Blättere auf die nächste Seite und suche danach.

Seite 2

Das Herz

Wenn du an ein Herz denkst, stellst du es dir bestimmt wie ein Lebkuchenherz vor. Aber eigentlich sieht das Herz in deinem Körper nicht so aus. Dicke Rohre laufen in das Herz hinein und aus dem Herz heraus. Diese Rohre heißen Blutgefäße oder Adern. Erinnerst du dich? Sie sind überall in deinem Körper, wie ein Netz.

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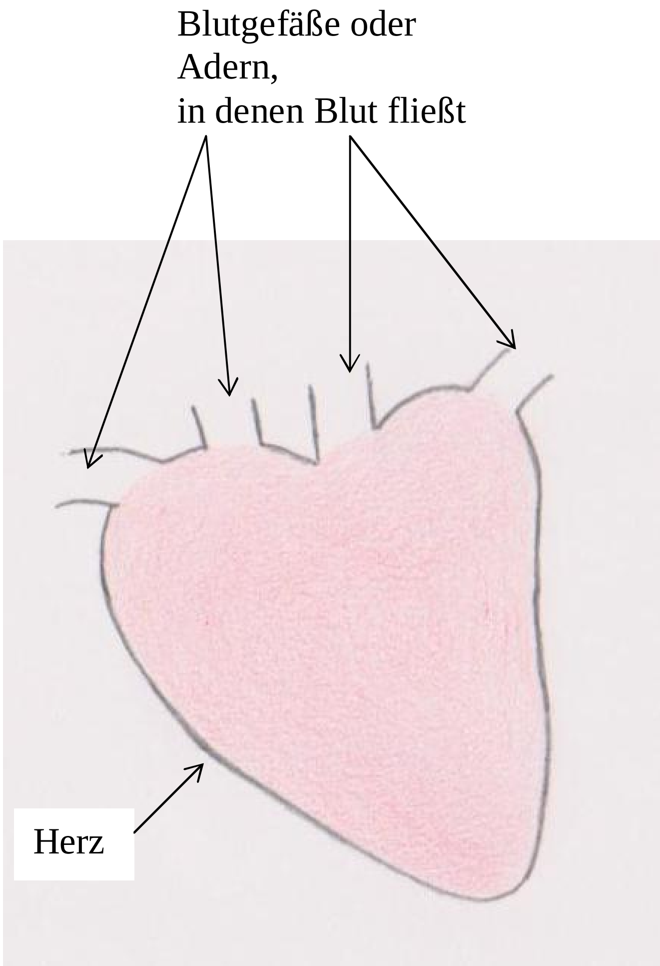


STOPP!

Aufgabe 5

Merke dir das Wichtigste vom Text!

Aufgabe 6

Ergänze den Satz!

________________bringen das Blut **vom Herz weg**. Damit du das nicht vergisst, merke dir folgendes: Das Wort „Ferien“ reimt sich auf „Arterien“. In den „Ferien“ fahren viele Menschen weg. Also bringen **Arterien** das Blut **vom Herz weg!**

Seite 3

Wie sieht das Herz innen aus?

Das Herz wird durch eine Wand in zwei Hälften geteilt: in die schwächere und in die stärkere Herzhälfte.

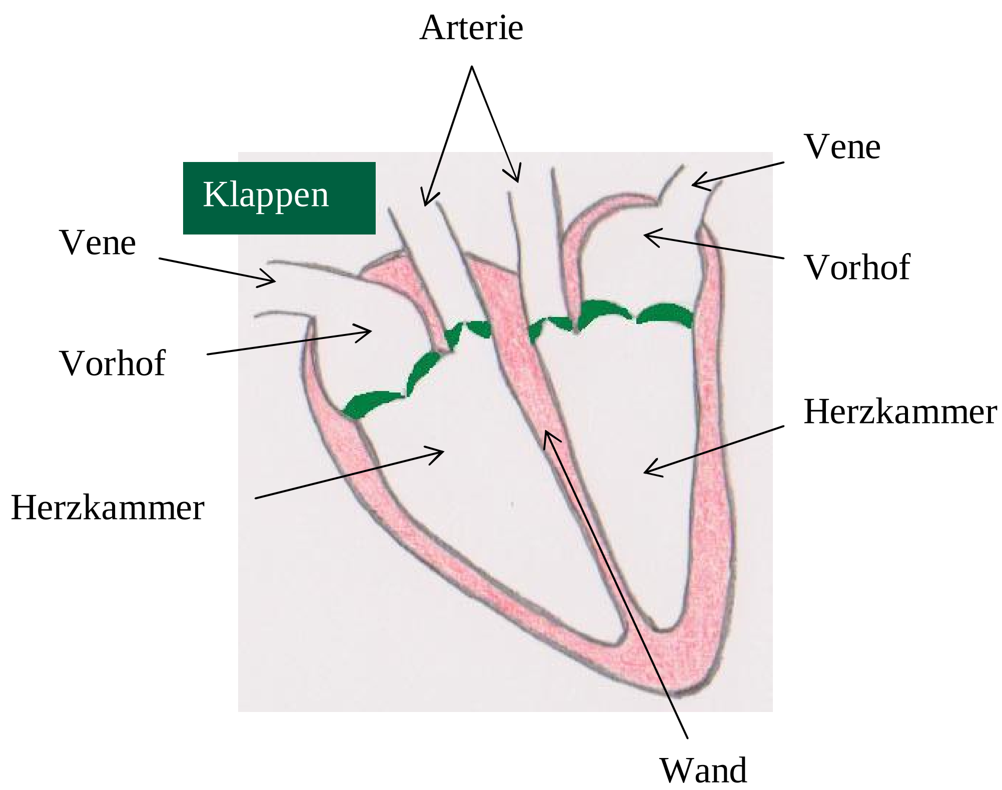
Jede Herzhälfte besteht aus zwei Teilen: einem kleinen Vorhof und einer größeren Herzkammer. Der Vorhof liegt über der Herzkammer und ist mit dieser verbunden.

In den Vorhof hinein läuft eine Vene. Das ist eine Ader, die das Blut zum Herz hin bringt. Von der Herzkammer heraus läuft eine Arterie. Das ist eine Ader, die das Blut vom Herz weg bringt.

STOPP!

Aufgabe 7

Merke dir das Wichtigste vom Bild!



STOPP!

Aufgabe 8

Findest du Sachen, die im Text und im Bild vorkommen? Blättere auf die nächste Seite und suche danach.

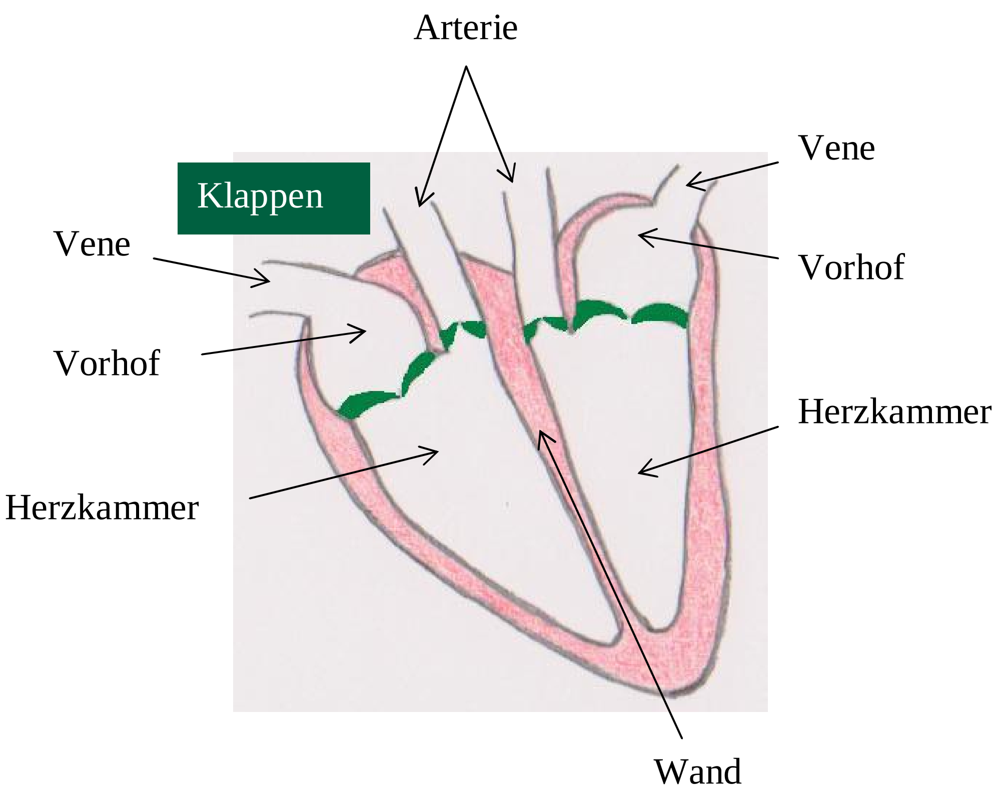
<u>Seite 3</u>

<u>Wie sieht das Herz innen aus?</u>

Das Herz wird durch eine Wand in zwei Hälften geteilt: in die schwächere und in die stärkere Herzhälfte.

Jede Herzhälfte besteht aus zwei Teilen: einem kleinen Vorhof und einer größeren Herzkammer. Der Vorhof liegt über der Herzkammer und ist mit dieser verbunden.

In den Vorhof hinein läuft eine Vene. Das ist eine Ader, die das Blut zum Herz hin bringt. Von der Herzkammer heraus läuft eine Arterie. Das ist eine Ader, die das Blut vom Herz weg bringt.



STOPP!

Aufgabe 9

Merke dir das Wichtigste vom Text!

Aufgabe 10

Ergänze den Satz!

Der ____________ Lungenkreislauf **startet** immer in der ____________________ Herzhälfte. Merke dir das gut!

Aufgabe 11

Ergänze den Satz!

In der stärkeren Herzhälfte __________ der kleine Lungenkreislauf. Merke dir das gut!

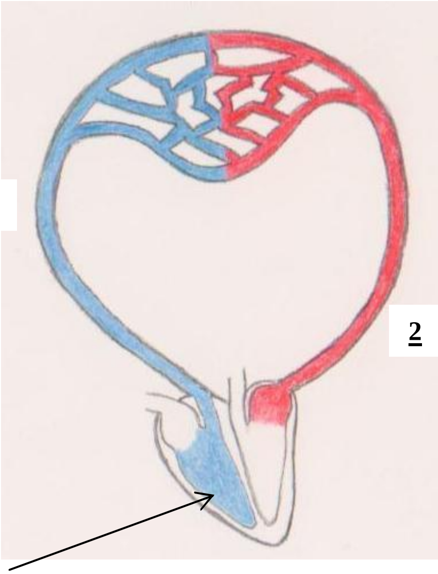
Seite 4

Jetzt lernst du, wie der Lungenkreislauf, der Körperkreislauf und das Herz zusammen funktionieren.

Der kleine Lungenkreislauf

Im kleinen Lungenkreislauf tankt das Blut Sauerstoff auf. Der kleine Lungenkreislauf startet immer in der schwächeren Herzhälfte. Diesen Weg nimmt das Blut: Das Blut fließt innerhalb des Herzens vom Vorhof in die Herzkammer. Von dort gelangt es nun in die Lunge. Von der Lunge fließt das Blut in den Vorhof der stärkeren Herzhälfte. In der stärkeren Herzhälfte endet der kleine Lungenkreislauf.

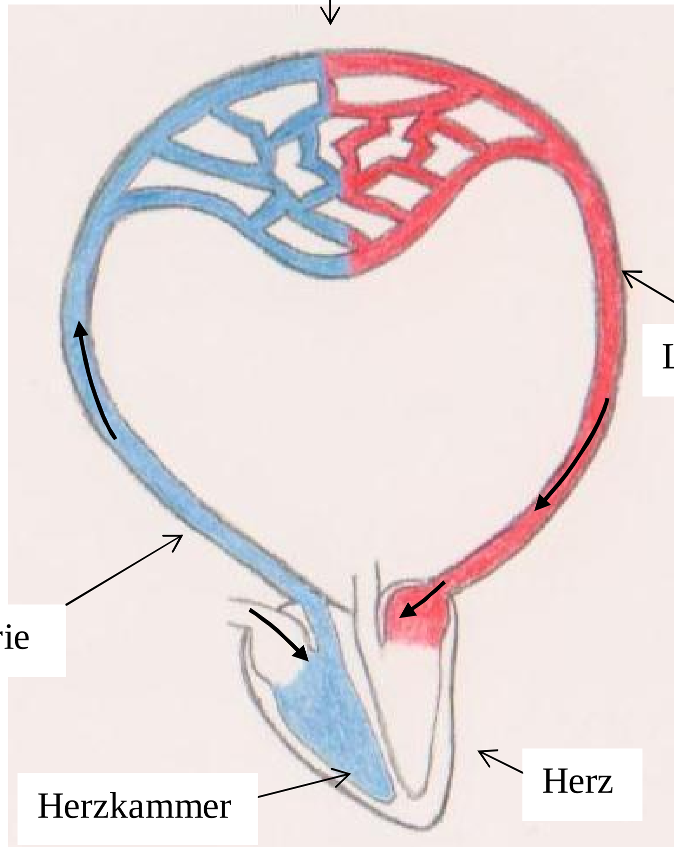
STOPP!



Aufgabe 12

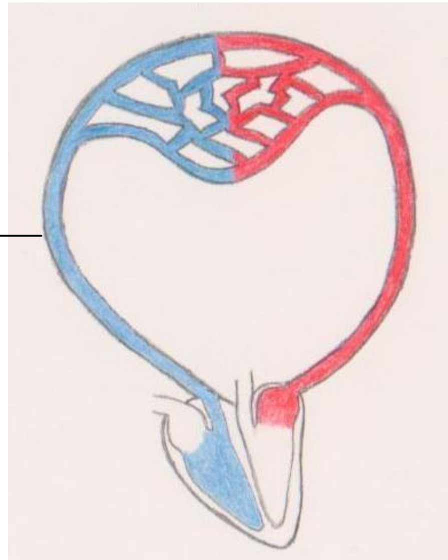
Wie laufen die Pfeile immer in den Kreisläufen? Sie laufen im ____________________sinn. Zeichne die beiden Pfeile im oberen Bild bei den Zahlen 1 und 2 ein!

Der kleine Lungenkreislauf



rot = Blut mit viel Sauerstoff

blau = Blut mit wenig Sauerstoff



rot = Blut mit viel Sauerstoff

blau = Blut mit wenig Sauerstoff

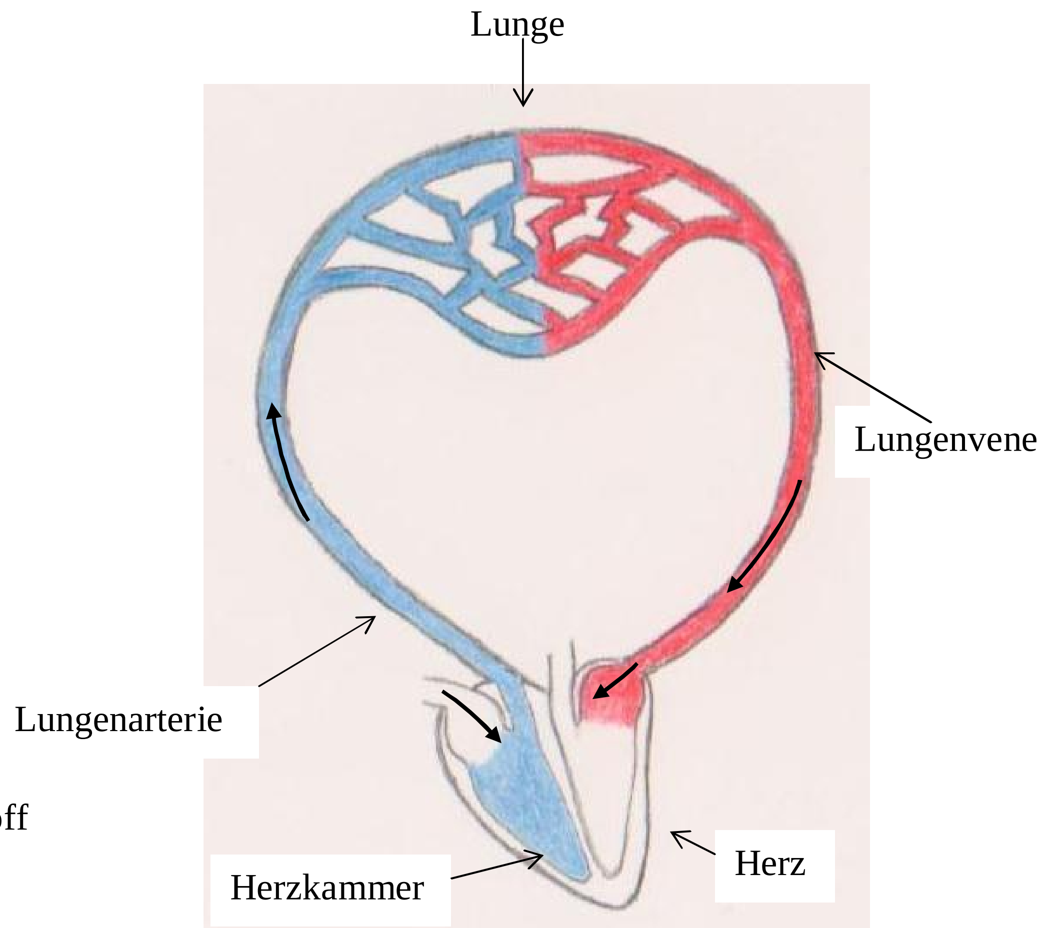
<u>Aufgabe 13</u>

Schreibe den Namen von der Ader, in der wenig Sauerstoff fließt, ins obere Bild!

<u>Aufgabe 14</u>

Merke dir das Wichtigste vom großen Bild!

Der kleine Lungenkreislauf



rot = Blut mit viel Sauerstoff

blau = Blut mit wenig Sauerstoff

STOPP!

Aufgabe 15

Findest du Sachen, die im Text und im Bild vorkommen? Blättere auf die nächste Seite und suche danach.

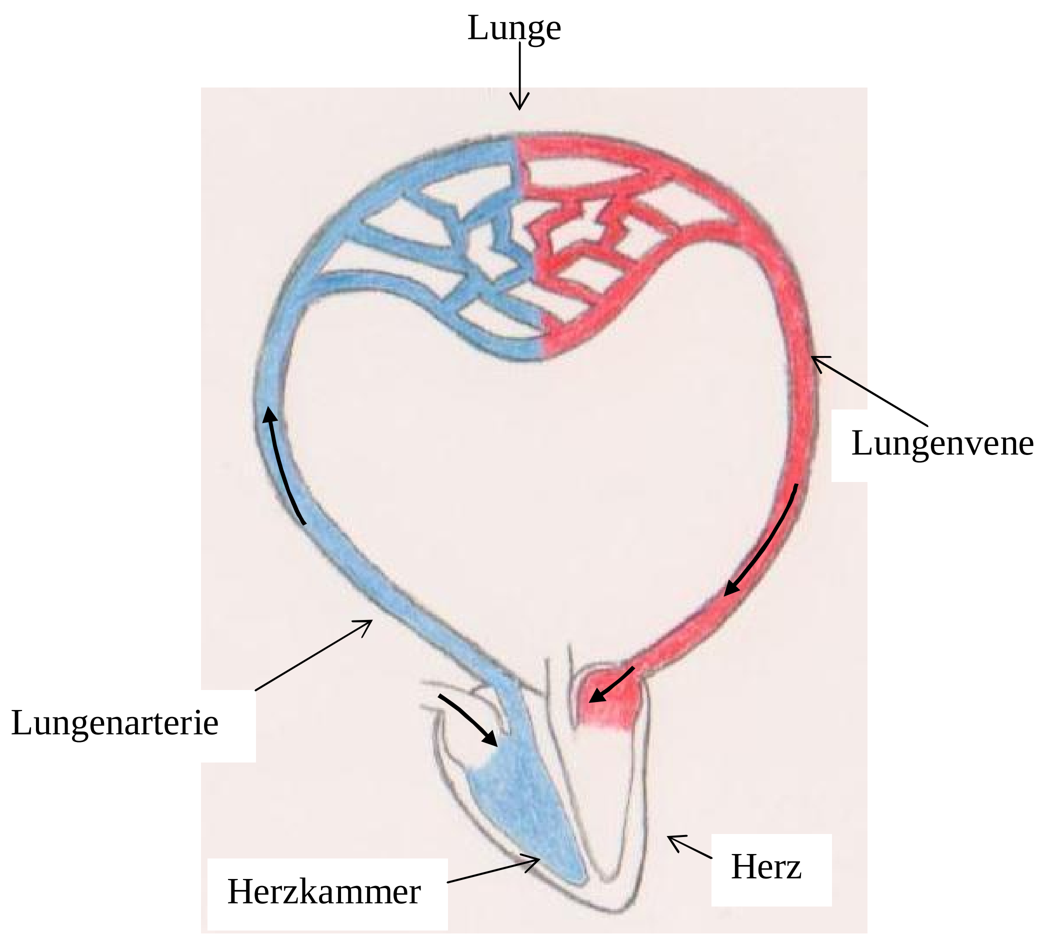
Seite 4

Jetzt lernst du, wie der Lungenkreislauf, der Körperkreislauf und das Herz zusammen funktionieren.

Der kleine Lungenkreislauf

Im kleinen Lungenkreislauf tankt das Blut Sauerstoff auf. Der kleine Lungenkreislauf startet immer in der schwächeren Herzhälfte. Diesen Weg nimmt das Blut: Das Blut fließt innerhalb des Herzens vom Vorhof in die Herzkammer. Von dort gelangt es nun in die Lunge. Von der Lunge fließt das Blut in den Vorhof der stärkeren Herzhälfte. In der stärkeren Herzhälfte endet der kleine Lungenkreislauf.

Der kleine Lungenkreislauf



rot = Blut mit viel Sauerstoff

blau = Blut mit wenig Sauerstoff

STOPP!

Aufgabe 16

Merke dir das Wichtigste vom Text!

Aufgabe 17

Welcher Kreislauf **endet** immer in der **schwächeren Herzhälfte**? Kreise den richtigen Kreislauf ein!

kleiner Lungenkreislauf

großer Körperkreislauf

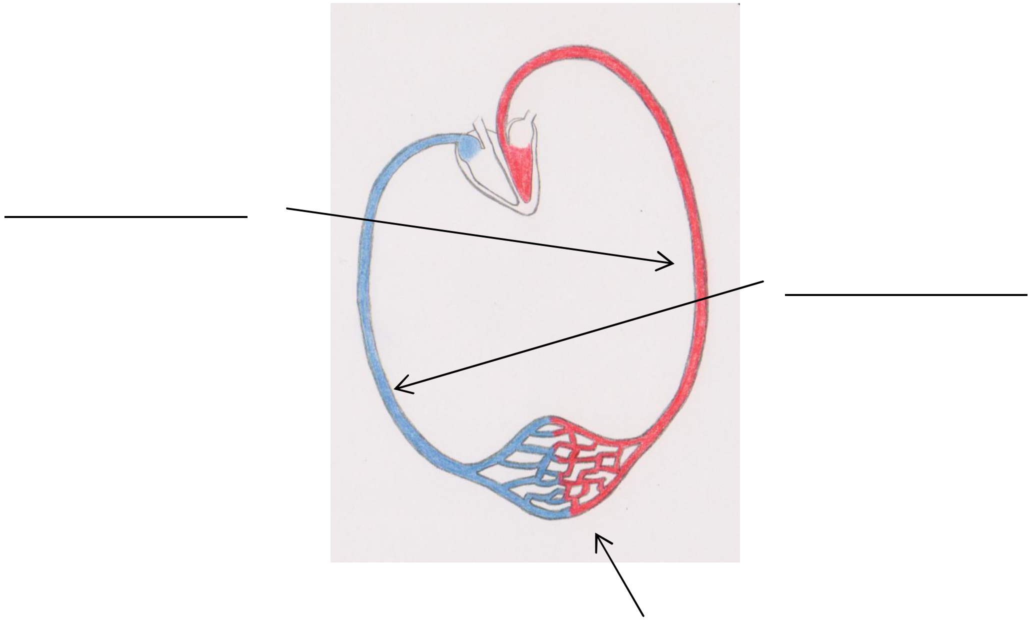
Seite 5

Der große Körperkreislauf

Im großen Körperkreislauf wird der Sauerstoff überall in deinem Körper verteilt. Der große Körperkreislauf startet immer in der stärkeren Herzhälfte. Diesen Weg nimmt das Blut: Das Blut fließt innerhalb des Herzens vom Vorhof in die Herzkammer. Von dort gelangt es nun in deinen Körper. Wenn das Blut durch deinen Körper geflossen ist, kommt es in den Vorhof der schwächeren Herzhälfte zurück. In der schwächeren Herzhälfte endet der große Körperkreislauf.

STOPP!

Der große Körperkreislauf



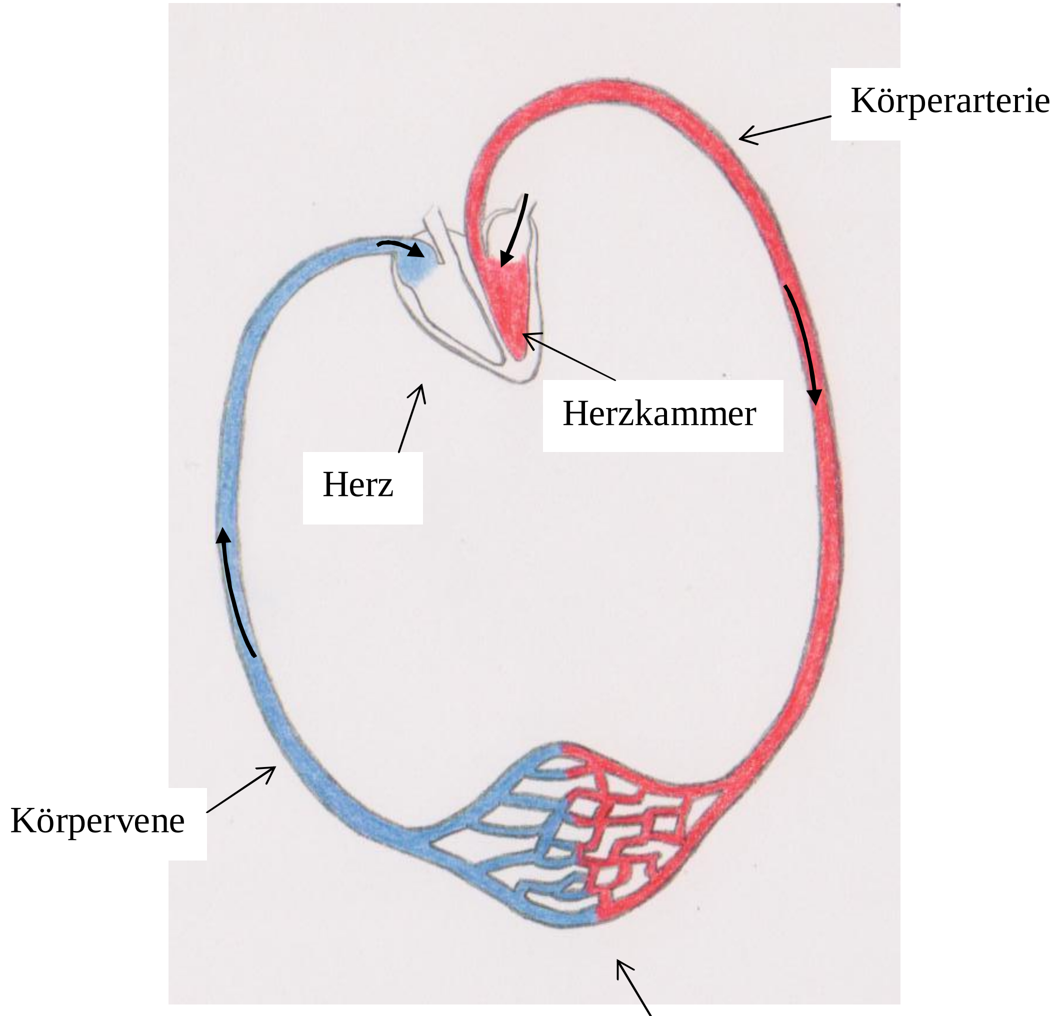
rot = Blut mit viel Sauerstoff

blau = Blut mit wenig Sauerstoff

<u>Aufgabe 18</u>

Beschrifte die Pfeile! Merke dir die Namen gut!

Der große Körperkreislauf



rot = Blut mit viel Sauerstoff

blau = Blut mit wenig Sauerstoff

<u>Aufgabe 19</u>

Merke dir das Wichtigste vom Bild!

<u>Aufgabe 20</u>

Merke dir gut, welche Ader die Körpervene ist und welche die Körperarterie! Ergänze die Sätze!

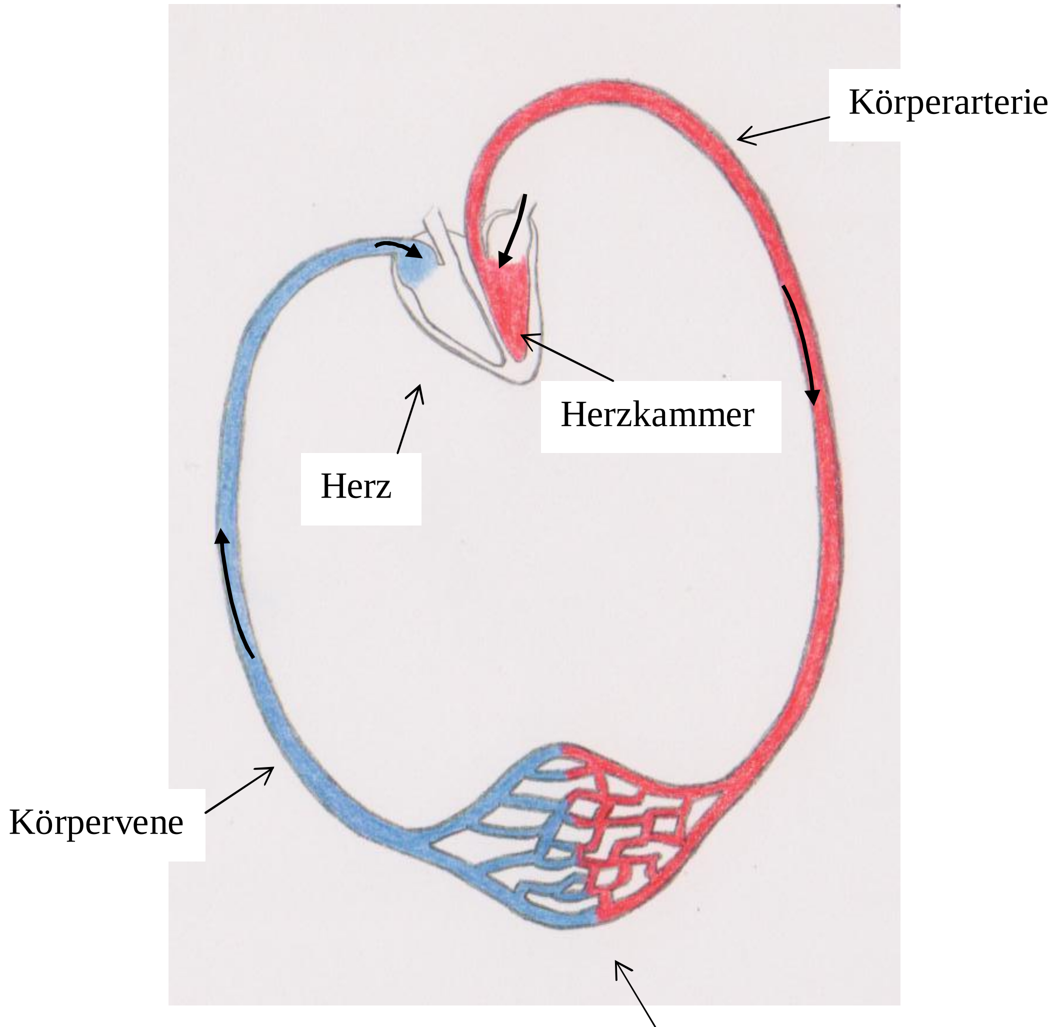
In der ________________________________

fließt Blut mit wenig Sauerstoff.

In der ________________________________

fließt Blut mit viel Sauerstoff.

Der große Körperkreislauf



rot = Blut mit viel Sauerstoff

blau = Blut mit wenig Sauerstoff

STOPP!

Aufgabe 21

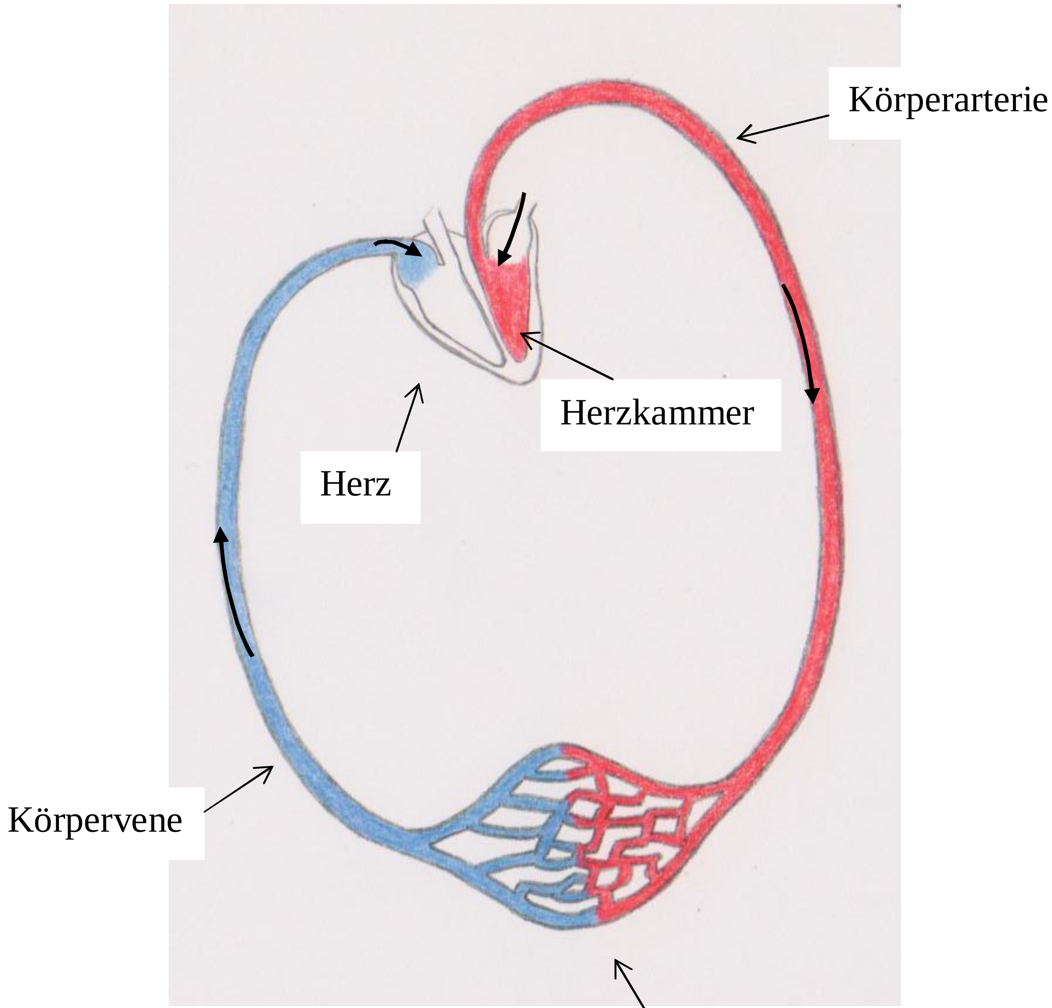
Findest du Sachen, die im Text und im Bild vorkommen? Blättere auf die nächste Seite und suche danach.

Seite 5

Der große Körperkreislauf

Im großen Körperkreislauf wird der Sauerstoff überall in deinem Körper verteilt. Der große Körperkreislauf startet immer in der stärkeren Herzhälfte. Diesen Weg nimmt das Blut: Das Blut fließt innerhalb des Herzens vom Vorhof in die Herzkammer. Von dort gelangt es nun in deinen Körper. Wenn das Blut durch deinen Körper geflossen ist, kommt es in den Vorhof der schwächeren Herzhälfte zurück. In der schwächeren Herzhälfte endet der große Körperkreislauf.

Der große Körperkreislauf



rot = Blut mit viel Sauerstoff

blau = Blut mit wenig Sauerstoff

STOPP!

Aufgabe 22

Merke dir das Wichtigste vom Text!

Aufgabe 23

Ergänze den Satz!

Der ______________________________ besteht aus dem _____________ Körperkreislauf und dem ________________ Lungenkreislauf.

Seite 6

Nun beginnt alles wieder von vorne: Das Blut kommt wieder in den Lungenkreislauf, dann in den Körperkreislauf, dann wieder in den Lungenkreislauf…

Nun weißt du, dass unser Blutkreislauf aus dem kleinen Lungenkreislauf und dem großen Körperkreislauf besteht.

STOPP!

Appendix T

Experiment 2: Learning Unit 2 – "written text + pictures + selection/organization aids + integration aids" condition

Unser Blutkreislauf (2)

Stopp!

Aufgabe 1

Merke dir das Wichtigste vom Text!

Seite 1

Unser Blutkreislauf

Einleitung

Nina singt: „Lungenkreislauf, Körperkreislauf, Lungenkreislauf, Körperkreislauf…“ Tom klatscht dazu in die Hände und ruft: „Hey, Sauerstoff tanken und verteilen, das sind die beiden Sachen, die das Blut in den Kreisläufen macht.“

OK, das ist klar! Im kleinen Lungenkreislauf tankt das Blut den Sauerstoff auf. Und im großen Körperkreislauf verteilt es den Sauerstoff. Aber wie funktionieren der Lungenkreislauf, der Körperkreislauf und das Herz zusammen? Das lernst du heute.

STOPP!

Aufgabe 2

Merke dir das Wichtigste vom Text!

Seite 2

Das Herz

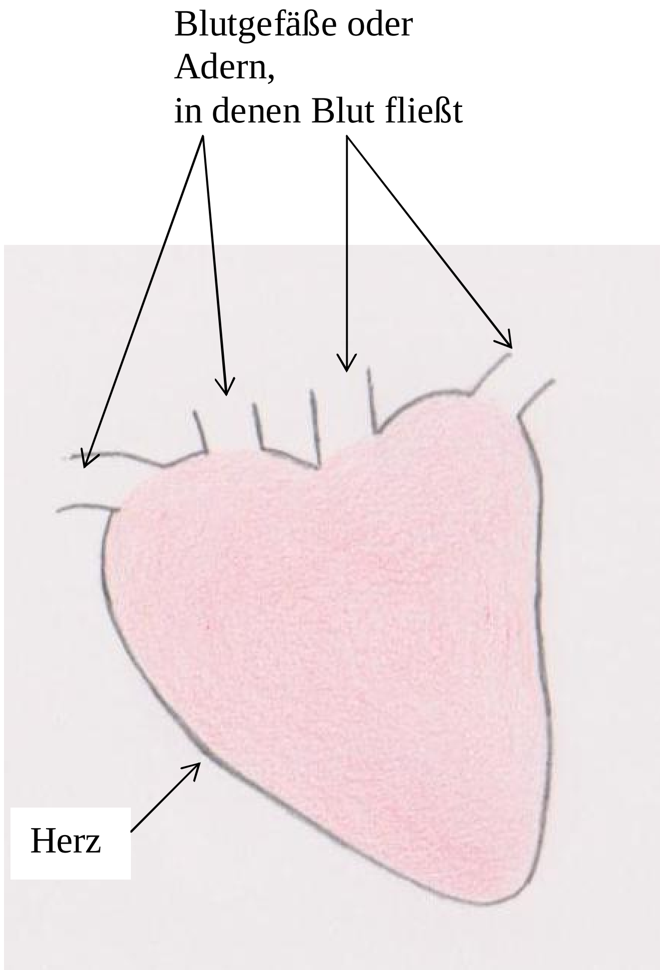
Wenn du an ein Herz denkst, stellst du es dir bestimmt wie ein Lebkuchenherz vor. Aber eigentlich sieht das Herz in deinem Körper nicht so aus. Dicke Rohre laufen in das Herz hinein und aus dem Herz heraus. Diese Rohre heißen Blutgefäße oder Adern. Erinnerst du dich? Sie sind überall in deinem Körper, wie ein Netz.

Das Herz ist innen hohl. Deshalb kann das Blut hinein und heraus fließen. Das Herz hilft dem Blut dabei, indem es sich immer wieder zusammenzieht und ausdehnt. So pumpt das Herz das Blut voran. Du kannst das Pumpen als deinen Herzschlag fühlen.

STOPP!

Aufgabe 3

Merke dir das Wichtigste vom Bild!



STOPP!

Aufgabe 4

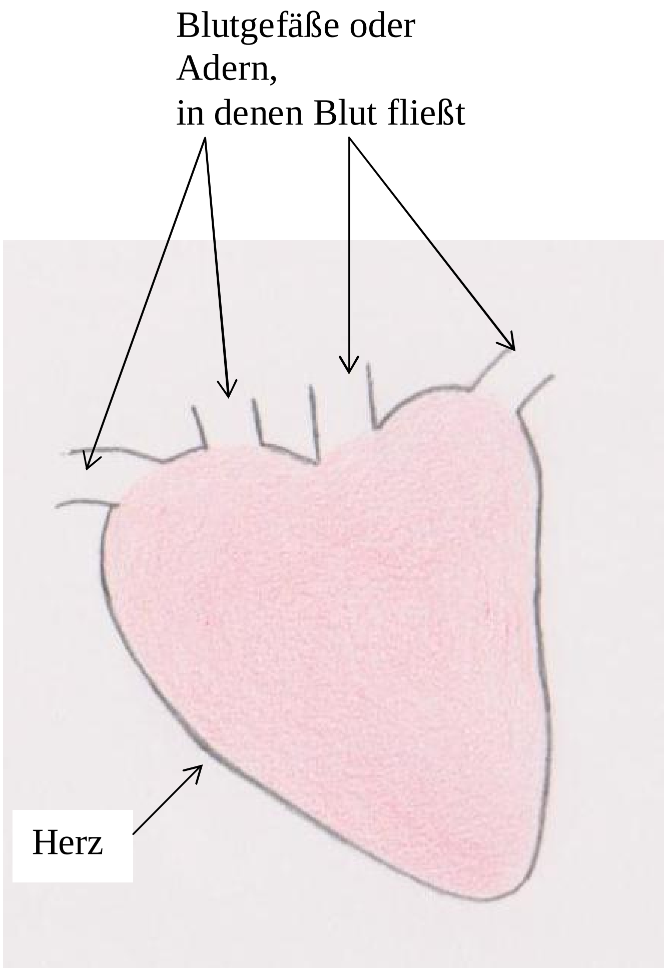
Findest du Sachen, die im Text und im Bild vorkommen? Blättere auf die nächste Seite und suche danach.

Seite 2

Das Herz

Wenn du an ein Herz denkst, stellst du es dir bestimmt wie ein Lebkuchenherz vor. Aber eigentlich sieht das Herz in deinem Körper nicht so aus. Dicke Rohre laufen in das Herz hinein und aus dem Herz heraus. Diese Rohre heißen Blutgefäße oder Adern. Erinnerst du dich? Sie sind überall in deinem Körper, wie ein Netz.

Das Herz ist innen hohl. Deshalb kann das Blut hinein und heraus fließen. Das Herz hilft dem Blut dabei, indem es sich immer wieder zusammenzieht und ausdehnt. So pumpt das Herz das Blut voran. Du kannst das Pumpen als deinen Herzschlag fühlen.



STOPP!

Aufgabe 5

Merke dir das Wichtigste vom Text!

Aufgabe 6

Ergänze den Satz!

________________bringen das Blut **vom Herz weg**. Damit du das nicht vergisst, merke dir folgendes: Das Wort „Ferien“ reimt sich auf „Arterien“. In den „Ferien“ fahren viele Menschen weg. Also bringen **Arterien** das Blut **vom Herz weg!**

Seite 3

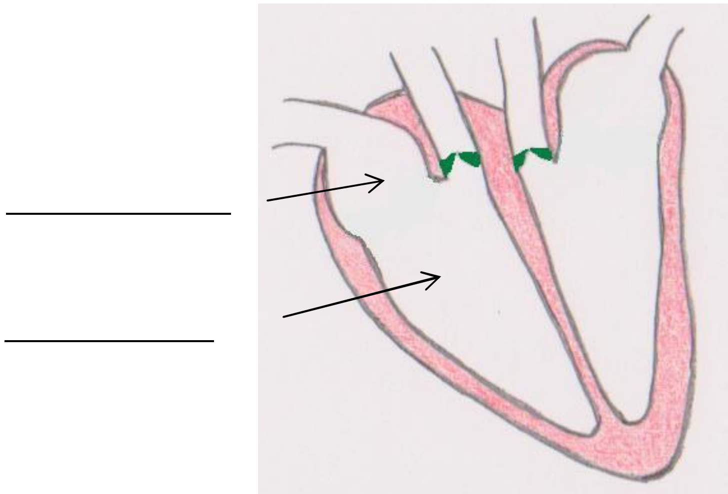
Wie sieht das Herz innen aus?

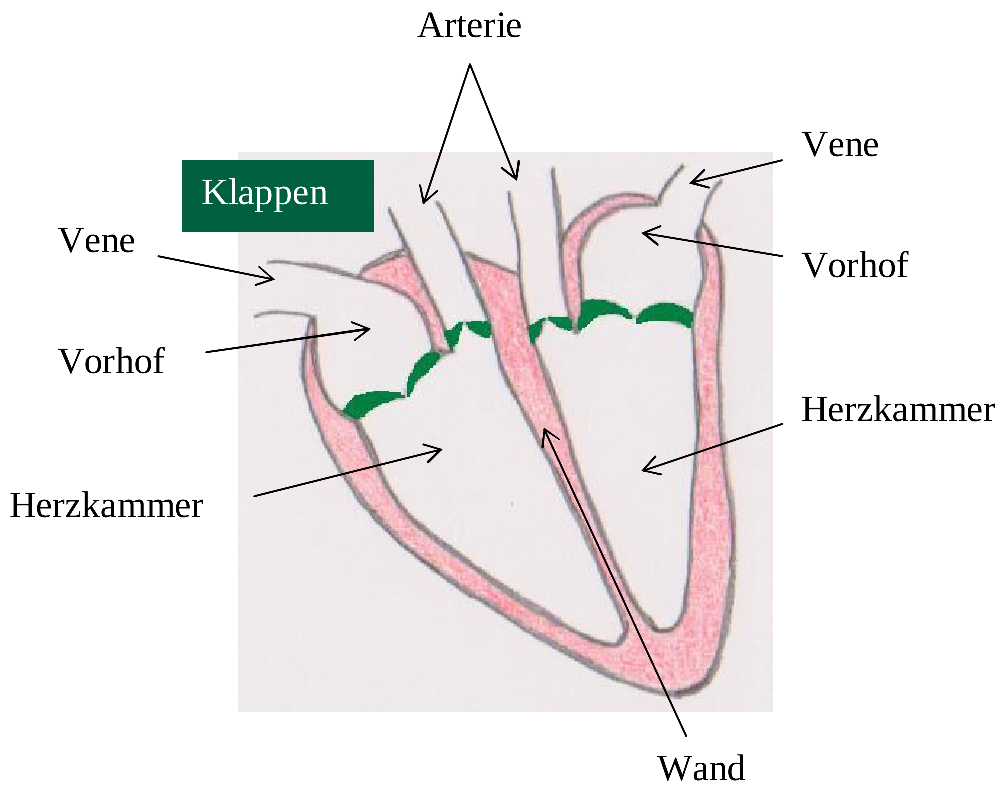
Das Herz wird durch eine Wand in zwei Hälften geteilt: in die schwächere und in die stärkere Herzhälfte.

Jede Herzhälfte besteht aus zwei Teilen: einem kleinen Vorhof und einer größeren Herzkammer. Der Vorhof liegt über der Herzkammer und ist mit dieser verbunden.

In den Vorhof hinein läuft eine Vene. Das ist eine Ader, die das Blut zum Herz hin bringt. Von der Herzkammer heraus läuft eine Arterie. Das ist eine Ader, die das Blut vom Herz weg bringt.

STOPP!





<u>Aufgabe 7</u>

Zeichne zuerst die fehlenden Klappen ein! Beachte, dass die Klappen gebogen sind! Sie können sich deshalb nur in eine Richtung öffnen. Beschrifte dann die beiden Pfeile!

<u>Aufgabe 8</u>

Merke dir das Wichtigste vom großen Bild!

STOPP!

Aufgabe 9

Findest du Sachen, die im Text und im Bild vorkommen? Blättere auf die nächste Seite und suche danach.

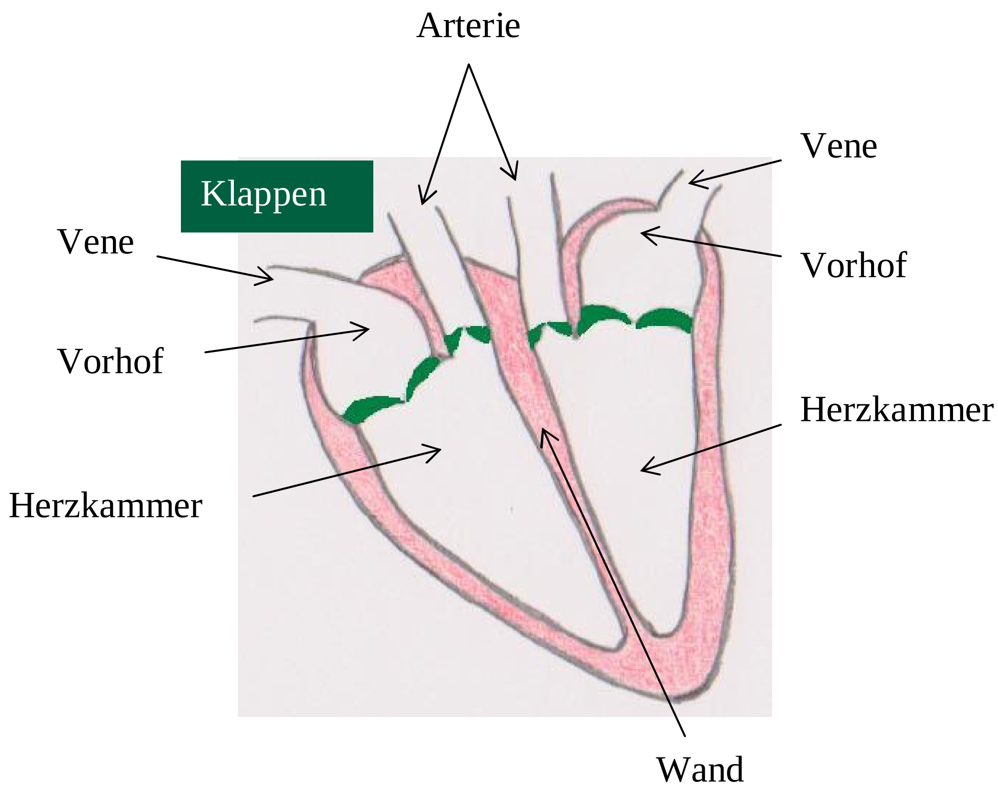
Seite 3

Wie sieht das Herz innen aus?

Das Herz wird durch eine Wand in zwei Hälften geteilt: in die schwächere und in die stärkere Herzhälfte.

Jede Herzhälfte besteht aus zwei Teilen: einem kleinen Vorhof und einer größeren Herzkammer. Der Vorhof liegt über der Herzkammer und ist mit dieser verbunden.

In den Vorhof hinein läuft eine Vene. Das ist eine Ader, die das Blut zum Herz hin bringt. Von der Herzkammer heraus läuft eine Arterie. Das ist eine Ader, die das Blut vom Herz weg bringt.



STOPP!

Aufgabe 10

Merke dir das Wichtigste vom Text!

Aufgabe 11

Ergänze den Satz!

Der ____________ Lungenkreislauf **startet** immer in der ____________________ Herzhälfte. Merke dir das gut!

Aufgabe 12

Ergänze den Satz!

In der stärkeren Herzhälfte __________ der kleine Lungenkreislauf. Merke dir das gut!

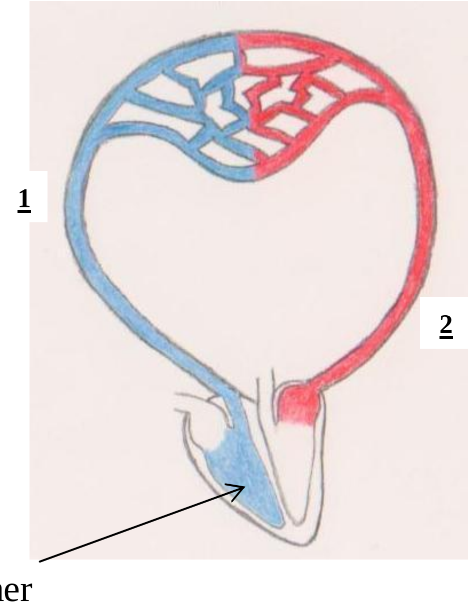
Seite 4

Jetzt lernst du, wie der Lungenkreislauf, der Körperkreislauf und das Herz zusammen funktionieren.

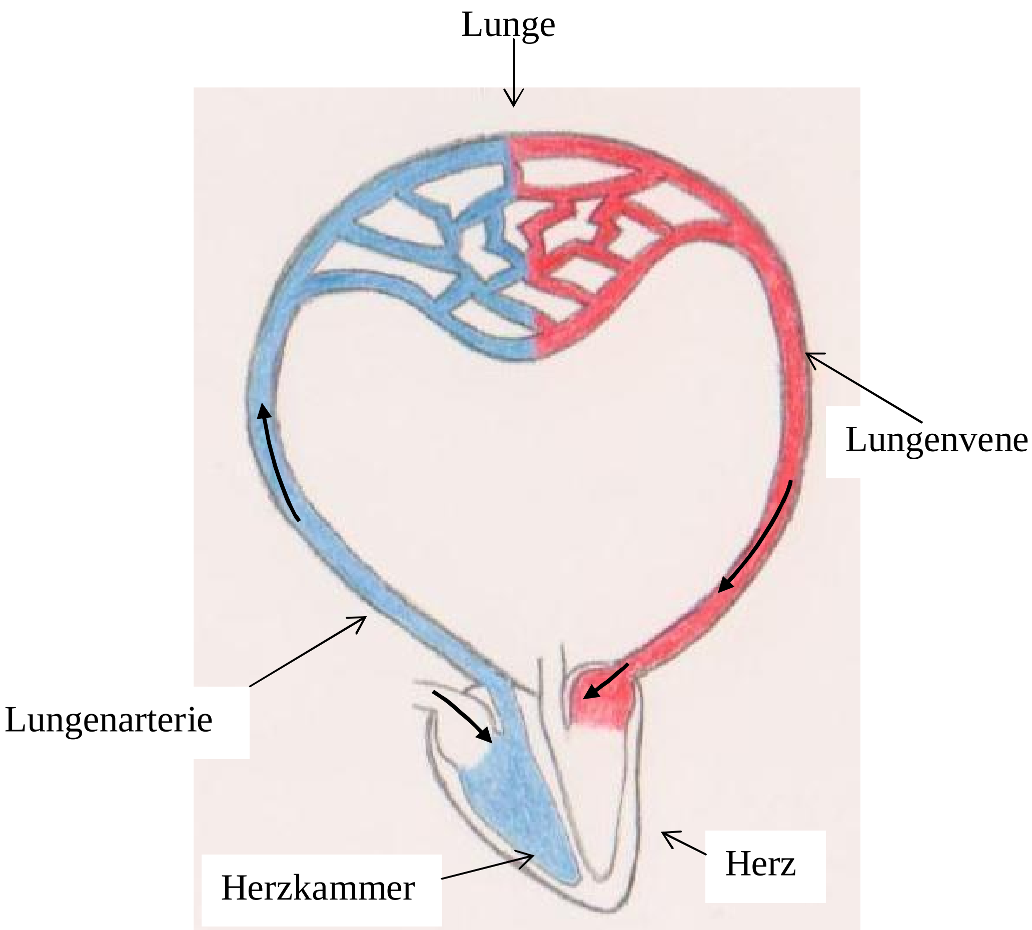
Der kleine Lungenkreislauf

Im kleinen Lungenkreislauf tankt das Blut Sauerstoff auf. Der kleine Lungenkreislauf startet immer in der schwächeren Herzhälfte. Diesen Weg nimmt das Blut: Das Blut fließt innerhalb des Herzens vom Vorhof in die Herzkammer. Von dort gelangt es nun in die Lunge. Von der Lunge fließt das Blut in den Vorhof der stärkeren Herzhälfte. In der stärkeren Herzhälfte endet der kleine Lungenkreislauf.

STOPP!



Der kleine Lungenkreislauf

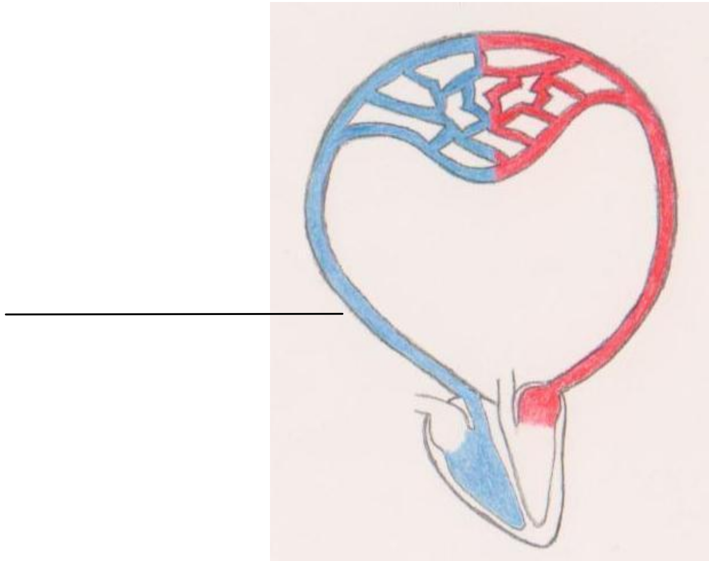


<u>Aufgabe 13</u>

Wie laufen die Pfeile immer in den Kreisläufen? Sie laufen im ____________________sinn. Zeichne die beiden Pfeile im oberen Bild bei den Zahlen 1 und 2 ein!

rot = Blut mit viel Sauerstoff

blau = Blut mit wenig Sauerstoff



rot = Blut mit viel Sauerstoff

blau = Blut mit wenig Sauerstoff

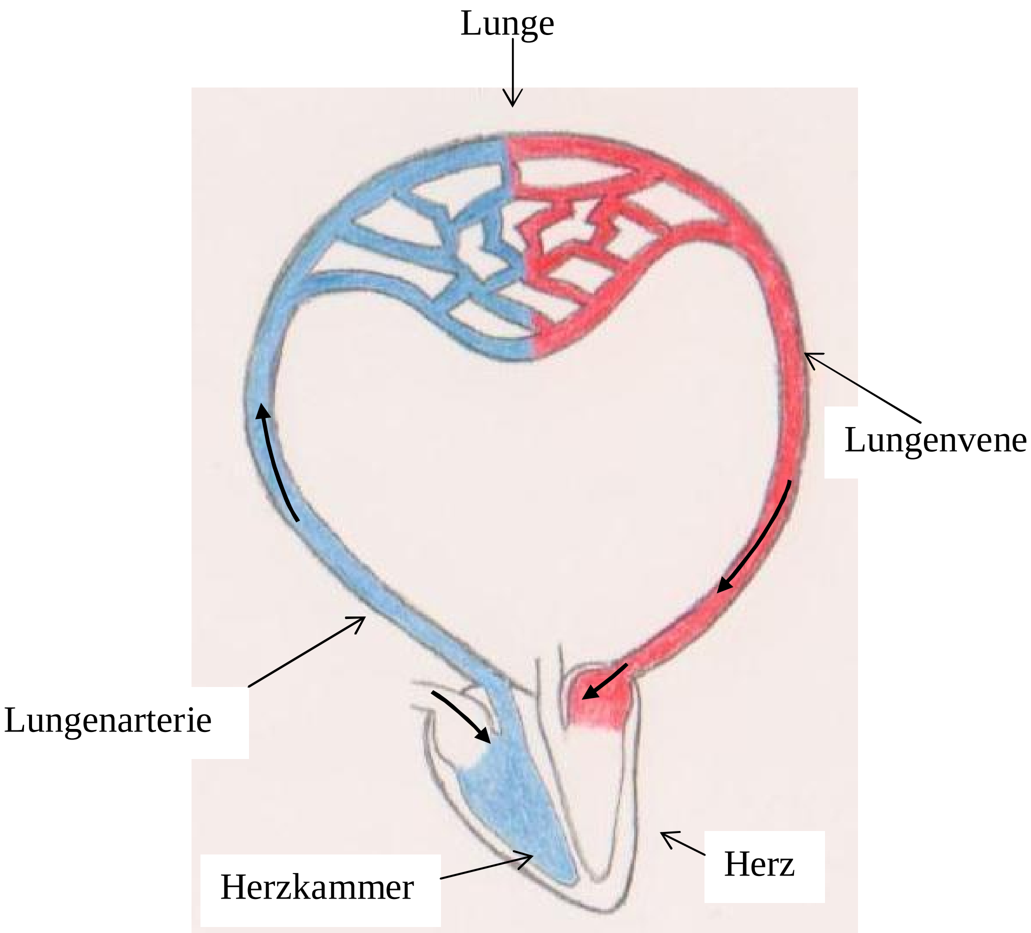
Aufgabe 14

Schreibe den Namen von der Ader, in der wenig Sauerstoff fließt, ins obere Bild!

Aufgabe 15

Merke dir das Wichtigste vom großen Bild!

Der kleine Lungenkreislauf



rot = Blut mit viel Sauerstoff

blau = Blut mit wenig Sauerstoff

STOPP!

Aufgabe 16

Findest du Sachen, die im Text und im Bild vorkommen? Bearbeite zuerst die Aufgaben und suche dann nach diesen Sachen. Blättere jetzt auf die nächste Seite.

Seite 4

Jetzt lernst du, wie der Lungenkreislauf, der Körperkreislauf und das Herz zusammen funktionieren.

Der kleine Lungenkreislauf

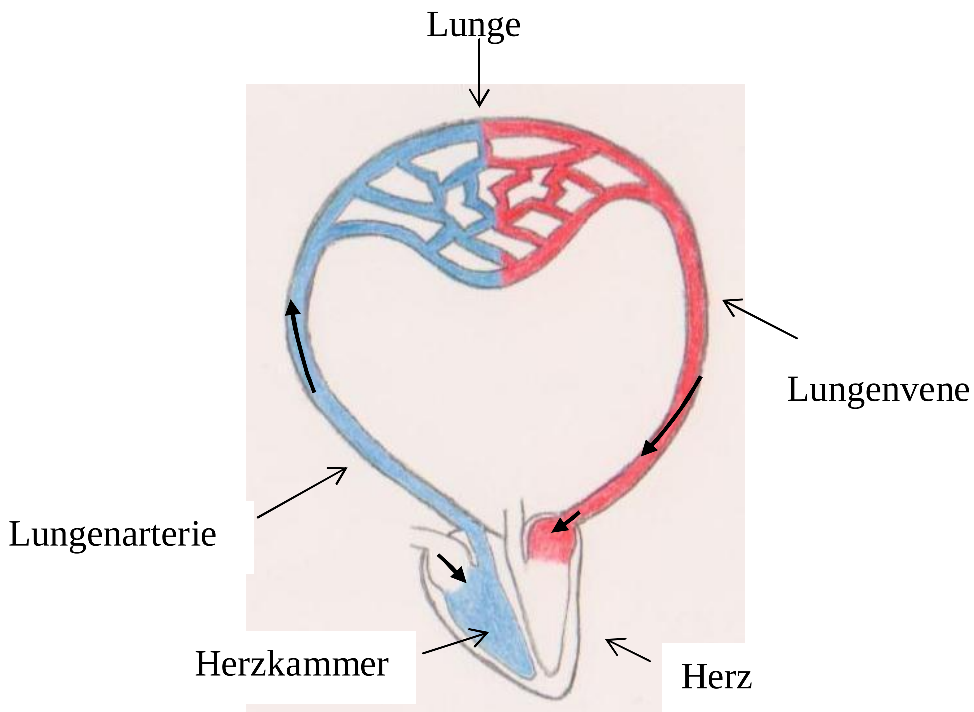
Im kleinen Lungenkreislauf tankt das Blut Sauerstoff auf. Der kleine Lungenkreislauf startet immer in der schwächeren Herzhälfte. Diesen Weg nimmt das Blut: Das Blut fließt innerhalb des Herzens vom Vorhof in die Herzkammer. Von dort gelangt es nun in die Lunge. Von der Lunge fließt das Blut in den Vorhof der stärkeren Herzhälfte. In der stärkeren Herzhälfte endet der kleine Lungenkreislauf.

Aufgabe 17

Schaue dir das Bild genau an! Welche Ader führt von der Herzkammer zur Lunge? Kreise diese Ader im Bild ein!

Aufgabe 18

Weißt du, welche Herzhälfte im Bild die stärkere Herzhälfte ist? Schaue dir den Text und das Bild hierfür gut an! Kreise die stärkere Herzhälfte ein!



rot = Blut mit viel Sauerstoff

blau = Blut mit wenig Sauerstoff

STOPP!

Aufgabe 19

Merke dir das Wichtigste vom Text!

Aufgabe 20

Welcher Kreislauf **endet** immer in der **schwächeren Herzhälfte**? Kreise den richtigen Kreislauf ein!

kleiner Lungenkreislauf

großer Körperkreislauf

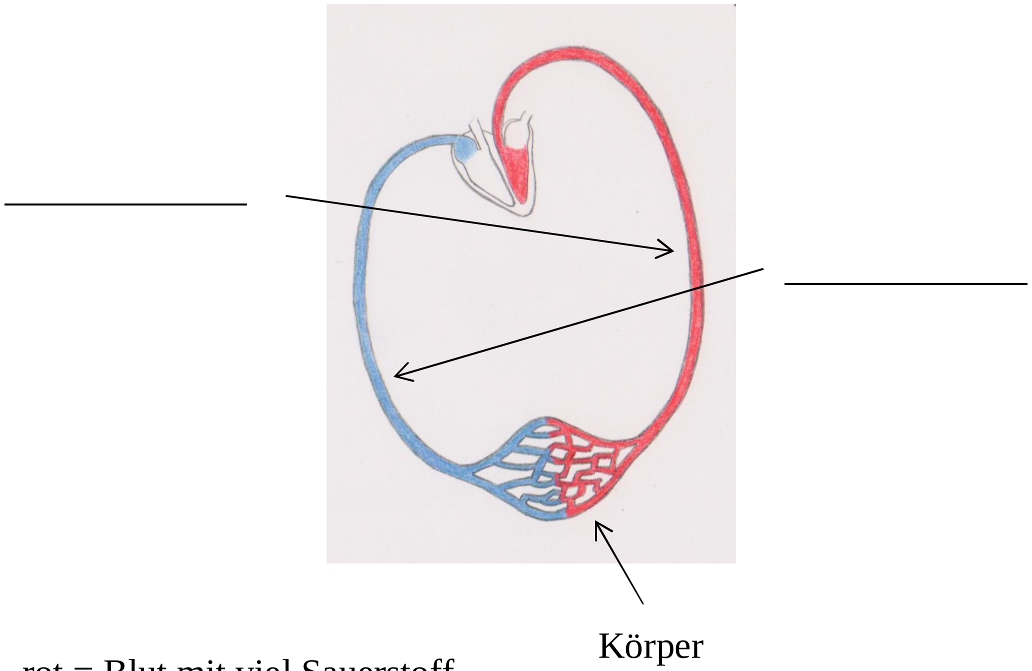
Seite 5

Der große Körperkreislauf

Im großen Körperkreislauf wird der Sauerstoff überall in deinem Körper verteilt. Der große Körperkreislauf startet immer in der stärkeren Herzhälfte. Diesen Weg nimmt das Blut: Das Blut fließt innerhalb des Herzens vom Vorhof in die Herzkammer. Von dort gelangt es nun in deinen Körper. Wenn das Blut durch deinen Körper geflossen ist, kommt es in den Vorhof der schwächeren Herzhälfte zurück. In der schwächeren Herzhälfte endet der große Körperkreislauf.

STOPP!

Der große Körperkreislauf



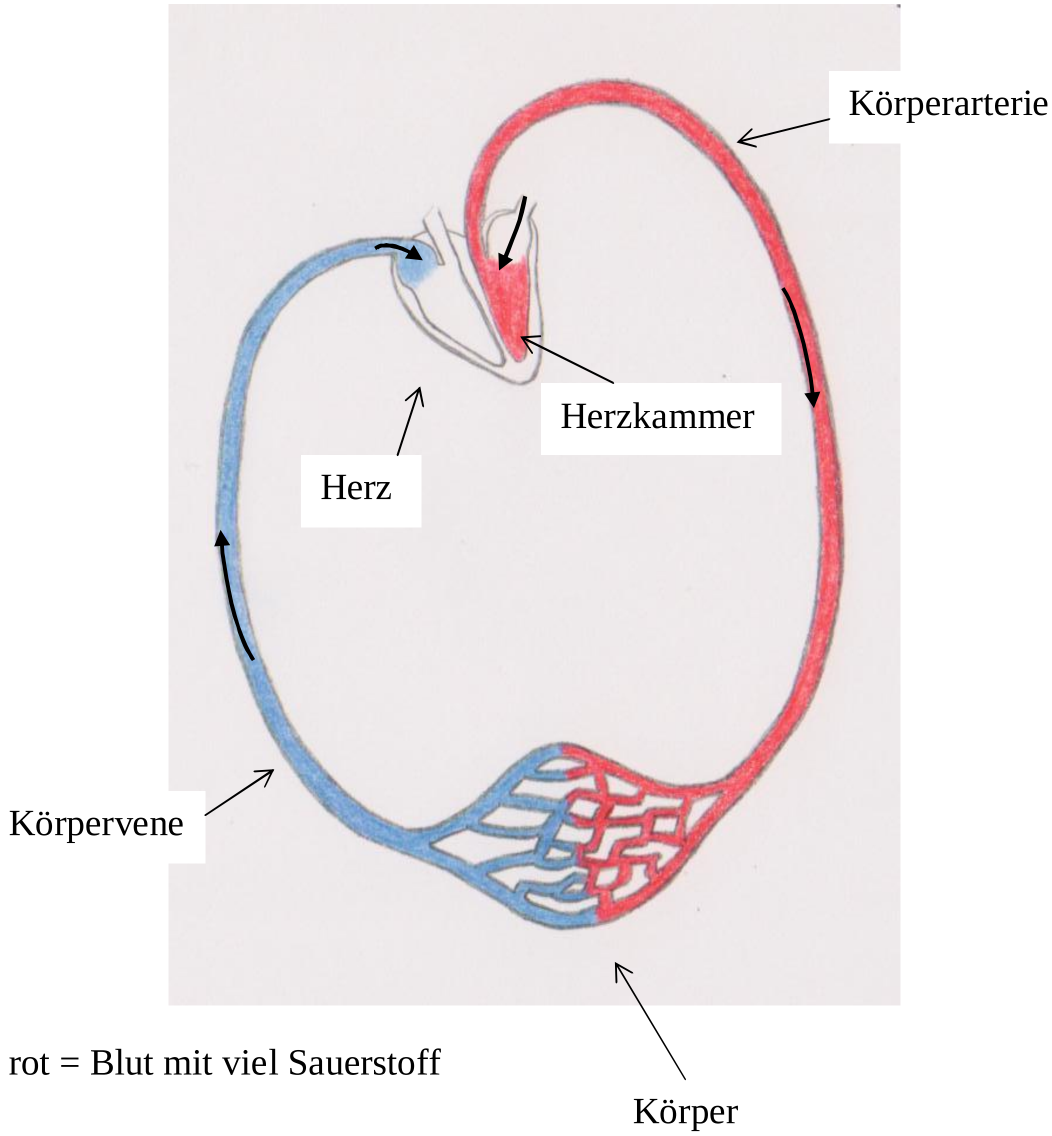
rot = Blut mit viel Sauerstoff

blau = Blut mit wenig Sauerstoff

Aufgabe 21

Beschrifte die Pfeile! Merke dir die Namen gut!

Der große Körperkreislauf



rot = Blut mit viel Sauerstoff

blau = Blut mit wenig Sauerstoff

Aufgabe 22

Merke dir das Wichtigste vom Bild!

Aufgabe 23

Merke dir gut, welche Ader die Körpervene ist und welche die Körperarterie! Ergänze die Sätze!

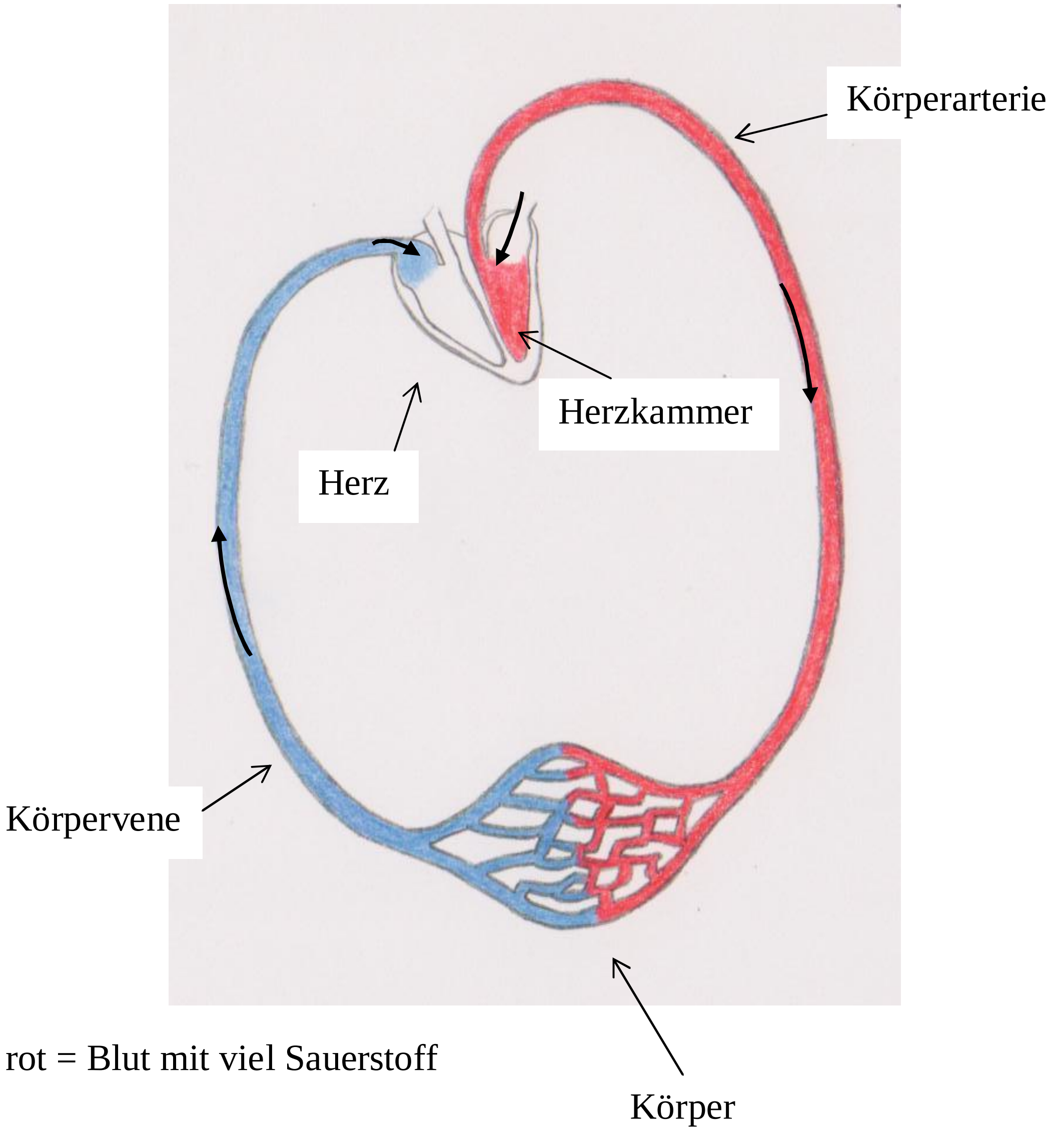
In der ________________________________

fließt Blut mit wenig Sauerstoff.

In der ________________________________

fließt Blut mit viel Sauerstoff.

Der große Körperkreislauf



rot = Blut mit viel Sauerstoff

blau = Blut mit wenig Sauerstoff

STOPP!

Aufgabe 24

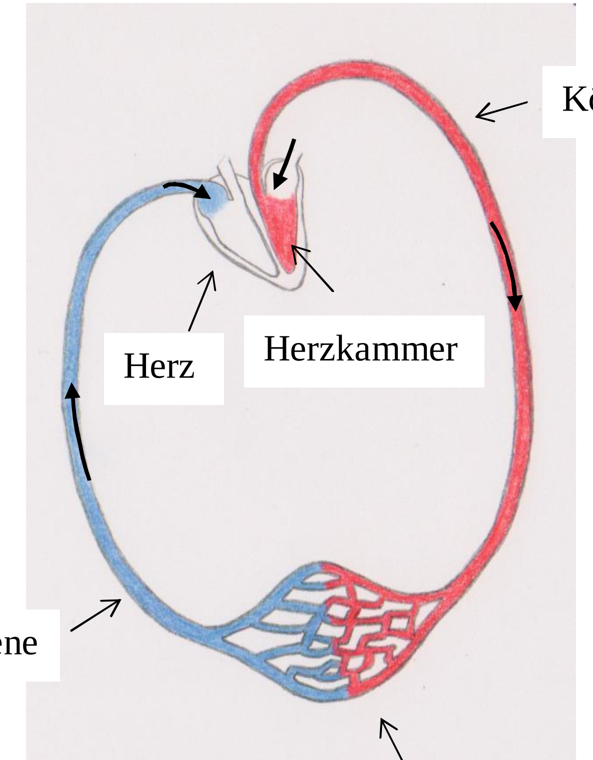
Findest du Sachen, die im Text und im Bild vorkommen? Bearbeite zuerst die Aufgaben und suche dann nach diesen Sachen. Blättere jetzt auf die nächste Seite.

<u>Seite 5</u>

<u>Der große Körperkreislauf</u>

Im großen Körperkreislauf wird der Sauerstoff überall in deinem Körper verteilt. Der große Körperkreislauf startet immer in der stärkeren Herzhälfte. Diesen Weg nimmt das Blut: Das Blut fließt innerhalb des Herzens vom Vorhof in die Herzkammer. Von dort gelangt es nun in deinen Körper. Wenn das Blut durch deinen Körper geflossen ist, kommt es in den Vorhof der schwächeren Herzhälfte zurück. In der schwächeren Herzhälfte endet der große Körperkreislauf.

Der große Körperkreislauf



rot = Blut mit viel Sauerstoff

blau = Blut mit wenig Sauerstoff

<u>Aufgabe 25</u>

Schaue dir das Bild genau an! Ergänze den Satz!

Die Körpervene führt vom Körper zum _______________.

STOPP!

Aufgabe 26

Merke dir das Wichtigste vom Text!

Aufgabe 27

Ergänze den Satz!

Der ___________________________ besteht aus dem ____________ Körperkreislauf und dem _______________ Lungenkreislauf.

Aufgabe 28

Merke dir gut, dass **beide Kreisläufe im Herz starten und enden**!

Seite 6

Nun beginnt alles wieder von vorne: Das Blut kommt wieder in den Lungenkreislauf, dann in den Körperkreislauf, dann wieder in den Lungenkreislauf…

Nun weißt du, dass unser Blutkreislauf aus dem kleinen Lungenkreislauf und dem großen Körperkreislauf besteht.

STOPP!

Appendix U

Experiment 2: Learning Unit 2 – “spoken text” condition

The text used in the “written text” condition (Experiment 2: Learning Unit 2 – “written text” condition) was spoken.

Appendix V

Experiment 2: Learning Unit 2 – "spoken text + pictures" condition

The text used in the "written text + pictures" condition (Experiment 2: Learning Unit 2 – "written text + pictures" condition) was spoken.

Unser Blutkreislauf (2)

Stopp!

Aufgabe 1

Seite 1

Merke dir das Wichtigste vom Text!

STOPP!

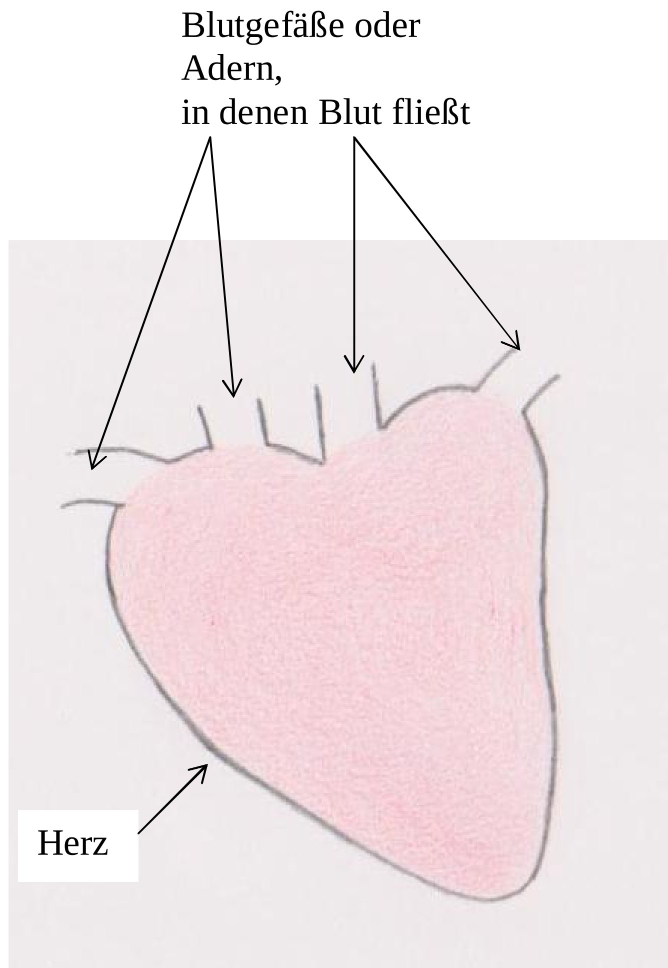
Aufgabe 2 **Seite 2**

Merke dir das Wichtigste vom Text!

STOPP!

Aufgabe 3

Merke dir das Wichtigste vom Bild!

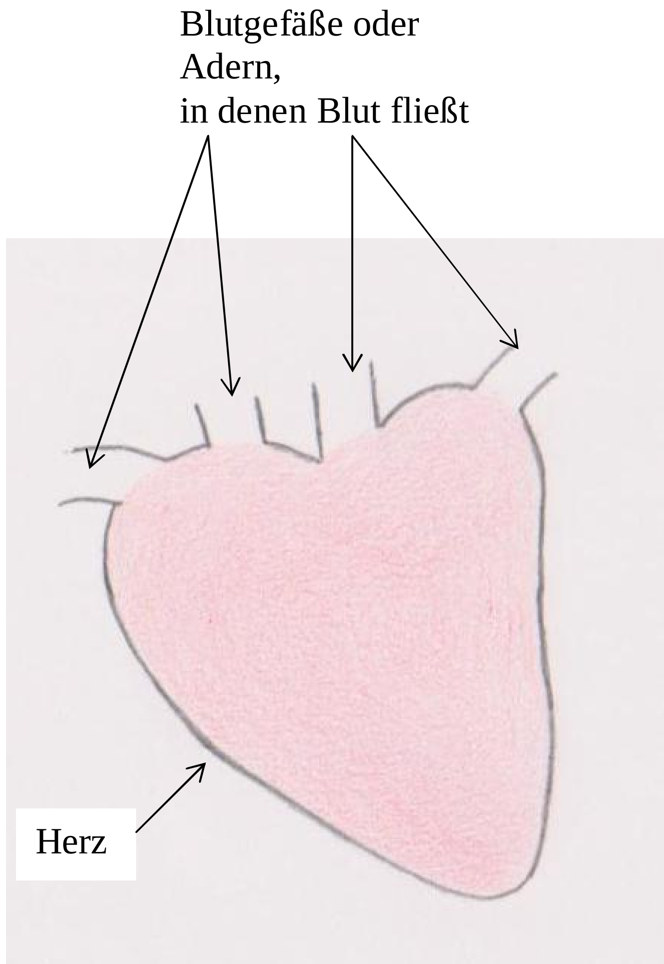


STOPP!

Aufgabe 4

Findest du Sachen, die im Text und im Bild vorkommen? Blättere auf die nächste Seite und suche danach.

Seite 2



STOPP!

Aufgabe 5

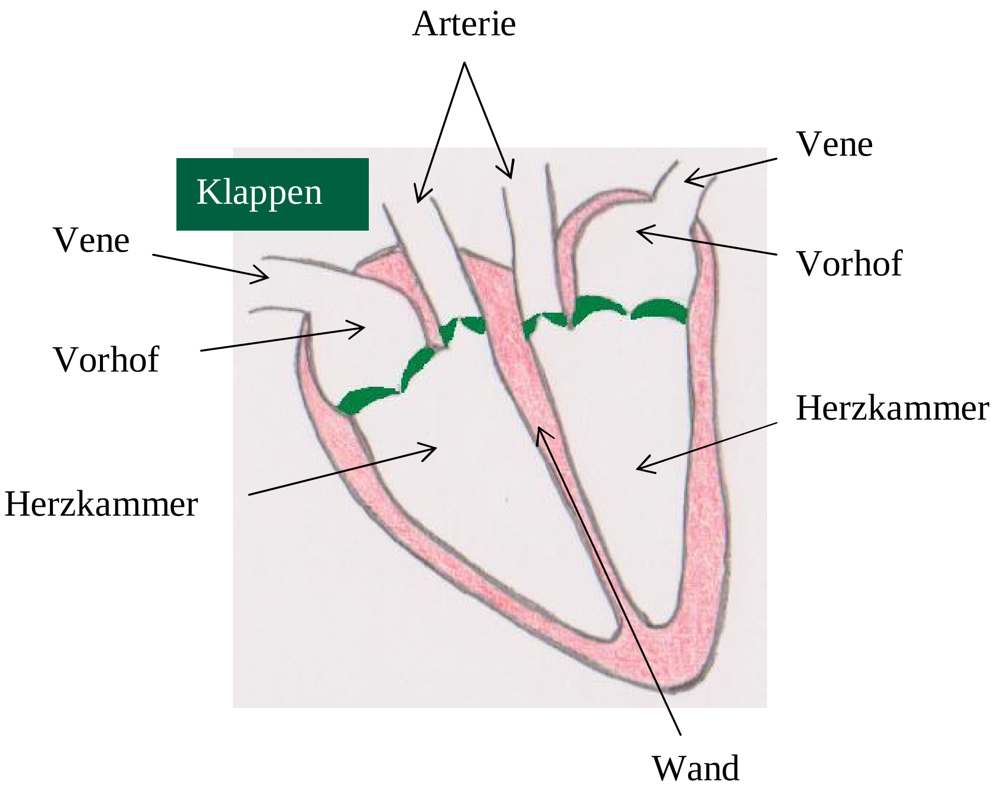
Seite 3

Merke dir das Wichtigste vom Text!

STOPP!

<u>Aufgabe 6</u>

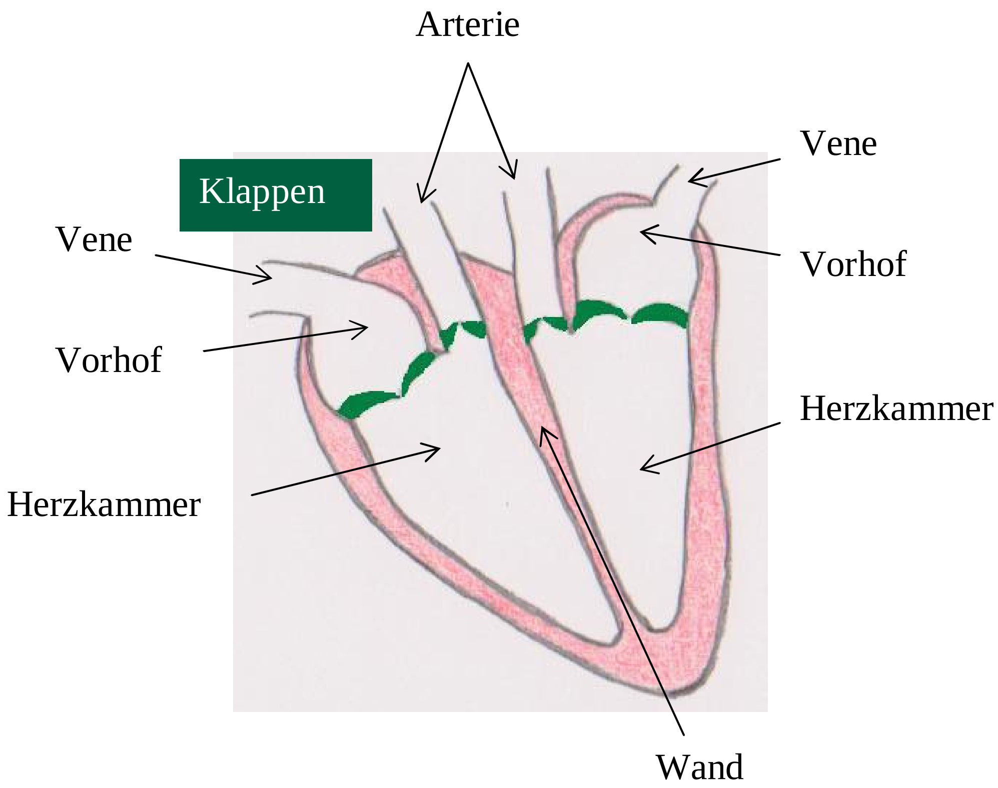
Merke dir das Wichtigste vom Bild!



STOPP!

Aufgabe 7

Findest du Sachen, die im Text und im Bild vorkommen? Blättere auf die nächste Seite und suche danach.


Arterie
Vene
Klappen
Vene
Vorhof
Vorhof
Herzkammer
Herzkammer
Wand

STOPP!

Aufgabe 8 **Seite 4**

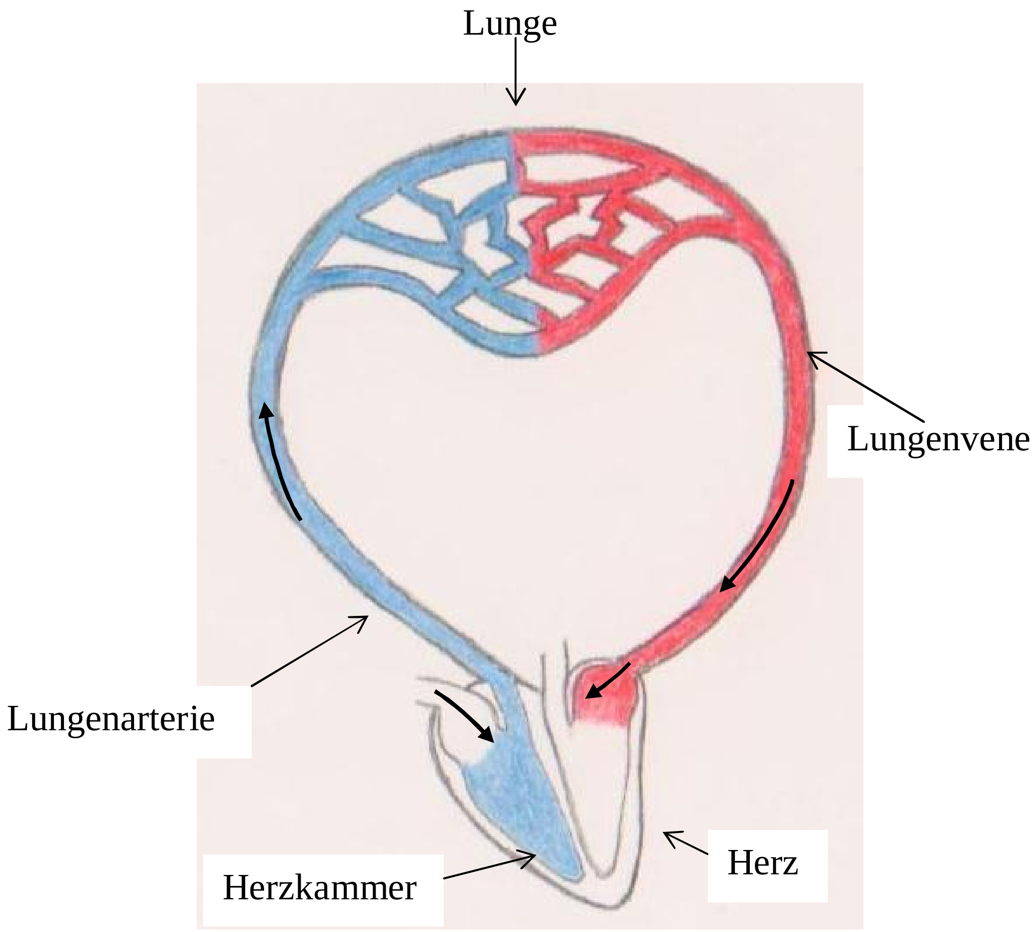
Merke dir das Wichtigste vom Text!

STOPP!

<u>Aufgabe 9</u>

Der kleine Lungenkreislauf

Merke dir das Wichtigste vom Bild!



rot = Blut mit viel Sauerstoff

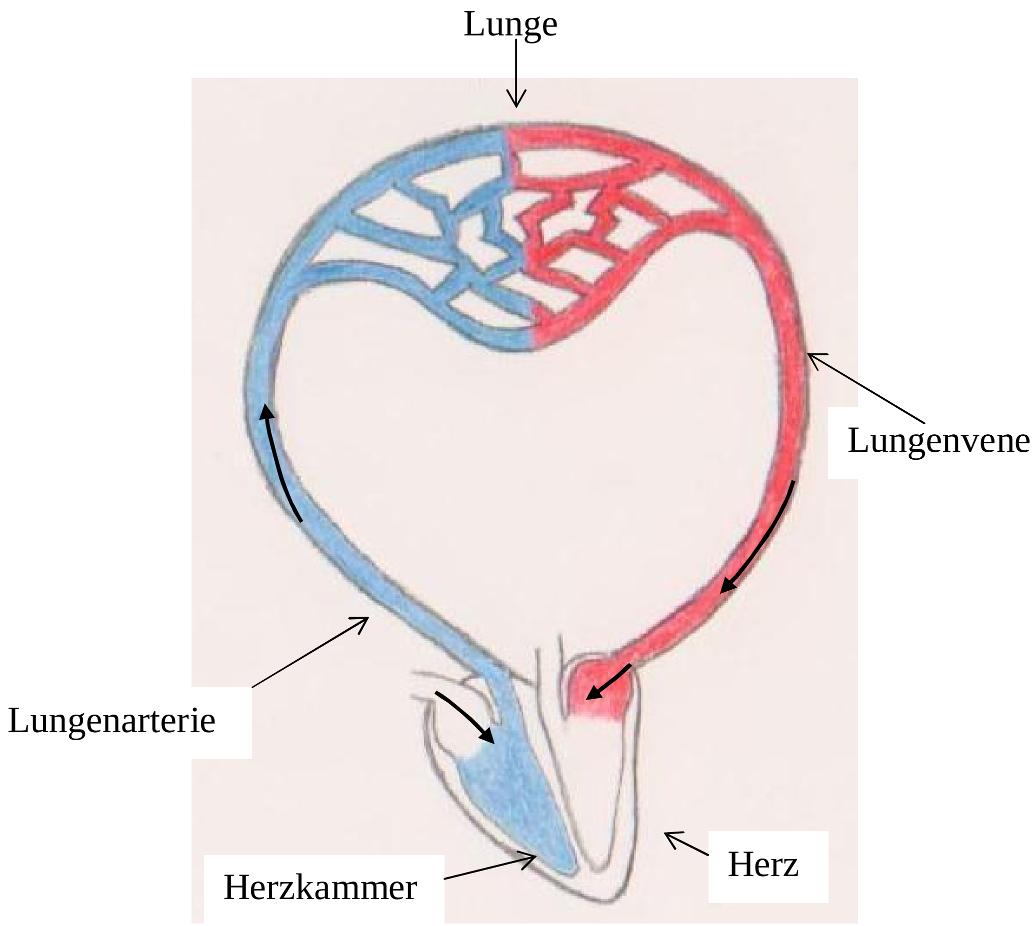
blau = Blut mit wenig Sauerstoff

STOPP!

Aufgabe 10

Findest du Sachen, die im Text und im Bild vorkommen? Blättere auf die nächste Seite und suche danach.

Der kleine Lungenkreislauf



rot = Blut mit viel Sauerstoff

blau = Blut mit wenig Sauerstoff

STOPP!

Aufgabe 11

Seite 5

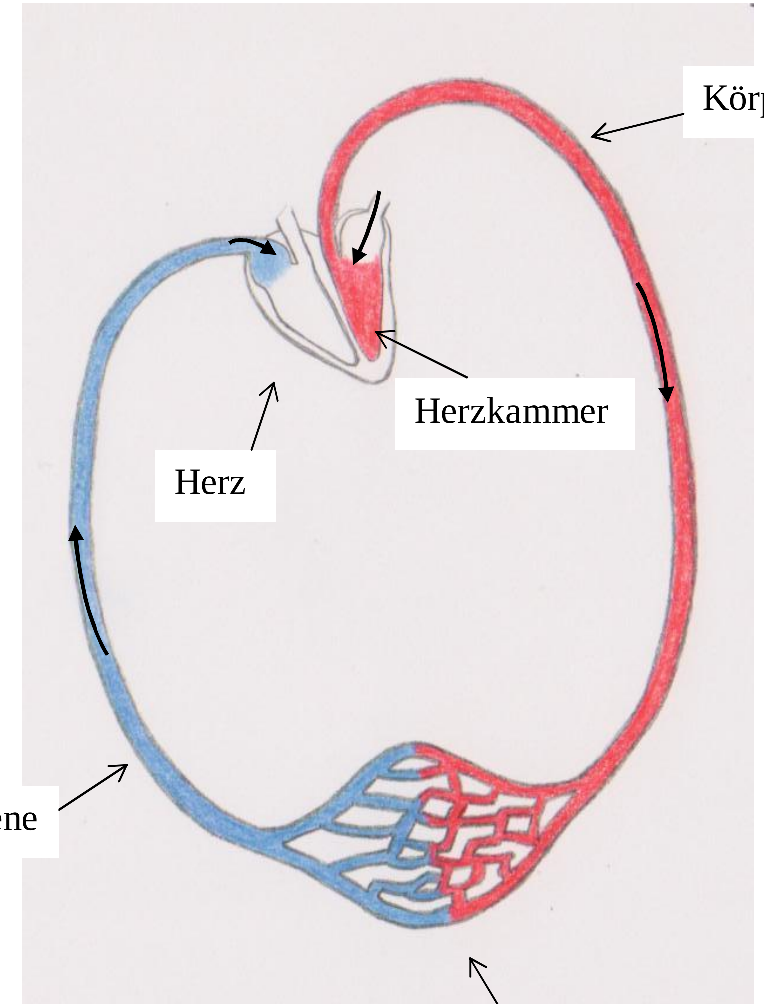
Merke dir das Wichtigste vom Text!

STOPP!

Aufgabe 12

Der große Körperkreislauf

Merke dir das Wichtigste vom Bild!



rot = Blut mit viel Sauerstoff

blau = Blut mit wenig Sauerstoff

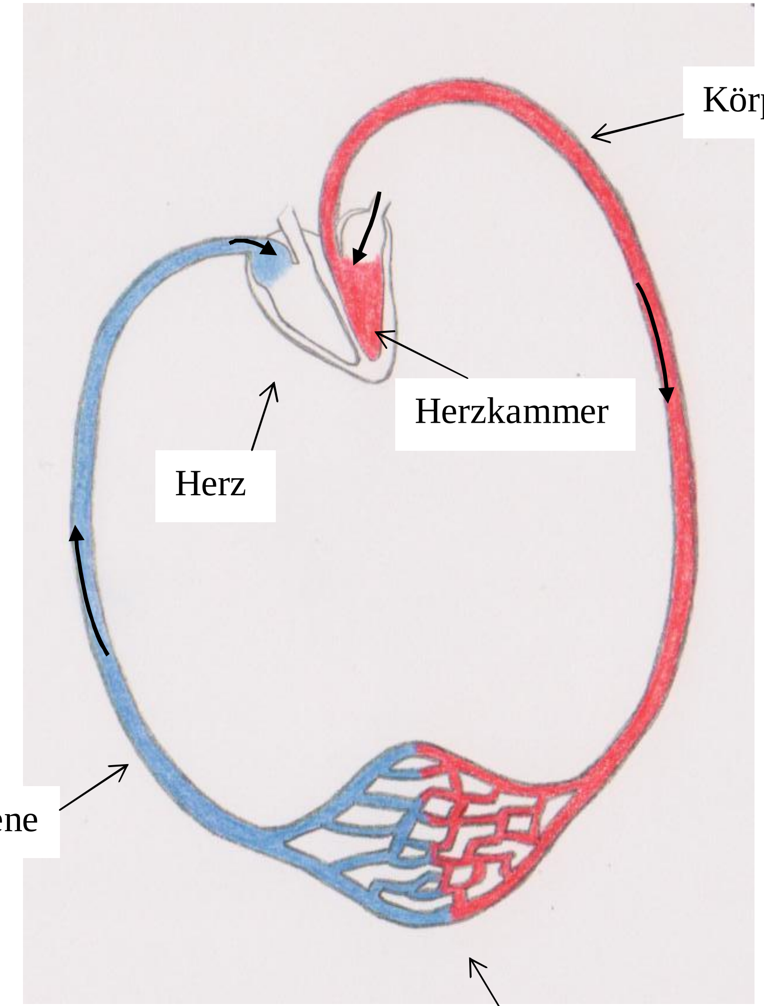
STOPP!

Aufgabe 13

Findest du Sachen, die im Text und im Bild vorkommen? Blättere auf die nächste Seite und suche danach.

Seite 5

Der große Körperkreislauf



rot = Blut mit viel Sauerstoff

blau = Blut mit wenig Sauerstoff

STOPP!

Aufgabe 14 **Seite 6**

Merke dir das Wichtigste vom Text!

STOPP!

Appendix W

Experiment 2: Learning Unit 2 – “spoken text + pictures + selection/organization aids” condition

The text used in the “written text + pictures + selection/organization aids” condition (Experiment 2: Learning Unit 2 – “written text + pictures + selection/organization aids” condition) was spoken.

Unser Blutkreislauf (2)

Stopp!

Aufgabe 1

Seite 1

Merke dir das Wichtigste vom Text!

STOPP!

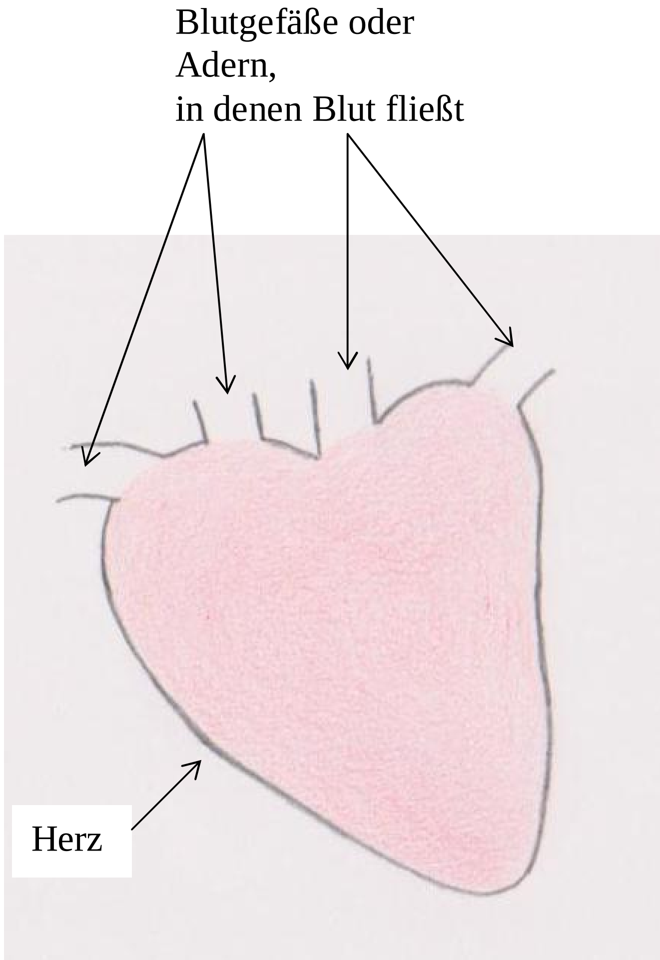
Aufgabe 2 **Seite 2**

Merke dir das Wichtigste vom Text!

STOPP!

Aufgabe 3

Merke dir das Wichtigste vom Bild!



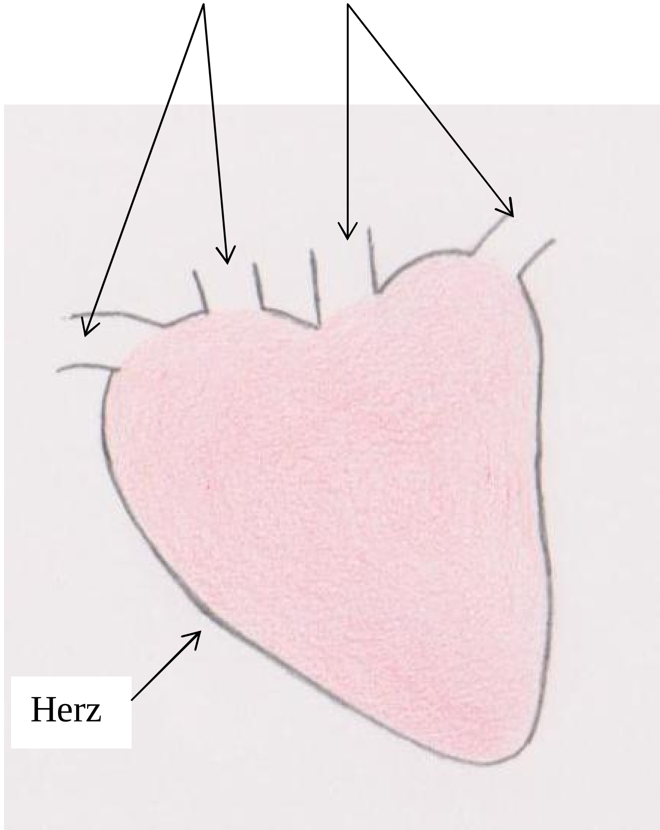
STOPP!

Aufgabe 4

Findest du Sachen, die im Text und im Bild vorkommen? Blättere auf die nächste Seite und suche danach.

Seite 2

Blutgefäße oder
Adern,
in denen Blut fließt



STOPP!

Aufgabe 5

Seite 3

Merke dir das Wichtigste vom Text!

Aufgabe 6

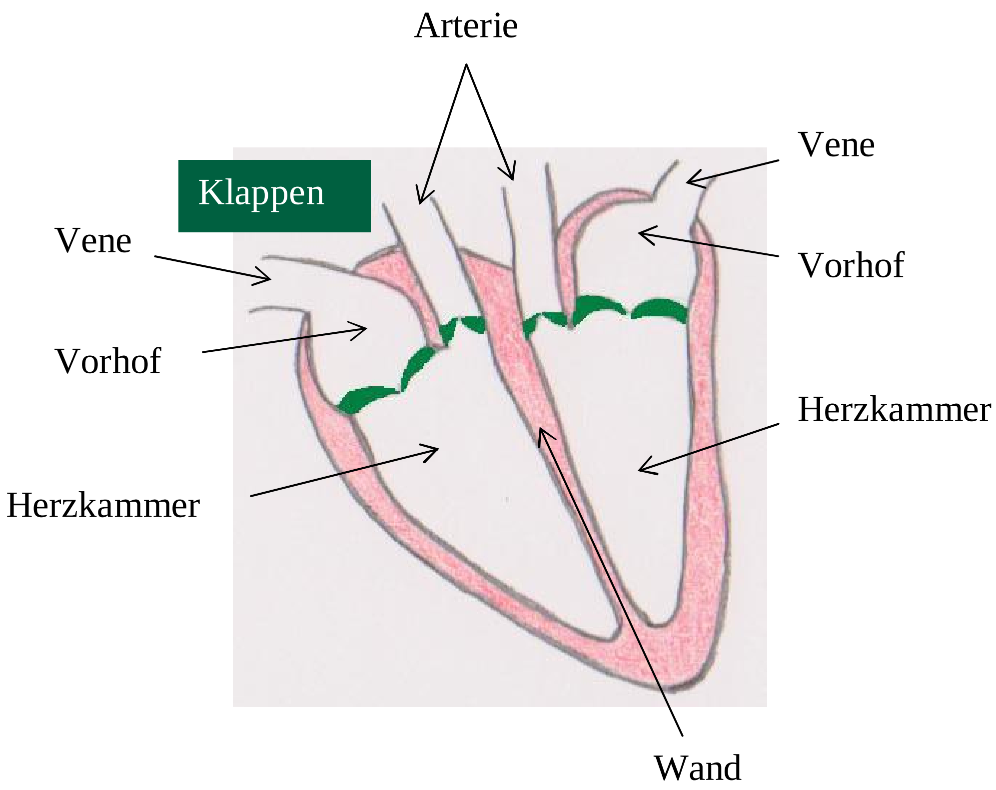
Ergänze den Satz!

_______________bringen das Blut **vom Herz weg**. Damit du das nicht vergisst, merke dir folgendes: Das Wort „Ferien“ reimt sich auf „Arterien“. In den „Ferien“ fahren viele Menschen weg. Also bringen **Arterien** das Blut **vom Herz weg!**

STOPP!

Aufgabe 7

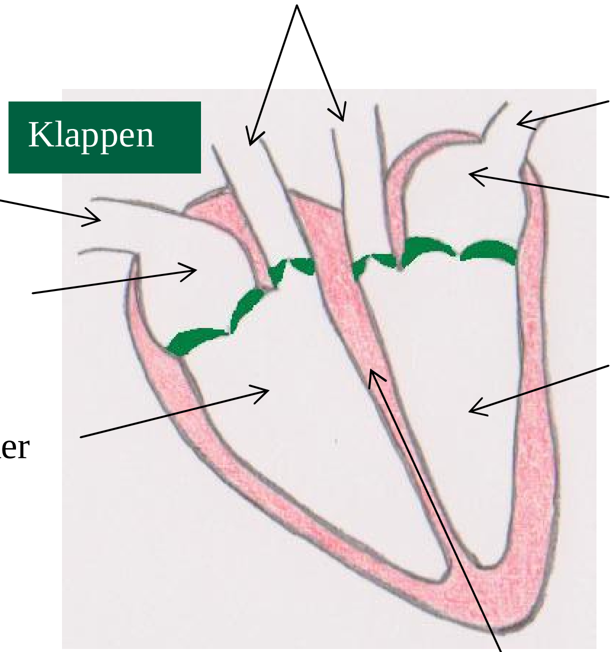
Merke dir das Wichtigste vom Bild!



STOPP!

Aufgabe 8

Findest du Sachen, die im Text und im Bild vorkommen? Blättere auf die nächste Seite und suche danach.


Arterie
Vene
Klappen
Vene
Vorhof
Vorhof
Herzkammer
Herzkammer
Wand

STOPP!

Aufgabe 9 **Seite 4**

Merke dir das Wichtigste vom Text!

Aufgabe 10

Ergänze den Satz!

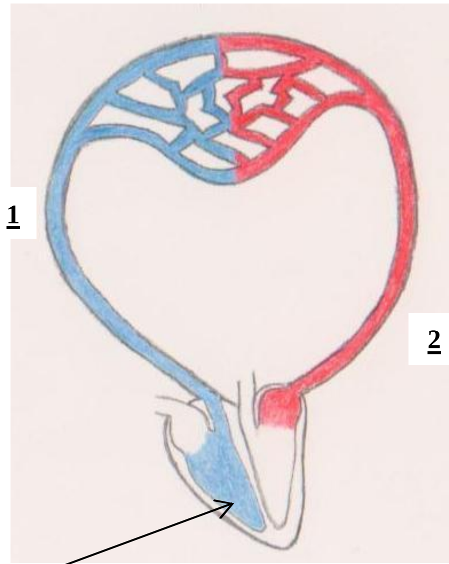
Der ____________ Lungenkreislauf **startet** immer in der ____________________ Herzhälfte. Merke dir das gut!

Aufgabe 11

Ergänze den Satz!

In der stärkeren Herzhälfte __________ der kleine Lungenkreislauf. Merke dir das gut!

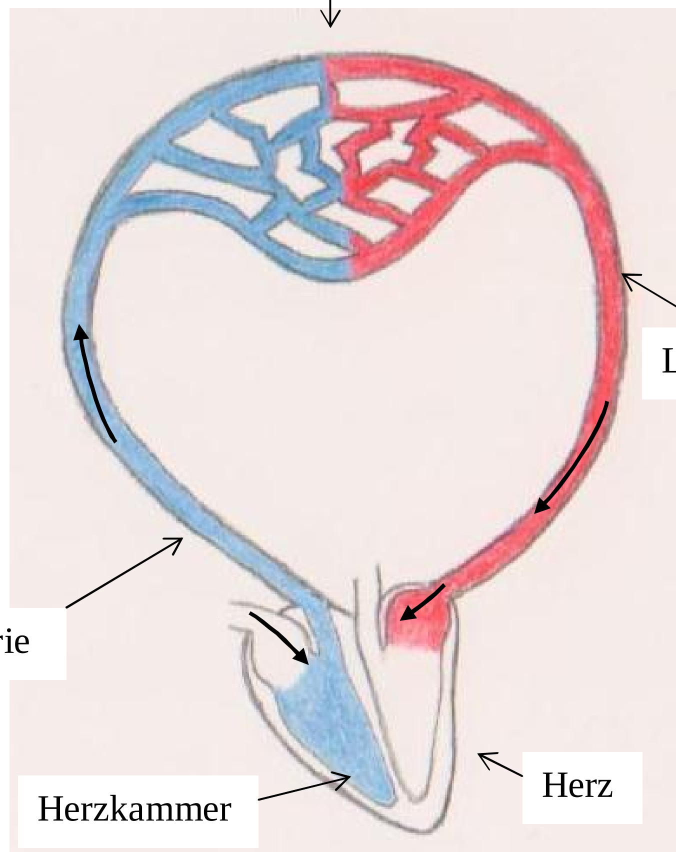
STOPP!



Aufgabe 12

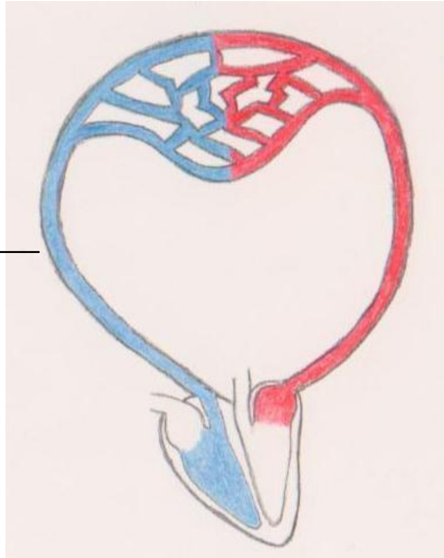
Wie laufen die Pfeile immer in den Kreisläufen? Sie laufen im ____________________sinn. Zeichne die beiden Pfeile im oberen Bild bei den Zahlen 1 und 2 ein!

Der kleine Lungenkreislauf



rot = Blut mit viel Sauerstoff

blau = Blut mit wenig Sauerstoff



rot = Blut mit viel Sauerstoff

blau = Blut mit wenig Sauerstoff

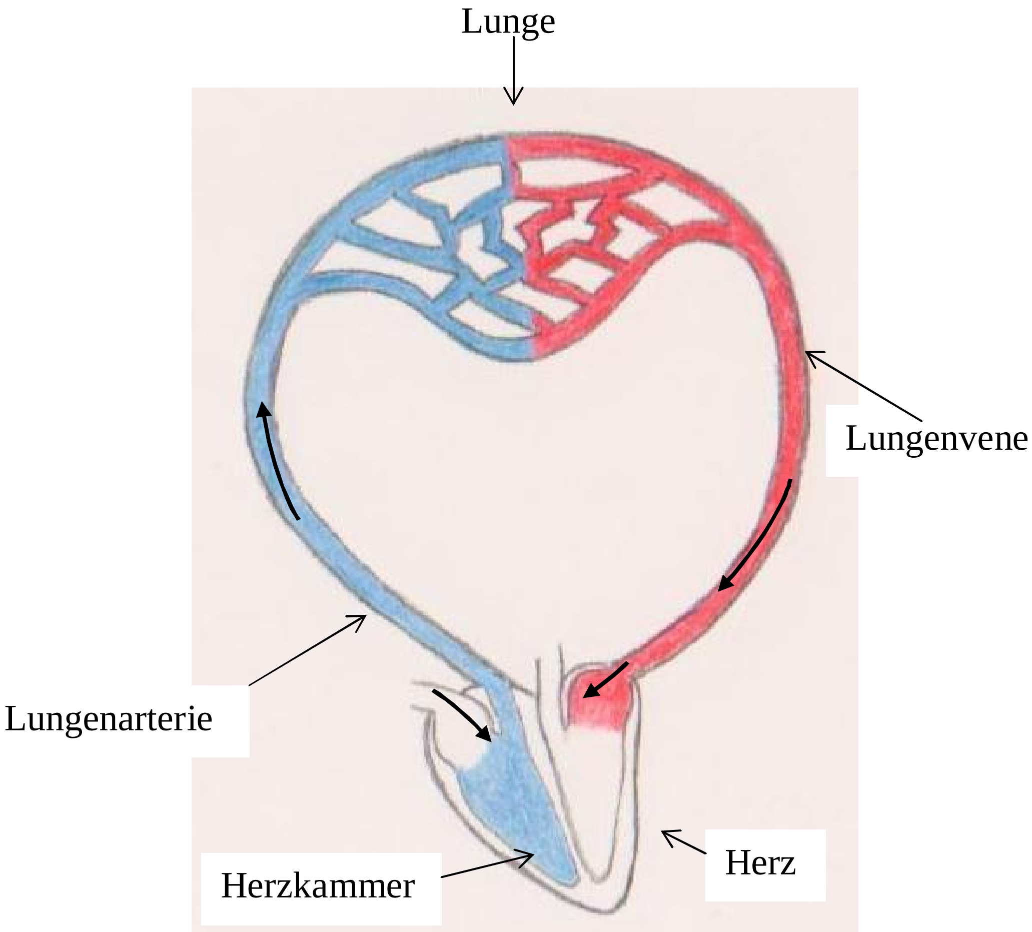
Aufgabe 13

Schreibe den Namen von der Ader, in der wenig Sauerstoff fließt, ins obere Bild!

Aufgabe 14

Merke dir das Wichtigste vom großen Bild!

Der kleine Lungenkreislauf



rot = Blut mit viel Sauerstoff

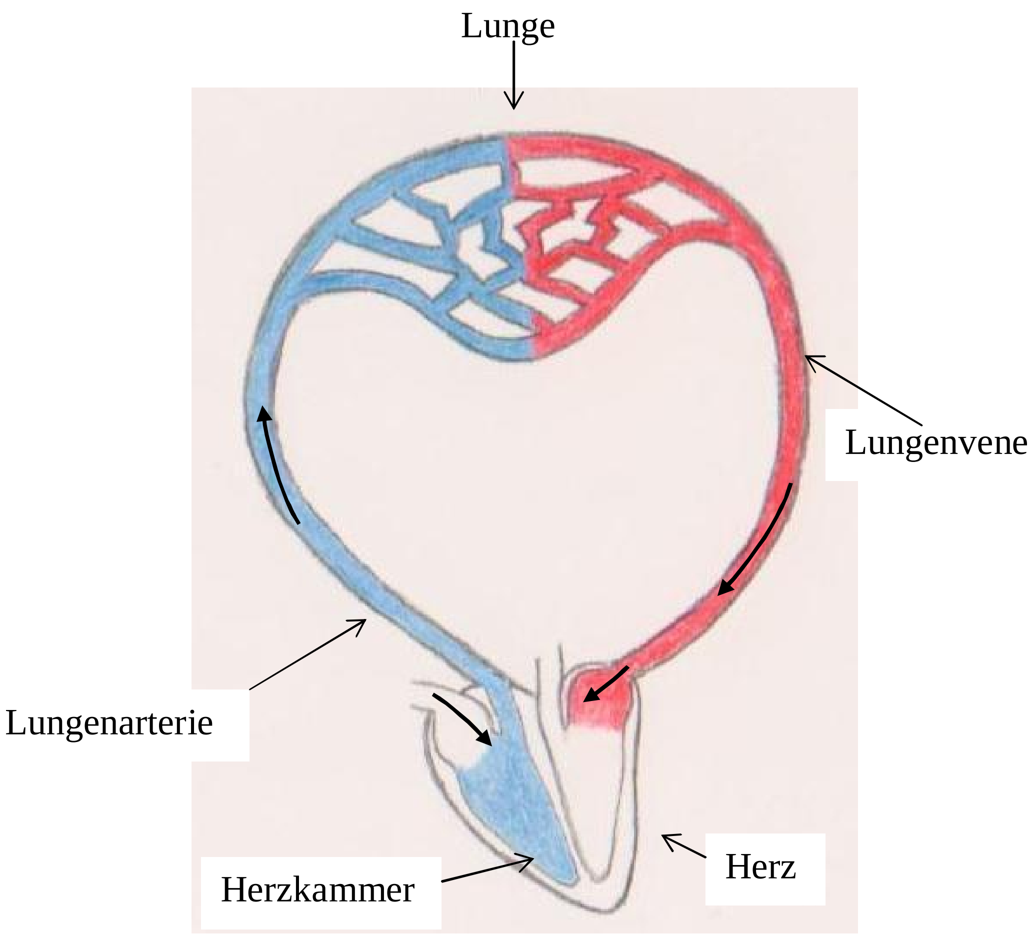
blau = Blut mit wenig Sauerstoff

STOPP!

Aufgabe 15

Findest du Sachen, die im Text und im Bild vorkommen? Blättere auf die nächste Seite und suche danach.

Der kleine Lungenkreislauf



rot = Blut mit viel Sauerstoff

blau = Blut mit wenig Sauerstoff

STOPP!

Aufgabe 16

Seite 5

Merke dir das Wichtigste vom Text!

Aufgabe 17

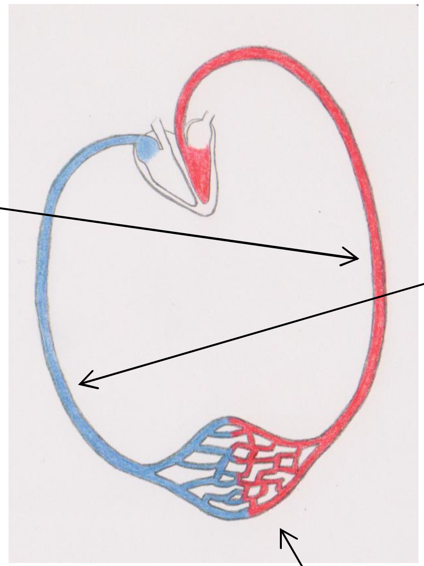
Welcher Kreislauf **endet** immer in der **schwächeren Herzhälfte**? Kreise den richtigen Kreislauf ein!

kleiner Lungenkreislauf

großer Körperkreislauf

STOPP!

Der große Körperkreislauf



Körper

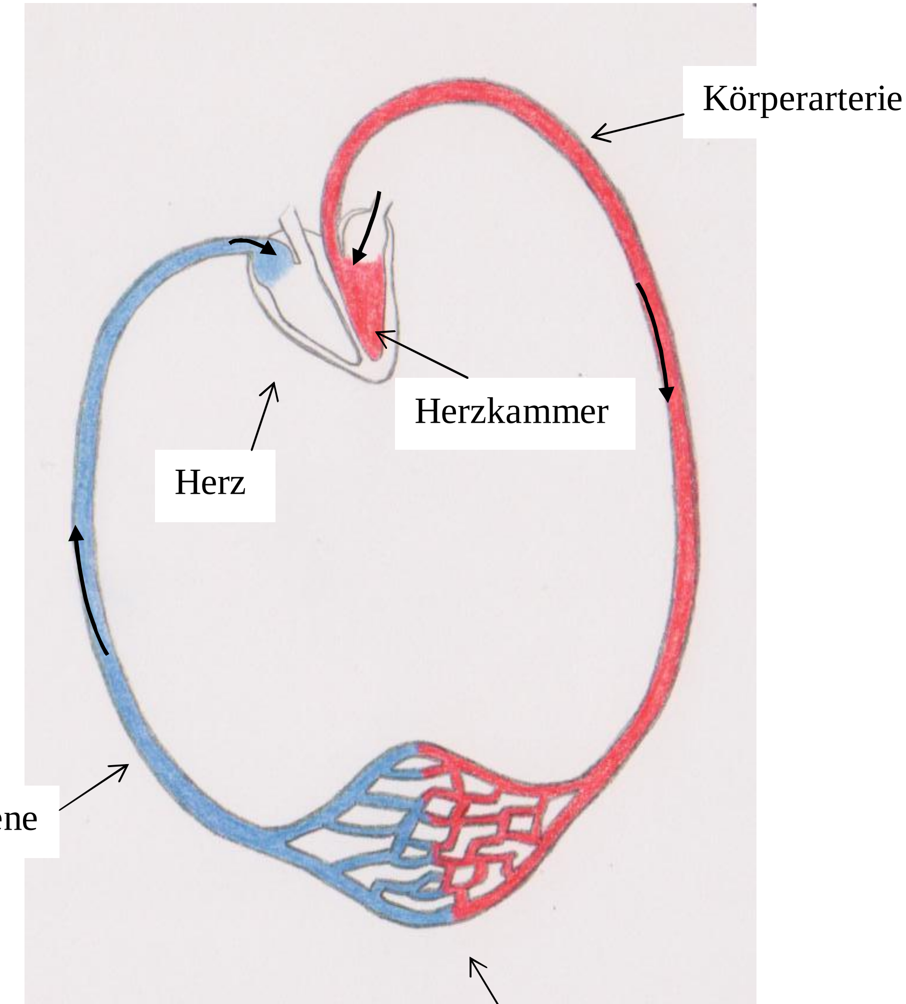
rot = Blut mit viel Sauerstoff

blau = Blut mit wenig Sauerstoff

<u>Aufgabe 18</u>

Beschrifte die Pfeile! Merke dir die Namen gut!

Der große Körperkreislauf



rot = Blut mit viel Sauerstoff

Körper

blau = Blut mit wenig Sauerstoff

<u>Aufgabe 19</u>

Merke dir das Wichtigste vom Bild!

<u>Aufgabe 20</u>

Merke dir gut, welche Ader die Körpervene ist und welche die Körperarterie! Ergänze die Sätze!

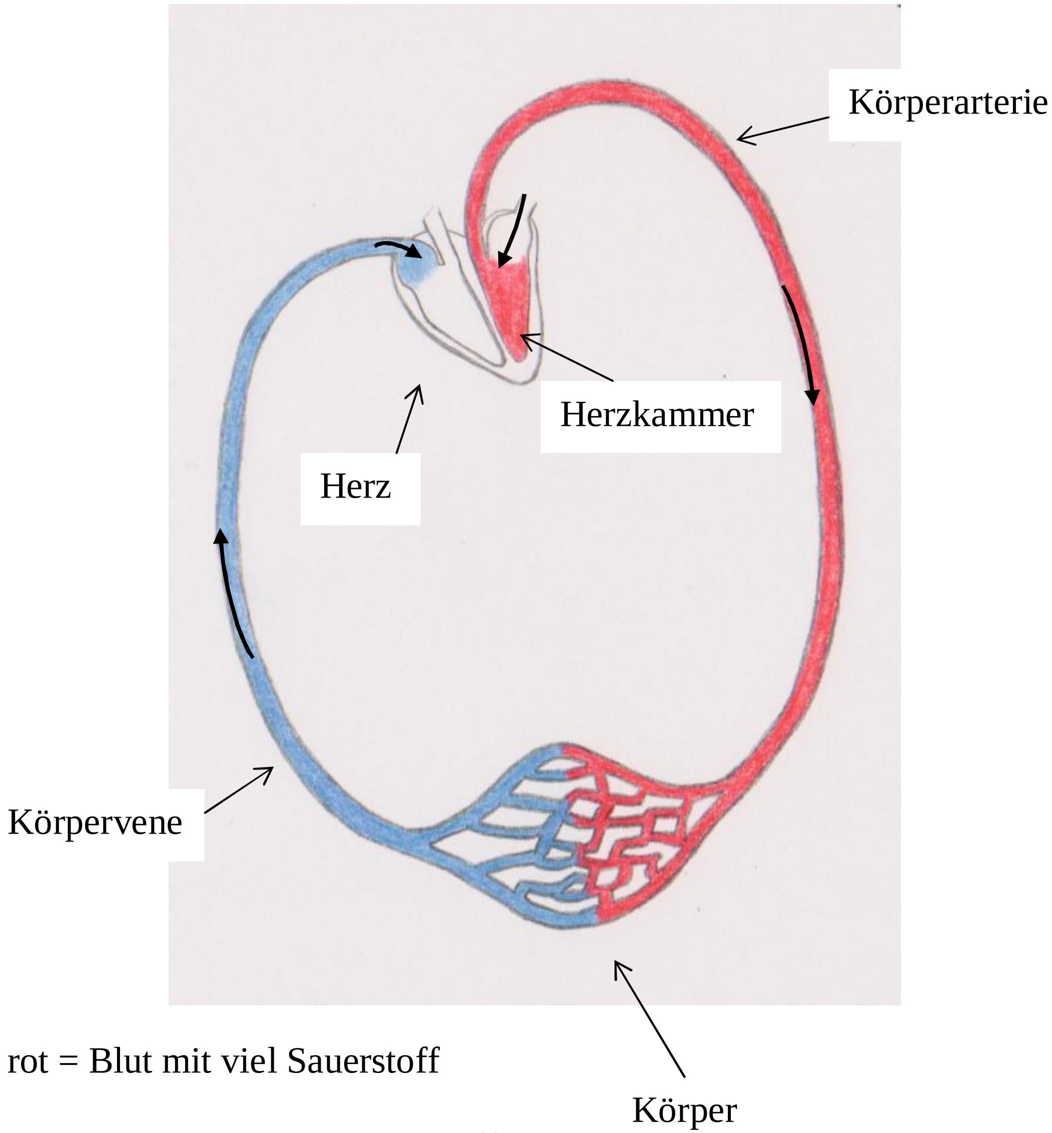
In der ________________________________

fließt Blut mit wenig Sauerstoff.

In der ________________________________

fließt Blut mit viel Sauerstoff.

Der große Körperkreislauf



rot = Blut mit viel Sauerstoff

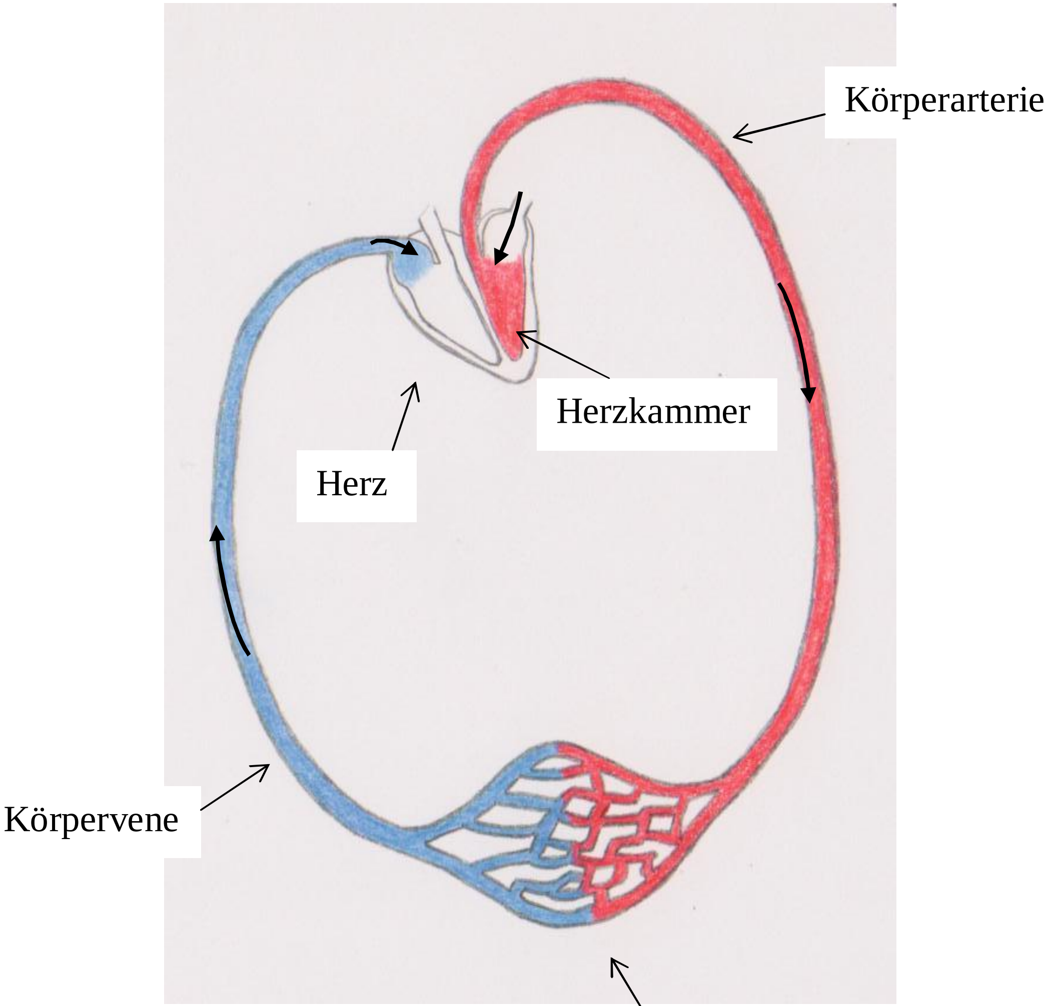
blau = Blut mit wenig Sauerstoff

STOPP!

Aufgabe 21

Findest du Sachen, die im Text und im Bild vorkommen? Blättere auf die nächste Seite und suche danach.

Der große Körperkreislauf



rot = Blut mit viel Sauerstoff

blau = Blut mit wenig Sauerstoff

STOPP!

Aufgabe 22

Seite 6

Merke dir das Wichtigste vom Text!

Aufgabe 23

Ergänze den Satz!

Der ______________________________ besteht aus dem _____________ Körperkreislauf und dem ________________ Lungenkreislauf.

STOPP!

Appendix X

<u>Experiment 2: Learning Unit 2 – "spoken text + pictures + selection/organization aids + integration aids" condition</u>

The text used in the "written text + pictures + selection/organization aids + integration aids" condition (Experiment 2: Learning Unit 2 – "written text + pictures + selection/organization aids + integration aids" condition) was spoken.

Unser Blutkreislauf (2)

Stopp!

Aufgabe 1

Seite 1

Merke dir das Wichtigste vom Text!

STOPP!

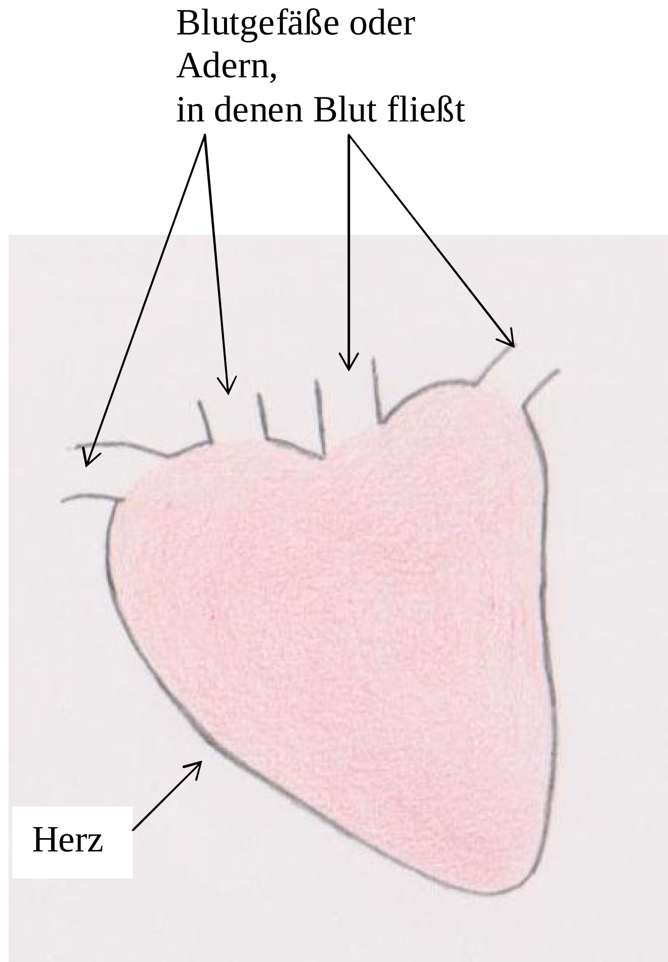
Aufgabe 2 **Seite 2**

Merke dir das Wichtigste vom Text!

STOPP!

Aufgabe 3

Merke dir das Wichtigste vom Bild!

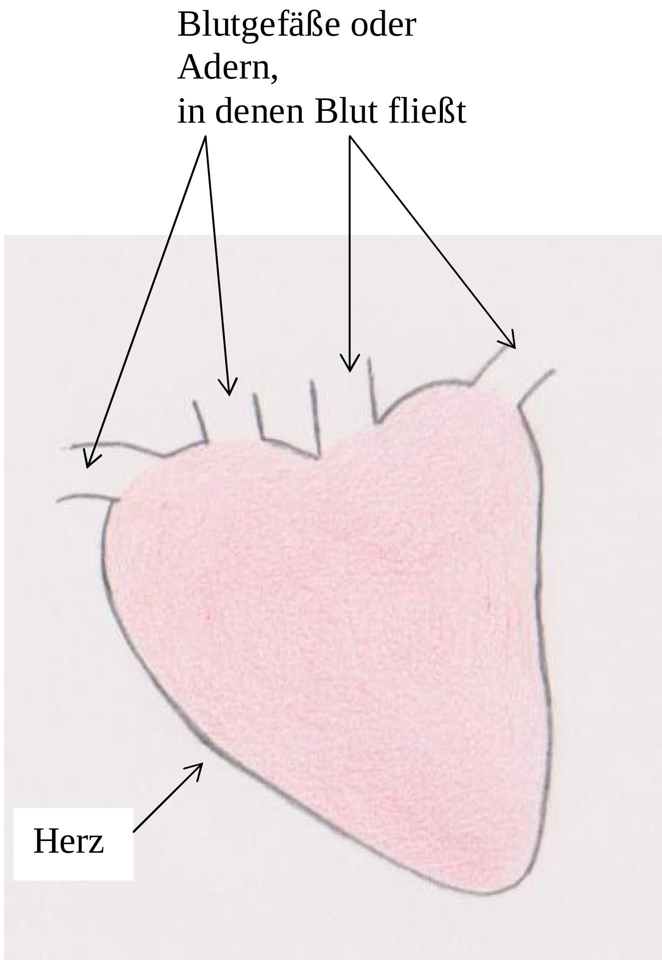


STOPP!

Aufgabe 4

Findest du Sachen, die im Text und im Bild vorkommen? Blättere auf die nächste Seite und suche danach.

Seite 2



STOPP!

Aufgabe 5

Seite 3

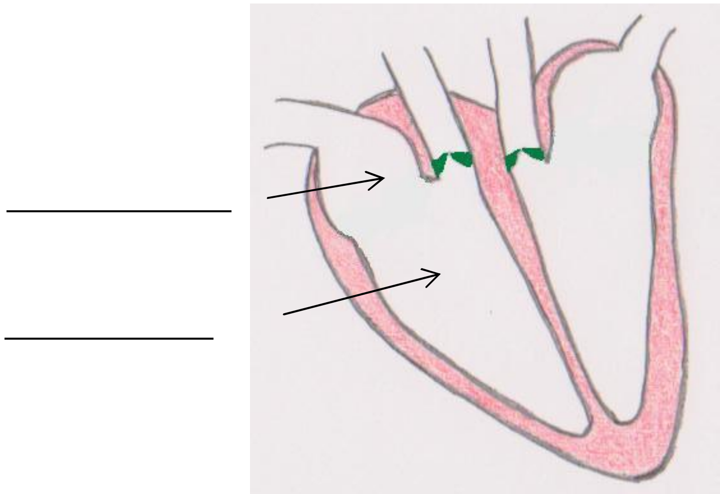
Merke dir das Wichtigste vom Text!

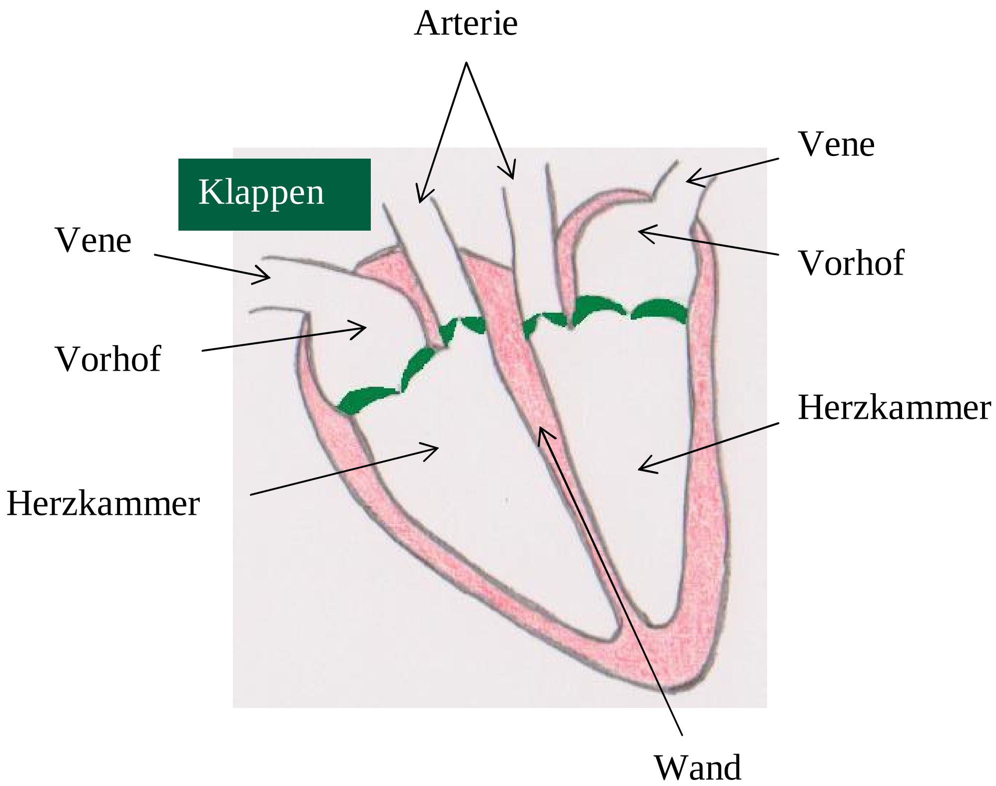
Aufgabe 6

Ergänze den Satz!

_______________bringen das Blut **vom Herz weg**. Damit du das nicht vergisst, merke dir folgendes: Das Wort „Ferien“ reimt sich auf „Arterien“. In den „Ferien“ fahren viele Menschen weg. Also bringen **Arterien** das Blut **vom Herz weg!**

STOPP!





Aufgabe 7

Zeichne zuerst die fehlenden Klappen ein! Beachte, dass die Klappen gebogen sind! Sie können sich deshalb nur in eine Richtung öffnen. Beschrifte dann die beiden Pfeile!

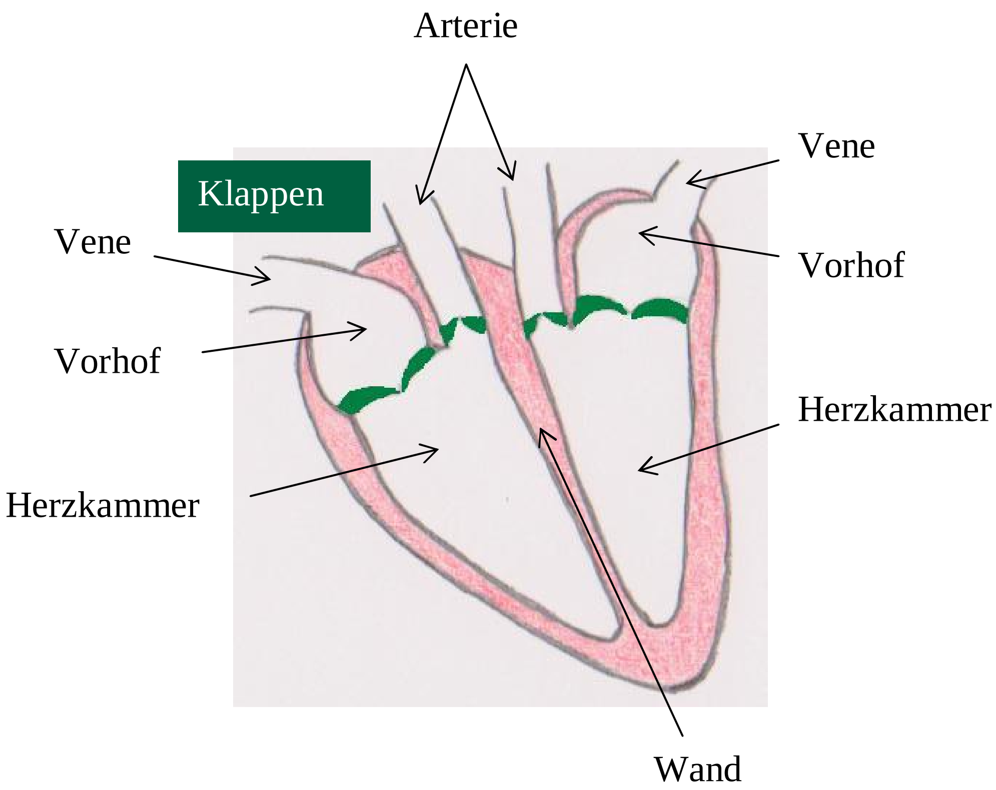
Aufgabe 8

Merke dir das Wichtigste vom großen Bild!

STOPP!

Aufgabe 9

Findest du Sachen, die im Text und im Bild vorkommen? Blättere auf die nächste Seite und suche danach.


Arterie
Vene
Klappen
Vene
Vorhof
Vorhof
Herzkammer
Herzkammer
Wand

STOPP!

Aufgabe 10

Seite 4

Merke dir das Wichtigste vom Text!

Aufgabe 11

Ergänze den Satz!

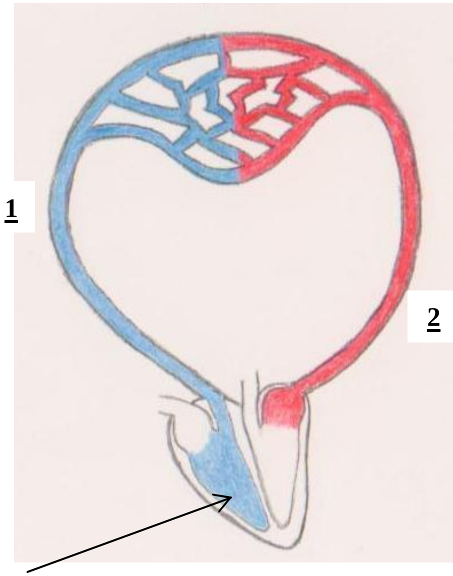
Der ____________ Lungenkreislauf **startet** immer in der ____________________ Herzhälfte. Merke dir das gut!

Aufgabe 12

Ergänze den Satz!

In der stärkeren Herzhälfte __________ der kleine Lungenkreislauf. Merke dir das gut!

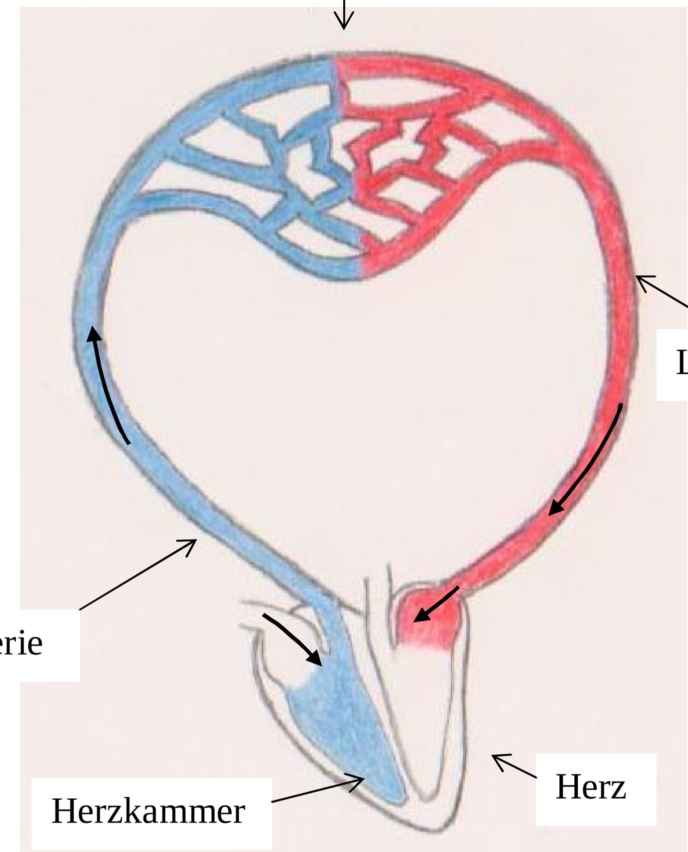
STOPP!



Aufgabe 13

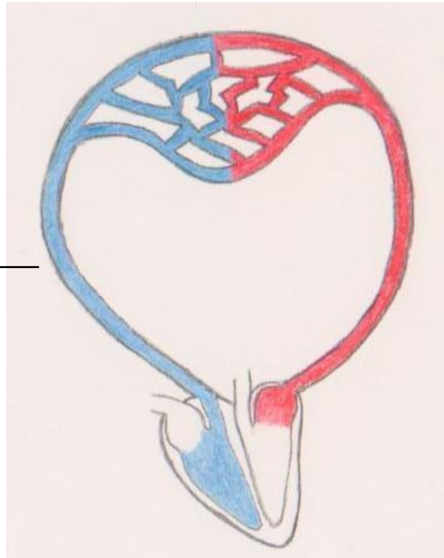
Wie laufen die Pfeile immer in den Kreisläufen? Sie laufen im ____________________sinn. Zeichne die beiden Pfeile im oberen Bild bei den Zahlen 1 und 2 ein!

Der kleine Lungenkreislauf



rot = Blut mit viel Sauerstoff

blau = Blut mit wenig Sauerstoff



rot = Blut mit viel Sauerstoff

blau = Blut mit wenig Sauerstoff

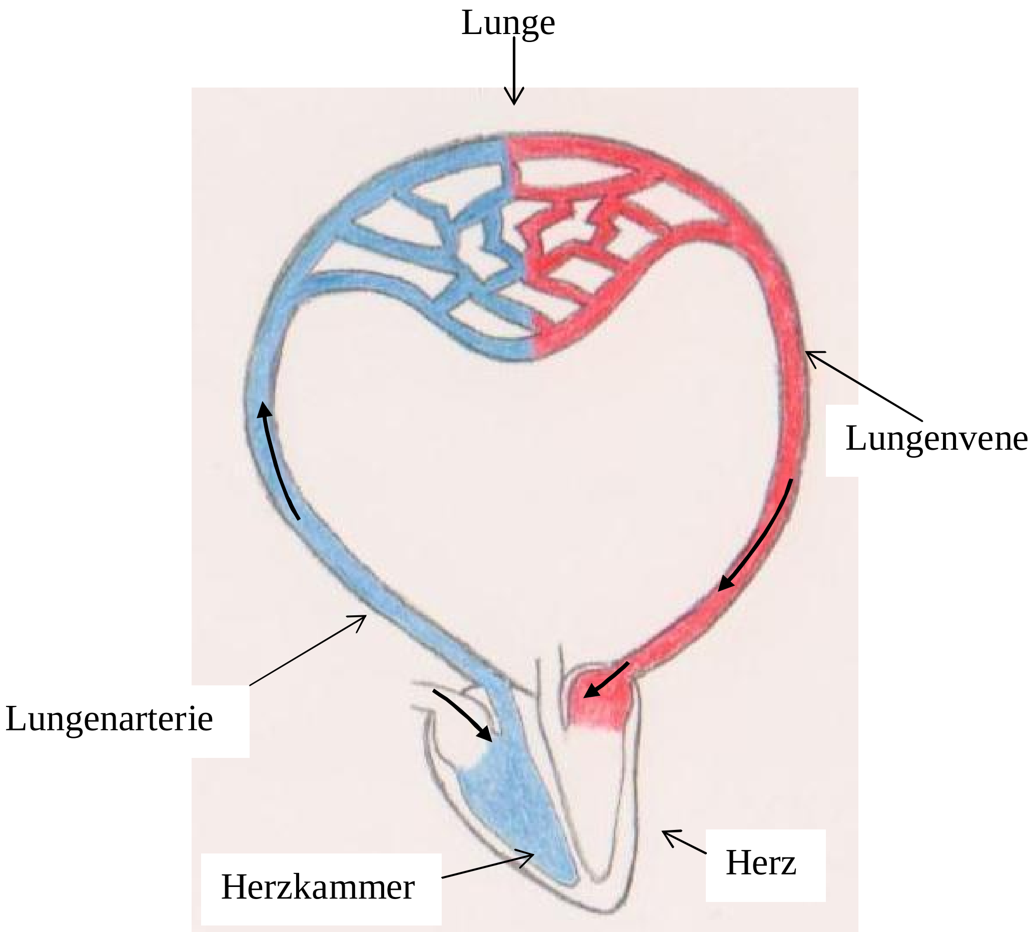
Aufgabe 14

Schreibe den Namen von der Ader, in der wenig Sauerstoff fließt, ins obere Bild!

Aufgabe 15

Merke dir das Wichtigste vom großen Bild!

Der kleine Lungenkreislauf



rot = Blut mit viel Sauerstoff

blau = Blut mit wenig Sauerstoff

STOPP!

Aufgabe 16

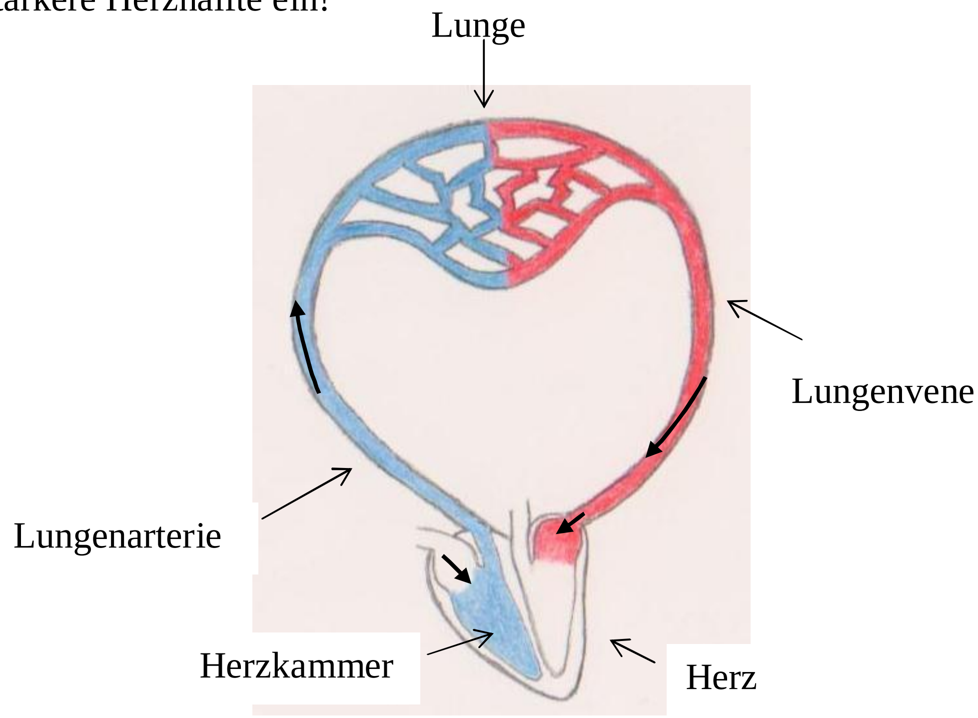
Findest du Sachen, die im Text und im Bild vorkommen? Bearbeite zuerst die Aufgaben und suche dann nach diesen Sachen. Blättere jetzt auf die nächste Seite.

Aufgabe 17

Schaue dir das Bild genau an! Welche Ader führt von der Herzkammer zur Lunge? Kreise diese Ader im Bild ein!

Aufgabe 18

Weißt du, welche Herzhälfte im Bild die stärkere Herzhälfte ist? Schaue dir den Text und das Bild hierfür gut an! Kreise die stärkere Herzhälfte ein!



rot = Blut mit viel Sauerstoff

blau = Blut mit wenig Sauerstoff

STOPP!

Aufgabe 19

Seite 5

Merke dir das Wichtigste vom Text!

Aufgabe 20

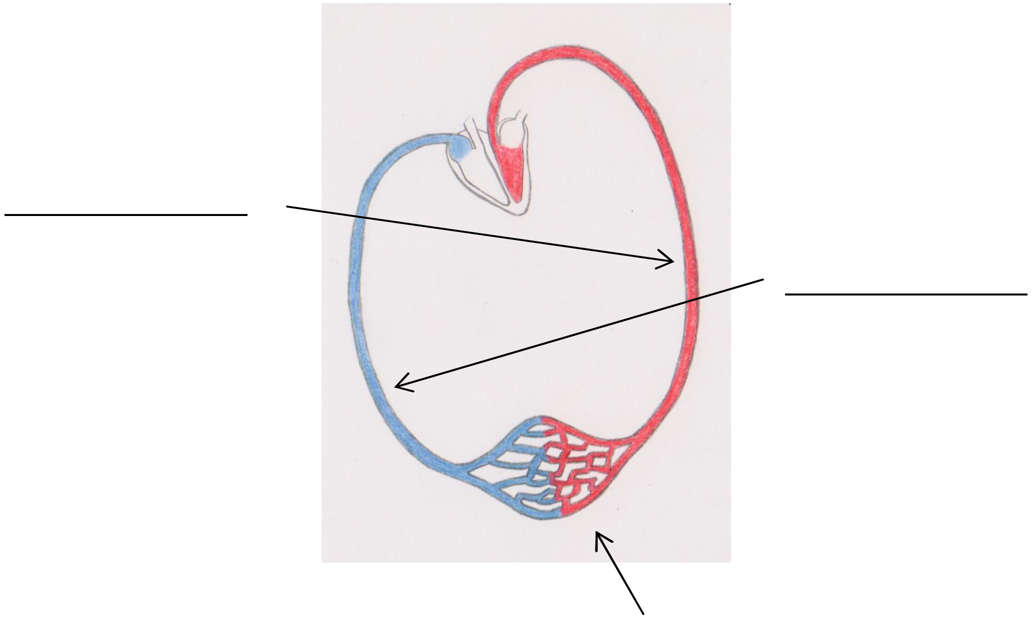
Welcher Kreislauf **endet** immer in der **schwächeren Herzhälfte**? Kreise den richtigen Kreislauf ein!

kleiner Lungenkreislauf

großer Körperkreislauf

STOPP!

Der große Körperkreislauf



Körper

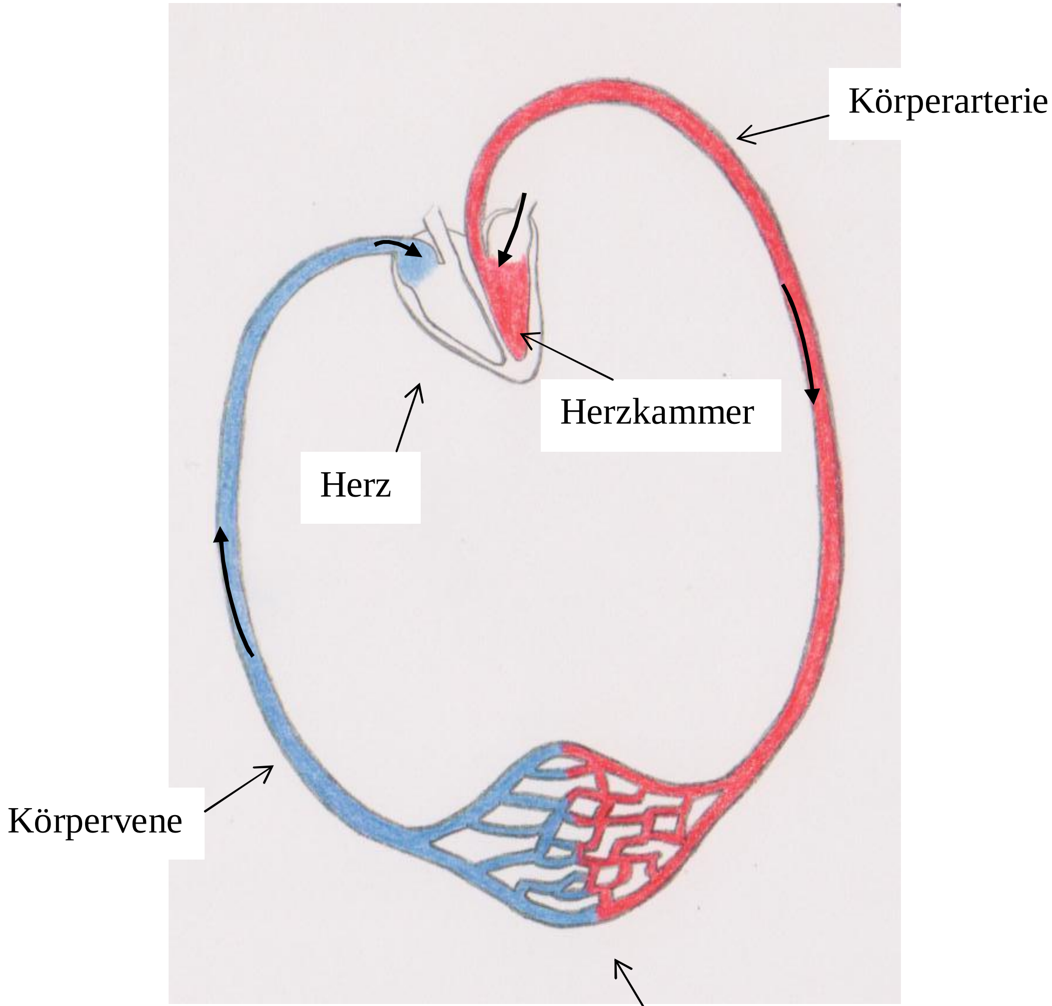
rot = Blut mit viel Sauerstoff

blau = Blut mit wenig Sauerstoff

<u>Aufgabe 21</u>

Beschrifte die Pfeile! Merke dir die Namen gut!

Der große Körperkreislauf



rot = Blut mit viel Sauerstoff

Körper

blau = Blut mit wenig Sauerstoff

Aufgabe 22

Merke dir das Wichtigste vom Bild!

Aufgabe 23

Merke dir gut, welche Ader die Körpervene ist und welche die Körperarterie! Ergänze die Sätze!

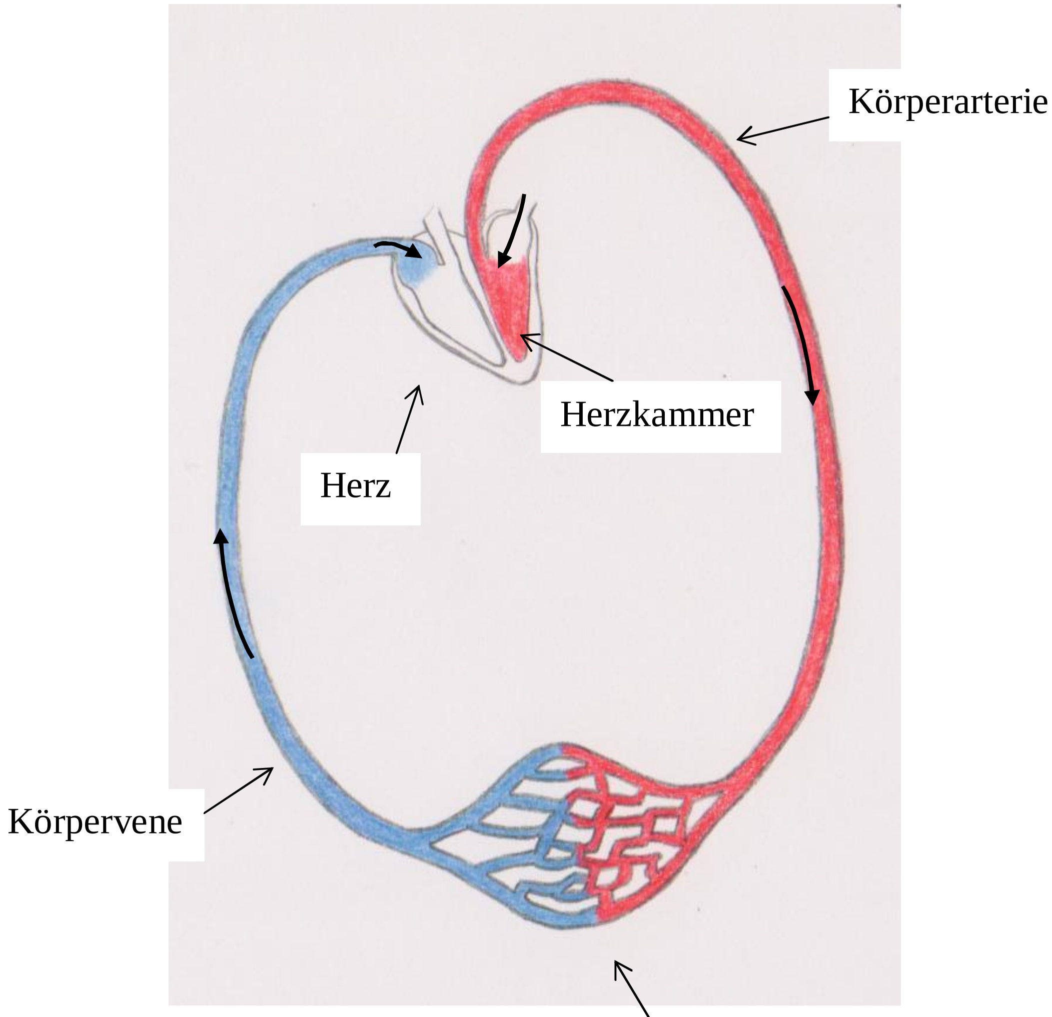
In der ________________________________

fließt Blut mit wenig Sauerstoff.

In der ________________________________

fließt Blut mit viel Sauerstoff.

Der große Körperkreislauf



rot = Blut mit viel Sauerstoff

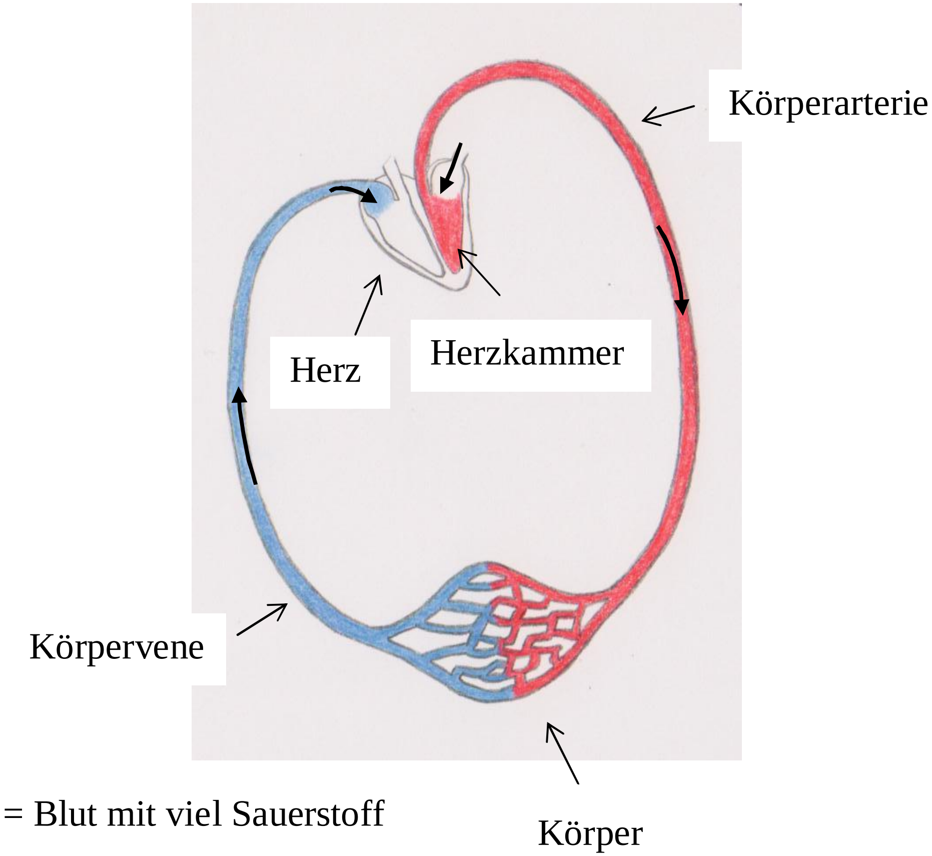
blau = Blut mit wenig Sauerstoff

STOPP!

Aufgabe 24

Findest du Sachen, die im Text und im Bild vorkommen? Bearbeite zuerst die Aufgaben und suche dann nach diesen Sachen. Blättere jetzt auf die nächste Seite.

Der große Körperkreislauf



rot = Blut mit viel Sauerstoff

blau = Blut mit wenig Sauerstoff

Aufgabe 25

Schaue dir das Bild genau an! Ergänze den Satz!

Die Körpervene führt vom Körper zum ______________.

STOPP!

Aufgabe 26

Seite 6

Merke dir das Wichtigste vom Text!

Aufgabe 27

Ergänze den Satz!

Der ______________________________ besteht aus dem _____________ Körperkreislauf und dem ________________ Lungenkreislauf.

Aufgabe 28

Merke dir gut, dass **beide Kreisläufe im Herz starten und enden**!

STOPP!

Appendix Y

Experiment 1 & Experiment 2: Learning Unit 1 – Multiple-choice test

Unser Blutkreislauf (1)

Erinnerst du dich noch an deinen Code? Den brauchen wir jetzt noch einmal…

1. Erster Buchstabe von deinem Vornamen in das erste Kästchen
2. Erster Buchstabe von deinem Nachnamen in das zweite Kästchen
3. Der Tag, an dem du Geburtstag hast, in das dritte Kästchen
4. Der Monat, in dem du geboren bist, in das vierte Kästchen

Dein Code:

Was musst du jetzt machen?

Du bekommst Fragen mit vier verschiedenen Antworten. Eine Antwort ist immer richtig. Es können auch Fragen kommen, die du gar nicht beantworten kannst. Wenn du eine Antwort nicht weißt, kreuze das Kästchen „Ich weiß es nicht." an. Kreuze bitte immer nur EIN Kästchen an. Bitte rate nicht.

<u>Beispielaufgabe</u>

Wozu braucht jeder Mensch das Herz, unseren Motor?

- □ um leben zu können
- □ um fliegen zu können
- □ um in den Urlaub fahren zu können
- □ um atmen zu können
- □ ich weiß es nicht

Zum Schluss bekommst du auch Fragen, zu denen du eine kurze Antwort schreiben sollst.

Beispielaufgabe

Schaue dir das Bild an. Auf welcher Körperseite liegt das Herz?

____

____

□ Ich weiß es nicht.

Arbeite ruhig und konzentriere dich. Du hast genug Zeit.

Stopp!

Unser Blutkreislauf (1)

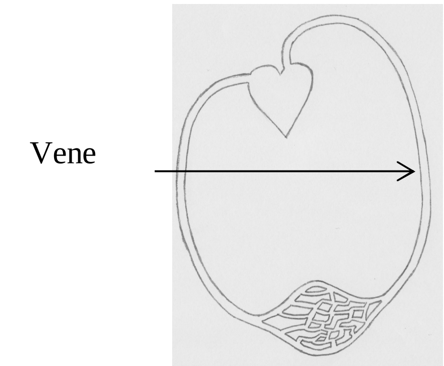
1. Das Blut fließt in kleinen Rohren, die Blutgefäße heißen. Wie heißen die Blutgefäße noch?
   - ◻ Leitungen
   - ◻ Sehnen
   - ◻ Muskeln
   - ◻ Adern
   - ◻ ich weiß es nicht

2. Wie heißt der Weg des Blutes durch den Körper?
   - ◻ großer Körperkreislauf
   - ◻ schwacher Körperkreislauf
   - ◻ kleiner Körperkreislauf
   - ◻ starker Körperkreislauf
   - ◻ ich weiß es nicht

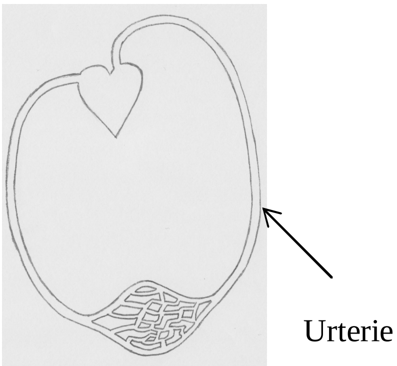
3. Was müssen wir tun, damit Sauerstoff in die Lunge kommt?
   - ◻ essen
   - ◻ trinken
   - ◻ schlafen
   - ◻ atmen
   - ◻ ich weiß es nicht

4. Wie heißt die Ader, auf die der Pfeil zeigt? Kreuze das richtige Bild an.

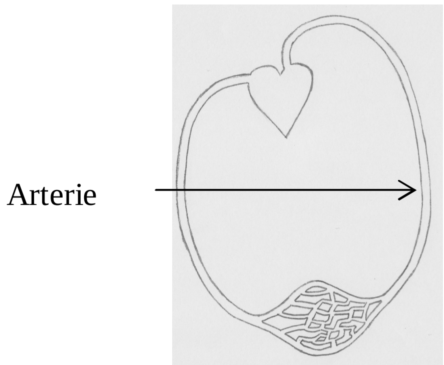
□



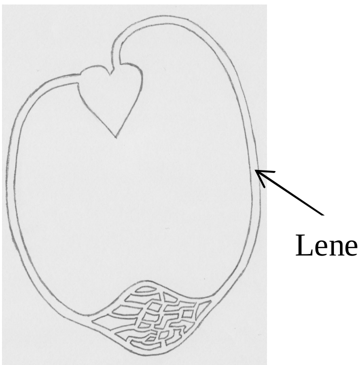
□



□



□

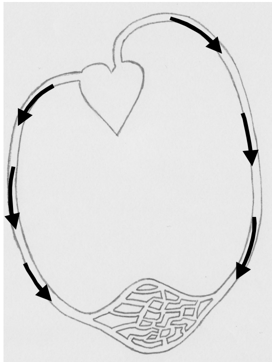


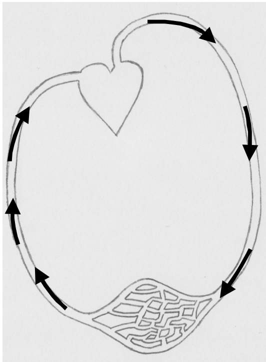
□ Ich weiß es nicht.

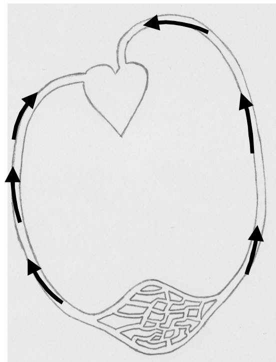
5. In welcher Farbe wird Blut mit wenig Sauerstoff gemalt?
   - □ in grün
   - □ in blau
   - □ in rot
   - □ in gelb
   - □ ich weiß es nicht

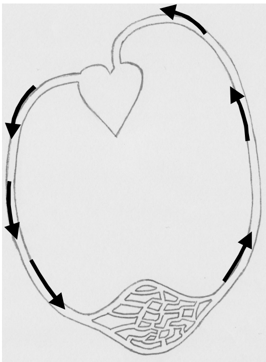
6. Was macht das Blut in der Lunge?
   - □ Das Blut gibt Sauerstoff ab.
   - □ Das Blut gibt Stickstoff ab.
   - □ Das Blut tankt Sauerstoff auf.
   - □ Das Blut tankt Stickstoff auf.
   - □ Ich weiß es nicht.

7. Wie fließt das Blut im Körperkreislauf? Kreuze das richtige Bild an.

□ 

□ 

□ 

□ 

□ Ich weiß es nicht.

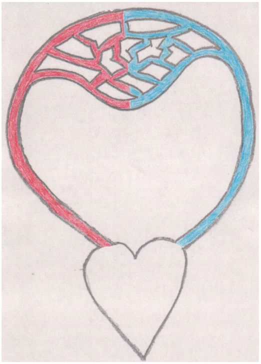
8. Im Blut sind viele Stoffe. An welchen Stellen braucht der Körper diese Stoffe?

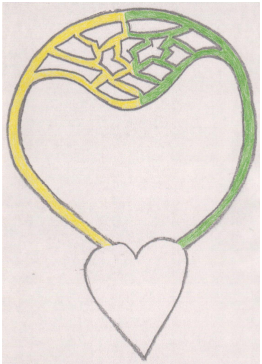
- □ an vielen Stellen
- □ an gar keinen Stellen
- □ an allen Stellen
- □ an wenigen Stellen
- □ ich weiß es nicht

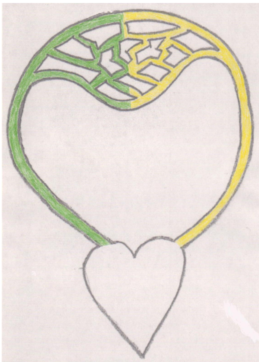
9. Wie heißt der Weg des Blutes in die Lunge?

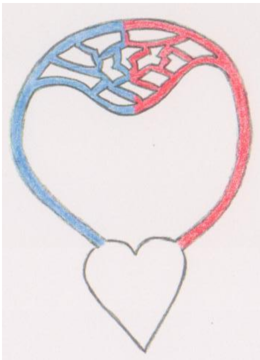
- □ starker Lungenkreislauf
- □ schwacher Lungenkreislauf
- □ kleiner Lungenkreislauf
- □ großer Lungenkreislauf
- □ ich weiß es nicht

10. Wann ist im Blut wenig und wann viel Sauerstoff? Kreuze das richtige Bild an.

□ 

□ 

□ 

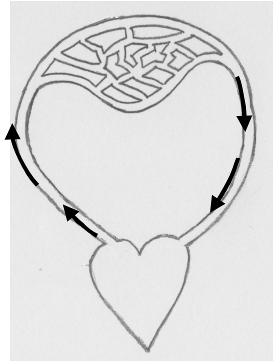
□ 

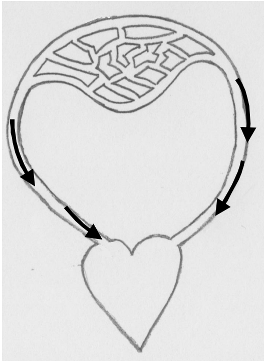
□ Ich weiß es nicht.

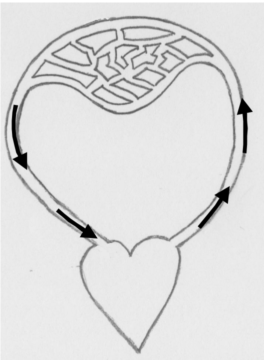
11. Welche Adern gibt es?

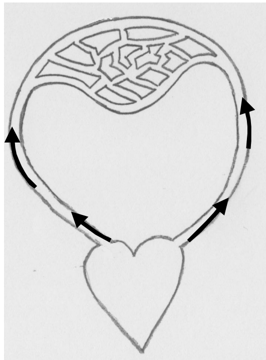
- □ die braunen Adern und die schwarzen Adern
- □ die Arterien und die Venen
- □ das Blut und den Sauerstoff
- □ die Leitungen und die Sehnen
- □ ich weiß es nicht

12. Wie fließt das Blut im Lungenkreislauf? Kreuze das richtige Bild an.

□ 

□ 

□ 

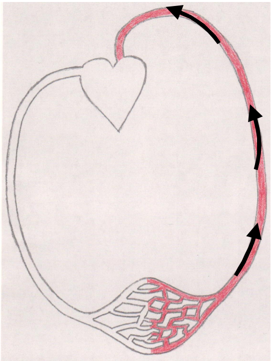
□ 

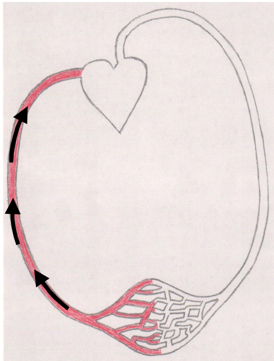
□ Ich weiß es nicht.

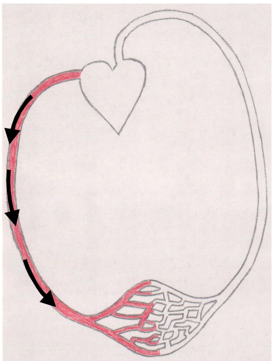
13. Wohin führen Arterien?
    - □ vom Herz weg
    - □ vom Körper weg
    - □ zum Herz hin
    - □ von der Lunge weg
    - □ ich weiß es nicht

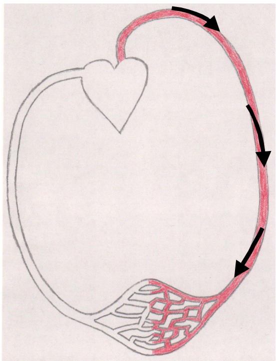
14. Wo pumpt das Herz das Blut immer zuerst hin?
    - □ in das Herz
    - □ in den Körperkreislauf
    - □ in die Lunge
    - □ in den Körper
    - □ ich weiß es nicht

15. In welche Richtung fließt Blut mit viel Sauerstoff? Kreuze das richtige Bild an.

□ 

□ 

□ 

□ 

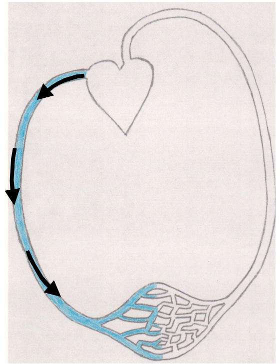
□ Ich weiß es nicht.

16. Wo sind Adern?
   - □ überall in dem Körper
   - □ nur im Herz
   - □ nur im Kopf
   - □ nur auf der linken Körperseite
   - □ ich weiß es nicht

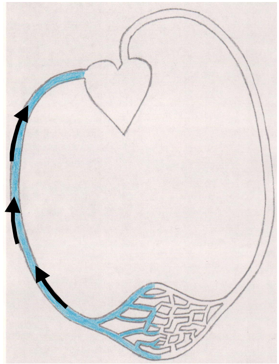
17. Wohin führen Venen?
   - □ zur Lunge hin
   - □ zum Herz hin
   - □ zum Körper hin
   - □ vom Herz weg
   - □ ich weiß es nicht

18. In welche Richtung fließt Blut mit wenig Sauerstoff? Kreuze das richtige Bild an.

□



□



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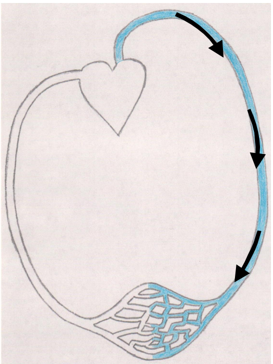

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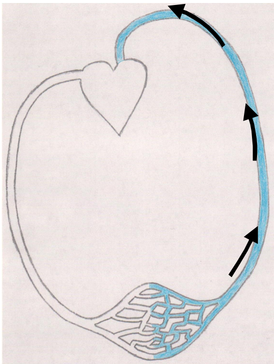
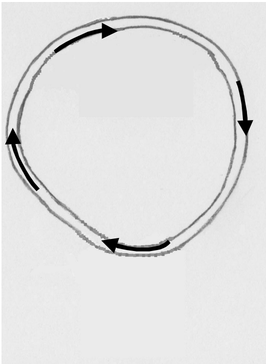


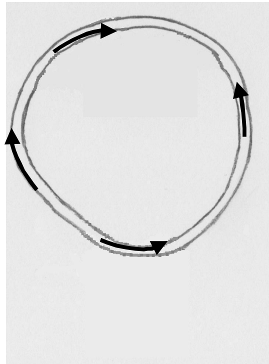
□ Ich weiß es nicht.

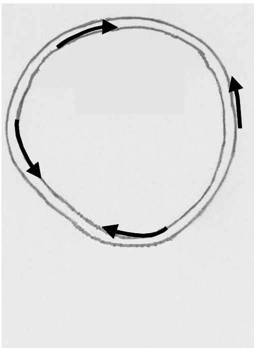
19. Aus welchen Kreisläufen besteht unser Blutkreislauf?

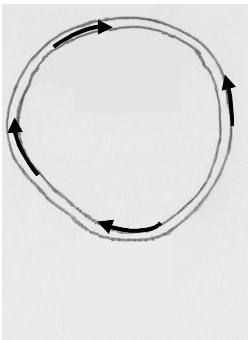
- □ aus dem starken Lungenkreislauf und dem schwachen Körperkreislauf
- □ aus dem großen Lungenkreislauf und dem kleinen Körperkreislauf
- □ aus dem kleinen Lungenkreislauf und dem großen Körperkreislauf
- □ aus dem schwachen Lungenkreislauf und dem starken Körperkreislauf
- □ ich weiß es nicht

20. Welches Bild zeigt einen Kreislauf?

□ 

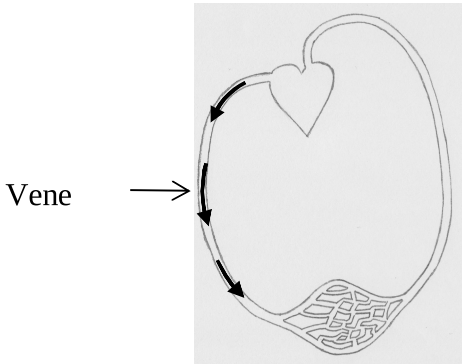
□ 

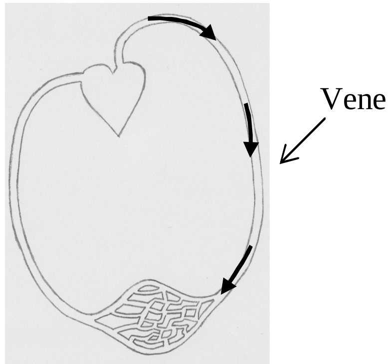
□ 

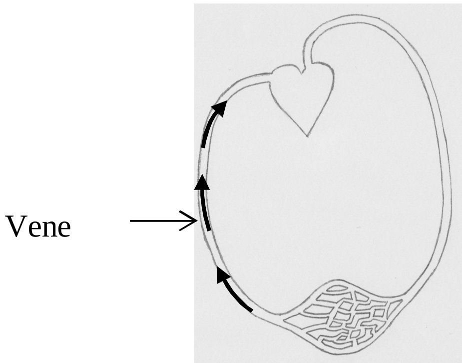
□ 

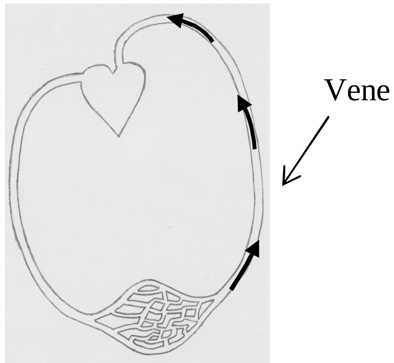
□ Ich weiß es nicht.

21. In welche Richtung muss das Blut in der Vene fließen? Kreuze das richtige Bild an.

□ 

□ 

□ 

□ 

□ Ich weiß es nicht.

22. Woran siehst du in einem Bild zum Lungenkreislauf, dass die Lunge Sauerstoff aufnimmt?

____

____

□ Ich weiß es nicht.

23. Woran siehst du in einem Bild zum Körperkreislauf, dass der Sauerstoff im Körper verteilt wird?

____

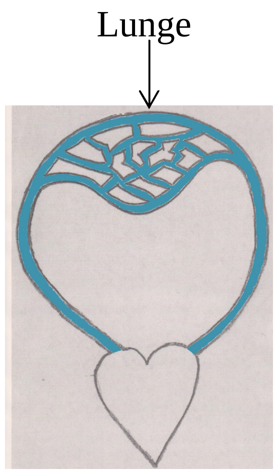
____

□ Ich weiß es nicht.

24. Wie du weißt, fließt das Blut in Adern. Welcher Satz ist richtig?
   - □ Es gibt nur Adern, in denen Blut mit viel Sauerstoff fließt.
   - □ Es gibt Adern, in denen Blut mit viel Sauerstoff fließt. Und es gibt Adern, in denen Blut mit wenig Sauerstoff fließt.
   - □ Es gibt nur Adern, in denen Blut mit wenig Sauerstoff fließt.
   - □ Es gibt Adern, in denen Blut mit viel Sauerstoff fließt. Und es gibt Adern, in denen kein Blut fließt.
   - □ Ich weiß es nicht.

25. Das Wort Kreislauf heißt, dass das Blut wie im Kreis gepumpt wird. Wie wird das Blut genau gepumpt?
   - □ Das Blut wird vom Körper weggepumpt und fließt zum Körper zurück.
   - □ Das Blut wird vom Herz weggepumpt und fließt zum Herz zurück.
   - □ Das Blut wird vom Herz weggepumpt und fließt zum Körper zurück.
   - □ Das Blut wird von der Lunge weggepumpt und fließt zur Lunge zurück.
   - □ Ich weiß es nicht.

26. Schaue dir das Bild genau an. Funktioniert die Lunge richtig? Erkläre kurz warum.



____

____

____

□ Ich weiß es nicht.

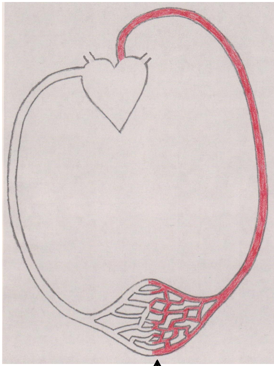
27. In welchem Kreislauf gibt das Blut den Sauerstoff an den Körper ab?

- □ im großen Lungenkreislauf
- □ im kleinen Körperkreislauf
- □ im kleinen Lungenkreislauf
- □ im großen Körperkreislauf
- □ ich weiß es nicht

28. Wie fließt das Blut innerhalb der Adern?

- □ in alle Richtungen
- □ in kleinen Kreisen
- □ in entgegen gesetzte Richtungen
- □ in die gleiche Richtung
- □ ich weiß es nicht

29. Schaue dir das Bild an. Wo war das Blut, bevor es vom Herz in den Körper gepumpt wurde?



Körper

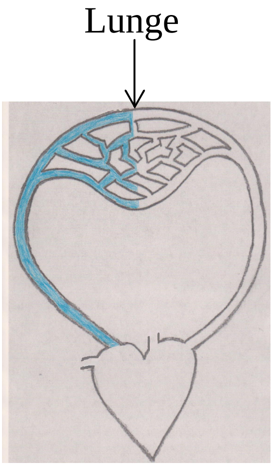
____

____

□ Ich weiß es nicht.

30. Gehört Sauerstoff zu den wichtigen Stoffen im Blut, die unser Körper braucht?
    - □ Ja, denn Sauerstoff ist im Blut und wird überall im Körper gebraucht.
    - □ Nein, denn Sauerstoff ist nur in unserer Lunge.
    - □ Ja, denn Sauerstoff ist immer im Blut und wird nie abgegeben.
    - □ Nein, denn Sauerstoff ist nur in unserem Herz.
    - □ Ich weiß es nicht.

31. Schaue dir das Bild an. Wo war das Blut, bevor es vom Herz in die Lunge gepumpt wurde?

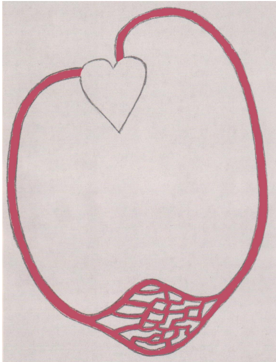


____

____

□ Ich weiß es nicht.

32. Schaue dir das Bild genau an. Wird der Sauerstoff im Körper verteilt? Erkläre kurz warum.



↑

Körper

____

____

____

□ Ich weiß es nicht.

Appendix Z

Experiment 1 & Experiment 2: Learning Unit 2 – Multiple-choice test

Unser Blutkreislauf (2)

Erinnerst du dich noch an deinen Code? Den brauchen wir jetzt noch einmal…

5. Erster Buchstabe von deinem Vornamen in das erste Kästchen
6. Erster Buchstabe von deinem Nachnamen in das zweite Kästchen
7. Der Tag, an dem du Geburtstag hast, in das dritte Kästchen
8. Der Monat, in dem du geboren bist, in das vierte Kästchen

Dein Code:

Was musst du jetzt machen?

Du bekommst Fragen mit vier verschiedenen Antworten. Eine Antwort ist immer richtig. Es können auch Fragen kommen, die du gar nicht beantworten kannst. Wenn du eine Antwort nicht weißt, kreuze das Kästchen „Ich weiß es nicht.“ an. Kreuze bitte immer nur EIN Kästchen an. Bitte rate nicht.

Beispielaufgabe

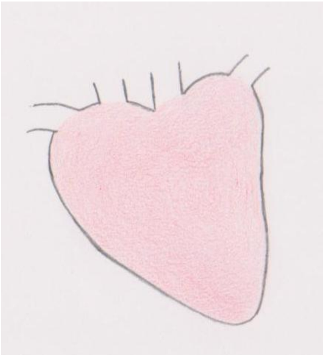
Wo sind Blutgefäße oder Adern?

- □ nur in der Lunge
- □ überall im Körper
- □ nur im Herz
- □ nicht überall im Körper
- □ ich weiß es nicht

Zum Schluss bekommst du auch Fragen, zu denen du eine kurze Antwort schreiben sollst.

Beispielaufgabe

Was ist auf dem Bild zu sehen?



____

____

□ Ich weiß es nicht.

Arbeite ruhig und konzentriere dich. Du hast genug Zeit.

Stopp!

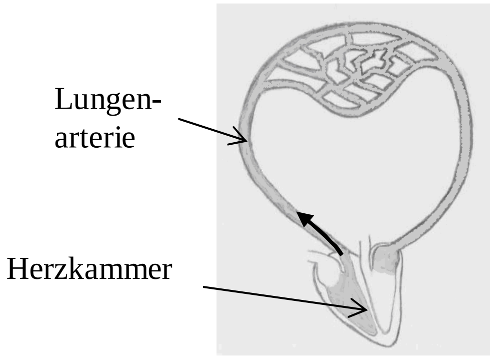
Unser Blutkreislauf 2

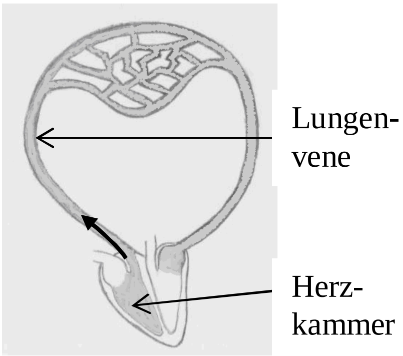
1. In welchem Kreislauf tankt das Blut Sauerstoff auf?
   - □ im kleinen Körperkreislauf
   - □ im großen Körperkreislauf
   - □ im kleinen Lungenkreislauf
   - □ im großen Lungenkreislauf
   - □ ich weiß es nicht

2. Wohin laufen die dicken Rohre, die Blutgefäße oder Adern heißen?
   - □ Sie laufen in das Herz hinein und aus dem Herz heraus.
   - □ Sie laufen nur aus dem Herz heraus.
   - □ Sie laufen nur in das Herz hinein.
   - □ Sie laufen nicht in das Herz hinein und nicht aus dem Herz heraus.
   - □ Ich weiß es nicht.

3. Aus welchen Herzhälften besteht das Herz?
   - □ aus einer schwächeren und einer stärkeren Herzhälfte
   - □ aus einer niedrigen und einer hohen Herzhälfte
   - □ aus einer jungen und einer alten Herzhälfte
   - □ aus einer kleineren und einer größeren Herzhälfte
   - □ ich weiß es nicht

4. Wie fließt das Blut in diesem Kreislauf? Kreuze das richtige Bild an.

□


□


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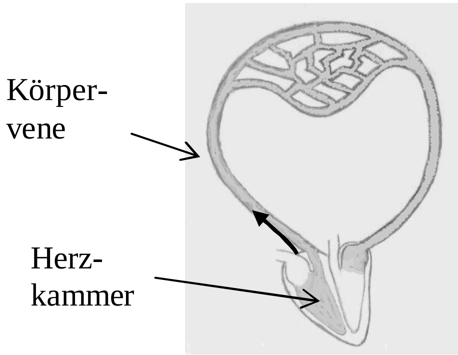

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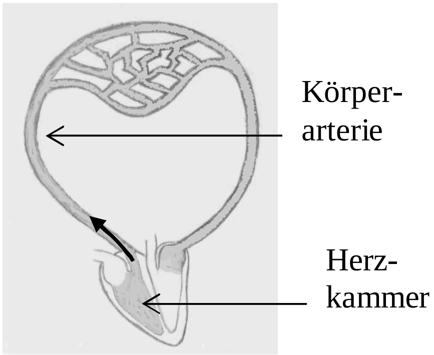


□ Ich weiß es nicht.

5. Wir können uns alle ein Herz vorstellen. Wie sieht das Herz in deinem Körper aber auf keinen Fall aus?
   - □ wie eine Zitrone
   - □ wie eine Pflaume
   - □ wie ein Lebkuchenherz
   - □ wie ein Ballon
   - □ ich weiß es nicht

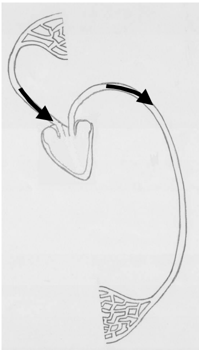
6. Arterien sind Adern, die das Blut…
   - □ …zum Herz hin bringen.
   - □ …vom Herz weg bringen.
   - □ …von der Lunge weg bringen.
   - □ …zum Herz hin leiten.
   - □ …ich weiß es nicht

7. Jede Herzhälfte besteht aus einem kleinen Vorhof. Und aus was noch?
   - □ aus einem größeren Herzzimmer
   - □ aus einem größeren Herzraum
   - □ aus einem größeren Herzhof
   - □ aus einer größeren Herzkammer
   - □ ich weiß es nicht

8. Welcher Kreislauf besteht aus dem Lungenkreislauf und dem Körperkreislauf?
   - □ der Körperkreislauf
   - □ der Blutkreislauf
   - □ der Wasserkreislauf
   - □ der Lungenkreislauf
   - □ ich weiß es nicht

9. Wie muss das Blut fließen, damit es von der Lunge in den Körper kommen kann?

□



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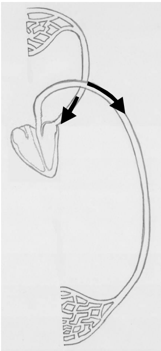

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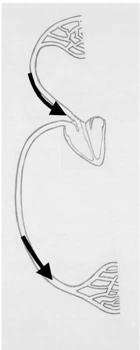

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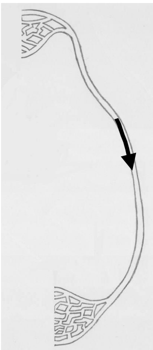


□ Ich weiß es nicht.

10. Von woher kommt das Blut, wenn es in den Vorhof der stärkeren Herzhälfte fließt?
    - □ von dem Körper
    - □ von dem Magen
    - □ von dem Herz
    - □ von der Lunge
    - □ ich weiß es nicht

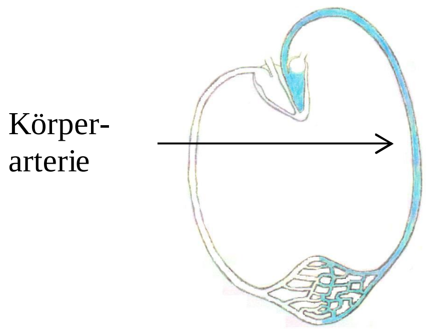
11. Welcher Kreislauf startet immer in der schwächeren Herzhälfte?
    - □ der große Lungenkreislauf
    - □ der kleine Körperkreislauf
    - □ der kleine Lungenkreislauf
    - □ der große Körperkreislauf
    - □ ich weiß es nicht

12. Wie fließt das Blut innerhalb des Herzens?

- □ von der Herzkammer in den Vorhof
- □ von der Vorkammer in den Herzhof
- □ vom Vorhof in die Herzkammer
- □ von dem Herzhof in die Vorkammer
- □ ich weiß es nicht

13. Wie heißt die Ader richtig, in der Blut mit wenig Sauerstoff fließt?

□



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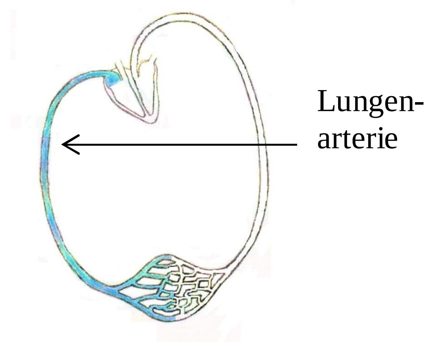

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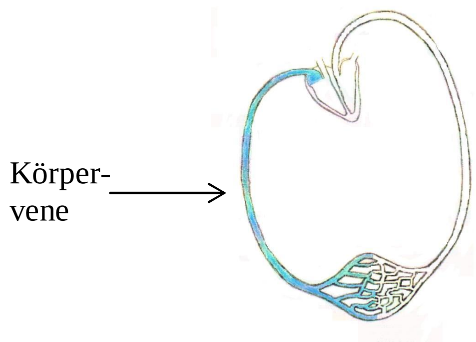

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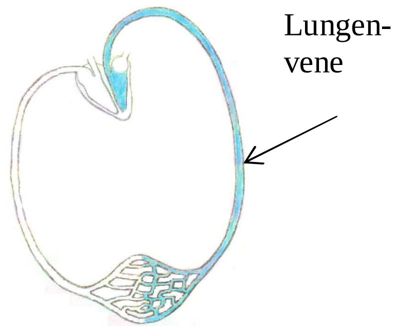


□ Ich weiß es nicht.

14. Was macht der kleine Lungenkreislauf in der stärkeren Herzhälfte?

- □ Er endet dort.
- □ Er beginnt dort.
- □ Er fängt dort von vorne an.
- □ Er macht dort eine Pause.
- □ Ich weiß es nicht.

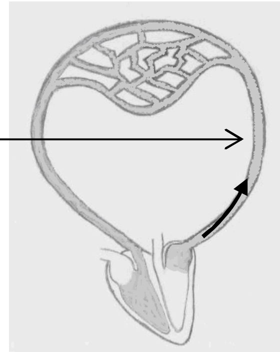
15. Was macht das Blut im Körperkreislauf?

- □ Das Blut verteilt Sauerstoff.
- □ Das Blut tankt Sauerstoff.
- □ Das Blut tankt Stickstoff.
- □ Das Blut verteilt Stickstoff.
- □ Ich weiß es nicht.

16. In welche Richtung fließt das Blut? Kreuze das richtige Bild an.

□

Lungen-
vene



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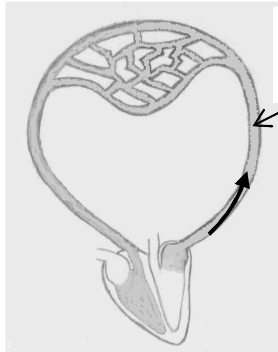
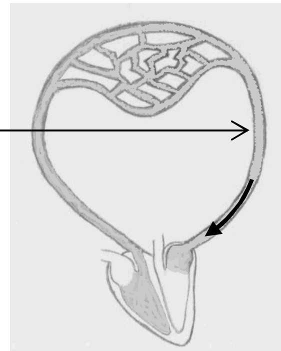


Lungen-
arterie

□

Lungen-
arterie



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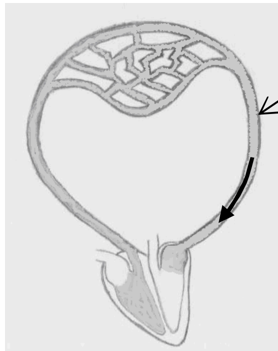
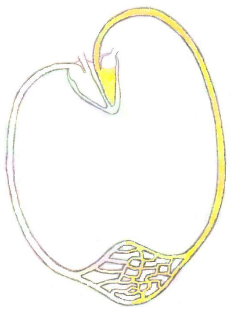


Lungen-
vene

□ Ich weiß es nicht.

17. Wie viel Sauerstoff ist in der Körperarterie drin?

□



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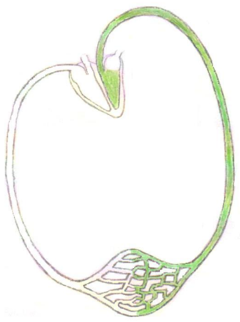

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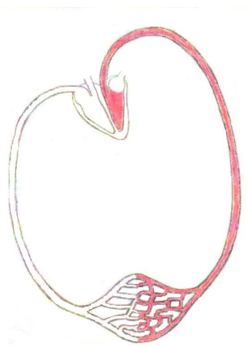

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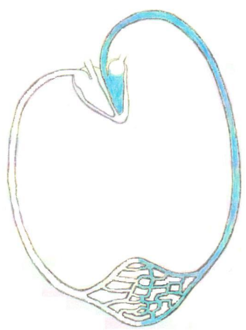


□ Ich weiß es nicht.

18. Beim Lungenkreislauf fließt das Blut von der Herzkammer …

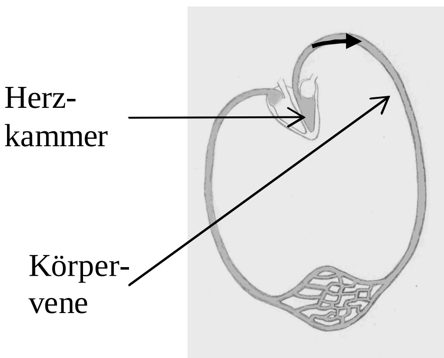
- □ …in den Körper.
- □ …in das Herz.
- □ …in den Magen.
- □ …in die Lunge.
- □ …ich weiß es nicht

19. Welche Gemeinsamkeiten haben der Lungenkreislauf und der Körperkreislauf?

- □ Keine.
- □ Beide Kreisläufe beginnen im Herz und enden im Herz.
- □ Beide Kreisläufe beginnen in der Lunge und enden in der Lunge.
- □ In beiden Kreisläufen fließt nur Blut mit viel Sauerstoff.
- □ Ich weiß es nicht.

20. Wie fließt das Blut in diesem Kreislauf? Kreuze das richtige Bild an.

□



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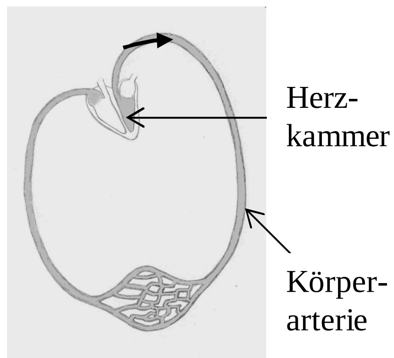

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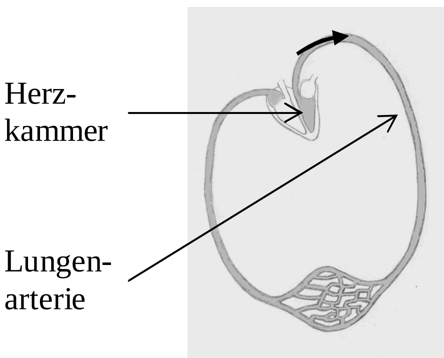

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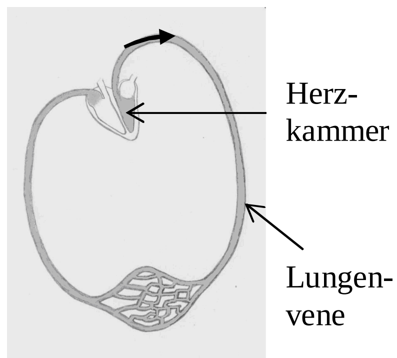
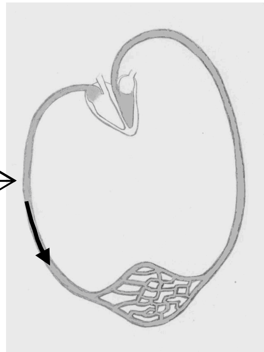


□ Ich weiß es nicht.

21. In welche Richtung fließt das Blut? Kreuze das richtige Bild an.

☐

Körper-arterie



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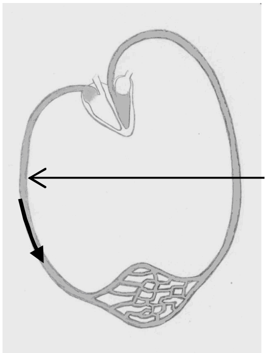
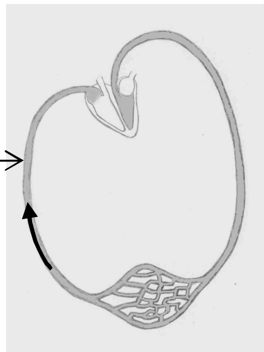


Körper-vene

☐

Körper-arterie



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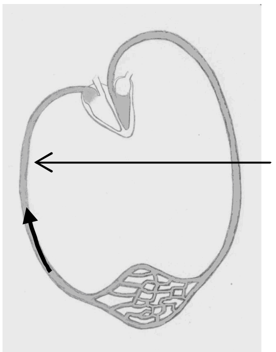


Körper-vene

☐ Ich weiß es nicht.

22. Eva fragt sich, ob sich das Blut der beiden Herzhälften vermischen kann. Kennst du die richtige Antwort?

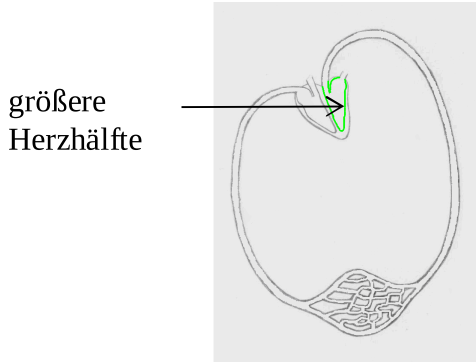
- ☐ Ja, das Blut kann sich vermischen. Das ist so, weil das Herz innen hohl ist.
- ☐ Ja, das Blut kann sich vermischen. Das passiert immer dann, wenn sich das Herz zusammenzieht.
- ☐ Nein, das Blut kann sich nicht vermischen. Das ist so, weil die beiden Herzhälften durch den Vorhof getrennt sind.
- ☐ Nein, das Blut kann sich nicht vermischen. Das ist so, weil die beiden Herzhälften durch eine Wand getrennt sind.
- ☐ Ich weiß es nicht.

23. Welcher Kreislauf endet immer in der schwächeren Herzhälfte?

- ☐ der große Körperkreislauf
- ☐ der kleine Körperkreislauf
- ☐ der große Lungenkreislauf
- ☐ der kleine Lungenkreislauf
- ☐ ich weiß es nicht

24. Wie heißt die Herzhälfte, auf die der Pfeil zeigt, richtig? Kreuze das richtige Bild an.

☐



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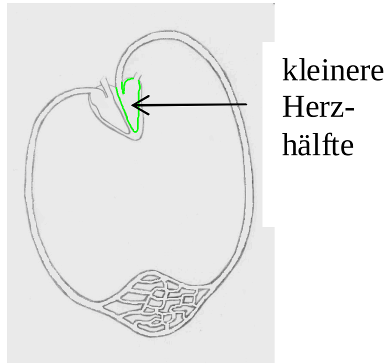

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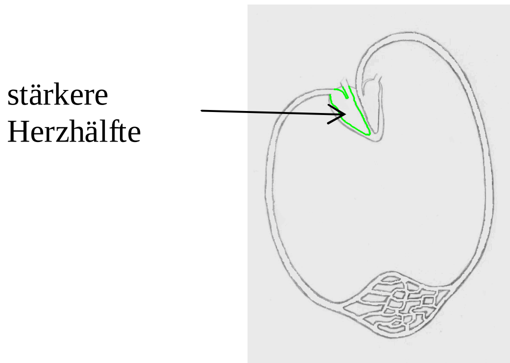

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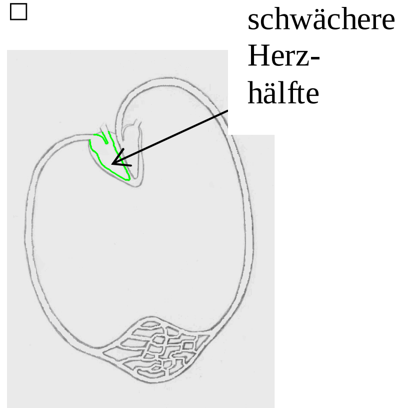


☐ Ich weiß es nicht.

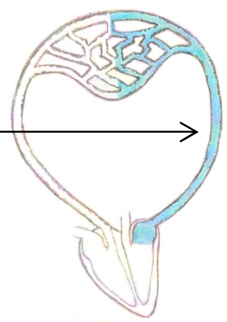
25. In welcher Reihenfolge kommt das Blut in die Kreisläufe? Das Blut kommt …
    - □ …in den Körperkreislauf, dann wieder in den Körperkreislauf, dann in den Lungenkreislauf.
    - □ …in den Lungenkreislauf, dann in den Körperkreislauf, dann wieder in den Körperkreislauf.
    - □ …in den Körperkreislauf, dann in den Lungenkreislauf, dann wieder in den Körperkreislauf.
    - □ …in den Lungenkreislauf, dann in den Körperkreislauf, dann wieder in den Lungenkreislauf.
    - □ …ich weiß es nicht

26. Beim Körperkreislauf fließt das Blut von der Herzkammer …
    - □ …in den Körper.
    - □ …in die Lunge.
    - □ …in den Magen.
    - □ …in das Herz.
    - □ …ich weiß es nicht

27. Wie heißt die Ader richtig, in der Blut mit wenig Sauerstoff fließt?

□

Körper-
arterie



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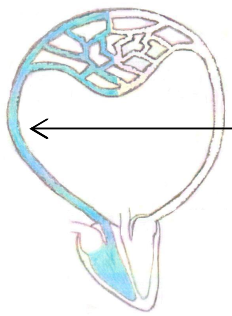
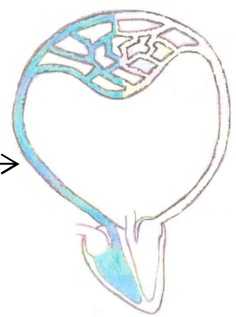


Lungen-
arterie

□

Körper-
vene



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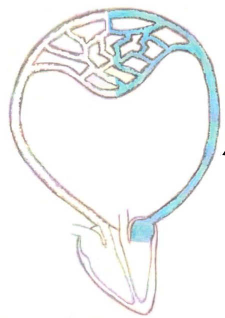


Lungen-
vene

□ Ich weiß es nicht.

28. Warum kann das Blut nicht von der Herzkammer in den Vorhof zurückfließen?

Tipp: Überlege, wie das Herz innen aussieht.

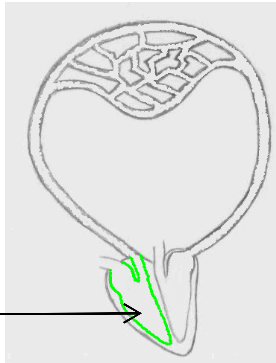
Weil zwischen dem Vorhof und der

Herzkammer________________________________

□ Ich weiß es nicht.

29. Wie heißt die Herzhälfte, auf die der Pfeil zeigt, richtig? Kreuze das richtige Bild an.

□



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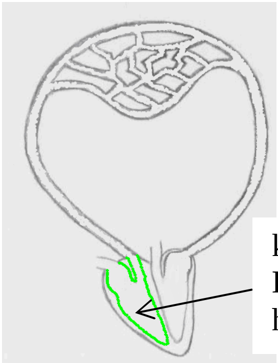

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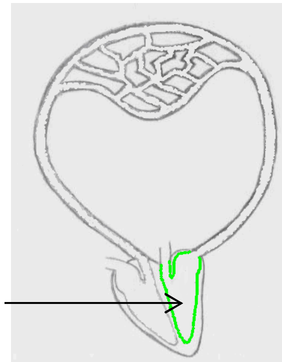

□

□ Ich weiß es nicht.

30. Die Lungenarterie verbindet die Herzkammer mit……..?

____

____

□ Ich weiß es nicht.

31. Die Körpervene verbindet den Körper mit……..?

____

____

□ Ich weiß es nicht.

32. Kannst du dir denken, warum die stärkere Herzhälfte für den großen Körperkreislauf zuständig ist?

____

____

□ Ich weiß es nicht.