

**AN EXPERIMENTAL STUDY OF SELF-  
REGULATED LEARNING IN BIOLOGY  
WITH SPECIAL REFERENCE TO  
INSTRUCTIONAL CONTROL,  
LOCUS OF CONTROL, AND  
ACADEMIC PERFORMANCE**

**by**

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**submitted in fulfilment of the  
requirements for the degree of Master  
of Education in the Faculty of Education  
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## DECLARATION

I declare that this dissertation is my own unaided work. It is being submitted for the degree of Master of Education in the Faculty of Education of the University of Cape Town. It has not been submitted before for any degree or examination in any other university.

A handwritten signature in black ink, appearing to read 'Craig Chalmers Paterson', written in a cursive style.

Craig Chalmers Paterson

January 1993

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## ABSTRACT

Applying theoretical conceptualisations of current theories of self-regulated learning, a biology instructional programme facilitating learner perceptions of control by offering choices in task engagement was undertaken with two intact samples of Caucasian standard ten higher grade biology pupils in Cape Town, with the student groups matched for IQ and ability.

A counter-balanced, quasi-experimental research design was implemented for two five-day cycles. Learner locus of control and self-regulatory behaviour were established using, respectively, the Intellectual Achievement Responsibility Questionnaire (Crandall, *et al.*, 1965), and the Motivated Strategies for Learning Questionnaire (Pintrich and De Groot, 1990).

The primary aim was to test the prediction that, in contrast to teacher-regulated instruction, academic performance after learner self-regulation would be appreciably greater. Differences between the experimental and control group mean achievement scores at the end of the programme were highly significant.

These findings, together with a low, but significant correlation between self-reports of self-regulatory behaviour and self-regulated posttest performance suggested that learner regulated instruction produced superior scores which were marginally linked to learners' percepts of employing self-regulated learning strategies.

A second aim involved investigating how such an intervention would impact on academic performances of learner cohorts with differentially discernable loci of control. The findings suggest greater congruence between performances after self-regulatory instruction and internality of control locus, than with externality. Differences between posttest performances of internals and externals were not attributed to anxiety.

Internals significantly outperformed externals after self-regulating instruction in the first cycle only, although a similar trend was evident in the second cycle. Self-regulated internals significantly outperformed teacher-regulated internals in both cycles. Externals who self-regulated their instruction significantly outperformed externals receiving teacher-regulated instruction in both achievement posttests.

Differences in self-regulatory measures between internals and externals were significant. Despite a positive relationship between self-regulatory strategy use and internality of control locus, a causal relationship between control locus and self-regulated performance has not been inferred.

Findings regarding associations between self-regulatory and motivational learning variables confirmed results obtained in previously documented studies. Higher measures of self-regulation were significantly associated with higher academic performance scores after self-regulated instruction, but not after teacher-regulated instruction.

Post hoc analyses of associations between effort and self-regulated posttest performance were ambivalent. A moderately significant relationship was demonstrated for the first experimental group, but a low correlational relationship in the second cycle, was not significant.

The theoretical and practical implications of these findings for self-regulatory instructional design in biology are explored and recommendations for further research proposed.

"All learning which is acquired under compulsion

has no hold upon the mind"

PLATO - The Republic (4 B.C.)

(quoted from Tripp, 1970)

## **CHAPTER 1**

### **THE RESEARCH PROBLEM**

#### **1.1. Introduction**

Educational researchers have indicated that learner-directed instruction can yield benefits usually denied to pupils in traditional classrooms (Waterhouse, 1985). One such benefit is the enhancement of self-regulated behaviour (Grolnick and Ryan, 1989:143, citing Deci and Ryan, 1985, Thomas, 1980, and Krathwohl, et al., 1974). The cognitive skills realised through self-management of learning also tend to amplify learner beliefs of self-efficacy, a fundamental basis upon which self-regulation of learning is believed to occur (Zimmerman, 1989:333; Schunk, 1991:213).

Since learner directedness is one of the variables in which open classrooms differ from traditional ones (Stipek and Weisz, 1981:129), individual differences in pupils' ability, motivation, and opportunity to be self-instructive have important implications for instructional practices and learning outcomes.

#### **1.2 The problem**

Recently, the writer became concerned with the limitations inherent in traditional instruction-dominated teaching, that restricted learner-responsibility for academic performance.

A pilot programme which guided and facilitated pupil self-regulated learning was implemented with standard nine higher grade biology pupils (aged 16-17 years) in 1991, in order to address, and ameliorate this problem. The outcomes spawned the following research question:

"Can a carefully designed self-regulated instructional programme, promoting self-responsibility for management of learning, facilitate the attainment of significantly greater academic performance, than that achieved by means of traditional teacher-dominated instruction?"

As self-regulation involves substantial learner commitment in the self-initiation of learning strategies, the ability and will of different learners to benefit from self-regulated instruction was questioned. A literature review, related to the problem, suggested that the construct locus of control appears to be a potentially significant variable associated with learners' abilities to benefit from such a method of instruction.

An instructional format that fosters the kind of intrinsic motivation needed to become self-reliant in learning appears to be maintained by perceptions of greater learner-control (Chan, et al., 1986, cited by McCombs and Whisler, 1989:284) and less teacher control (Isaacs, 1990:85).

McCombs and Whisler (1989:278) have pointed out that learning success is both quantitatively, and qualitatively, a function of an individual's motivation and ability to self-regulate. This implies that learners display individual differences in their capacity, or desire, to assume responsibility for their learning (viewed in this study as confluent with locus of control).

This thesis contends that, in general, traditional teacher-dominated instruction tends to impede the development of pupil self-regulated academic learning by not providing optimal opportunities to develop self-regulatory skills, such as the use of independent resources, self-monitoring, and goal-orientated learning.

A critique on traditional instructional practices is beyond the scope of the immediate discussion. However, an essay illuminating the need to reconsider contemporary instructional practices in the light of the rapid increase in information flow, and the needs of a futuristic society for self-directed citizens, is located in Appendix L.

By way of a summary, the following questions are posed:

- 1.2.1 Is locus of control (a motivational attribute), associated with self-regulated instruction and increased performance?

1.2.2 What are the design considerations for developing an appropriate self-regulated learning environment?

1.2.3 What is the role of the teacher in supporting self-regulation?

### 1.3 Purposes of the Investigation

This thesis has posited that a structured, field-based instructional programme, facilitating perceived pupil control of learning, will foster greater self-regulated learning behaviour, increase academically engaged time, and result in significantly greater academic performance, when compared with a traditional teacher-regulated approach of similar duration. More specifically, this investigation has attempted to establish:

1.3.1 The impact on academic performance of an instructional design facilitating self-regulated performance, compared to a traditional teacher-regulated instructional approach.

1.3.2 How learners, differing in locus of control, perform academically when self-regulating their instruction.

1.3.3 The relationship between self-regulated behaviour, as measured using a self-report instrument, and posttest performance in a self-regulated learning environment.

- 1.3.4 The relationship between learner control locus, and self-regulated learning behaviour.
- 1.3.5 The design criteria for a classroom environment which provides opportunities for each learner to develop the required competence for being self-instructive.

This study is intended to broaden the extant research base on self-regulated learning using a field instructional design in senior high school biology to demonstrate that self-regulated instruction can enhance academic performance.

Research paradigms utilised to investigate self-regulated learning traditionally involved manipulatory (laboratory) studies (Ridley, 1991:47), student self-report interviews (Zimmerman and Martinez-Pons, 1986) and correlation between observed behaviour and standardised test achievement (Nist, et al., 1991:851). These research findings have provided a theoretical basis for developing teaching strategies facilitating self-regulated learning, but have generally overlooked field validation.

Schunk (1990:3) has recommended that greater attention be paid to how instructional practices influence learner motivation, beliefs of self-efficacy, and the promotion of autonomous (self-regulated) academic learning.

Similarly, Wang and Peverly (1986:372) point out that greater research is needed into the specific role that learners need to play in self-regulation.

With the exception of work done by Slabbert (1988; 1992) on **Metalearning**, and Singh (1992) on **Self-Regulation and Giftedness**, no field studies, to the best of this writer's knowledge, have been conducted in South Africa on self-regulated learning in Biology (NAVO database search by CSD, 1992).

#### 1.4 Delimitations of this study

The confluency of a biology instructional design supporting self-regulated learning through learner choice in task engagement (Clark, 1986:314; Wang and Peverly, 1986), with learner locus of control, has been explored using academic performance as the basis of analysis, in an quasi-experimental research paradigm.

Confluency describes the dynamic mutuality of the specified independent variables. This study is primarily concerned with the field utility of the intervention in fostering self-regulated learning. Its main focus is on academic performances after self-regulated and teacher-regulated instruction. Inferences of specified causality are not intended.

Generalisations are limited to English-speaking, Caucasian biology higher grade learners, from a middle to upper socio-economic community stratum and aged, on average, between 17 and 18 years, in the final (12<sup>th</sup>) year of schooling in Cape Town, RSA.

The samples are relatively small (48 and 54 Ss) and interpretation of data will be at group level. Significance levels of 0,05, or less, will indicate appreciable statistical differences. Extrapolation of findings from such data to practical applications will be done with the necessary circumspection.

### 1.5 The Meaning of Self-Regulation in this Study

Learners described as self-regulated are behaviourally, metacognitively, and motivationally active in their own learning (Zimmerman and Martinez-Pons, 1988:284). Self-regulatory theories focus on phenomenological (i.e., self), behavioural, and task-related informational processes (Zimmerman, 1986:307). Various terms and related concepts have been used to explain self-regulated learning (Vermunt and Van Rijswijk, 1988:648).

Included, are performance-centred (Slabbert, 1992:35), independent (Nist, et al., 1991:850), self-study (Waterhouse, 1985), self-directed (Grow, 1991:128), and autonomous (McCombs and Whisler, 1989:278).

Metacognitively, self-regulated learners are ones who plan, organise, and self-monitor their learning (Pintrich and De Groot, 1990:33). Behaviourally, such learners organise the learning environment proactively, for example, by eliminating distracting influences. Motivationally, they perceive themselves as self-efficacious, autonomous, and intrinsically motivated.

Learners who autonomously initiate achievement-related behaviours are regarded as more self-regulating than those who need direct interpersonal controls, or rewards, before adopting the appropriate learning behaviours (McCombs and Whisler, 1989:278; Deci, et al., 1991:327; Ryan and Powelson, 1991:51). Consequently, self-regulation should be viewed as a continuum from less to more autonomy (Grolnick and Ryan, 1989:145) and not as an absolute state of functioning (Zimmerman and Martinez-Pons, 1990:51).

#### 1.6 The Meaning of Locus of Control in This Study

Differences have been found to exist among individuals, regarding their self-beliefs in being able to influence the outcomes of situations. Individuals who believe that rewards or punishments meted out to them are beyond their control, will have little reason to internalise responsibility for changing their behaviour (Deci, et al., 1991:335).

Consequently, any modifications in behaviour will be attributed to the external reinforcers, rather than to internal mediating agents, i.e., to conscience (Hurlock, 1980:244). Such individuals are viewed as being 'external' in their control locus. Individuals who hold that contingency relationships exist between their actions and the outcomes, are seen as having an 'internal' locus of control (Deci, et al., 1991:327).

The Intellectual Achievement Responsibility Questionnaire (IAR) (Crandall, et al., 1965) has been used to measure control locus in this study. Subsequent to the development of this instrument, more elaborate conceptualisations of locus of control have been posited (cf. Skinner, et al., 1990:23).

This study will take cognisance of these findings, but any inferences that may be drawn from the data will be limited by the theoretically conceptualised constraints imposed by the instrument (e.g., social learning theory). As with many other similar instruments, the IAR attempts to measure beliefs in internal, versus external, reinforcement responsibility but, unlike other instruments which note a variety of agents such as luck, fate, impersonal social forces, etc., the IAR is targeted at beliefs in exclusively intellectual-achievement situations.

The specificity of the domain assessed by the instrument was the prime reason for its use. The frame of reference of the IAR limits the source of external control to persons (teachers, parents, peers) in direct interpersonal contact with the respondent.

### 1.7 The Context

It appears likely that the fostering of self-regulated behaviour is dependent on the creation of a learning environment which strengthens learner-perceptions of control. It has been shown that when such perceptions are held by learners who have low anxiety (Dowaliby and Schumer, 1973:125) or achieve well (Campbell, 1964 quoted by Klein and Keller, 1990:141), responsibility for learning outcomes is internalised (Deci, *et al.*, 1991:336; Thomas, 1980:235; Tenenbaum, 1988:158), increased engagement in learning activities occurs (Allen, *et al.* 1974:968; Skinner, *et al.* 1990:22) producing higher levels of academic achievement (Klein and Keller, 1990:141).

The overt promotion of self-regulated learning strategies by teachers during instructional time is believed to be useful in developing autonomous learners. The importance of such acquired behaviour in enabling learners to access and to assimilate information after the cessation of formal education is particularly pertinent.

There is evidence to suggest that learner perceptions of control facilitate the self-initiated application of effort to perform the learning tasks which constitute self-regulated performance (Zimmerman, 1989:330; Tuckman, 1990:292). Since an internal locus of control may be positively related to self-regulation, instruction that elicits perceptions of control, could support self-regulated learning behaviour, and thereby enhance academic performance.

Investigative behaviours in biology include skills that are individually acquired such as problem-solving, observation, investigation, and explanation (Slabbert, 1992:36). Self-regulated learning strategies are also individually acquired and, arguably, require the exercise of similar metacognitive processes as those for an investigative discipline. Self-regulated instruction in biology is likely to serve the dual role of facilitating self-regulation and developing the investigative skills of individuals associated with a scientific discipline.

### **1.8 Background to the Problem**

The lack of motivation for being self-responsible and self-instructive in learning appeared to be an important contributor to teacher-dependency behaviours exhibited by learners during lessons in geometry (Amidon and Flanders, 1961:290).

Despite reports of positive results obtained with learner-centred activities and metacognitive strategies, busy teachers persist in time-efficient teacher-directed methods as the dominant mode of instruction (Gee and Rakow, 1991:109). Understandably, learners are more prone to remain teacher-dependent. This is likely to stunt their growth towards fully autonomous learners.

Furthermore, Deci, et al., (1991:335) have maintained that although behaviour characterised by external controls is useful in achieving learner-compliance, it probably contributes to learner perceptions of control loss, heightens levels of anxiety, and undermines motivation (Zimmerman, 1988:333). Such undesirable outcomes may militate against the self-determination needed by learners to regulate their learning processes (Deci et al., 1991:342).

### 1.9 Importance of the Problem

Self-regulated learning strategies are regarded as particularly relevant in facilitating some successful academic outcomes (Zimmerman and Martinez-Pons, 1986:614 cited Bandura, 1982, 1986, Schunk, 1984, and Zimmerman, 1983). Giving learners increased control may be an effective way to assist them become more adaptable people (Isaacs, 1990:85), and equipped to deal with an unpredictable future.

Furthermore, investigative behaviours such as planning, monitoring, evaluating, and executing (Slabbert, 1992:38), internalised through pupil self-control procedures, may also be more resistant to extinction, than when the teacher repeatedly initiates and prosecutes them.

Klein and Keller (1990:140) found that, although learner ability and perceptions of control did enhance performance in a 15-item multiple-choice posttest measuring the degree of learning of concepts presented during a computer-based lesson, the mode of instructional control (learner control over instructional strategy versus externally regulated control) did not influence learning outcomes. They also considered the motivational outcome of confidence (self-efficacy), but they did not link this variable to self-regulation.

Watkins (1984) reported that learners' locus of control perceptions, and self-esteem percepts, were directly linked to their perceptions of learning, and motivation to engage in academic study which, in turn, influenced their use of self-regulatory strategies and academic achievement (McCombs, 1986:321). The confluence of locus of control beliefs and self-efficacy is enhanced by perceptions of choice in the learning environment (Deci et al., 1991:342; Schunk, 1991:208). However, the capacity for choice is frequently circumscribed by factors beyond the learner's control.

The restriction of choice, as it often occurs in contemporary traditional teacher-dominated classrooms, may be educationally sub-optimal.

Pintrich and De Groot (1990:33) reported significant associations between learner motivational orientation, self-regulated learning, and classroom academic performance among 173 seventh-graders from eight science and seven English classes, but did not consider the effects on learning outcomes of the associations between perceptions of control and motivational learning variables.

Zimmerman, (1989:337) has cited several studies conducted under rigorous laboratory conditions to examine the functional relationship between learners' abilities to self-regulate their learning, and the learning outcomes. However, despite some sacrifice of experimental rigour, greater field work to test theoretical conceptualisations and increase generalisation of these results has been recommended (Zimmerman and Martinez-Pons, 1986:616).

The present study, in part, has addressed these deficiencies by suggesting that self-regulated instruction will foster self-responsibility (Zimmerman, 1989:336), will enhance academic performance, and might be confluent with locus of control when investigated under field conditions.

To sum up, perceived control (Perry and Penner, 1990:262) may be achieved during biology instruction by providing a variety of choice in learning tasks (Clark, 1988:317; Isaacs, 1990:86) which have a possible payoff through proximal goal achievement (Bandura and Schunk, 1981:586; Schutz, 1991:65), and which promote self-regulated learning strategies (Henderson, 1986:412).

#### 1.10 Presuppositions

The **social cognitive model** of self-regulation is a helpful one in guiding academic analyses and instructional interventions by identifying self-regulated learning processes and illuminating the kinds of variables associated with such learning (Zimmerman, 1989: 337). A fundamental presupposition emanating from such models, is that learning is **generative**.

This describes the **selective** attending to, and transformation of, environmental stimuli into relatively stable and dynamic knowledge **structures** (McCombs and Whisler, 1989:277). Furthermore, cognitive instructional psychologists suggest an active learner role in learning (Wang and Peverly, 1986:371 cited Flavell, 1976, Brown, 1978, Bransford, 1979, Belmont, Butterfield, and Ferretti, 1982).

Several principles of learning (cf. McCombs, 1991:118-119) should be noted as antecedent to successful self-regulated instruction. First, self-regulated learning is an active, volitionally mediated, and individual process of constructing meaning.

Second, socioemotional support is needed, and facilitated through respectful, caring relationships. These reinforce learner states of security, which are imperative for higher order thinking, and finally, it is assumed that beliefs derived from previous learning experiences can enhance, or interfere with, the quality of thinking.

Hence, learners should begin to value and enjoy learning, and gain a sense of personal confidence in solving problems via the creation of an instructional climate that reinforces feelings of interest, and competency, and minimises anxiety. The raised states of self-efficacy which accompany such an instructional environment, are assumed to be an integral part of self-regulated instruction.

### 1.11 Definition of Terms

**CONTROL LOCUS** - the concept that perceived control can be located either within the individual or externally (Clark, 1988:317). An individual with internalised locus perceives events as being a consequence of their own volition and therefore under personal control.

External locus refers to the perception of events (positive or negative) as being unrelated to one's own behaviour and therefore beyond personal control.

**METACOGNITIVE PROCESSES** - decision-making processes that regulate the selection and use of various forms of knowledge (Zimmerman, 1989:329).

**SELF-EFFICACY** - concerned with will-power judgements about how efficient one can organize and execute courses of action in potential situations which are possibly ambiguous, and unpredictable.

**SELF-REGULATED LEARNING STRATEGY** - an action or process directed at acquiring information, or skill, that involves agency, purpose and instrumentality perceptions by learners.

**SELF-REGULATED PERFORMANCE** - the self-initiated application of effort to perform a task using knowledge and skill that the learner has already acquired (Tuckman, 1990:292).

**SELF-INSTRUCTIVE SKILLS** - the learner's ability to access, organise, and use, relevant knowledge for new learning (Wang and Peverly, 1986:376).

## 1.12 Hypotheses

The essence of this investigation may be captured by presenting the hypotheses. Null hypotheses, and definitions of operational terms are presented in Chapter Four. The hypotheses are as follows:

- 1.12.1 That the academic performance scores of learners receiving biology instruction in an environment where they regulate their own learning will be significantly greater than the scores attained where traditional teacher regulation of equivalent instruction occurs for the same duration.
- 1.12.2 That the academic performance scores of learners with an internal locus of control will be significantly greater than those of learners with an external locus of control, after receiving biology instruction in a self-regulated environment.
- 1.12.3 That the academic performance scores of learners with an internal locus of control, who receive biology instruction in a self-regulated environment, will be significantly greater than those of learners with an internal locus of control who receive instruction in a traditional teacher-regulated environment.
- 1.12.4 That the academic performance scores of learners with an external locus of control, who receive biology instruction in a self-regulated environment, will be significantly greater than those who receive instruction in a traditional teacher-regulated environment.

1.12.5 That increasing scores on measures of self-regulatory behaviour will be significantly related to increasing scores on locus of control measures.

1.12.6 That scores on measures of self-regulatory behaviour will not be significantly related to performance scores on paper-and-pencil achievement tests after traditional teacher-regulated instruction in biology.

1.12.7 That scores on measures of self-regulatory behaviour will be significantly related to performance scores on paper-and-pencil achievement tests after self-regulated instruction in biology.

### 1.13 Chapter Summary

The basis of this thesis is that traditional classroom learning practices fail to provide an optimum climate for fostering self-regulation. Self-regulatory learning theory has recently received appreciable attention from social learning theorists. Its value lies in identifying motivational learning variables associated with successful learning outcomes, and linking these to learning behaviours employed by successful learners.

Such an understanding of self-regulation has important implications for learning outcomes, conferred by the instructional context and motivational dispositions of learners. This study attempts to incorporate elements of self-regulation theory into normal scheduled classroom practice and, as such, represents a response to regular appeals for field applications.

The investigation of the association of self-regulated instruction, and locus of control, among senior high school biology learners, is believed to be an innovation which can make a contribution to self-regulation learning theory.

#### 1.14 Organisation of the remainder of this thesis

In this chapter the purposes and delimitations of the investigation, and the key variables - namely self-regulated instruction and locus of control - have been elucidated. The context of the study, problem identification and its importance to classroom instruction have also been covered. The presuppositions and null hypotheses have been presented.

Chapter two presents a more elaborate conceptualisation of the key variables addressed in this study. The discussion is intended to serve as a basis for the literature review of chapter three.

This focuses primarily on qualitative empirical findings, discussed in relation to each hypothesis.

Chapter four explains all aspects of the research design. Methods of data capture and analytical procedures are presented. The hypotheses are formally stated in null form, and are operationally defined.

The summary statistics, findings and outcomes of the statistical analyses are presented in chapter five. The interpretation of the refuted or supported hypotheses, their limitations, and a consideration of the merits and limitations of the research design, are presented in chapter six.

Attention is drawn to the design features of a self-regulated learning environment, and the important background role of the teacher, in chapter seven. Recommendations for theory and practice are made in chapter eight. Chapter nine concludes the study by summarising the salient features and findings of the investigation.

## CHAPTER 2

### THE THEORETICAL FOUNDATIONS

#### 2.1 Introduction

In this chapter, a brief résumé of the conceptualisation of research findings pertaining to perceived control and self-regulation is undertaken. Following this, is a concise discussion on the nature, importance, and associated constructs of the self-system.

Current theories of motivation have emphasised the critical role the self plays in motivation and self-regulated learning (Whisler, 1991:15, cites McCombs, 1989; McCombs and Marzano, 1990; McCombs and Whisler, 1989). The view has been adopted that motivation is part of a dynamic, self-determining process operating as one of the components of of the self-regulatory process (Ridley, 1991:31), confluent with the self.

#### 2.2 Models of Perceived Control

Three models of perceived control over academic outcomes have received attention from researchers. Stipek and Weisz (1981:129) attribute this to the idiosyncratic nature of learner percepts of "control".

Social learning theorists have focused on the subject's belief in contingency, that academic outcomes are contingent on the subject's behaviour (internal), or occur independently of how they act (external).

This contingency dimension is termed locus of control by proponents of this model (Schunk, 1991:209). Attribution theorists suggested that an individual's perceptions of the causes of success and failure are determined mainly by domain-specific variables. They embraced the contingency dimension, calling it "locus of causality" (analogous to 'locus of control'), but added a control dimension of causality, dichotomised into internal controllability (effort), and internal uncontrollable (ability) (Stipek and Weisz, 1981:120).

The control dimension included the learner's perceptions of their ability to influence outcome by modifying aspects which cause the outcome. Weiner (1979), cited by Stipek and Weisz (1981:120), later incorporated a third stability dimension into the equation of causality, and dichotomised it into stable (intelligence or task difficulty), or unstable (mood or effort) components.

Theories of intrinsic motivation have acknowledged the role of intrinsic motive in determining events as under personal control.

However, they drew a distinction between individuals' perceptions of the **agent(s)** which control behaviour, and their perceptions of **control over the outcomes** (Stipek and Weisz, 1981). Their focus has been on the learner's perceptions of the controlling agents in achievement situations.

Skinner, et al. (1990:23) proposed a model of perceived control comprising three sets of beliefs. **Means-end (strategy)** beliefs referred to the extent that potential causes (**agents**) are effective in determining outcomes; **capacity beliefs** suggested that the individual believes the ability to act decisively rests internally; and, **control beliefs** indicated the extent to which the learner can effect changes without resorting to any explicit means.

The emphasis of this **process model** of motivation is that teachers' behaviour towards learners is a major determinant of children's perceived control in the **academic domain**. It is appropriate to point out that the **Intellectual Achievement Responsibility Questionnaire (IAR)** assesses locus of control in this domain, but it has assumed that internal and external causes are inversely related and regarded as a single bipolar dimension. Schunk (1991:210) believes that self-efficacy corresponds most closely to **capacity beliefs**.

Implicit in this review is the consideration that it is the learner's perceptions of the causes of success or failure which possibly deserve greater attention than learning outcomes, successful or otherwise. Success in learning is an important objective, but learners must comprehend the relationship which exists between their learning behaviours and their performance.

Emanating from this realisation is the belief that effort and persistence (Skinner, et al., 1990:23 cited Bandura, 1977, Weiner, 1979, and Abramson et al., 1978) are as influential as ability in effecting successful learning. It is this awareness that is instrumental in modifying externality of control locus, catalysing intrinsic motivation, or internalising causality of events. Such an awareness is exemplified by self-regulators who acknowledge the functional confluence between their cognition, the learning initiatives adopted, and the learning outcomes (Zimmerman and Martinez-Pons, 1988:284).

This thesis posits that creating a learning environment that can foster such awareness will contribute to enhanced academic performance as a short term objective and, over a longer term, elicit greater learner self-responsibility, characteristic of self-regulation.

This section is aptly concluded with an observation by McCombs and Marzano (1980) :

"Students must realise that they are creative agents, responsible for, and capable of, achieving self-development and self-determination goals, and they must appreciate and understand their capabilities for reaching these goals"

(quoted by Wigfield and Karpathian, 1991:252)

### 2.3 An Instructional Model of Self-Regulation

Learners have been regarded by cognitive psychologists as creative participants in active control of their learning who acknowledge the existence of functional relationships between the use of learning strategies, and the existence of social and environmental relationships (Nist, et al., 1991:850). Furthermore, such learners realise that they are responsible for determining and reaching goals congruent with their ability (Pintrich and De Groot, 1990:33).

Several models have been cited to describe learners who are self-regulating (Nist, et al., 1991:850, cited Bransford, 1979, Brown, et al., 1981, Jenkins, 1979, and Thomas and Rohwer, 1986). The tetrahedral model proposed by Jenkins (1979), modified by Wang and Peverly (1986) in their conceptualisation of an instructional design, has been used as a guide in designing the instructional environment. The tetrahedral model considers four variables that must interact for optimal learning to occur.

These are: (a) learner characteristics (motivation, interest, anxiety) (b) learning materials, (c) instructional tasks, and (d) learning activities (strategies) (Nist, et al., 1991:850).

Figure 2.1 illustrates the model for the study of the self-instructive process in classroom learning contexts (Wang and Peverly, 1986:373). Three assumptions regarding self-regulated learners are made. First, such learners have a repertoire of learning strategies which they use to learn, remember, and understand the material (Zimmerman and Martinez-Pons, 1986, 1988).

Second, they seek congruence between the task and the appropriate strategy to use to engage it - an aspect of metacognition (Zimmerman and Martinez-Pons, 1986, 1988; Corno, 1986); and third, they have the necessary motivational maturity for controlling effort and strategy use (Pintrich and De Groot, 1990:33). This has envisaged three components; beliefs of competence, intrinsic interest, and the emotional response to the task.

#### 2.4 Behavioural Regulation

Current research (McCombs and Whisler, 1989:279) has proposed that innate needs for self-determination and self-development energise motivation.

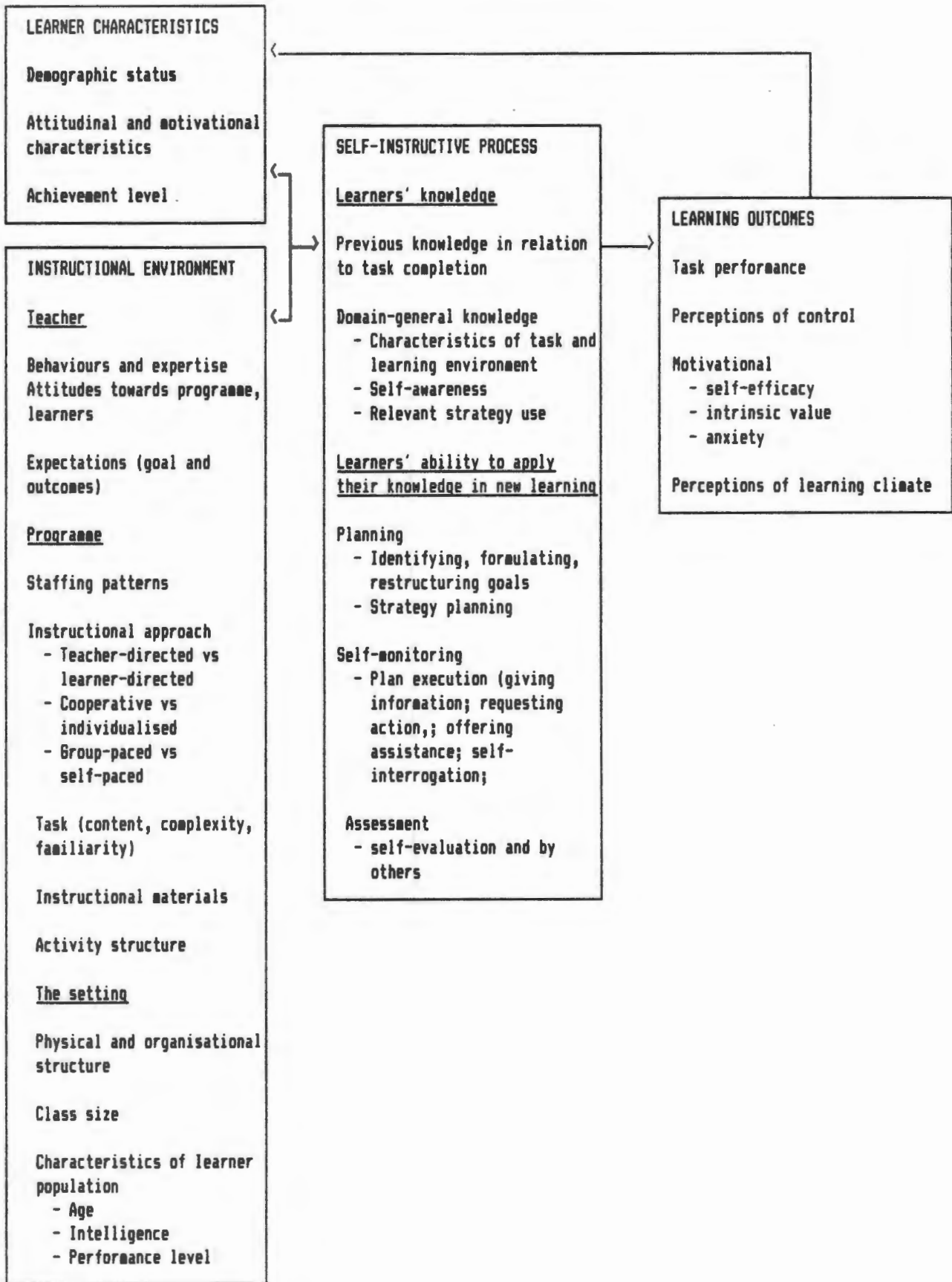


FIGURE 2.1. A model for the study of the self-regulatory process in classroom learning contexts (modified from Wang and Peeverly, 1986:373).

Deci, et al. (1991:327) maintain that motivation, performance, and development will be maximally supported when the environment fosters these innate needs for **self-efficacy, autonomy and socioemotional support.**

At the heart of most theories of motivation is the idea of intention. Self-determination theory (Deci, et al., 1991:326) distinguishes between two kinds of intentional or motivated behaviour. Intentional behaviour regulated entirely through volition, and endorsed by the self is **self-determined** behaviour. This is contrasted by **controlled** behaviour where the regulatory process is a compliance with manipulatory interpersonal or intrapsychic forces, not endorsed by the self.

Deci, et al. (1991:328) distinguish between four levels of extrinsic motivation which may arise after differential internalisation of external regulation into self-regulation. These four levels are a consequence of the extent to which internalisation occurs: -

**External regulation** refers to behavioural outcomes for which the locus of initiative is external to the subject. This form of regulation represents the least self-determined form of extrinsic motivation. Anticipation of praise or threats and confrontation drive the subject to respond in accordance with the stimulus.

**Introjected regulation** involves the internalised rules and regulations that coerce the subject to behave and which are concomitant with threatened sanctions, or incentives. Superficially, such regulation appears internal, but it represents conformity to external contingencies, and is not reflective of self-determined choice; it has not been coherently subsumed into the self.

**Identified regulation** is distinguishable when the subject values the nature of the behavioural outcome, and accepts the regulatory process instigating such behaviour. Identification with the behaviour allows a sense of volition.

**Integrated regulation** occurs when the regulatory process is fully integrated with the subject's sense of self. Such regulation identifies closely with intrinsic motivation, as both are autonomous forms of self-regulation. Intrinsic motivation is characterised by inherent interest in the activity; integrated regulation is characterised by the activity being personally important for a valued outcome.

These forms of regulation are all evident in traditional classrooms to a greater or lesser extent. However, self-regulated instruction seeks actively to elicit, promote, and maintain **integrated regulation** in the hope that this will lead to intrinsically motivated self-regulation.

It would be presumptuous to believe that the design utilised in this investigation has ensured completely intrinsically motivated self-regulation. However, it has been a conscious effort to address the issue of learner self-responsibility, by introducing learners to a form of instruction which required greater internalisation of control. It has been a premise of this thesis that such internalisation of control will promote greater integrated regulation, and thereby foster truly self-regulated learning.

Because the regulatory processes of traditional instruction and self-regulated instruction are distinctly different, the outcomes are both experientially and behaviourally different. In schools with highly structured curricula, or where the code of conduct is restricted, many forms of self-regulated learning are inhibited (Zimmerman, 1989: 330).

Table 2.1 illustrates a summation of essential differences between self-regulated instruction and teacher-regulated learning.

## **2.5 Motivation and the Self-System**

The single most important, irreducible aspect of human experience is the self, described by Covington (1991:83) as the progenitor of all human behaviour.

Table 2.1 Differences between Self-Regulated Instruction and Teacher-Regulated Instruction

SELF-REGULATED INSTRUCTION	TEACHER-REGULATED INSTRUCTION
1. Freedom, individuality, innovation, experimentation.	1. Conformity and submissiveness.
2. Co-operation and peer group interaction.	2. Competition with minimal peer interaction.
3. Decision-making, and independent.	3. Dependent on authority figure for decision-making.
4. Self-dependent in learning.	4. Dependence on teacher for direction.
5. Divergent thinking, inductive approach.	5. Convergent thinking, deductive approach.
6. Intrinsic motivation.	6. Extrinsic motivation.
7. Self-evaluation/monitoring, self-reinforcement.	7. Teacher-based evaluation.
8. Problem-solving.	8. Socratic questioning, discussion.
9. Integration: media and inter-disciplinary; use of independent resources	9. Textbook and prescribed subject matter.
10. Metacognition	10. Cognition.
11. Locus of control vested in learner.	11. Locus of control vested outside learner.
12. Continuous evaluation	12. Intermittent evaluation
13. Emphasis on quality relationships.	13. Lack of emphasis on quality relationships.
14. Awareness of learner needs for choice	14. Indifference to learner needs for choice.

(Modified and adapted from Singh, 1992:474 and McCombs, 1991:474)

All domains, including the affective, cognitive, conative, social, behavioural, and metacognitive are therefore considered to be sub-systems under central control of the self as agency.

In a recent review of motivational research, McCombs (1991:7) has reported an awareness that higher order processes exist, which operate outside the cognitive or intellectual system, and which actively create personal realities. These higher order processes are part of an intrinsic state of mind comprising the higher self (Mills, 1991:74) and include insight, creativity, wisdom, common sense (McCombs, 1991:7) and motivation, all of which are distinguishable, but inseparable.

This paradigm suggests that two distinct, mutually independent sources of motivation exist, termed higher and lower order states. The higher order source of motivation emanates from the self; the lower order source is a consequence of conditioning, and comprises the learned self-image or self-concept (Mills, 1991:74), which is bound to the immediate perceived context (Ridley, 1991:33).

One assumption of this paradigm is that all individuals, irrespective of external behaviours or background, are equipped with an innate intrinsic motivation to learn, which is activated by the higher self.

The most important implication of such an innate state is that motivation does not need to be developed or inculcated; rather, it needs only to be inspired.

The self fosters and sustains intrinsic motivation and mediates external reinforcers (Mills, 1991:68 has cited Bandura, 1989, 1991, Carver and Scheir, 1990, Deci and Ryan, 1991, Harter, 1988, McCombs and Marzano, 1990, and Iran-Nejad, 1990). One example of such a reinforcer, shown to be vital, is socio-emotional support. It provides the critical context within which youth are able to access higher levels of mental functioning and intrinsic motivation (Whisler, 1991: 23).

A major barrier to accessing this higher state of motivation is the belief that stress is a necessary motivator, or that people are motivated by largely external means, or by overt comparisons with others' accomplishments (Mills, 1991:75). Practices based on such misconceptions condition learners to become dependent on external motivators to activate lower order states of motivation. Learning which is dependent on such motivators is vulnerable to, and dependent on, the influence of the immediate surroundings (Ridley, 1991:35), and is unlikely to foster lateral transfer in future tasks (Mills, 1991:76).

## 2.6 The Importance of the Self-System

The development of the self-system and related components is believed to be a critical antecedent of learners' appropriation of personal responsibility, and their capacities to be self-regulatory (McCombs, 1986:324).

Because the self-system is the causal agent in perceiving, transforming, encoding, and retrieving information, any negative experience which threatens the self-concept is likely to impact negatively on learning. Harter (1978, 1981) maintained that when failure occurs, competence perceptions and internal perception of control decrease, reducing motivation (cited by Wigfield and Karpathian, 1991:247).

When circumstances threaten the self-concept, distortions can occur in the manner in which information is processed and stored (McCombs, 1986:325). Several reports (Caine and Caine, 1990:66; Clark, 1986:22 cited Krech, 1969, Lozanov, 1977, Martindale, 1975, and Restak, 1979) have indicated that stress and threat inhibit higher cognitive processing. This has important implications for pupil perceptions of the learning environment, their motivational orientations, and their beliefs about learning.

For example, Corno (1986:336), citing Ryan, et al. (1985) and Schunk (1984), reports that a lack of perceived control and low self-efficacy are reinforced by traditional teaching practices, which characteristically show a lack of choice in activities and goals, and generally coerce learners to think and act in teacher-determined ways.

Nummela and Rosengren (1986:52) have cited findings by Lozanov (1978) and Barzakov (1983) which indicate that certain teacher behaviours or events impede learner assimilation of content, for example, real or imagined threat due to mistrust or fear, information that is (to the learner) illogical, or sensory input which violates the learner's principles or ethics.

A function of the self-system is the maintenance of illusions of control. These illusions sustain the self-esteem. Lacking such perceptions of control, the motivation to engage in self-regulated learning is reduced and, with it, the responsibility for self-managing learning activities. Extrinsic rewards and a highly structured environment have been shown to contribute to a loss of internal locus of control (Clark, 1988:318) and reduce the perception of freedom needed to explore learner-control (self-regulation) strategies (Thomas, 1980: 236).

The self-system also creates and maintains states of self-efficacy during learning. Such states reinforce learner motivation to employ the necessary self-regulated learning processes. Oka and Paris (1985) have pointed out that learners will choose to engage in activities which facilitate self-efficacy beliefs and self-control and which lead towards the fulfilment of their goals and aspirations (McCombs, 1986:319).

## 2.7 Self-efficacy

Social cognitive theorists regard self-efficacy as a key variable underlying the ability of the learner to self-regulate (Zimmerman, 1989:331). Self-efficacy beliefs are self-judgements of innate ability to exercise personal control necessary for self-regulation (McCombs, 1986:320).

Learner's percepts of self-efficacy have been found to be positively related to such learning outcomes as task persistence, task choice, effective study activities, skill acquisition, academic achievement, better quality learning strategies, and self-monitoring (Zimmerman, 1989:331 citing several studies).

Controlling behaviours by teachers - such as criticism, punitive measures, or judgmental actions - may undermine perceptions of self-efficacy. Learning barriers such as a low self-concept, a lack of motivation and self-control, and poor judgement may then arise (Whisler, 1991:22).

## 2.8 Self beliefs

The role of the self is to integrate self-beliefs into decisions and goal-orientated behaviour. Perceived self-control is one motivational variable influencing academic performance (Stipek and Weisz, 1981:101; Clark, 1988:317; Wang and Peverly, 1986:375 cite Haertal, et al., 1979; Klein and Keller, 1990: 141).

It has been demonstrated that learner beliefs, in their ability to exert control over success in school, result in better academic progress (Clark, 1988:317). Learners' personal characteristics also interact with the learning environment to elicit certain learning behaviours (Wang and Peverly, 1986:375 cite DeStefano, et al., 1984). Such beliefs interact with control beliefs and facilitate strategy usage when the learner is free to access self-processes to regulate behaviour and the learning environment (Zimmerman, 1989:330).

Other related beliefs include expectations regarding strategy-use success, and self-efficacy in using such strategies. Beliefs held regarding self-efficacy are particularly instrumental in facilitating self-regulated learning (Zimmerman and Martinez-Pons, 1990:51) by affecting choice of activities, effort expended, and perseverance (Bandura and Schunk, 1981:587).

Therefore, it is reasonable to assume that learner perceptions of control, in part, influence self-regulated behaviour. Furthermore, learners' motivational attributes are concomitant with their perceptions, they influence the way they interact with the environment, and they largely determine the success of the learning outcomes.

## 2.9 Self-Regulation

In educational theory, the term **self-regulation** has been used to explain the kinds of behaviours exhibited by learners who are metacognitively, motivationally, and behaviourally active participants in their own learning processes (Zimmerman, 1989:329). Strong similarities exist between theories of self-system processes and self-regulated learning processes (McCombs, 1986:320).

**Self-regulation** describes the metacognitive strategies employed to plan, monitor, and modify cognition (Zimmerman, 1988:284). It also refers to learner management and control of effort on learning tasks, as well as the approaches used to learn, understand, and remember (Pintrich and De Groot, 1990:33). It implies that the learner actively searches for meaning by utilising various feed-back mechanisms to assess the status of understanding. It is, therefore, reasonable to believe that learner perceptions of control facilitate the self-initiated application of effort to perform the learning tasks which constitute self-regulated performance (Zimmerman, 1989:330; Tuckman, 1990:292).

Ridley (1991:34) has challenged the paradigms of other theorists (Zimmerman, 1989, 1990; Pintrich and De Groot, 1990) who suggest that self-regulatory behaviour is intermittent. He maintained that all behaviour is inherently self-regulatory and varies only to the extent that it is reflectively monitored and controlled by the individual. Ridley has proposed that self-regulatory behaviour be viewed in terms of a continuum.

On one end is reflectively intentional self-regulation which refers to the use of second-order self processes such as consciousness, emotion, and volition. These control the interaction between the self-concept in a given context and the lower order conscious attending and acting.

On the other end is unreflective automatic self-regulation. This refers to thoughts and actions emanating from the interaction between first order self-conception and self-processes in the absence of second order self-processes.

The relevance of Ridley's thesis is that unreflective automatic self-regulation is linked to the immediate perceived context. Operating at this level, the learner reacts in an automatic manner with unexamined, conditioned thoughts which are determined by the immediate external environment.

Such a learner's perceptual experience is dictated by the interaction of unconscious internal and external events. This description is strikingly close to the perceptions held by learners with an external control locus.

At higher order levels, the self-processes become more independent of the immediate external environment. Initial self-beliefs and judgements are subjected to volitional and emotional considerations which are removed from the immediate external situation. This allows reflective consideration of external events to occur, creating an opportunity for self-directed modifications of lower order thinking to occur.

This proposition suggests that the learner is aware of a self-role in determining perception. This realisation is the essence of a sense of agency (Ridley, 1991:35). Figure 2.2 presents a schematic representation of reflectively intentional self-regulation.

Thomas, however, warns that where control locus over learning-related behaviours is entirely vested in the teacher, where the learning environment is highly structured, and where learner motivation is contingent on external rewards, a sense of agency is unlikely to form (1980:236). These conceptualisations all point to the importance of directing instructional interventions at primary self-system structures and processes.

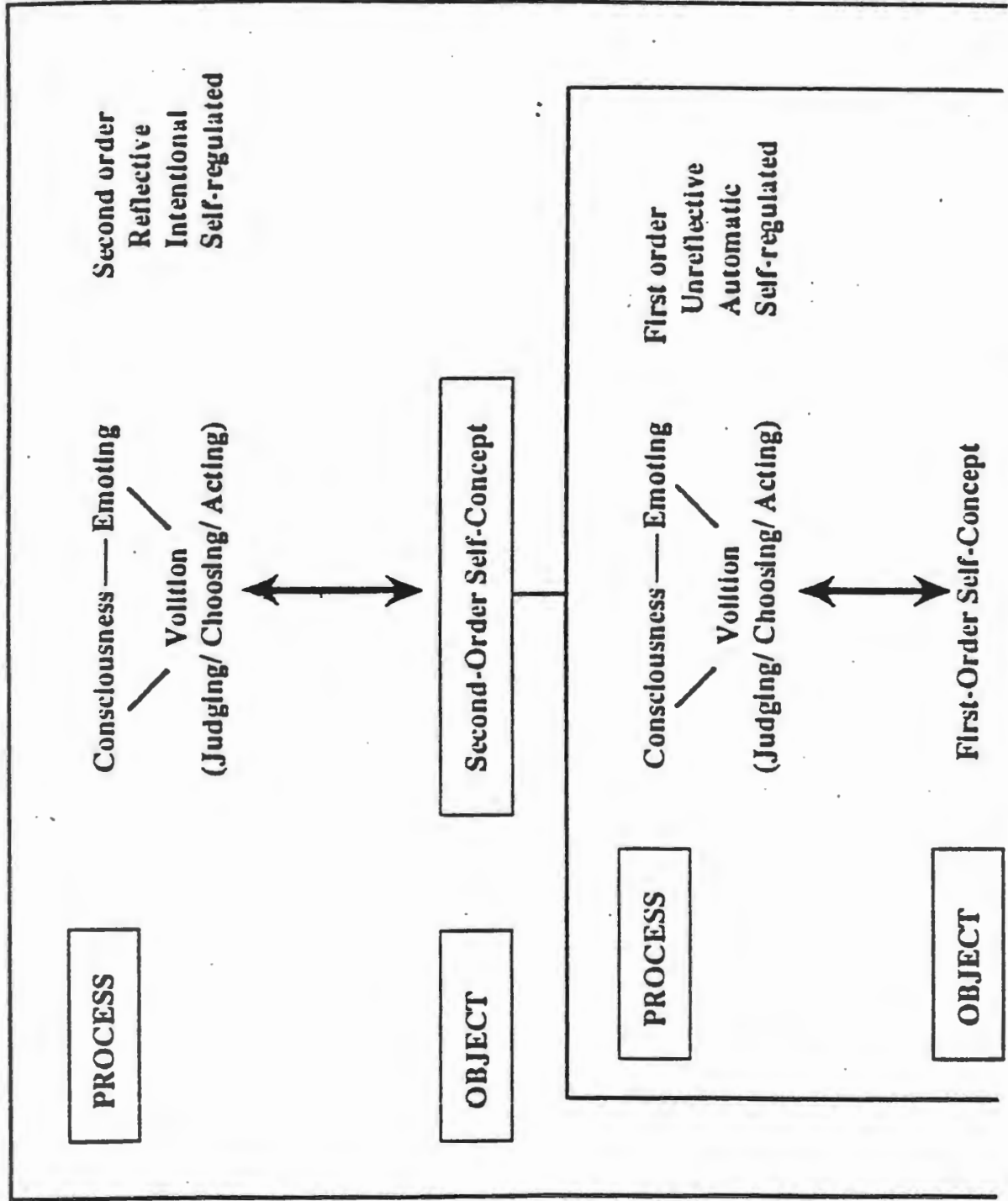


FIGURE 2.2. Schematic Representation of the Process of Reflectively Intentional Self-Regulation (from Ridley, 1990:33)

## 2.10 Conclusion

The propensities for self-development and self-determination, confluent with socio-emotional support, interface with the self-system. Awareness of self (self-structures) and the needs for autonomy energise internalisation of the self-processes.

Activation of these processes enhances states of self-consciousness. Such enhancements, via self-evaluation, impact on self-efficacy and control. They increase the motivation to persist at the self-development and self-determination levels that constitute autonomous learning.

Self-efficacy develops with a progressive increase in self-awareness, facilitated by self-monitoring and self-evaluation. Reciprocity between the outcomes, cognition, emotion and motivation, finally influence learning behaviours.

The centrality of the self in mediating the reciprocal relationships of the self-system processes, the self-structures, and the self-as-agency, is evident in the schematic "window" presenting these ideas in Figure 2.3.

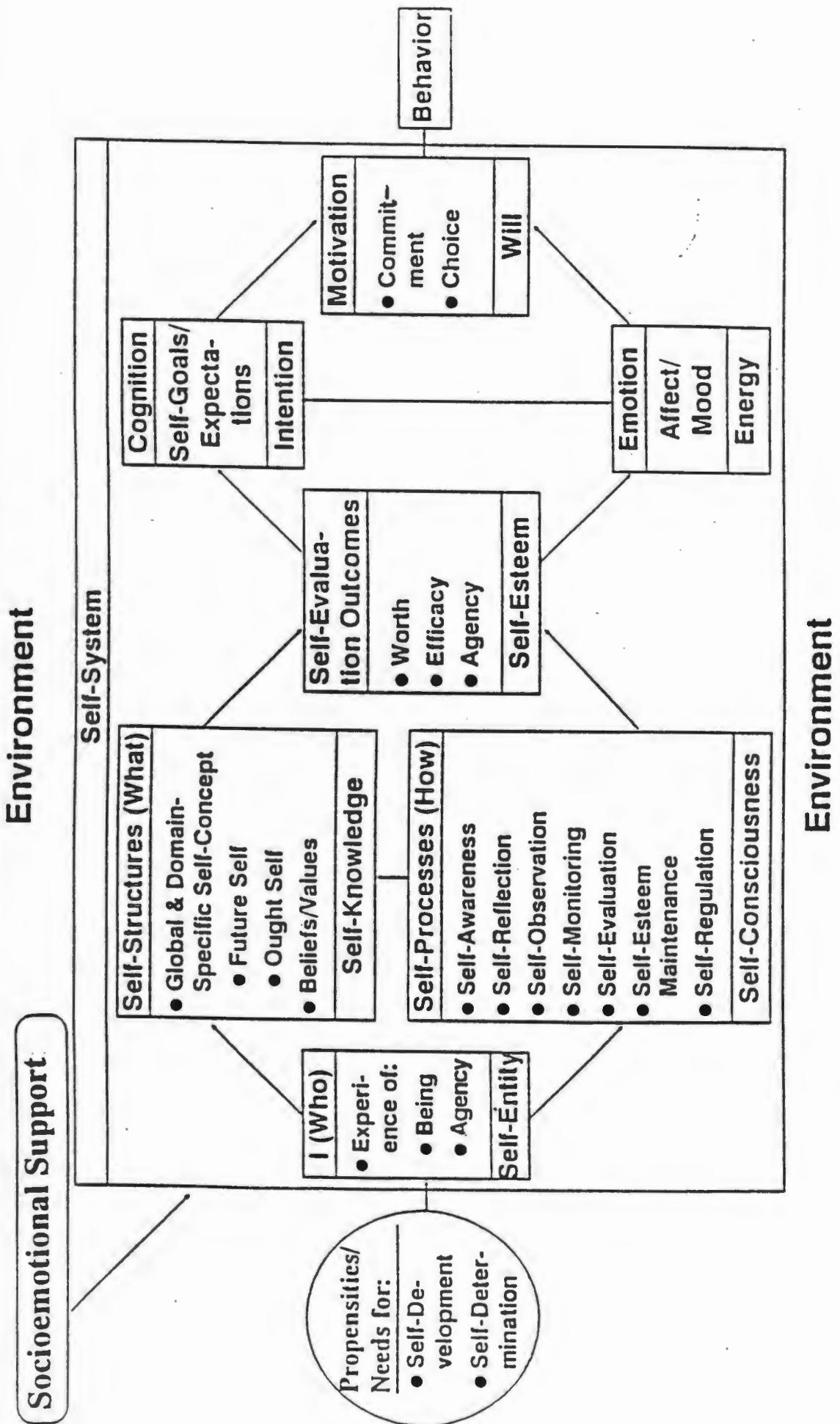


FIGURE 2.3. General Causal Model of the Role of the Self-System in Behaviour. (from McCombs and Whisler, 1989:280)

## **CHAPTER 3**

### **LITERATURE REVIEW**

#### **3.1 Introduction**

Before commencing an investigation it is prudent for a researcher to review other documented studies pertaining to the research problem. Such a literature study is selective, organized, and endeavours to illuminate the fundamental issues and make recommendations consonant with the proposed study.

In the first section of this chapter, empirical findings on learning outcomes after self-regulation, and directly relevant to the current study are discussed. Aspects associated with self-regulated learning, and the importance of such elements to successful learning outcomes are described and applied. To facilitate a succinct exposition of the essential facts, the second section of this review is divided into sub-sections. Documented findings presented in this chapter have been noted during the preparation the self-regulated instructional environment. Hypothesis generation is directed at the two key areas associated with the research problem:

- a) the academic performances of learners administered two separate treatments differing in the type of instructional control strategies employed; and

- b) the academic performances of learners with differing perceptions of control locus.

### 3.2 Self-Regulation and Learning Outcomes

The primary aspect of the investigation addresses the identification of learners competent in utilising self-regulatory strategies.

In a study by Pintrich and De Groot (1990), the relationships between motivational orientation (self-efficacy, intrinsic value, and anxiety), self-regulated learning, and performance, were evaluated using 173 learners in their seventh year of schooling. The sample was heterogeneous with respect to gender, ability, and race. The socioeconomic variable reflected a middle class suburban community stratum. The subjects were from English and Science classes.

Their findings hold promise regarding the identification and motivational attributes of self-regulators. Self-efficacy ( $r = 0,44$ ) and intrinsic value ( $r = 0,73$ ) beliefs were positively associated with self-regulated performance, and self-efficacy ( $r = 0,33$ ) and intrinsic value ( $r = 0,63$ ) with cognitive strategy use. Test anxiety (partial  $r = - 0,19$ ) was negatively associated with performance and self-efficacy ( $r = - 0,34$ ).

Higher levels of self-efficacy and intrinsic value were also associated with higher levels of performance. Learner reports of self-regulatory behaviour were a better predictor of performance than cognitive strategy use. The possible implications of their findings for self-regulation are:

- a) the importance of perceived intrinsic value in the learning content for enhancing learners' choice in becoming cognitively engaged and self-regulating;
- b) the raising of self-efficacy beliefs for increasing cognitive engagement;
- c) the teaching of cognitive and self-regulatory strategies for improved academic performance; and
- d) self-regulatory strategies, being the best predictor of academic performance, are preferable in some classroom learning.

Thus, in the present investigation, ways of stimulating subject interest have been used to foster self-regulation in the experimental groups, and to support learning in the control groups. Design aspects that promote mastery learning are intended to interface with the learning content. Learning which accrues will be self-evaluated using learner-marked mini-tests. Such self-monitoring of learning is expected to raise self-efficacy beliefs, and promote cognitive engagement.

The overt teaching of self-regulatory strategies, recommended by Pintrich and De Groot (1990:37), is noted, but will not occur prior to the treatments.

An important postulate of this thesis is that self-regulation can be supported by elements in the design of the intervention. Subtle aspects that induce learners to self-monitor, self-reinforce, set goals, plan, and manage effort, will be expected to promote self-regulation without the need to instruct in these skills. They are also expected to eliminate overt teacher controlling behaviour.

In South Africa, Singh (1992) investigated the extent to which standard nine pupils (aged 17-18 years), gifted in Accounting, had the ability to study subject matter at an advanced level, without the direct intervention of the teacher, using self-regulatory learning strategies. Academic performance was the dependent variable. The findings indicated that academically gifted pupils who self-regulated, performed as well as their coevals receiving direct instruction from a competent teacher.

This investigation seeks to demonstrate that a sample of learners, heterogeneous with regard to academic ability in biology, can outperform an equivalent group, receiving direct teacher-regulated (controlled) instruction, when the instructional environment supports self-regulation.

The natures of the current study and Singh's study are similar. A comparison of methodologies, and sample characteristics used in the two investigations are summarised in Table 3.1.

Both South African studies employ an experimental posttest-only-control-design with similar sample sizes (48 and 53 Ss) of senior high school subjects of comparable age. The use of a counter-balanced ("flip-flop") design in the current study is believed to be a **methodological improvement** by increasing the likelihood of observed variance between experimental and control groups being attributed to the intervention, rather than to uncontrolled, confounding variables. **External validity** will probably be enhanced by using intact groups under authentic conditions.

In summary, the relevance of this study in relation to the Accountancy investigation, is that self-regulatory instruction is not necessarily merely the domain of the academically gifted. Considering that the non-gifted constitute the vast proportion of high school pupils, its findings might be particularly useful to educationists. Successful learning outcomes have been found to be positively related to some instructional approaches that advocate an active role for learners in **mediating their own learning**.

Table 3.1  
 Summary of Similarities and Differences between Singh's (1992)  
 Study of Self-Regulation with Gifted Learners, and this Study.

THIS STUDY	SINGH'S STUDY
<u>Subjects' academic status</u>	
<ul style="list-style-type: none"> <li>- Heterogeneous</li> <li>- 12th school year</li> <li>- Biology</li> <li>- Higher grade, South Africa</li> </ul>	<ul style="list-style-type: none"> <li>Homogeneous (gifted)</li> <li>11th school year</li> <li>Accounting</li> <li>Higher grade, South Africa</li> </ul>
<u>Design considerations</u>	
<ul style="list-style-type: none"> <li>- Quasi-experimental</li> <li>- Counter-balanced (flip-flop)</li> <li>- 48 subjects</li> <li>- Low teacher-direction</li> <li>- No orientation programme</li> <li>- Routinely scheduled</li> <li>- Academic performance is the dependent variable</li> <li>- Treatment duration: two weeks</li> </ul>	<ul style="list-style-type: none"> <li>Experimental</li> <li>Posttest only</li> <li>53 subjects</li> <li>No teacher-direction</li> <li>No orientation programme</li> <li>Specially scheduled</li> <li>Academic performance is the dependent variable</li> <li>Treatment duration: five weeks</li> </ul>

They have been found to be negatively correlated with group instructional methods and teacher-directed instruction (Wang and Peverly, 1986:371 cited Belmont, et al., 1982, Brown, 1978, Flavell, 1976, and Brown, et al., 1983).

Perceived control of learning events is one motivational variable influencing some academic performances (Stipek and Weisz, 1981:101).

Deci, et al., (1991:336) reviewed several studies on the impact of controlling versus non-controlling behaviour on intrinsic motivation. For example, when college students were given choices regarding task engagement, and the allotment of time to each, they were more intrinsically motivated than subjects assigned tasks and times (cited Zuckerman, et al., 1978, and Swann and Pittman, 1977). Emphasising choice, rather than using a controlling style, contributed to subjects internalising regulation of an uninteresting activity (Deci, 1991).

Also, by allowing learners to express feelings of disapproval of the manner in which instructions were conveyed, or their dislike for a particular activity, feelings of self-determination and of intrinsic motivation were promoted (Koestner, et al., 1984, cited by Deci, et al., 1991:336). This increased internalisation of regulation (Deci, et al., 1991).

The current investigation maintains that, since perceptions of control represent a particularly significant variable in self-regulation, the construct locus of control is appreciably implicated in any attempt to foster self-regulatory behaviour.

A second study relevant to this investigation was the influence of learner ability, locus of control, and type of control, on academic performance and confidence (Klein and Keller, 1990).

Two heterogeneous samples (in respect of ability, gender, race and socio-economic background) of learners in their seventh year of schooling received a computer assisted lesson on advertising. Consequently, possible teacher effects were eliminated. Both groups had control of the pace of delivery. One group viewed a lesson delivered in a fixed sequence which offered a single concept definition, one example, and one practice item with feedback restricted merely to correct results. The second group viewed the same lesson, but learner-choice was facilitated by providing three additional practice items, greater analytic feedback, and three additional expository items. Although able to assert greater control, the subjects in this group were not overtly informed of this. Any acquired notions of control were therefore perceptual.

It was established that locus of control and learner ability were significantly related to academic performance and confidence. However, no relationship was found between instructional control and performance. The finding of a lack of relationship between learner control over instruction and performance may be attributed to several factors in their study.

The short duration of the experimental implementation (three hours) may have been insufficient to demonstrate effects of learner control. The amount of control given to learners may also have been insufficient to elicit notions of learner control. Since both groups were able to exercise control over pace of delivery, this may have eliminated the potentially weaker effects of choice offered in respect to more practice involving the content. No indications were given by the researchers of the extent of use of this facility.

Learner power to select and sequence instructional strategies (self-regulation) has been linked to increased effectiveness, efficiency, and appeal of instruction (Klein and Keller, 1990:145, cited Merrill, 1983, and Reigeluth and Stein, 1983) and may have impacted more on performance in the study had the experimental (learner-control) group been afforded greater opportunity for control over strategy use.

In summary, their findings indicated that:

- a) greater internality of locus of control was associated with greater performance (5% of variance), and increased self-efficacy (6,7% of variance);
- b) ability accounted for 42% of the variance in performance and 27% of the variance in confidence scores; and
- c) no data was observed to support effects of learner-regulated instruction.

Because self-regulation reputedly enhances some types of academic performance, and is largely a function of self-confidence (self-efficacy) and self-control (locus of control), these findings suggest that locus of control is one variable that should be taken into account when studying self-regulation.

Ability level (assessed by averaging previous examination performances) and IQ will be controlled in this study. Greater percepts of learner control over instruction will be elicited by providing greater choice in curriculum materials, increasing the duration of the programme, and increasing the disparity in the learner-control of instructional delivery pace between control and experimental groups (a possible shortcoming noted in the Klein and Keller study).

The task environment of the experimental intervention in this study will reflect the importance this writer attaches to these findings. During the biology lessons several assignment options will be provided at each learning centre. Moreover, learners will be free to attend the learning centres in a sequence of their choice. No restrictions will be placed on learner mobility or seating. Time management will be at the learners' discretion.

When learners are given almost total management control of their learning, self-regulatory behaviours occur, such as goal-orientation, internalisation of the relationship between effort and achievement, self-initiated study activities, and the structuring of a personal set of standards (Thomas, 1980:234).

Efforts, matching performance with internal standards, may be sustained until congruence is reached (Bandura and Schunk (1981:586) producing increased achievement gains. Tuckman (1990:292) reported that goal-setting was shown to improve academic performance in fields as diverse as English (Gaa, 1979) and Mathematics (Schunk, 1984:1985).

The experimental design employed will facilitate goal-oriented behaviour by encouraging pupil commitment to "contracts", established prior to the onset of each daily lesson.

Such agreements will require that the volume of work selected by the learner will need to be completed within the lesson. Learner pacing will be determined directly by the extent of engagement during the lesson, and determined indirectly by the size of the "contracts" selected. Longer term goals will represent the daily accrual, and then later conversion of credits, to bonus percentage points included in post-module evaluation, indicative of work quality and quantity.

Self-monitoring has contributed significantly to increased performance scores in mathematics, and also increased learner time-on-task (Sagotsky, et al., 1978). In the light of this, self-marked mini-evaluations at some learning centres will form part of the treatment, affording learners an opportunity to self-appraise their progress. The tutorial supervised by the instructor is also intended to convey feedback to learners on their understanding.

The use of some self-regulated learning strategies, following instruction in their utility, has reportedly raised self-efficacy and achievement (Schunk, 1991:215). Although no formal instruction in strategy use will occur in the present investigation, a note summarising self-regulatory behaviours likely to assist learners during the course of the intervention will be distributed.

In summary, the key elements of the design have included active learning, goal-setting, self-monitoring of performance, choice, and generally, the covert fostering of perceptions of learner control.

### 3.3 Academic performance in a self-regulated learning environment can be greater than in a traditional learning environment

Under certain circumstances an instructional environment which encourages participants to take responsibility for their instruction, can facilitate better academic performances (Stipek and Weisz, 1981:119). Traditional educational structures and practices may be experienced as controlling and may have negative consequences for the development of autonomous self-regulation (Deci, et al., 1991:336). Many forms of self-regulated behaviour are inhibited in traditional learning environments with highly structured curricula and strict codes of conduct (Zimmerman, 1989).

When learners are permitted to become self-directed, they are often able to mobilise internal resources, and adjust environmental conditions (Zimmerman (1989:336). Responsibility for such regulatory behaviour occurs with the development of self-control and competence, and the internalisation of selected external standards (Connell and Ryan, 1984, cited by McCombs, 1986:323).

Deci, et al. (1991:337) have stressed that the manner of presentation is particularly important. For example, although positive feedback normally promotes intrinsic motivation, such motivation decreased when given in a controlling fashion. Moreover, even though rewards generally diminished intrinsic motivation, such motivation was maintained if the language of presentation was non-pressuring, and implied competence. From this, it can be noted that non-controlling styles of presentation may contribute to self-regulatory behaviour through the internalisation of regulation.

Elementary school learners who were guided in **self-monitoring** procedures, demonstrated significant gains in performance and study behaviour in mathematics (Sagotsky, et al., 1978:242; Thomas, 1980:222; Dunlap, et al., 1991:17). Such procedures also increased learner independence, heightened self-efficacy beliefs (Schunk, 1983:93), decreased adult supervision, facilitated greater generalisation in learning (Dunlap, et al., 1991), and appeared to increase learners' sense of control over their learning (Corno, 1986:339).

Because self-regulated learners are aware of functional relationships between the learning strategies they adopt (such as self-monitoring) and the outcomes of instruction (Zimmerman, 1986:308), it is assumed they will be motivated to engage in activities that yield learning success.

Intentional decisions to utilise the cognitive, affective, and motoric learning processes which constitute self-regulated learning behaviour, will require effort, but should also lead to enhanced academic performance (Corno, 1986:334; Zimmerman, 1986:308; Wang and Peverly, 1986:371; McCombs, 1986:314; Zimmerman, 1989:329; Schunk, 1990:4; Zimmerman and Martinez-Pons, 1986:614; Wang and Peverly, 1986:382).

In summary, it is noted that traditional instructional environments, characterised by external controlling mechanisms, may be likely to restrict self-regulation by inhibiting the intrinsic motivation needed to energize the self-processes associated with self-regulation. The promotion of self-monitoring processes is one tangible means of eliminating percepts of external control. It is believed that the self-initiated exercise of such processes, usually inhibited in traditional instructional settings, will facilitate enhanced academic performance.

### **3.4 Learners with an internal locus of control will outperform those with an external locus of control in a self-regulated learning environment**

The literature reviewed strongly suggests that internal locus of control learners prefer learner controlled instruction.

They also appear to perform better than externals who prefer teacher-directed environments (Allen, et al., 1974; Daniels and Stevens, 1976; Parent, et al., 1975; Petersen, 1979; Klein and Keller, 1990:141).

The opportunity to learn, and to use a learning strategy - or, in this case, to receive learner-regulated instruction, perceived to be helpful in learning - can foster a sense of control over achievement outcomes (Schunk, 1991:215 citing Corno, 1989, Schunk, 1989). In one instance a sense of control over the learning environment was the best single predictor of academic achievement among Blacks (Thomas, 1980: 219, citing Coleman, et al., 1966).

The construct locus of control, together with self-esteem, is associated with the motivation to learn. Arguably, it fosters the use of self-regulatory strategies in learners with an internal locus of control (McCombs, 1986:321 citing Watkins, 1984). When learners can make choices, perceptions that they control their learning should be strengthened. Their use of feedback to evaluate the effectiveness of their behaviour fosters the self-initiation of the reinforcements needed to sustain such behaviour (Chan, et al., 1986, cited by McCombs and Whisler, 1989:248).

Tobin and Capie (1982:113) using the Intellectual Achievement Responsibility Questionnaire (Crandall, et al., 1965) reported that locus of control was significantly associated with rates of attending ( $r = 0,23$ ,  $p < 0,01$ ) and total engagement ( $r = 0,20$ ,  $p < 0,05$ ). Although these correlates are low, they suggest that learners who perceive causality between their actions and the learning outcomes (internals) might display higher rates of attending and engagement.

In self-regulated instruction such behavioural displays are regarded as essential. The evidence cited suggests that internals might be more adept at taking advantage of such an environment.

Other attributes of internals which might enable them to take advantage of a self-regulated environment are a greater ability to engage in data gathering, and their use of information (Tobin and Capie, 1982:114, citing Davis and Phares, 1967). Internals have been shown to achieve higher on process skill outcomes and to demonstrate greater objectives-related behaviour in science classes (Saunders and Yeany, 1979, cited by Tobin and Capie, 1982:114). The similar nature of the learning content in these studies and in the present one has been noted, providing some scope for external validation of this study. Internality of control locus could be reinforced when learners are expected to regulate their own learning.

Hence, learner percepts of contingency relationships between actions and outcomes tend to be strengthened, and it is therefore credible to suggest the hypothesis that internals will outperform externals in a learner regulated environment. Finally, the posited congruence between self-regulated instruction and internality of control locus is expected to facilitate increased engagement in learning tasks and enhanced performance.

**3.5 Learners with an internal locus of control who receive instruction in a self-regulated environment will tend to outperform internals in a traditional learning environment**

The possible contribution of the learning environment to developing learner perceptions of self-responsibility, and its outcomes, has been documented (Wang and Stiles, 1976:167; Petersen, 1979:66).

Arlin and Whitney (1978:988) reported that their particular academic environment had to be perceived by learners as learner-managed before acceptance of learning outcomes could be internalised. The importance was noted of overtly informing learners of their responsibility for managing their learning during instruction.

Some advantages which an instructional environment has yielded in the past include a heightened sense of personal agency, and a sustained motivation to continue learning (Thomas, 1980:234). Petersen (1979:66) reported that a less restrictive learning environment facilitated creativity, independence, and curiosity.

Tenenbaum (1988:155, citing Doby, 1980), indicated that **feedback** and **corrective procedures**, both important facets of self-regulatory behaviour, increased the correlations assessed every four months, over a single year, between achievement and locus of control (from  $r = 0,09$  to  $r = 0,51$ ).

Ryan and Powelson (1991:53) have maintained that learners are likely to feel highly motivated in learning situations where they experience support for their autonomy. By contrast, when the environment is controlling, as is the case in many traditional learning contexts (Deci, et al., 1991:336), and where personal support has been perceived to be lacking, learner alienation and disengagement have been reported (Skinner, et al., 1991:53). This increased anxiety, and decreased self-efficacy perception, results in an undermining of metacognitive control processes. Test anxiety has been shown to be negatively associated with self-efficacy beliefs and with test performance scores (Pintrich and De Groot, 1990:38).

These findings lend credibility to the notion that internals can lose self-efficacy beliefs rapidly in an environment which is threatening. Lack of control, either temporary or permanent, over academic performance undermined the effects of good instruction (Magnusson and Perry, 1989; Perry and Dickens, 1984, cited by Perry and Penner, 1990:262).

Clark (citing Deci, 1975) has reported that when external control of learners in academic contexts was increased, loss of inner locus occurred (1988:318). Conversely, it has also been demonstrated that intrinsic motivation to learn increased when perceptions of choice existed (Deci, et al., 1991:342).

Those who self-regulated their learning elicited greater teacher support for self-regulatory behaviour (cited by Grolnick and Ryan, 1989) leading to greater self-determination (Ryan and Powelson, 1991:55) in their approach to academic work.

Skinner, et al., (1990:22) maintained that teacher involvement and feedback (contingency) are instrumental in reinforcing learner beliefs of control. These behaviours produced greater engagement in learning activities, and enhanced academic success (grades and achievement test scores) among suburban primary school children (ages 9-12) in mathematics and reading.

Finally, the unfamiliar nature of an autonomous instructional programme necessitates regular signals of socioemotional support to avert the danger of learner anxiety. A self-regulated learning environment must convey percepts of teacher encouragement for learner autonomy through direct teacher feedback.

### **3.6 Learners with an external locus of control who receive instruction in a self-regulated environment will outperform externals in a traditional learning environment**

The hypothesis has been supported by Klein and Keller's (1990:140) literature review that the appeal and effectiveness of instruction can increase when learners are given greater control (Reigeluth and Stein, 1983), and that motivation may increase where freedom exists for learners to select materials and resources (Rogers, 1969).

A common assumption that learners, in part, possess attitudinal problems which undermine learning (Whisler, 1991:22), sometimes increases controlling behaviours by teachers to try to rectify the problem. Ironically, loss of control by learners caused by controlling teacher behaviours has also been shown to interfere with learning by impeding learners' capabilities to benefit from effective instruction (Perry and Magnusson, 1987:453; Perry, 1985, cited by Perry and Penner, 1990:262).

It has been suggested that information processing activities which influence motivation and achievement, and are primed during instructional activities, are also vulnerable to disruption (Clark, 1988:388 cites Hart, 1981) through the application of pressure imposed by teachers for learner conformity.

Teachers, overtly through language, and covertly, through the structure of the learning environment can access higher order control mechanisms mediated by the individual's awareness of the self as an agent in motivating behaviour and thereby reinforce learner perceptions of control (Wigfield and Karpathian, 1991:252, cited McCombs and Marzano, 1990).

Since creating an environment that induces a relaxed, positive frame of mind minimises threat to the self-concept and emphasises internalised standards of performance, the encouragement of objective information processing, use of common sense, and reflective self-regulatory behaviour, is likely to result (Mills, 1991:73,76; McCombs, 1991:122; McCombs and Whisler, 1989:297; Whisler, 1991:22; Ridley, 1991:46).

The evidence suggests that where the environment nurtured intrinsic motivation, enhanced self-efficacy beliefs and provided feedback on performance enhancing behaviours, learners were likely to have more positive attitudes.

Externals, in particular, can be expected to demonstrate better problem-solving ability, increased motivation to learn, and goal-achievement behaviour (Whisler, 1991:22). Such attributes are consistent with greater internal behaviour (Henderson, 1986: 417, cites Lefcourt and Taub, 1969).

By individualising instruction, the self-beliefs of the individual are considered, creating greater opportunity for the dominant self-concept to be reinforced, thereby sustaining heightened states of self-efficacy which can facilitate performance (Tuckman, 1990:298; Schunk, 1991:214; Wigfield and Karpathian, 1991:252).

Gaa (1979:595) examined the effect of individual goal-setting conferences, facilitating feedback, on academic achievement and locus of control orientation in high school students.

The Intellectual Achievement Responsibility Questionnaire (IAR) was used to determine locus of control disposition. The research findings suggested that an individual's perception of control in academic situations can be made more internal. One derivative of this finding is the provision of an environment which allows control. By overtly reminding the learners of their ability to control their instruction percepts of causality can be increased.

Tobin and Capie's (1982:120) recommendation that strategies be devised to assist learners become more internal has been implemented in this investigation by facilitating self-regulatory instruction and comparing the performances of externals exposed to such instruction with those of their coevals, receiving traditional teacher-directed instruction. The implications of these findings for this study are that goal-setting and self-monitoring may reinforce learner percepts of the causal relationship between behaviour and academic outcomes thereby increasing internality and self-responsibility for learning outcomes.

In conclusion, a learning environment supporting self-regulatory behaviours, and actively encouraging learners to adopt greater initiative, thereby promoting associated perceptions of control, may provide externals with the necessary motivation, beliefs of self-efficacy, and heightened levels of performance to enable them to outperform their coevals in a traditional teacher-directed learning environment.

### **3.7 A positive association between self-regulation and locus of control will be evident.**

Arlin and Whitney (1978:988) explored a causal interpretation between learner-perceptions of self-managed learning and locus of control.

Their results indicated that **percepts of self-management** were a **stronger predictor** of locus of control than locus of control of self-management. They consequently posited that **self-managed instruction** creates perceptions of control which could arguably influence learners to take **greater responsibility** for **learner outcomes**. Self-management of learning is viewed as analogous with self-regulation in this study and, according to Arlin and Whitney's findings, is associated with perceptions of control.

Allen, et al., (1974:972) demonstrated the usefulness of the locus of control measure in predicting academic performance after self-controlled student learning. Despite the equivalence of internal and external control locus subjects on prior scholastic aptitude and performance measures, internals produced reliably better results in academic posttests after self-controlled learning, suggesting that the hypothesis currently posited is credible or plausible.

Tenenbaum (1988:155), citing De Charms (1972), reported that correlations between achievement and locus of control perceptions increased substantially after systematic feedback and corrective procedures among 46 classrooms of lower-class Black seventh- and eighth-grade students.

Tenenbaum (1988:158) measuring locus of control with the Intellectual Achievement Responsibility Questionnaire reported that when learners were exposed to differential instruction in sixth-grade science and ninth-grade algebra, locus of control became more internal with increased quality of instruction. The qualities of the non-conventional instruction used in that study, included elements of self-regulation such as feedback and reinforcement.

Studying the interaction between differential locus of control (internal versus external) and two methods (traditional versus contract-for-grade) of college instruction, Daniels and Stevens (1976:103) reported a disordinal interaction between type of instruction and locus of control. When instruction was traditional and teacher-controlled, externals performed better than internals. Internals performed better than externals when involved in a contract-for-grade plan.

The findings cited suggest a positive association between instructional methods which simulate aspects of a self-regulatory instructional programme and internal locus of control disposition. As such instruction contains components consonant with those in the self-regulated treatment, the proposed hypothesis has some support in the extant research literature. The possibility of a similar association will be explored by this study.

3.8 A positive association between degree of self-regulation and posttest scores after application of self-regulated instruction may be evident.

Greater intrinsic interest in task processing has been linked to greater metacognitive activity, more cognitive strategy use and increased displays of effort (Pintrich and De Groot, 1990:34, cite Ames and Archer, 1988, Dweck and Elliot, 1983, Eccles, 1983, Nolen, 1988, and Paris and Oka, 1986).

Support for the thesis that test anxiety may reduce learning by blocking retrieval of memorised information has been cited by Clark (1988:388-392) and Caine and Caine (1990:69).

Zimmerman (1986:308) has reported that self-regulators perceive themselves as being competent, autonomous, and self-efficacious. Self-efficacy has been associated with increased levels of self-monitoring, academic motivation and achievement (Zimmerman and Martinez-Pons, 1990:51 cited Schunk, 1984). Schunk (1991:208) reported that self-efficacy also affected an individual's choice of tasks, effort, and persistence. Self-efficacy has also been related to greater strategy use among gifted and regular learners (Zimmerman and Martinez-Pons, 1990:51).

It is clear that percepts of self-efficacy are instrumental in empowering learners to self-regulate their learning in a variety of contexts and situations. The ability of self-regulated learners (with high self-efficacy beliefs) to tend to learn more effectively in a self-regulated learning environment suggests that performance after such an opportunity will be positively associated with learner measures of self-regulatory behaviour.

Pintrich and De Groot demonstrated that self-regulation, as reported by the subjects, was the best predictor of academic performance in their study which involved 173 seventh-graders from eight science and seven English classes, and that self-regulatory mechanisms were employed by the more successful learners (1990:38).

Zimmerman (1986:614) reported that 14 categories of self-regulated learning strategies adopted by high school learners were significantly related to their academic achievement. Knowledge of their self-regulatory strategies enabled some 93% of learners to be correctly classified into their appropriate achievement stream. These strategies, by virtue of their relevance to the self-regulated instructional treatment of this study, have been listed in Table 3.2. Applications of these strategies have been indicated and will be elaborated on in chapter four.

Table 3.2. Definitions of Self-Regulated Learning Strategies and their Points of Application during Instruction.

Categories of strategies		Definitions	Applications
1.	Self-evaluation	Learner-initiated evaluations of the quality or progress of their work.	Credit selection; monitoring at DESIGN LC. †
2.	Organising and transforming	Learner-initiated overt or covert rearrangement of instructional materials to improve learning.	RESEARCH and PRACTICAL LC's
3.	Goal-setting and planning	Learner-setting of goals and planning for sequencing timing and completing activities related to those goals.	Daily credit contracts; time management at DESIGN LC.
4.	Seeking information	Learner-initiated efforts to secure further task information from non-social sources when undertaking an assignment.	RESEARCH LC.
5.	Keeping records and monitoring	Learner-initiated efforts to record events or results.	PRACTICAL; COMPREHENSION; RESEARCH; TUTORIAL.
6.	Environmental	Learner-initiated efforts to select or arrange the the physical setting to make learning easier.	Choice regarding seating positions.
7.	Self-consequences	Learner-arrangement or imagination of rewards and deterrents for success or failure.	Conversion of credits into bonus % and amalgamated with test result.
8.	Rehearsing and memorising	Learner-initiated efforts to memorise material by overt or covert practice.	DESIGN LC
9-11	Seeking social assistance	Learner-initiated efforts to solicit help from peers (9), teachers (10), and adults (11).	TUTORIAL LC, PRACTICAL LC, Library, etc
12-14	Reviewing records	Learner-initiated attempts to reread tests (12), notes (13), or textbooks (14) to prepare for class or testing.	TUTORIAL LC; upon completion of instruction.

Adapted from Zimmerman and Martinez-Pons (1986:618).

† LC = Learning Centre

### 3.9 Conclusions and Implications of the Review

Although the use of overt instruction in self-regulatory strategy application is not discounted, the premise that the physical and emotional learning environment alone may elicit such strategies has been abstracted from the literature. Despite the enhancement value of "traditional" teaching strategies, the restrictions imposed by conventional "spoon-feeding" instruction, and amplified by the concomitant controlling behaviours of the teacher, are assumed to impede learner progress towards instructional self-sufficiency, and full self-responsibility for learning outcomes.

Perceived control appears to be a fundamental discriminant between the natures of traditional and self-regulated instruction. Learner orchestration of many innate learning variables appears to be enhanced when the locus of control is internal. Such learners appear more able to exploit the advantages of self-regulated instruction.

However, the prosecution of an instructional design incorporating elements "supportive" of learners with an external locus of control may prove to be a useful compromise between the need to foster learner independence, and the recognition that learners are qualitatively different and in need of differential instructional support strategies, given the same common subject matter content.

## CHAPTER 4

### METHODS

#### 4.1 Introduction

This chapter presents the setting of the investigation. The nature and prosecution of the research design is described. The sample group, experimental design, measures and variables, procedures, instructional designs of the experimental and control groups, term definitions, and null hypotheses are stated. The methods of data collection, and analysis are outlined in the final section.

In section 4.5 considerable attention is devoted to details of the explanation of the experimental intervention. This will enable replication by others of the design for future research, and will provide the reader with a clear overview of the nature of the design. Included in Appendix H are photographs to facilitate this. The active role played by the researcher in the intervention in 1992 precluded meaningful observations of many interactions. A video was therefore made of the classroom interactions to provide additional information.

Although a quasi-experimental research design will generally deliver results promoting **external validity**, some degree of **internal validity** may be sacrificed in the process.

The repetitive nature of the counter-balanced ("flip-flop") approach is intended to counter any parochial or idiosyncratic limitations imposed by the opportunistic field nature of the investigation.

On 17/03/92 application, in writing, for permission to conduct this research was made to the Cape Education Department. An affirmative response (25/03/92), notwithstanding certain conditions, was received (Appendix K). Clarification of item 2.7 in the response was made telephonically. Consequently, procedures for implementing the research design were initiated.

#### 4.2 The Sample

The experimental and control groups are two intact classes of senior biology pupils ( $N_1 = N_2 = 24$ ) in a co-educational school located within an upper-middle to high socio-economic community stratum in suburban Cape Town. The selection of this age group was made following Harter's (1982) observation that certain self-regulatory behaviours are poorly developed in younger children, and Findley and Cooper's (1983) literature review, that the strength of the relationship between internal locus of control perceptions and higher academic achievement increases with age (McCombs, 1986: 321). Moreover, success in school is believed to be highly dependent on learner self-regulation in upper grades (Zimmerman and Martinez-Pons, 1986:615).

Initially, fifty-six higher grade pupils were selected from a standard ten (12<sup>th</sup> year) higher grade population of 62 pupils on the basis of their verbal IQ scores. Pupils with an IQ of less than 100 were not included in the sample to facilitate matching across classes. The subjects were Caucasian, with an average age of 17 years, six months.

A single teacher (the writer), with seven years of high school teaching experience, administered the alternating treatments in both classes. Thus the variable "nature of the teacher" was held constant, as well as the lesson content. The field nature of this investigation made the completely random allocation of subjects to groups difficult. This was due to the classes being constituted on the basis of certain preselected subject choices, either Home Economics or Accounting.

Although the subjects in this study were able to attend alternative lessons if they objected to the instruction, they were not overtly informed of this option.

Cook and Campbell (1979), cited by Whitener (1989:82), term this less rigorous research procedure a cohort design. They point out that such a design cannot achieve as high a level of comparability as groups with a random assignment of subjects.

One solution to this dilemma is the random assignment of cohorts to treatments for the first cycle of instruction, followed by a rotation of treatments for the second.

A second precaution to increase group equivalence was the constitution of the cohorts on variables which moderated the relationships being considered, thereby eliminating selection or other differences, which could threaten the interpretation of results: -

First, 24 subjects in one class were matched with 24 in the other, on the bases of averaged previous biology examination performance, and verbal IQ scores. Results of a handful of other pupils who could not be matched were silently excluded from analysis. The results of this first step included 48 pupils (18 males and 30 females) representing two classes.

Second, each class was dichotomized into two cohorts by median splits (Stipek and Weisz, 1981:6) using the results obtained by the Intellectual Achievement Responsibility Questionnaire (Crandall, et al., 1965). Each cohort comprised 12 subjects. The means of the larger class groups, and the smaller cohorts were derived for all variables considered namely, **previous examination performance means, verbal IQ, and control locus scores** were inspected for equivalence. These together, with the variances, are presented in Table 4.1.

Table 4.1

Learner Locus of Control Cohort Summary Statistics  
for Verbal IQ, and Average Previous Examination Performance

	Group 1 (N = 24)					Group 2 (N = 24)				
	IQ		Prev. Perf.			IQ		Prev. Perf.		
Control	M	SD	M	SD	N	M	SD	M	SD	N
Internal	112,5	8,0	55,4	11,1	12	113,0	7,2	55,9	12,0	12
External	112,1	9,2	55,0	9,3	12	112,1	7,5	54,3	8,5	12
Total	112,4	8,5	55,2	10,0	24	112,5	7,2	55,1	10,2	24

Note. The two cohorts were designated as either internal, or external, locus of control. (Cohort size: n = 12).

Prev. Perf. = Previous Performance averaged over three examinations.

Calculated ANOVA's indicated that no significant initial differences existed between cohorts and main groups on these biographical details. The initial random sampling (original class constitution), followed by matching on performance and IQ, is therefore considered to have produced satisfactory group equivalence with respect to the biographical (initial) variables under consideration.

#### 4.3 Experimental Design

A parallel, equated and two-group quasi-experimental design has been utilised using an alternating ("flip-flop") design for two cycles with content (subject matter) held constant. The design is illustrated in Figure 4.1. During Cycle One, one group received the experimental treatment and the second group (control) received a conventional teacher-directed lesson. Upon commencing Cycle Two, the groups' status (experiment versus control) was exchanged, and a second module (chapter) of subject content was delivered. Special precautions to make the lessons effective are explained later.

Notwithstanding the experimental design rigour for a control group, the content represented examinable material in the Cape Senior Certificate, and for ethical reasons the instruction had to be competent, and was so, as attested by colleagues and the school Principal.

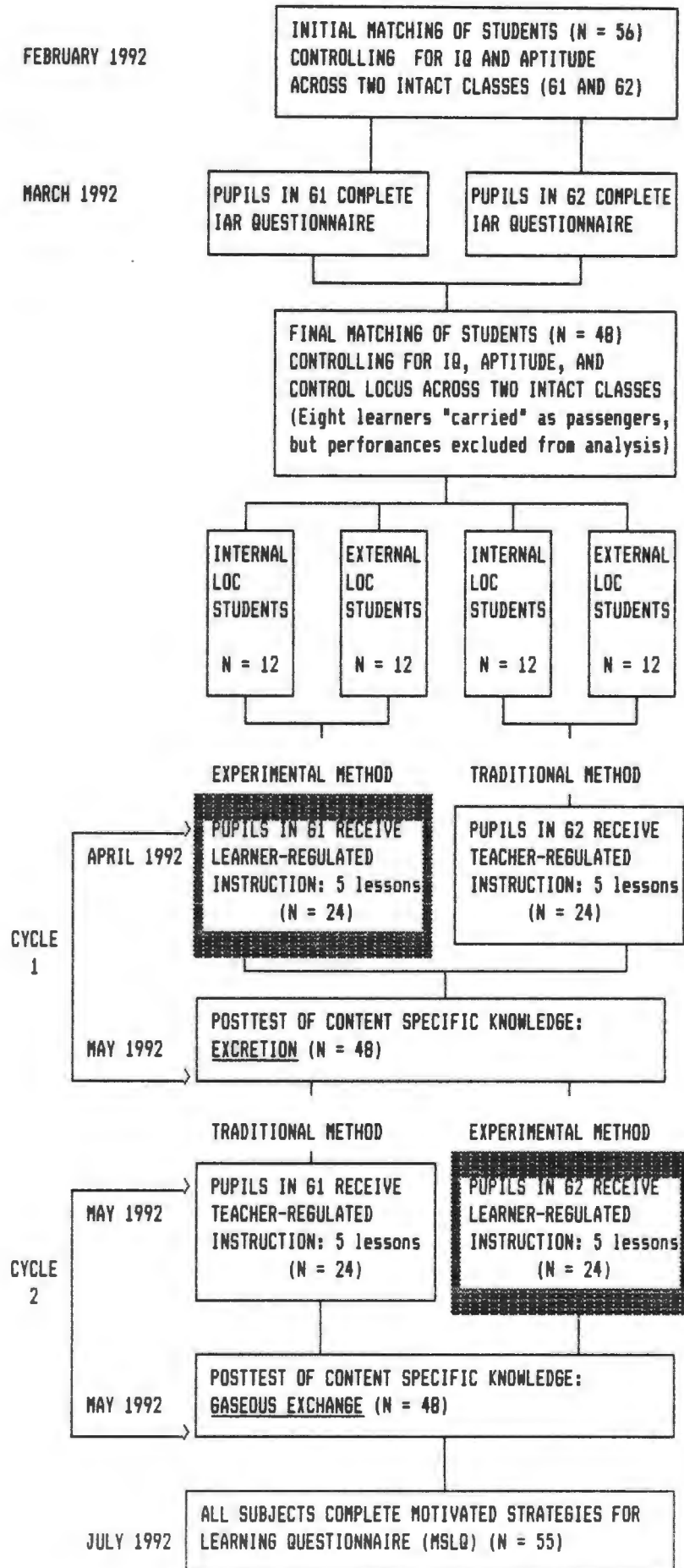


Figure 4.1: The Executed Research Design

#### **4.4 The Measures and their Variables**

Copies of these instruments are attached in Appendices B and C.

##### **4.4.1 Intelligence Quotient**

Intelligence quotients (verbal scores) of the subjects were obtained from school records (Appendix A). These data were measured using the Manual for the New South African Group Test (intermediate series) with a reliability coefficient for verbal scores of 0,88 (unpublished).

##### **4.4.2 Previous Examination Performance (Aptitude)**

The previous three examination performances (September and November 1991; March, 1992) were averaged to indicate performance ability (see Appendix A). This enabled pupils to be matched on two criteria, i.e., potential performance level (IQ), and observed performance level (examinations).

##### **4.4.3 The Intellectual Achievement Responsibility Questionnaire (Crandall, Katkovsky, and Crandall, 1965).**

This instrument was adopted for reasons listed by Stipek and Weisz (1981:106), and because it ascertains learner control locus status (see Appendix B).

- (a) Domain: This study was conducted under domain-specific conditions of school achievement. Lefcourt (1981:386), after reviewing locus of control research, concluded that "global" instruments were inferior to specific measures, when predicting relevant criteria (cited by Marsh and Gouvernet, 1989:59).  
It is likely that academic performance would be more highly correlated with perceptions of control in achievement situations rather than in more diverse circumstances. The IAR measures school achievement control perceptions, making it more suitable in this context. It also consistently yields positive relationships between internality and achievement.
- (b) Usage: The IAR is the most widely used instrument, with a choice of attribution format facilitating comparisons between the findings of this study and others.
- (c) Reliability: Compared to other instruments measuring locus of control, the reliability indices are favourable.
- (d) Gender: An overview of studies conducted to determine differential scores for boys and girls indicates no variance in scores attributable to gender.
- (e) Age: The IAR was grade-appropriate for the sample group used, namely standard ten.

This instrument (34 items) has a choice of attribution format. Each item stem describes either a negative or a positive achievement experience routinely occurring in childrens' academic lives. The total score obtained reflects the degree of internal control locus regarding academic achievement.

The sample used by Crandall, et al. (1965) comprised 923 primary and high school students drawn from five schools in diverse communities to make the sample as representative as possible. Test-retest reliability was estimated at 0,65 for ninth grade children, and 0,63 for this study, with an interval of six months; the internal consistency of each of the subscales had a correlation of 0,60; the established mean (for eighth-graders) was 26,1 with standard deviation of 3,7; the range was 21 (Crandall, et al., 1965).

This instrument was used because it was recommended for use with children in grades 3-12 (Stipek and Weisz, 1981:105) and was appropriate for this study. Scores for standard 10 pupils in this study compared favourably with those cited above. They varied from 15 to 32, with a mean of 25,9 and a standard deviation of 3,4.

#### 4.4.4 The Motivated Strategies for Learning Questionnaire (MSLQ) (Pintrich and De Groot, 1990:40).

This self-report instrument, was administered to 55 subjects approximately one month after the completion of the programme. This was to control and eliminate any possible effects of the programme on learners' motivational and learning strategies. This facilitated comparisons with the IAR Instrument which was administered prior to the onset of the programme. One of the original subjects was absent.

It was adapted from various instruments utilised to assess student motivation, cognitive strategy use, and metacognition (eg., Eccles, 1983; Harter, 1981; Weinstein, et al., 1987 cited by Pintrich and De Groot, 1990:34).

This instrument comprises five sub-scales and was used to measure learners' motivational beliefs and self-regulated learning in Biology. Three motivational scales, **Self-Efficacy** ( $r = 0,89$ ) comprising nine items, **Intrinsic Value** ( $r = 0,87$ ) also comprising nine items, and **Test Anxiety** ( $r = 0,75$ ) with four items, were evident. Two cognitive scales, **Cognitive Strategy Use** ( $r = 0,83$ ) containing 13 items, and **Self-Regulation** ( $r = 0,75$ ) with nine items were also used (reliability coefficients, reported by Pintrich and De Groot, 1990, are indicated).

Scoring on four of the items in the Self-Regulation scale was later revised when it became evident that the wording of those items solicited opposite responses to those expected from high self-regulating learners.

- (a) The Self-Efficacy scale assesses perceived competence and confidence in performance of classwork (e.g., "I expect to do very well in this class.").
- (b) The Intrinsic Value scale ascertains learners' beliefs regarding intrinsic interest (e.g., "I like what I'm learning in Biology"), and perceived importance of Biology classwork (e.g., "I think that what I learn in Biology is useful to know"), as well as a preference for challenge and mastery (e.g., "I prefer challenging classwork so I can learn new things").
- (c) Items such as "I have major worries when it comes to writing tests" and "I am so nervous during tests that I forget facts that I have learned", representing worry and cognitive interference when writing a test, were incorporated into the Test Anxiety scale.

- (d) The use of rehearsal strategies (e.g., "When learning Biology facts, I say them over and over to myself to help me remember"), elaboration strategies (e.g., "When studying I put important ideas in my own words"), and organisational strategies (e.g., "When I'm studying a chapter of Biology, I try to link the ideas with those in other chapters") were used in the Cognitive Strategy Use scale.
- (e) The Self-Regulation scale contained items reflecting **effort management strategies**. It included persistence at difficult or boring tasks (e.g., "I keep trying to understand what the teacher is saying even if it doesn't seem to make sense", and "Even when the work is boring, I keep going until I'm finished"), and **metacognitive strategies** (e.g., "When studying I practice saying the important facts over and over").

Subjects responded to the 44 items using a 7-point Likert-type scale ranging from 1 (not true of me) to 7 (very true of me). There was no time limit although respondents were asked to work quickly. As an incentive to answer honestly, the respondents were informed that (a) their scores would provide valuable insight into personal learning strengths, and possible deficiencies, and (b) that the results were confidential, but available for their perusal. All subjects agreed to complete the questionnaire.

#### 4.4.5 Posttests

Two pencil-and-paper content-specific biology posttests of 35 items each were formulated by the author. Their formats included 20 multiple-choice questions, 10 one-word terminology responses, and the identification of a total of five error labels from diagrams. Each item counted one mark.

- (a) The posttest **Excretion** (in Appendix C) included approximately 21 items requiring content recall (60%), 10 items requiring a synthesis of related facts (30%), and three items testing interpretation and application abilities (10%).
  
- (b) The posttest **Gaseous Exchange** (in Appendix C) included approximately 20 items testing content recall (57%), 10 items requiring a synthesis of related facts (29%), and five items testing interpretive and applicative abilities (14%).

The tests were not speed tests, although an estimation of the time needed for completion was provided. Raw scores for the tests were converted to percentages. The tests were subjected to analysis and minor alterations by two colleagues, and deemed an acceptable measure of syllabus prescribed content-knowledge.

Reliability coefficients for Excretion and Gaseous Exchange were, respectively, 0,93 and 0,90. The KR<sub>21</sub> formula was used, and the assumptions for its use were met (Sax, 1979:213). A pilot test examining biology learning content had been previously administered to familiarise pupils with instructions and test format, as well as to eliminate ambiguities in instructions.

#### 4.5 Programme Execution and Implementation

The first experimental group was decided by tossing a coin. In April 1992, prior to the commencement of Cycle One, both samples (Groups 1 and 2) received instruction for 5 lessons (55 minutes each) over 5 consecutive Biology periods. These were presided over by the author. Group 1 (EXPERIMENT) received learner-regulated instruction. Group 2 (CONTROL) received teacher-regulated instruction with identical content.

Posttests were administered, with no prior warning, in the period following the conclusion of the final lesson of each cycle, i.e., 7/05/92 and 20/05/92. This was done to assess the effectiveness of the instructional methods on actual classroom learning, and to ensure that all pupils were exposed to the same content for the same duration of time. The posttests were administered under examination conditions. All subjects were seated in an auditorium at desks arranged in five columns, 12 desks per column. Pupils were permitted to sit wherever they chose.

On the occasion of the first posttest, it was stressed that the programme effectiveness was being evaluated, not the pupils. The subjects were encouraged to do their best. This reassured pupils who felt concerned about not being forewarned of the test.

Subjects were also informed that the time indicated on the question paper was merely a guide. The same message was conveyed prior to writing the second posttest. Having been reassured in these ways, it appeared that test anxiety was minimal.

In Cycle Two (Gaseous Exchange), instruction commenced in the period following the first posttest. The sample groups were rotated and the same format design as Cycle One was followed. This reduced the influence of any uncontrolled factors, providing a more convincing test of experimental treatment superiority.

Subjects in the experimental group received notes explaining the instructional procedure. These are located in Appendix D. A guided tour of the learning environment was conducted. Both small-group, and individual coaching occurred to clarify instructional procedures. Brief learning exercises were administered during regular class time to give the subjects an opportunity to get the "feel" of the new design.

All these efforts were aimed at familiarising the subjects with the ethos of the new approach to pre-empt confusion once the programme had begun. The same precautions were carried out with the second experimental group, prior to the onset of Cycle Two.

Four senior colleagues monitored the application of the experimental treatment, and completed a questionnaire corroborating their observations with the guidelines for the experimental treatment stipulated a priori. These are located in Appendix E. The school Principal monitored the control treatments on an ad hoc basis and confirmed that the lessons were delivered competently.

#### **4.6 Instructional Design (Self-Regulated Learning)**

##### **4.6.1 Overview**

An author-constructed cognitive programme, comprising two modules entitled **Excretion and Gaseous Exchange** represented the content. It corresponded to that contained in the pupils' prescribed textbook (Du Toit, et al., 1987), although additional reading materials for purposes of enrichment were available. Posttest content was entirely congruent with Cape Education Department syllabus requirements.

Content delivery included practical work, modelling, comprehensions, problem-solving, overhead transparencies, course objectives, essay formulation, videos, and self-evaluations. Reading matter was collated from various sources such as Reader's Digest, and was available during class time.

#### 4.6.2 Modus operandi

Each assignment and task was quantified in terms of a numerical credit rating. The credit value was determined by the treatment designer, and considered the amount of time and effort needed to complete the task, and its level of difficulty. In most cases, learners were free to select the types of tasks they wished to complete, their sequences, and the quantity. Occasionally, particularly important assignments were compulsory.

Before commencement of the programme, learners were encouraged to "reserve" their places at the Learning Centres. As only a maximum of seven could be accommodated at any one time, learners who reserved seats at particular centres on specific days had priority. Most learners took advantage of this suggestion. The Booking Schedules appear in Appendix D. Learners selected their tasks, and recorded the accumulative credit total on a class credit score sheet before commencement of the daily lesson. The sheets used in both cycles appear in Appendix D.

Upon completion, the teacher monitored the individual pupil's standard of work and, if satisfactory, confirmed the learner's credit score. After completion of the programme, the accumulated credit total was noted and translated into a grade.

The grade was converted into a bonus percentage which was added to the result of the evaluation test, but was not considered during data analysis. It served to give learners a way of determining goal-oriented outcomes through effective planning. The link between credit selection and satisfactory task completion - as a series of sub-goals which eventually determined the bonus percentage earned through large and/or difficult assignments - has a theoretical justification in the findings of Tuckman (1990:291) and Bandura and Schunk (1981:586).

#### **4.6.3 Features of the Self-Regulated Learning Environment**

The features of the learning environment followed those advocated by Clark (1988:299). These included the intentional positioning of furniture to support learning and simultaneous access to several learning activities. Generally, a highly structured setting presented a complex of activities which could meet the needs of individual learners.

An emphasis was placed on the learner being an active and unique partner in the learning process, and this was facilitated by a classroom atmosphere engendering trust, respect, and cooperation. Learners were supported in self-directed learning by on-going assessment, contracting, and goal-oriented procedural mechanisms. Productivity, involvement, active enquiry, and experimentation were encouraged, making the atmosphere resemble that of a quiet workshop.

#### **4.6.4 Design Elements Supporting Self-Regulated Learning**

Clark's (1988:301) suggestions on the creation of learner perceptions of control were utilised. Learners were free to exercise choice relating to activities, timing of assignment completion, and ways of learning. Choices were real and, with the exception of stated non-negotiable mini-assignments, carried no hidden preferences of the teacher. Learners were provided with opportunities to plan their learning in terms of the sequence of learning centre attendance, the timing of assignment submission, the number of assignments and their level of difficulty, and the overall desired credit total.

#### 4.6.5 Environment Structure for Self-Regulated Learning

A science laboratory measuring approximately 100 m<sup>2</sup> was divided into five areas termed **LEARNING CENTRES**. Figure 4.2 represents a plan of the instructional environment. The following components were incorporated following the recommendations of Pflum and Waterman (1974), cited by Clark (1988:327).

Written directions were simple and clearly presented, and the purpose of the centre was explicitly stated in the directions and explained by the teacher during the lead up to the commencement of the programme. All materials are presented in Appendix G.

Manipulative materials, media, books, and human resources were used to communicate the content. Activities were varied and several modalities were used (aural, visual, tactile). Application of learned material and evaluation of learning also occurred at each learning centre.

Each centre was allocated pupil tables (0,75m<sup>2</sup>) to accommodate a maximum of seven learners. Cardboard or wood partitioning was used to isolate learners sitting alongside each other in some learning centres to limit social distractors (Chernick, 1990:693; Corno, 1986:334).

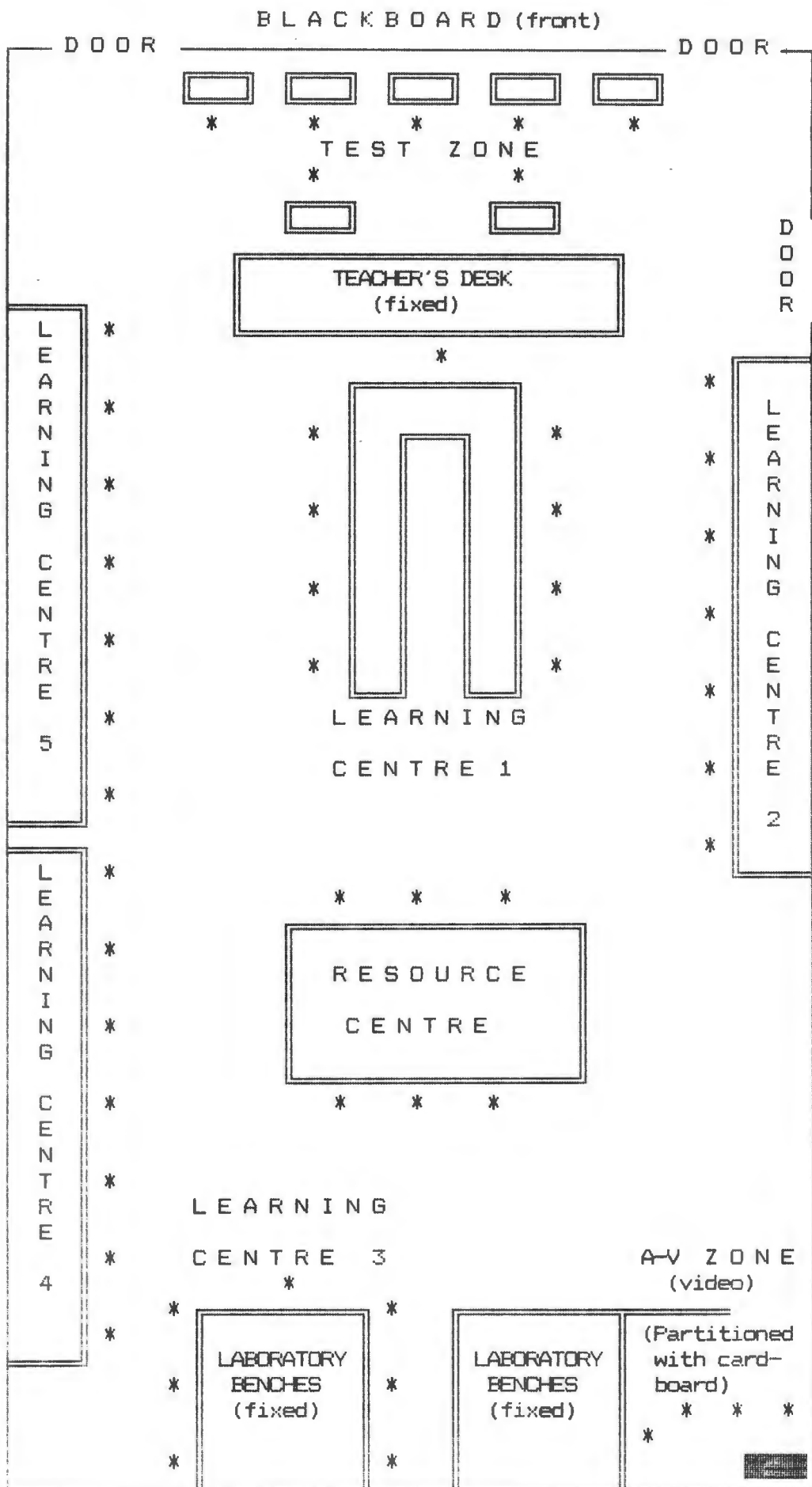


Figure 4.2 Floor Plan of Self-Regulated Learning Environment. Seating is indicated by \*.

In others, learners were able to communicate in small groups (Chernick, 1990:691; Stevens, et al., 1991:9). The centres were named in accordance with the type of learning activity facilitated, and numbered. A general zone was also available and contained a Resources Centre with books, magazines, and duplicated notes. A pin board with general instructions, booking schedules, and credit tables was also publically displayed.

#### **4.6.6 Physical Feature of the Learning Centres**

The following learning centres were evident: **TUTORIAL, DESIGN, PRACTICAL, COMPREHENSION, AND RESEARCH.** An explication of the Learning Centres follows.

##### **(a) Tutorial**

The seating format followed a horse-shoe design suggested by Degenaar (1986:84). General instructions, learning objectives, reading notes, a selection of examination-type questions with answers, charts and plastic models of the learning content, and an overhead projector, were present.

##### **(b) Design**

This learning centre required learners to work intensively on a biological design (construction) task. A learner-marked minitest was then written.

The nature of the task dictated the division of the learning centre into two separate zones, one to accommodate the initial task, and the other to permit both privacy and distance from the learning content. Laboratory stools were replaced with wooden chairs, for greater comfort, and to conform with those used in the control.

Pupil tables, each seating two learners, were arranged end-to-end along one wall. Wooden partitions were used to create two-learner cells. Each cell was provided with a brief note explaining the objectives of the centre, scrap paper, and plasticine of assorted colours. Two different diagrams of the learning content were present, one enclosed in an envelope, and the other fixed on the table surface.

A detailed structural description of the enclosed diagram accompanied instructions for learner scrutiny. A coloured card advising of the need to work quickly was also prominent.

The Test Zone contained spaced single-pupil tables. A brief explanation regarding the test conditions, and three tests differing in duration and complexity were available. Each test was enclosed in a separate envelope which indicated the credits available, and the mark allocation. A second envelope contained the memorandum. Scrap paper was available for writing the test. A cardboard box was used to hold all completed tests.

(c) **Practical**

Existing fixed laboratory benches were used in this learning centre. A note indicating the different options available to learners, biological material and related dissecting instruments, dissecting microscopes, and related laboratory equipment were displayed. Notes and diagrams pertaining to the dissections represented support material. Additional information was made available at the Resource Centre.

(d) **Comprehension**

The physical setting of this learning centre corresponded to that of the DESIGN centre. However, instead of a Test Zone, an Audio-Visual Centre was available with a VCR and monitor. Viewing a video, and responding to written questions on its content, represented one of the optional tasks in this learning centre. In addition to the instruction brief, a list of optional topics, and the related reading matter, with related questions, was provided.

(e) **Research**

The physical setting for this learning centre also corresponded closely with that of the DESIGN and COMPREHENSION centres.

The RESOURCE centre was largely available to learners attending this centre. The Introductory brief, and a collection of topics, were contained in the information sheet displayed.

#### 4.6.7 Content Delivery

Researchers have stressed consideration of learning styles when planning content delivery (O'Brien, 1989:86; Griggs and Dunn, 1984:115). Low auditory preferences among high school pupils were confirmed by Griggs and Price (1980), cited by Griggs and Dunn (1984:115). Cognisance was taken of these findings in the design of the current investigation into teaching and learning effectiveness.

##### (a) Tutorial

The TUTORIAL learning centre required that learners attend to the requirements of the centre before the lesson. A cursory reading of the prerequisite reading material was necessary. Specified items on the learning objective note had be researched in advance, using the prescribed textbook (Du Toit, et al., 1987). The time-on-task of this exercise was rendered equivalent by pupils in the control group who were required to make notes in their classwork books after the lesson. Once in session, learners fielded questions on the prescribed reading and discussed the learning objectives covered for homework with the teacher.

This initial discussion was widened at the teacher's discretion to cover salient details of the content, uncover misconceptions in the learners' minds and indicate the syllabus requirements. As also occurred in the control group, overhead transparencies, models, charts and other resource material were used as teaching aids. The remaining time in the period was utilised by the learners to complete a series of examination-type questions. The answers to these were provided on the day following completion of the programme.

(b) **Design**

The overall purpose of this learning centre was to facilitate the memorisation of diagrammatic details, an important feature of biological work. Learners were required to study a description of the anatomical features of a body part and attempt to visualise its appearance intuitively.

A plasticine model incorporating all the details provided in the description was then constructed by each individual pupil, based on the learner's intuitive perceptions of its structure. Upon completion, a diagram of the structure (originally enclosed in an envelope) was compared with the model. Relevant names, and specific structural features, had to be noted.

A second diagram, presented overtly, also had to be memorised. Specific guidelines were given on the learning procedures. Learners were encouraged to memorise as much detail as possible, diagrammatic and written, regarding the diagram, as possible within two minutes. With no further reference to the diagram, the learner had to recreate the diagram, with labels, within two minutes. This effort was compared with the original. Learners were instructed specifically to note the details which did not appear in their rendition. This procedure was repeated until a diagram, complete in all aspects, was produced.

Having mastered the learning content comprising the factual description and illustrated diagram, the learner selected one test from a possible three. These were graded in terms of difficulty and were allocated different credit values. A learner had to obtain a minimum of 80% to obtain the available credits. Ten credits were deducted for every ten percentage points below 80%. All tests covered only the content encountered at the Design learning centre. The test was self-marked, and made available for moderation by the teacher.

Motoric operations are important for successful encoding. The manipulation of plasticine during learning was believed to clarify spatial details, and assist learners in acquiring psychomotor skills (Degenaar, 1986:135).

**(c) Practical**

Practical work followed syllabus recommendations and provided for enrichment. Biological material, laboratory apparatus and duplicated notes represented the learning matter. Dissections, collection and manipulation of data, problem-solving, and measurement of various parameters comprised the learning tasks. Tasks were allocated differential credit values. An emphasis was placed on physical activity by every learner. Learners were required to maintain records of data. A short summary of the conclusions drawn had to be evident in the practical write-up.

**(d) Comprehension**

The task format resembled that of a traditional comprehension exercise. Selected reading matter, linked to the prescribed learning content, was available. Learners were required to assimilate content they selected and respond, in writing, to a series of content-based questions. The inclusion of a video option permitted both visual and aural learning. Viewers made notes and responded to questions on the content.

**(e) Research**

Learners were presented with a selection of pertinent topics which were, with one exception, non-compulsory.

Some required a discussion of the statement. Others involved the answering of specific questions. The required length of response, and the credit values were indicated. Learners were also expected to complete one compulsory essay, assigned on the basis of its importance to the syllabus requirements. In addition to the compulsory assignment, learners were free to select additional topics, thereby accumulating more credits. All facts pertinent to the successful completion of all topics were available as extra reading matter, available at the Resource Centre, although the use of literature other than that provided was also encouraged.

Class time was largely used to gather facts and arrange these in a logical format. Homework constituted a reworking of the details into a neat presentation. Assignment control was conducted by the teacher. All assignments were moderated, and the credit selection was confirmed if found satisfactory. Unsatisfactory work was returned with suggestions on how improvements could be effected. Once found to be satisfactory, the original credit value was confirmed. Selected artifacts of learner efforts are presented in Appendix F. Materials used in the interventions are presented in Appendix G.

#### **4.6.8 Teacher Behaviours**

During instructional time two roles, "travelling" and "tutor", were performed following suggestions by Wang and Stiles (1976:173). During travelling which occurred during the final third of the lesson, the teacher circulated among learners facilitating, prompting and giving feedback on learner performance.

The tutor role was performed at the TUTORIAL learning centre. The teacher worked intensively with learners describing conceptual aspects of the work, demonstrating models, referencing the learning objectives, assessing learner knowledge of the reading material, and fielding questions on problematic content areas.

In both roles the teacher functioned as a consultant using questioning and probing techniques, assisting in planning, and making suggestions regarding the accessing of information.

#### **4.7 Instructional Design (Teacher-Regulated Learning)**

##### **4.7.1 Overview**

The control group learning content represented the prescribed textbook, videos, notes, course objectives, overhead transparencies, biological charts, biological models, and demonstration practical materials.

Teaching aids included a chalkboard, overhead projector, and video recorder with monitor, i.e., the same teaching aids (resources) utilised in the experimental treatment were available in the control treatment.

The essential difference between the control and experimental treatments was the degree of pupil manipulation of the teaching resources. For example, the teacher controlled the time available for viewing, and the sequence of material presentation during the control lessons.

Direct instruction involved a traditional lecture format including an explanation of concepts, presentation of examples, demonstrations, and summarisation.

#### **4.7.2 Environment structure**

Lessons were conducted in a conventional classroom (approximately 64 m<sup>2</sup>) containing standard pupil tables and wooden chairs.

#### **4.7.3 Content delivery**

Learning activities in the control groups were similar to those conducted in the experimental groups. For example, the first lesson was used to view the same video available to the experimental group. All subjects had to view it.

Following this, the teacher summarised the main points and fielded questions pertaining to the video. The remaining time was used to distribute the learning objectives. These were available to all subjects in both treatment groups.

The textbook (Du Toit, et al., 1987) was used extensively. During subsequent lessons, the same charts, models, and overhead transparencies used in the intervention were viewed by the control group. A short test reviewing the previous lesson's work was written, and marked by the pupils, during the first ten minutes of each period. A expository lesson then followed. Pupils were required to take notes and ask questions. Printed matter with summaries, diagrams, etc., were also distributed and discussed. During the penultimate lesson, dissected biological matter was made available for viewing.

#### 4.8 Explanations of operational terms used in the hypotheses.

**BIOLOGY LEARNING CONTENT** - the syllabus-prescribed content listed in the set of learning objectives distributed to all learners, copies of which are located in Appendix G.

**LEARNER-REPORTED** - the responses of individual learners to statements contained in the instruments used for assessing locus of control, and motivational learning variables, cognitive and self-regulated strategy use.

**LOCUS OF CONTROL SCORES** - the total score obtained by a respondent to the Intellectual Achievement Responsibility Questionnaire (Crandall, et al., 1965).

**MEASURES OF SELF-REGULATION** - derived from learner-reports of self-regulated strategy use, utilising the Motivated Strategies for Learning Questionnaire (Pintrich and De Groot, 1990).

**POSTTEST** - the formal assessment of academic learning, accrued during **class-time**, at the end of each cycle.

**SELF-REGULATED** - the processes characterising independence, self-initiated, self-directed, and self-controlled learning. These processes include learners' metacognitive strategies for planning, monitoring, and modifying their cognition; management and control of their effort on academic tasks; and the actual cognitive strategies pupils use to learn, remember, and comprehend the subject matter.

**TEACHER-REGULATED** - teacher-initiative, control; restrictive of individual learner expression using norm-referenced criteria for evaluation of learner behaviours; prescriptive; resource manipulation by teacher.

**TRADITIONAL** - oral delivery of information or instruction; a long established, generally accepted custom or **method of procedure** (The Shorter Oxford English Dictionary, 1973).

## **4.9 Null Hypotheses**

### **4.9.1**

A series of null hypotheses was formulated to test the proposal that learner-regulated instruction would positively influence academic performance amongst learners, regardless of their control locus status, but that internal control locus learners would benefit more when regulating their own instruction.

#### **(a) Self-regulation versus teacher regulation**

H<sub>01</sub>: There will be no significant difference between the mean posttest scores of pupils receiving biology learning content in an environment where they perceive they regulate their own learning, and those in an environment where traditional teacher regulation of instruction occurs.

#### **(b) Control locus and learner regulation**

H<sub>02</sub>: There will be no significant difference between the mean posttest scores of pupils with an internal locus of control and the mean posttest scores of learners with an external control locus who receive identical biology learning content in a self-regulated environment.

**(c) Internal control locus and instructional regulation**

H<sub>03</sub>: There will be no significant difference between the mean posttest scores of learners with an internal locus of control, receiving biology learning content in a self-regulated environment, and those receiving identical learning content in a traditional teacher-regulated environment.

**(d) External locus of control and instructional regulation**

H<sub>04</sub>: There will be no significant difference between the mean posttest scores of learners with an external locus of control, receiving biology learning content in a self-regulated environment, and those receiving identical learning content in a traditional teacher-regulated environment.

**4.9.2**

A further three null hypotheses were generated to test the significance of correlations between measures of self-regulation, and measures of locus of control, posttest performance after application of the experimental treatments, and posttest performance after application of the control treatments.

**(a) Self-regulation and locus of control**

H<sub>o</sub>5: There will be no significant correlation between learner-reported measures of self-regulation and their locus of control scores.

**(b) Self-regulation and Control Treatment Posttests**

H<sub>o</sub>6: There will be no significant correlation between learner-reported measures of self-regulation and posttest scores obtained by subjects after the application of traditional teacher-regulated biology instruction.

**(c) Self-regulation and Experimental Treatment Posttests**

H<sub>o</sub>7: There will be no significant correlation between learner-reported measures of self-regulation and posttest scores obtained by subjects after the application of self-regulated biology instruction.

**4.10 DATA COLLECTION**

The following data were obtained for each of the two posttests:

**4.10.1 Posttest 1: Excretion**

- a) Experimental group (Group 1 ) scores on Excretion
  - b) Internal control locus scores on Excretion
  - c) External control locus scores on Excretion
- 
- a) Control group (Group 2) scores on Excretion
  - b) Internal control locus scores on Excretion
  - c) External control locus scores on Excretion

**4.10.2 Posttest 2: Gaseous Exchange**

- a) Experimental group (Group 2) scores on Gaseous Exchange
  - b) Internal control locus scores on Gaseous Exchange
  - c) External control locus scores on Gaseous Exchange
- 
- a) Control group (Group 1) scores on Gaseous Exchange
  - b) Internal control locus scores on Gaseous Exchange
  - c) External control locus scores on Gaseous Exchange

#### **4.10.3 Aptitude for Biology**

Examination performance in the previous three examinations was averaged, and converted to a percentage for each pupil. These ranged from 30% to 87%.

#### **4.10.4 Effort**

Credits accumulated during the course of the experimental treatment by the subjects were totalled and converted to a percentage. This represented the effort expended. The accumulated credits ranged from 195 to 500.

#### **4.10.5 Locus of Control Scores**

Scores from the Intellectual Achievement Responsibility Questionnaire were recorded.

#### **4.10.6 Intelligence Quotients**

Intelligence quotients (verbal scores) were extracted from school records.

#### **4.10.7 Self-Regulation Scores**

Scores from the Motivated Strategies For Learning Questionnaire (MSLQ) were recorded.

#### 4.11 Data Analysis

Slavin (1984:185) has listed assumptions which preclude the use of parametric tests until their criteria are met. These include a normal score distribution on an interval (continuous) basis, homogeneity of variance, and random assignment of samples to conditions. These criteria were noted and applied to the data prior to statistical analyses.

All statistical analyses were conducted by the researcher. A t-test for matched groups was conducted for each posttest to determine whether a significant difference existed between the achievement means subsequent to the experimental and control treatments.

An ANOVA (2 x 2) was used to establish the significance level of the F-ratios. Treatment condition (self-regulated vs teacher-regulated) and measured pupil control locus (internal vs external) were the variables. Using a parametric two-way analysis of variance, the significance of the F-ratios was tested. A t-test for two sets of independent data was used to test the third and fourth null hypotheses.

Partial correlations between effort expended for the duration of the experimental treatments, previous examination performance (averaged over three successive examinations), and posttest performance were computed, controlling for past examination performance.

The MSLQ represented several sub-scales (e.g., self-efficacy) with varying numbers of items. Item means were calculated by dividing the subscale test total by the number of items (e.g., by nine). Associations between reported motivated learning variables and self-regulated and cognitive learning strategies were determined. Further correlations between these variables and posttest performances after differential instructional treatments were calculated. Raw posttest scores were converted to percentages.

Pintrich and De Groot (1990:35) obtained a correlation between Self-Regulation and Cognitive Strategy Use sub-scales of 0,83, which was highly significant ( $p < 0,001$ ). It was decided to combine the scores obtained for the Cognitive Strategy Use and Self-Regulation sub-scales. This provided a more comprehensive measure of overall self-regulation, as items within them assessed learning strategies such as metacognition, effort management, rehearsal, elaboration (summarising and paraphrasing), and organisation.

The association between locus of control and self-regulation was determined. Groups differing in control locus were dichotomised, using group median splits. To maximise sample size, all available subject data was used, i.e., scores of all subjects (including those not originally matched for the purposes of equivalence).

#### 4.12 Summary of Chapter

The characteristics of the samples, and instructional designs have been identified. The relevance of these to the investigation has been explained.

The measures utilised as independent variables were: -

The Intellectual Achievement Responsibility  
Questionnaire

The Motivated Strategies for Learning Questionnaire

The dichotomous treatment employed as the independent variable was the intervention.

The dependent variable was the achievement posttest administered after each cycle.

Seven hypotheses, formulated operationally in null form to facilitate testing, and the methods of data collection and analysis were reported.

## **CHAPTER 5**

### **RESULTS**

#### **5.1 Introduction**

The primary aim of this thesis research has been to investigate whether posttest performances under the experimental treatments are equivalent to, or significantly greater than, those under the control treatments. It should be remembered that the groups remain constant, but receive alternating treatments. One product of evaluation is the justification for decisions and judgements made about the effectiveness of the intervention. The investigation has been confined to a determination of differences between mean performances of groups exposed to two types of instructional strategy. Preliminary correlations among academic performances will be conducted to indicate possible relationships between the variables under consideration.

#### **5.2 Assumptions for Parametric Tests**

The defensible use of parametric analyses is precluded until the assumptions for their use are met. These have been considered in Chapter Four (paragraph 4.11).

Preliminary data analyses of homogeneity of variance, following procedures in Slavin (1984:181), and score distribution have indicated that variant homogeneity was confirmed, prior to all parametric analysis of data. A table reflecting the results is included in Appendix J. As seen in Figure 5.1, the scores of both posttests approached a normal distribution with approximately equal scatter of variance, including similar bimodal distribution tendencies.

### 5.3 Self-Regulation versus Teacher-Regulation

The first consideration of the study concerned the impact of the experimental intervention on academic performance. Table 5.1 displays the summary statistics of performances in the posttests undertaken by control and experimental groups after the completion of the two cycles. Figure 5.2 illustrates the posttest performances of the experimental and control groups.

A 2 (regulation: teacher vs learner) x 2 (control locus: internal vs external) ANOVA was conducted on these data for cycles 1 and 2 with academic performance the dependent variable. The results are summarised in Table 5.2 (cycle one) and Table 5.3 (cycle two). The performance scores in the first posttest yielded a highly significant main effect for treatment ( $F = 42,74$ ;  $df = 1;44$ ;  $p < 0,001$ ).

# POSTTEST SCORES: CYCLES 1 AND 2

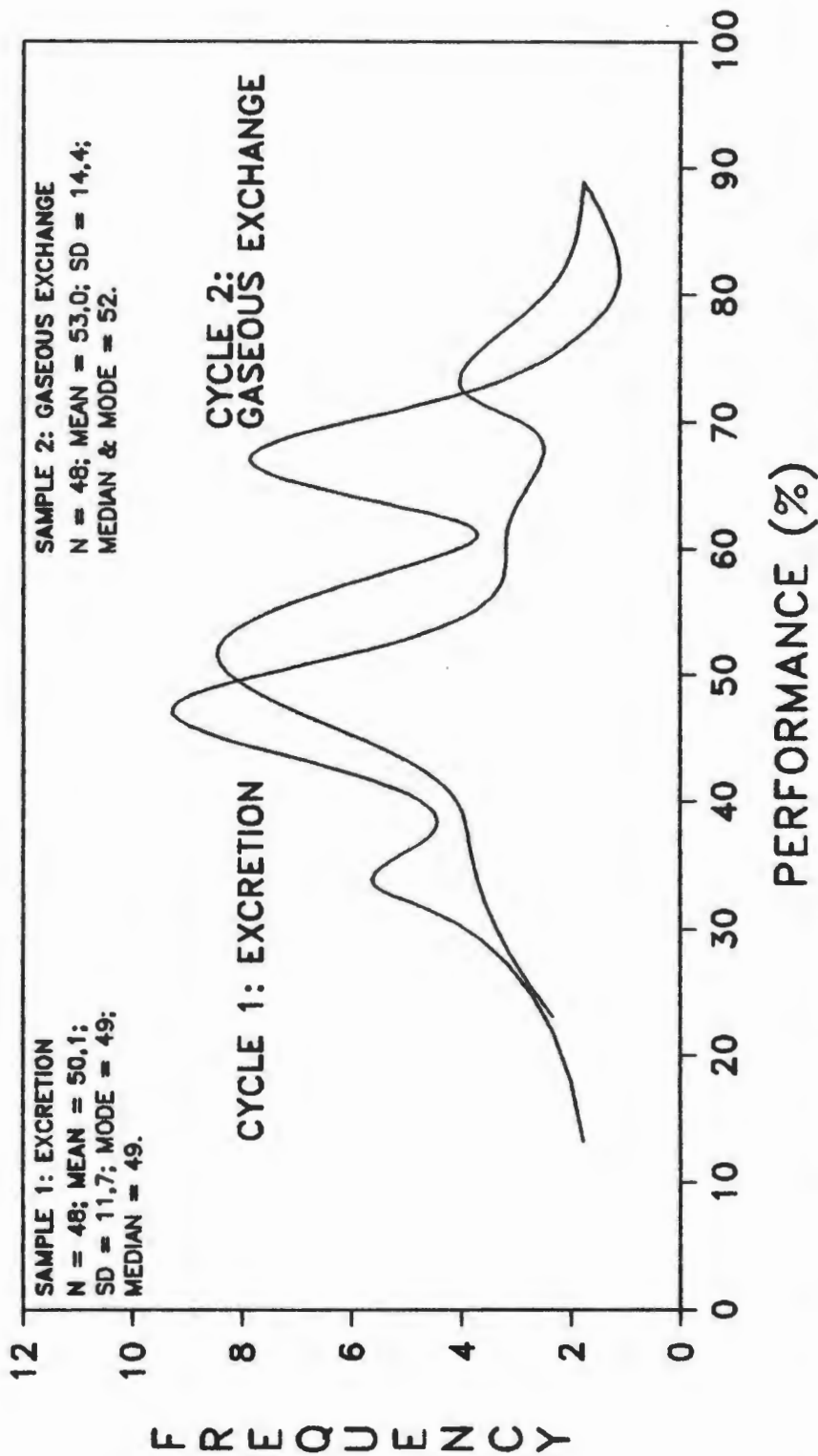


Figure 5.1. Frequency Distribution of Posttest Scores.

Table 5.1

Summary Statistics of Posttest Performance by Initially Equated Experimental and Control Groups after Cycles One and Two.

---

	Cycle 1			Cycle 2		
	M	SD	N	M	SD	N
Experiment	61,2	14,0	24	58,5	14,3	24
Control	39,1	10,0	24	47,5	14,3	24

---

Note. The content covered in Cycle 1 and Cycle 2 was respectively, Excretion and Gaseous Exchange. The reference was Du Toit, et al. (1987).

## Posttest results

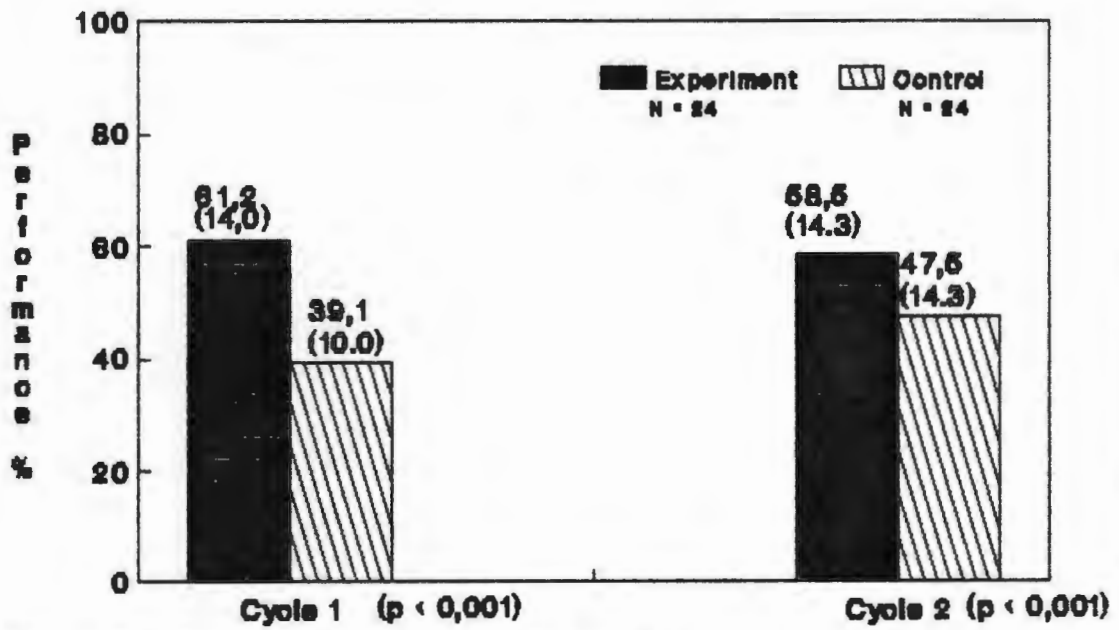


Figure 5.2. Group performances for Cycles 1 & 2. Standard deviations are indicated in ( ).

Table 5.2

Analysis of Variance of Mean Scores for Posttest 1

---

Source	MS	df	F
<hr/>			
Between subjects			
Treatment	6077,5	1	42,74 ***
Control locus	620,0	1	4,36 *
Treatment X control locus	6,25	1	0,044
error	142,25	44	

---

\*  $p < 0,05$     \*\*\*  $p < 0,001$

**Table 5.3**

**Analysis of Variance of Mean Scores for Posttest 2**

---

Source	MS	df	F
<hr/>			
Between subjects			
Treatment	1485,0	1	7,011 *
Control locus	60,0	1	0,283
Treatment X Control locus	21,3	1	0,100
error	211,8	44	

---

\*  $p < 0,05$

The outcome of the ANOVA for posttest 2 confirmed that the learner-regulated group outperformed the control group significantly ( $F = 7,011$ ;  $df = 1;44$ ;  $p < 0,05$ ).

The t-test for matched groups (first posttest) demonstrated that the experimental group ( $M = 61,2$ ) significantly outperformed the control group ( $M = 39,1$ ),  $t(24) = 7,404$ ,  $p < 0,001$ . The t-test conducted for matched groups after completion of the second posttest indicated that the experimental group ( $M = 58,5$ ) significantly outperformed the control group ( $M = 47,5$ ),  $t(24) = 3,784$ ,  $p < 0,001$ .

The findings are consistent with expectations that pupils in the self-regulated instructional environment would outperform matched pupils receiving teacher-regulated instruction.

The next aspect of this investigation considered differential loci of control and posttest performance, after two types of instruction had been delivered on a rotational basis for two consecutive cycles.

#### **5.4 Control Locus and Self-Regulated Performance**

This section considered the prediction that internal control locus learners would outperform externals after self-regulation of their learning in the same environment.

A t-test for independent data indicated no significant difference between mean test anxiety scores of internal ( $M = 11,1$ ) and external ( $M = 13,0$ ) locus of control learners  $t(52) = 0,210, p > 0,2$ . These findings suggest that test anxiety did not influence the outcomes of the posttest performances of learners with differential control loci. It is assumed that anxiety, at least in this study, can be discounted as a confounding variable.

The summary statistics of experimental and control group performances in the first posttest, of pupils with differential control loci, is presented in Table 5.4. The summary statistics of the second posttest are presented in Table 5.5.

In the first posttest, the performance of internal control locus learners was superior to that of externals ( $F = 4,36; df = 1;44; p < 0,05$ ) after both cohorts had simultaneously self-regulated their instruction. This is reflected in Table 5.2. No interaction occurred between treatment and control locus ( $F = 0,044; df = 1;44$ ).

Despite the apparent trend towards superior performance of internal control locus pupils ( $M = 60,3$ ) over externals ( $M = 56,8$ ) for the second posttest, the results, displayed in Table 5.3, were not significant ( $F = 0,283; df = 1;44$ ). There was no interaction between treatment and control locus. The posttest performances of all cohorts are illustrated in Figure 5.3

Table 5.4

Summary Statistics of Performance Scores in Posttest One  
(Excretion) for Differential Control Loci

	Condition								
	Experimental			Control			Total		
	M	SD	n	M	SD	n	M	SD	n
Internal	65,1	15,0	12	42,3	9,4	12	53,7	12,2	24
External	57,3	12,5	12	35,9	10,0	12	46,6	11,2	24
Total	61,2	13,7	24	39,1	9,7	24			

*Kristin(?)*

Table 5.5

Summary Statistics of Performance Scores in Posttest 2 (Gaseous Exchange) for Differential Control Loci.

Level	Condition								
	Experiment			Control			Total		
	M	SD	n	M	SD	n	M	SD	n
Internal	60,3	16,9	12	48,0	15,8	12	54,1	16,4	24
External	56,8	11,6	12	47,1	13,4	12	52,0	12,5	24
Total	58,5	14,2	24	47,5	14,6	24			

## Posttest results

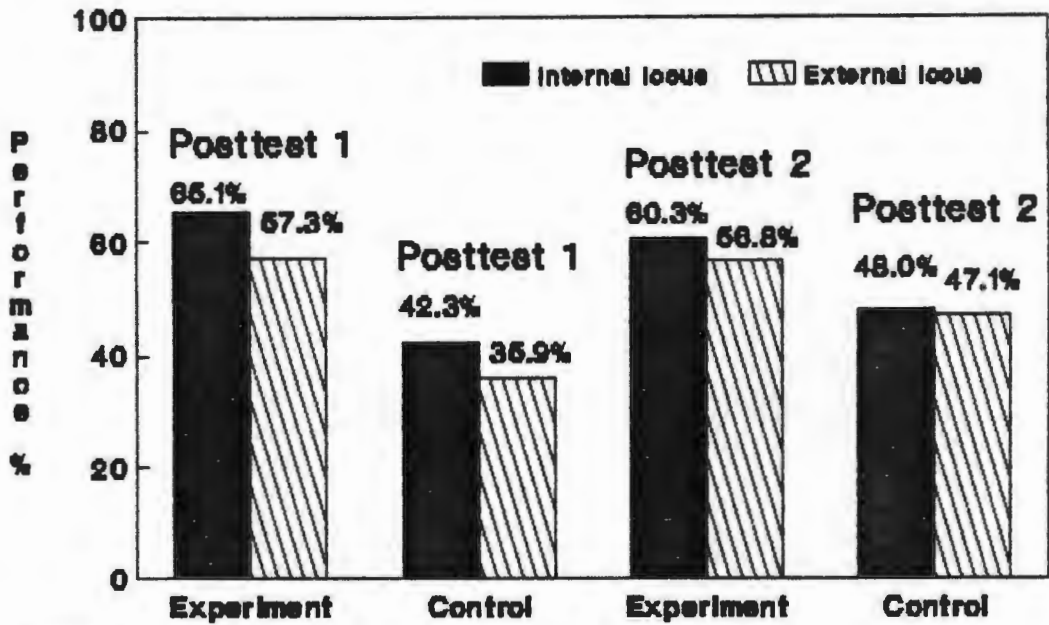


Figure 6.3. Performances of all locus of control cohorts in both Cycles.

### 5.5 Internal control locus and differential instructional regulation

The findings regarding the performances of internal locus of control learners under conditions of self-regulated and teacher-regulated instruction are reported. Internal control locus learners ( $M = 65,1$ ) in the self-regulated environment outperformed internals ( $M = 42,3$ ) in the teacher-regulated environment in the first posttest,  $t(22) = 4,277$ ,  $p < 0,001$ . Internal locus of control learners ( $M = 60,3$ ) who self-regulated instruction also outperformed internals ( $M = 48,0$ ) receiving teacher-regulated instruction in the second posttest,  $t(22) = 1,753$ ,  $p < 0,05$  (one-tailed test).

The hypothesis that internals in a self-regulated instructional environment will outperform those in a teacher-regulated one should be accepted cautiously.

### 5.6 External control locus and differential instructional regulation

The findings regarding the performances of external locus of control learners under conditions of self-regulated and teacher-regulated instruction are reported. External control locus learners ( $M = 57,3$ ) in the self-regulated environment outperformed externals ( $M = 35,9$ ) receiving teacher-regulated instruction in the first posttest,  $t(22) = 3,771$ ,  $p < 0,01$ .

In the second posttest, external locus of control learners ( $M = 56,8$ ) self-regulating instruction outperformed externals ( $M = 47,1$ ) receiving teacher-regulated instruction,  $t(22) = 1,809$ ,  $p < 0,05$ , (one-tailed test).

The hypothesis that externals who self-regulate their instruction outperform their coevals receiving teacher-regulated instruction, is supported.

#### 5.7 Association of Self-Regulated Strategy Use with Locus of Control

A t-test for independent data,  $t(52) = 2,853$ ,  $p < 0,01$ , indicated a significant difference between the mean self-regulatory strategy use scores obtained using the Motivated Strategies for Learning Questionnaire (MSLQ) (Pintrich and De Groot, 1990), of internal ( $M = 44,4$ ;  $SD = 7,73$ ) and external locus of control ( $M = 39,0$ ;  $SD = 4,91$ ) learners. Point biserial correlations indicated higher levels of reported self-regulatory strategy use ( $M = 41,8$ ;  $SD = 7,0$ ) which were significantly associated with internality of control locus ( $r = 0,39$ ;  $t(52) = 3,056$ ;  $p < 0,01$ ).

As predicted, higher levels of locus of control were significantly associated ( $r = 0,38$ ) with higher levels of self-regulation ( $p < 0,01$ ).

This suggested that learners which are more internal in their control locus report greater self-regulatory and cognitive strategy use than learners with an external locus of control.

### **5.8 Association of Self-Regulation with Posttest Performance after Self-Regulated, and Teacher-Regulated, Instruction**

The decision to combine cognitive and self-regulatory strategy - use scores, when assessing correlations with academic performance followed Pintrich and De Groot's (1990:38) observation that self-regulation and cognitive strategy use tended to be highly correlated in their investigation.

They also noted that cognitive strategy use without the concomitant use of self-regulatory strategies was not conducive to academic performance. Corno (1986:334) maintained that metacognition was necessary, but insufficient, for self-regulated learning. In short, although the two constructs can be distinguished conceptually, learners should be able to know how, and when, to use the appropriate strategies.

For 53 pupils, higher scores in measures of self-regulation ( $M = 52,6$ ), were significantly associated with higher academic performance scores ( $M = 59,5$ ) after self-regulated instruction ( $r = 0,29$ ;  $t(51) = 2,164$ ,  $p < 0,05$ ).

A low association with performance after teacher-regulated instruction ( $M = 44,2$ ) was not significant ( $r = 0,22$ ;  $t(51) = 1,610$ ,  $p > 0,2$ ). The findings are presented in Table 5.6.

## 5.9 Unanticipated Findings

The literature reviewed suggested that associations between self-efficacy, intrinsic value, test anxiety, and cognitive and self-regulatory strategy use might be evident. Although not hypothesised about, these variables might be suggested to impact on the variables considered in this study. Their suspected associations with the instructional control variables are therefore, possibly pertinent. They have also been explored in relation to each other, thereby extending the findings of Pintrich and De Groot (1991) to older learners. Finally, the importance of classroom effort to performance has been examined.

### 5.9.1 Motivational and Self-Regulated Learning Variables

For 55 pupils, associations between Self-Efficacy, Intrinsic Value, Test Anxiety, Cognitive Strategy Use and Self-Regulation scores were calculated. The findings are consistent with those of Pintrich and De Groot (1990:35). Higher levels of self-efficacy ( $r = 0,59$ ) and intrinsic value ( $r = 0,53$ ) were significantly associated with higher levels of self-regulation.

**Table 5.6**

**Summary Statistics and Correlations between Scores on Measures of Self-Regulation, and Self-Regulated Instruction (SRI) and Teacher-Regulated Instruction (TRI).**

---

Variable	1	2	3
1. Self-Regulation	-	0,29 *	0,22
2. SRI		-	0,76 ***
3. TRI			-
M	52,6	59,5	44,2
SD	7,7	14,3	13,3

---

Note. N = 53 \* p < 0,05 \*\*\* p < 0,001

Higher levels of self-efficacy ( $r = 0,39$ ) and intrinsic value ( $r = 0,57$ ) were significantly associated with reported cognitive strategy use. These findings are presented in Table 5.7.

### 5.9.2 Associations between Motivational and Instructional Control Variables

The posttest performances (recorded on page 120) reflect the academic learning outcomes of the type of instruction received by learners. It was anticipated that self-efficacy scores and intrinsic interest scores, as measured using the Motivated Strategies for Learning Questionnaire, would be positively associated with performance scores and, furthermore, that these motivational learning variables would be differentially associated with the type of instruction. Such associations are recorded in Table 5.8.

Higher levels of self-efficacy ( $r = 0,40$  and  $0,39$ ) were associated with higher levels of achievement after, respectively, self-regulated instruction and teacher-regulated instruction in both posttests. Surprisingly, intrinsic interest scores were more associated with posttest scores after teacher-regulated instruction ( $r = 0,37$ ) than self-regulated instruction ( $r = 0,31$ ).

Table 5.7

Summary Statistics and Product Moment Correlations for Motivation and Self-Regulated Learning Variables.

---

Variable	1	2	3	4
1. Self-Efficacy	-			
2. Intrinsic Interest	0,63***	-		
3. Strategy Use	0,39**	0,57***	-	
4. Self-Regulation	0,59***	0,53***	0,50***	-
M	4,47	4,91	4,83	4,63
SD	1,09	0,96	0,81	0,77

---

Note. N = 55    \*\* p < 0,01    \*\*\* p < 0,001

Table 5.8

**Summary Statistics and Product Moment Correlations for  
Motivational Learning Variables and Academic Posttest Scores  
after Differential Instructional Control**

Variable	1	2	3	4
1. SRI	-			
2. TRI	0,76 ***			
3. Self-Efficacy	0,40 **	0,39 **	-	
4. Intrinsic Interest	0,31 *	0,37 **	0,63 ***	-
M	59,5	44,5	4,53	4,93
SD	13,7	12,1	1,03	0,96

Note. N = 54 \* p < 0,05 \*\* p < 0,01 \*\*\* p < 0,001

SRI - Self-Regulated Instruction

TRI - Teacher-Regulated Instruction

The performance levels after both types of instruction were significantly and highly associated with each other ( $r = 0,76$ ,  $p < 0,001$ ). Because performance after self-regulated instruction has been shown to be significantly better than that after teacher-regulated instruction, this correlation suggests that instructional type did not produce a disordinal interaction between learner aptitude and performance.

### 5.9.3 Associations between Effort, Ability, and Performance

A cursory inspection of credit total and posttest scores after self-regulated instruction suggested that task-engagement may have impacted on the performance of learners. This unconsidered, but logical conclusion, was explored by computing correlations between effort and ability, as determined from three previous examinations, and posttest performance after self-regulated instruction. The results are presented in Table 5.9.

However, when partial correlations were computed, significant associations between effort and experimental posttest performances were obtained by the first experimental group (partial  $r = 0,53$ ;  $p < 0,01$ ).

Table 5.9

Summary Statistics and Product Moment Correlations between Effort, Previous Examination Performance (PEP), and Academic Posttest Performance (PP) for Experimental Treatments.

	Cycle 1			Cycle 2		
	1	2	3	1	2	3
	1 Effort		0,42 *	0,64 ***		0,50 *
2 PEP			0,61 **			0,63 ***
3 PP						
M	77,3	55,2	61,2	67,4	55,2	55,5
SD	13,3	9,8	13,7	14,2	10,0	14,0

Note. N = 24 \* p < 0,05 \*\* p < 0,01 \*\*\* p < 0,001

Higher levels of effort were also associated with higher levels of performance in the second cycle, but when controlling for previous examination performance, a low non-significant correlation between performance and effort was obtained ( $r = 0,27$ ;  $p > 0,05$ ).

## 5.10 Summary of the Results

### 5.10.1 Hypothesised Results

#### H<sub>0</sub> 1 Self-regulation versus teacher regulation

There will be no significant difference between the mean posttest scores of pupils receiving biology learning content in an environment where they perceive they regulate their learning, and those in an environment where traditional teacher regulation of instruction occurs.

The t-test for matched samples indicates that the experimental groups in both cycles significantly ( $p < 0,001$ ) outperformed the control groups. Thus H<sub>0</sub> 1, is refuted.

## **H<sub>0</sub> 2      Control locus and learner regulation**

There will be no significant difference between the mean posttest scores of pupils with an internal locus of control and the mean posttest scores of learners with an external control locus who receive identical biology learning content in a self-regulated environment.

The ANOVA indicates that internals significantly outperformed externals when self-regulating instruction, in the first cycle, but not in the second cycle.

The null hypothesis was therefore refuted when instructional content (**Excretion**) was delivered to the first experimental group, but not when content represented by **Gaseous Exchange** was delivered to the second experimental group.

## **H<sub>0</sub> 3      Internal control locus and instructional regulation**

There will be no significant difference between the mean posttest scores of learners with an internal locus of control, receiving biology learning content in a self-regulated environment, and those receiving identical learning content in a traditional teacher-regulated environment.

Self-regulating internals significantly outperformed teacher-regulated internals academically in the first and second cycles, thus enabling the null hypothesis to be rejected for both cycles.

**Ho 4 External locus of control and instructional regulation**

There will be no significant difference between the mean posttest scores of learners with an external locus of control, receiving biology learning content in a self-regulated environment, and those receiving identical learning content in a traditional teacher-regulated environment.

In both cycles, externals who self-regulated instruction outperformed their coevals receiving teacher-regulated instruction. The null hypothesis for both cycles was therefore refuted.

**Ho 5 Association: Self-Regulation and Locus of Control**

There will be no significant correlation between learner-reported measures of self-regulation and their locus of control scores.

Degree of internality of locus of control was significantly associated with higher levels of reported self-regulatory behaviour (albeit moderately). The null hypothesis was therefore rejected.

**H<sub>0</sub> 6 Association: Self-Regulation and Control Group**

There will be no significant correlation between learner-reported measures of self-regulation and posttest scores obtained by subjects after the application of traditional teacher-regulated biology instruction.

A low, non-significant association with performance after teacher-regulated instruction was obtained. H<sub>0</sub> 6 is therefore not rejected.

**H<sub>0</sub> 7 Self-Regulation and Experimental Treatment Posttests**

There will be no significant correlation between learner-reported measures of self-regulation and posttest scores obtained by subjects after the application of self-regulated biology instruction.

Higher levels of reported self-regulation were significantly associated with higher levels of academic performance after self-regulated instruction.  $H_0$  7 is therefore refuted.

#### 5.10.2 Unanticipated Findings

##### (a) Associations: Motivational and Self-Regulated Learning Variables

Among 55 pupils, high correlations between **Intrinsic Interest** and **Self-Efficacy** were significant ( $p < 0,001$ ) and positive ( $r = 0,63$ ). Moderate correlations were obtained with **Cognitive Strategy Use**, between **Intrinsic Interest** ( $r = 0,57$ ) and **Self-Efficacy** ( $r = 0,39$ ), and were significant ( $p < 0,001$  and  $p < 0,01$ , respectively). Moderate correlations with **Self-Regulation** were obtained between **Intrinsic Interest** ( $r = 0,53$ ) and **Self-Efficacy** ( $r = 0,59$ ), and were significant ( $p < 0,001$ ). **Cognitive Strategy Use** and **Self-Regulatory Use** were moderately correlated ( $r = 0,50$ ,  $p < 0,001$ ).

##### (b) Associations: Motivational Variables and Regulation

Among 54 pupils, the association between **Intrinsic Interest** and posttest performance scores after **Teacher-Regulated Instruction** was greater ( $r = 0,37$ ) than after **Self-Regulated Instruction** ( $r = 0,31$ ).

Moderate correlations were obtained between measures of **Self-Efficacy**, and **Self-Regulated Instruction** ( $r = 0,40$ ) and **Teacher-Regulated Instruction** ( $r = 0,39$ ). A high correlation was found between the academic posttest scores achieved under the two types of instruction ( $r = 0,76$ ,  $p < 0,001$ ).

(c) **Associations: Effort, Ability, and Academic Performance**

When controlling for previous examination performance (ability), a moderate correlation between **Effort** and academic posttest scores obtained after **Self-Regulated Instruction** for the first cycle ( $r = 0,53$ ,  $p < 0,01$ ), but a low, non-significant correlation was obtained after **Self-Regulated Instruction** for the second cycle ( $r = 0,27$ ).

## **CHAPTER 6**

### **DISCUSSION**

#### **6.1 Introduction**

The first section of this chapter is devoted to the interpretation of the results of the statistical analyses in terms of the purpose of the study, the hypotheses, and other related studies. A brief section will explore unhypothesized findings and the reader's attention will be directed towards limitations of the research findings. A defense of the design vis a vis internal and external validity will be undertaken. Finally, some suggestions for improving the current design will conclude the discussion.

#### **6.2 Interpretation of Results**

"The main part of intellectual education is not the acquisition of facts, but learning how to make facts live."

- O.W. Holmes (1886)  
(quoted from Tripp, 1970)

##### **6.2.1 Statistical and practical significance**

Before discussing the findings, several points concerning interpretation are noted.

1. Rejection of a null hypothesis does not prove the hypothesis; it merely supports it.
2. The value of an investigation is constrained by the nature of the conditions and context under which the study was carried out.
3. Despite hypotheses being significant at the required level ( $p < 0,05$ ), the nature of the study restricts possible generalisation of the findings to populations similar to the one used in this study.
4. Tests of significance support internal validity, but do not "prove" causality. They do not reveal the effects of the intervention and they do not, in themselves, increase external validity. A finding which is statistically significant is not necessarily educationally significant.

6.2.2 The following observation has been made by Messick (1970:183) regarding the criterion problem - in this case, the posttest scores - when evaluating instruction:

"Traditional questions in education ... have frequently spawned answers that are either wrong, since they summarise findings 'on the average' in situations where a hypothetical 'average person' does not exist, or else are seriously lacking in generality because they fail to consider the multiplicity of human differences and their interactions with environmental circumstances."

Such questions are typically concerned with the empirical comparisons in average gains in specific performance of learners receiving one treatment, with those receiving another treatment. It is true that, depending on the mix of learners in the groups, a group average analysis might demonstrate negligible mean differences in gain or loss, while very significant effects regarding individuals might have occurred. Had this investigation considered only treatment effects, the above objection would have been pertinent.

However, Messick (1970:184) has also pointed out that assessment of treatments in terms of their effects on individuals requires the measurement of affective and environmental variables, and not merely achievement levels. The present investigation is consonant with this recommendation: it incorporates both an affective variable locus of control and an environmental one namely, choice.

An analysis of association effects between locus of control (affective domain) and academic performance (cognitive domain) after differential treatments produced no interactive effects, suggesting that learners differing in control locus were not disordinally affected by treatment variables. Despite improved performance for all learners, regardless of locus of control disposition, internals appeared to benefit more.

In the light of this, the research design is considered to be an improvement on traditional designs which often ignore initial affective variables' influence on achievement outcomes when examining effects of differential treatments (Messick, 1970:184). This has evoked some comment on (a) personal characteristics that may interact with treatment variables to moderate learning, (b) dispositions to be monitored to detect possible undesirable side effects of instructional variables, and (c) qualities to be fostered as specific objectives of self-regulation.

### **6.3 Programme Purpose: Confirmatory Remarks**

The declared intention was the study of the application of a self-regulated instructional programme fostering learner responsibility in the self-management of learning processes during lesson time, in relation to academic performances, anticipated to be appreciably better than those obtained under traditional instruction.

Direct measurement of learner-responsibility as a dependent variable is complex, and beyond the scope of this thesis research. However, the statements of two participants, and the responses by 43 others (77% of the sample) to an informal questionnaire (in Appendix E), are helpful in gauging learner impressions of the programme. Other subject statements are included in Appendix I.

They are also useful as indicators of learner perceptions of learner-responsibility, fostered by the intervention.

Participant responses:

"The program was helpful in that you get involved in the chapter and are 'forced' to concentrate and participate in the work."

(Kevin)

and

"The program was (to me) an easier way of learning. The ... work load was sufficient to keep the pupils busy for the entire lesson. No time is wasted during the lesson and the pupil is compelled to do his/her work."

(Simon)

Questionnaire responses

The questionnaire included the questions below. The percentages in parentheses indicate the number of respondents affirming "... most ..." , or "... all of the time."

"In your opinion, did this programme ...

- (1) make you feel more responsible concerning your classwork? (79%)
- (2) expect you to manage (control) the learning yourself? (93%)
- (3) make you take more responsibility for your work?" (91%)

It is evident that, in the eyes of the most critical evaluators - the learners, the instructional purpose of the intervention (to foster self-responsibility i.e., self-regulated behaviour), was largely achieved.

The usefulness of the specific instructional methods and materials used in the investigation is underscored by the demonstration of the significantly better academic performances achieved under conditions of self-regulated instruction.

#### **6.4 Programme Prospects: Self-Regulation**

The findings of this study with regard to the enhanced academic performances of self-regulated groups hold exciting prospects for classroom instruction with senior average-to-strong achievers (i.e., higher graders).

Singh (1992) investigated the ability of gifted standard nine pupils to study Accounting at an advanced level, without the direct intervention of the teacher, using self-regulatory learning strategies. Academic performance was the basis of comparison. His findings indicated that gifted pupils who self-regulated performed as well as the pupils receiving direct instruction from a competent teacher.

Whilst Singh's investigation explored the relatively restricted, and instructionally difficult, terrain of gifted education (homogeneous), the findings of this study suggest that instructional programmes supporting self-regulatory behaviour are a realistic consideration for academically average-to-high (heterogeneous) achieving groups.

The intervention incorporated four learning processes which prompted learners to engage in self-regulated learning. These processes were operationalised during instructional time by using in-text guidance devices that included introductory explanations, directions for studying, learning objectives, central concept emphasis, problem-solving exercises, summaries, and self-tests with immediate feedback - principally to promote, support and guide learners in self-study (Vermunt and Van Rijswijk, 1988:647). The processes are listed, and defined as follows.

(a) **Encoding** refers to the cognitive processes of selection, comprehension, storage, and retrieval (Cook and Mayer, 1983, cited by Nist, et al., 1991:857). These mental processes are typically utilised by pupils who are self-regulators.

- (b) **Word meaning** defines the differential ability to comprehend texts. Comprehension is strongly influenced by knowledge of word meanings (Nist, et al., 1991:858, cite Stahl, 1983, Mezynski, 1983).
  
- (c) **Organizing**, as a self-regulatory learning process, requires a linking of concepts within a text and the relating of such ideas to prior knowledge. Implicit in this process is self-monitoring and self-testing, activities actively engaged in by self-regulated learners.
  
- (d) **Executive control** is an important aspect of metacognition, the coordination and control of cognitive learning strategies essential to self-regulators.

During the course of the self-regulating intervention, learners needed to utilise these key learning processes. The general competence with which learners were able to engage in learning activities, and successfully complete them, allude to the likelihood that the learners in this study were appreciably able to self-regulate their instruction.

## 6.5 Findings regarding Locus of Control

In chapter one questions were posed which addressed the qualitative nature of learner attributes that supported self-regulation. The construct locus of control, as a learner motivational attribute, has been explored. The next sections reflect on the findings associated with the relevant hypotheses.

### (a) Control Locus and Self-Regulation

Performances indicated that pupils predisposed to an internal control locus outperformed externals under conditions of self-regulated instruction. Despite the significant difference in performance between internal and external learners after self-regulated instruction, the difference between these matched cohorts after receiving teacher-regulated instruction, was negligible. A similar trend was evident in the second cycle. This suggested that in this investigation, self-regulated instruction was more advantageous to internals, confirming expectations that internals would benefit more than externals from self-regulated instruction.

One reason may be the novel aspect of the experimental intervention programme, confirmed through informal discussions with the pupils, and independent observers.

Social learning theorists (Phares, 1976; Rotter, 1966, cited by Klein and Keller, 1990) have suggested that (internal) locus of control may be particularly influential in (positively) influencing learner performance in unfamiliar circumstances.

Some learners regularly confronted with novel situations are prone to **learned helplessness** (Henderson, 1986:416), and focus on previous external or internal states, such as poor past performances, or performance anxiety. They are prone to what Kuhl (1985) - cited by Corno (1986:335) - called a **state-orientation**. They view **outcomes of their actions under such (novel) circumstances as outside their personal control**. Such learners are characterised as external in their locus of control perceptions (Clark, 1988: 317). A statement from such a learner in the biology class in August 1992 illustrates this.

**"You should try to ensure that the pupils do their notes so as to prevent them from falling behind."**

(Werner)

The words in bold print clearly depict a dependence on the biology teacher to take responsibility for ensuring that pupils do not "fall behind". In other words, the pupil interprets the possible **outcome** (falling behind) of **pupil behaviour** (failure to take notes) during **self-regulation** (novel circumstances) to be determined by teacher initiative, rather than pupil initiative.

This learner achieved 37% after the intervention and 40% after traditional instruction. Although the learner is clearly a low achiever, the lower score after self-regulation is in stark contrast to the improved scores of other external learners, 79% of which obtained higher scores after self-regulated instruction.

Under self-regulated instruction, internals in the first cycle demonstrated greater effort and outperformed externals. When correlations between performance after self-regulated instruction and effort were computed, greater effort during the intervention was associated with greater levels of performance.

These findings supported the hypothesis that internals would outperform externals in a self-regulated environment. The unfamiliar nature of the intervention may have disadvantaged some learners more than others. It is therefore recommended that **descriptive comment** from all learners be analysed after implementing self-regulated instruction for the first time, to ascertain whether novelty and strangeness may have been disadvantageous for some.

#### (b) Control Locus and Differential Instruction

Externals who self-regulated, outperformed externals receiving teacher-regulated instruction.

Some writers (Daniels and Stevens, 1976:103; Parent, et al., 1975:764) have alluded that externals receiving teacher-regulated instruction would outperform externals who self-regulated instruction. Because of its emphasis on autonomous learning, self-regulation could arguably increase anxiety (Allen, et al., 1974:968) in teacher-dependent, or external locus of control, learners.

The findings for many learners in this study were contrary to those cited above. The effects of the treatment appeared to mask the sensitive effects of control locus on performance of pupils with externality perceptions. This suggests that self-regulated instruction did not disadvantage externals. Other realities may explain why externals performed better when self-regulating.

The findings have indicated that internals who self-regulated performed better than their coevals learning under teacher-regulated instruction. Also, externals who self-regulated outperformed internals receiving traditional instruction.

Teacher behaviour towards learners is a major determinant of children's perceived control (Skinner, et al., 1990:23). One teacher behaviour is the provision of contingent (reinforced) feedback, necessary for perceptions of control.

When feedback was non-contingent, or absent, loss of perceptions of control occurred (Skinner, et al., 1990:23; Magnusson and Perry, 1989:362 citd Perry and Dickens, 1984). Self-efficacy theory has also posited that messages of competence to learners, can lead to higher levels of learner self-efficacy beliefs (Gorrell and Capron, 1988:123).

**Impositional behaviour** by the teacher under traditional instructional conditions may be construed by the learner as threatening, or frustrating, leading to a sense of loss of control and anxiety (Dowaliby and Schumer, 1973:126).

It is clear that, under certain conditions, teacher attitudes and/or behaviours can interfere with learning. Self-regulation removes the teacher from "centre-stage", thereby reducing possibilities of interference. This may offer some explanation for the improved performances of externals who self-regulated.

Accordingly, learners' self-efficacy beliefs may decline, resulting in lower levels of motivation, effort, and performance (Licht and Kistner, 1986, cited by Schunk, 1990:3). It is plausible that learners, desiring to assert control, may subconsciously reduce effort, and thereby legitimize possible failure (Jagacinsky and Nicholls, 1990:15) by attributing it to lack of effort, rather than to lack of ability (Schunk, 1990:4).

Because effort is largely under the learner's control, self-sanctioning of effort could be one strategy used by internals for maintaining percepts of self-control in a traditional learning environment. Internals, desiring control over their learning, might be motivated to engage less in a traditional lesson.

The opportunity for self-management may have provided the necessary incentive for greater engagement, reduced the incidence of non-contingent feedback and messages of incompetence, and resulted in greater motivation to perform. The findings concur with other studies that report increased academic performance, when learners are actively engaged, have percepts of control, and enjoy greater autonomy for learning (Skinner, et al., 1990; Tobin and Capie, 1982, cite Lomax and Cooley, 1979, Hecht, 1978, Cobb, 1972, Samuels and Tenure, 1974; Wang and Stiles, 1976; Zimmerman, 1989; Deci, et al., 1991; McCombs and Whisler, 1991).

## 6.6 Limitations Of These Findings

On the basis of their findings regarding perceived control and engagement, Skinner, et al., (1990:31) have suggested that, although predicted relations between perceived control and engagement were found, the amount of variance in engagement was small.

They argued that consideration of two other self-system processes occur namely, **perceived autonomy** and **relatedness** (socioemotional support). The importance of these variables for optimal self-regulation was noted earlier.

This study measured the construct **locus of control**, comprising a general set of beliefs. This generality has prevented the inference of specific causal relationships. Since engagement is likely to be heightened by the reciprocity in relations between increased relatedness, feelings of autonomy, and perceived control, it is recommended that these variables be intentionally incorporated into a self-regulated instructional programme.

Intuition suggests that the treatment inclusion of these variables may account for some of the variance in performance. How much can only be known by specifically measuring **perceived control**, **feelings of autonomy**, and **relatedness**, and subjecting them to multivariate and regression analyses. It is recommended that this be addressed by future research.

#### **6.7 Associations: Self-Regulation and Control Locus**

Correlations between reported strategy use and posttest performance after self-regulated instruction were significant and low, but not significant when correlated with teacher-regulated instruction.

Although causal relationships are not inferred, the moderate correlation between self-regulated strategy use and higher scores (internality) of control locus, support the findings that learners with an internal locus of control performed better than externals when self-regulating instruction. The calculation of correlations between the motivational learning variables and type of regulated performance yielded no differential associations.

No evidence existed that the motivational learning variables were differentially associated with the nature of regulated instruction. However, learners who reported greater self-regulatory strategy use were more likely to be internal in their control locus, and performed better after self-regulated instruction than non-strategy users, and externals.

These findings are tenuous. More confirmatory work is required to substantiate beliefs that self-regulators are more internal in control locus, and more effective as learners when they are engaging in self-regulated instruction.

## 6.8 Unanticipated Findings

A t-test for independent data indicated no significant difference between mean test anxiety scores of internal and external locus of control learners.

These findings suggest that test anxiety did not influence the outcomes of the posttest performances of learners with differential control loci. This appears to be a reversal of the results reported by Allen, et al., (1974:968) that external locus of control learners performed more poorly on written examinations.

Other findings, cited by Pintrich and De Groot (1990:38), indicated that, for test-anxious learners, anxiety during examinations engendered worry about their capabilities, and interfered with performance.

Tenuous results suggest that effort, as measured by the accumulated credits, is related to performance levels after self-regulated instruction. Since credit accumulation is under the learner's control, it represents a quantifiable measure which can be used to assess levels of engagement. Furthermore, possible relationships between self-beliefs of efficacy, intrinsic interest, self-regulation, and effort, should be explored.

## 6.9 General Limitations

Fortunately, despite the small sample ( $Ss = 48$ ) and relative inadequacy of the IAR reliability coefficient ( $r = 0,63$ ), statistical significance generally enabled rejection of the null hypotheses implicating control locus.

However, the findings implicating locus of control cannot be validly generalised until validated using more reliable measures of control locus and larger samples.

## **6.10 A Critique of the Research Design**

In this section a brief review is undertaken of the particular strengths of the research design, and possible threats to its internal and external validity.

### **6.10.1 Internal Validity**

Slavin (1984:109) has listed several potential threats to internal validity. Those likely to impact on this study have been considered.

#### **(a) Selection Bias**

Slavin (1984:112) explains the lack of sample equivalence as a common cause for low internal validity. Considerable effort was devoted to this problem due to the constraints of the intact classes and the inflexible nature of the school timetable.

The use of an alternating measurements design ("flip-flop") implied the utilisation of the same subjects under both treatment conditions.

The advantage of eliminating the effects of extraneous variables by using each subject as his or her own control is obvious. Sax (1979:136) has pointed out that the advantage of the repeated measurements design over randomisation occurs only if the association between the experimental and control scores is positive and high. Product moment correlations reflected in Table 5.8 confirmed that this requirement was met ( $r = 0,76$ ,  $p < 0,001$ ).

The further division of each class sample into equivalent cohorts necessitated matching of learners. The use of intervals - when subject IQ, or aptitude, is high or low, following Mulder (1982:5) - was helpful in classifying subjects. However, Sax (1979:139) pointed out that the elimination of extreme scores, or the elimination of subjects who are not matched, leads to biased sampling. It was fortunate that in this investigation the samples were largely homogeneous reducing the need to "interfere" with the samples in the matching process. Relatively few subjects (eight, or 14%) were bracketted out of the statistical analysis, to employ homogeneity in sample comparison. Finally, means and variances were computed and compared. In this investigation, means were used only to confirm that group equivalence had been, relatively speaking, attained.

(b) **Attrition**

The relatively short duration of the treatments minimised the accumulative impact of absenteeism. It was fortunate that all subjects were present when the posttests were written. In only one case did a continual bout of absenteeism by one subject compel the writer to ignore this subject's data when computing some of the motivational learning variables associated with the Motivated Strategies for Learning Questionnaire.

(c) **Measures used**

This study, and others, have been undermined by the instrumentation (locus of control) possessing only moderate internal reliability thus presenting as much a confounding variable as any other mentioned.

The high reliability coefficients reported for the Motivated Strategies for Learning Questionnaire needed to be more widely validated. Results in this study compared favourably with those reported in the literature.

The very high reliability coefficients for both posttests indicate that the latter appear not to undermine validity.

(d) **Class Effects**

One problem in this study was the subjects' status as final year matriculants. Whilst their use as subjects ensured cooperation during the investigation, the writer was particularly aware of the sensitive nature of their preparation for the final school-leaving examinations, and was understandably reluctant to "tamper" excessively with their instruction. This limited the exploration of 'informal' hypotheses formulated as the investigation continued. It is recommended that this study be replicated preferably using pupils in standard eight (10<sup>th</sup> year) or nine (11<sup>th</sup> year).

(e) **Teacher effects**

Experimenter bias in this study is a justifiable objection regarding internal validity. Since assurances of minimal disruption had to be given (letter requesting permission - Appendix K), the introduction of a new teacher could have threatened the future of the investigation.

However, all reasonable precautions were taken to minimise biased teaching e.g., numerous teaching aids with control groups, independent observers (and the everpresent threat that learners could leave if they sensed their instruction was being compromised!)

### 6.10.2 External Validity

Examples of threats to external validity may include:

#### (a) Artificiality

A major purpose was the response to calls for a field validation of theoretical findings. The authentic context of the study is, arguably, one of the strengths of the investigation.

#### (b) Reactivity: Hawthorne Effect

The possibility of a Hawthorne effect should be considered.

Despite the authenticity of the instructional context, the subjects were aware that their instruction was different. Informal interviews conducted on an ad hoc basis, suggested that two possible responses could be attributed this novelty.

- 1) The uncertainty associated with the "unproven" nature of the intervention, coupled with the realisation that the content would not be "re-taught", made some learners apprehensive of the outcomes. This concern may have motivated some learners to increase commitment and caused others to lose interest.

- (2) Some learners were clearly excited about the programme and its objectives (less homework; less teacher talk; more choice; greater variety, etc.), and were consequently, highly motivated. To balance this, some of their peers may have felt intimidated by the rivalry of this sudden enthusiasm.

However, Sax (1979:142) cited findings by Cook (1967), that Hawthorne effects are not as pervasive, nor as influential as are sometimes made out.

(c) **Non-representativeness**

With the exception of eight pupils, all senior higher grade biology pupils were involved in the treatments. It is therefore probable that the sample is a good reflection of the population delimited.

**6.11 Suggested Improvements for Follow-up Studies**

- (a) By extending the duration of the treatment, the influence of novelty would diminish, although problems of incomplete data collection may arise with increasing absenteeism.
- (b) Task choice as a variable should be experimentally manipulated within a self-regulated instructional design.

- (c) An independent (impartial) instructor could be used, to reduce prejudicial experimenter effects.
- (d) Posttests formulated by an independent examiner could also minimise experimenter bias.
- (e) The selection of control locus scores one standard deviation above and below the mean would have permitted greater distinction between learner loci of control. However, under the current circumstances this would have significantly reduced sample size, and increased the chances of a Type II experimental error (false negative error caused by being unable to refute the null hypotheses). A larger sample would eliminate this problem.
- (f) The use of a more reliable instrument than the Intellectual Achievement Responsibility Questionnaire could reduce Type II error, by creating meaningless variation, thereby improving the chances of finding statistically significant results.
- (g) The provision of an inventory characterising "traditional" teaching behaviours would have been helpful in describing specific differences between teacher behaviours during the intervention and traditional treatments.

## 6.12 Chapter Conclusion

Previous research, and the outcomes of the present intervention, have indicated the educational value of self-regulated instruction in senior biology. This has also been endorsed by the remarks of participants.

In contrast to a laboratory-controlled study, the authentic setting likely increased external validity. However, the strongest support for any research hypothesis comes by replicating the results. The counterbalanced design provided such a replication - two separate self-regulated groups received separate content, at separate times, wrote different criterion-referenced tests, and demonstrated significantly greater performances than when they themselves were traditionally instructed.

Finally, notwithstanding some corroborative contribution to theory, the fact that the findings appeared to have practical significance - as many learners working towards passing their final school examinations - was expressed aptly by one pupil: -

"The program is very good (brilliant). I find it easier to learn the sections than any others in the book."

## CHAPTER 7

### IMPLICATIONS OF THE STUDY

#### 7.1 Introduction

The issues raised through this investigation have direct, and indirect implications. The former emanate from the observations during the interaction phase, and the findings during the evaluation phase. The latter flow from observations made during the pre-active (preparatory) process, prior to application. These are discussed within the context of the role of the teacher.

#### 7.2 Direct Implications

7.2.1 On the basis of the empirical findings, a confident recommendation is made for further exploration of the effectiveness of the intervention with other groups of Year 12 biology learners, e.g., standard grade (slower learners). It should not be inferred that self-regulatory instruction must replace traditional instruction. Rather, the findings suggest that it has a valuable contribution to make alongside more conventional instruction.

7.2.2 Learner locus of control appears to bear a greater relationship with academic performance after self-regulation than after traditional instruction.

The identification of learners disadvantaged with regard to their control perceptions is recommended prior to the application of self-regulatory instruction. The use of the IAR to assess learner perceptions of control prior to the application of self-regulated instruction is suggested. Covert monitoring of all learners in general, but of externals in particular, would enable greater socio-emotional support to be provided to learners needing such support.

7.2.3 Instruction guided by incorporating self-regulatory elements into traditional instruction prior to application of a self-regulatory programme appears to be helpful in assisting learners to make the transition towards self-regulation.

7.2.4 The assumption that a high teacher-learner ratio (e.g., 1:35) necessarily affects learning detrimentally, should be qualified; it depends on various factors. The extent of active learner engagement seems, intuitively, to be particularly influential. Self-regulation promotes this variable, suggesting that individuals in groups who are able to self-regulate are not adversely affected by large class sizes, if afforded the freedom to do so.

- 7.2.5 The opportunity afforded by self-regulated instruction, particularly within a biology context, for a "hands-on" experience is important. Practical work by final year learners, often neglected by teachers under pressure to complete syllabus requirements, can be successfully implemented within the time-frame of the syllabus.
- 7.2.6 Given administrative pressures on teachers to produce increasingly higher standards, the tendency to become more controlling (Deci, et al., 1991:340 cites Deci, et al., 1982) can be successfully alleviated by yielding greater control of learning through self-regulation.
- 7.2.7 The presence of the learning centres for the duration of the intervention reduced the effects of learner absenteeism by affording "after-hours" opportunity to complete missed work in the case of one or two individuals.
- 7.2.8 A final observation of the writer's experience was the minimal expenditure of time and energy in **maintaining** the learning climate. Stress, and consequent fatigue, were considerably reduced, compared with traditional instruction.

### 7.3 Indirect Implications

7.3.1 The teacher as instructional planner is responsible for organising and transforming the learning environment to optimise self-regulation.

Important considerations are meeting learner (age-linked) needs for choice (McCombs and Whisler, 1989:299), task flexibility, self-monitoring, peer tutoring, learner initiated requests for assistance, a variety of learning materials, task-specific instructions, and learning objectives.

It is believed that additional aspects were addressed during the intervention. These included: challenge (Palardy, 1990:90; McCombs and Whisler, 1989:299), absence of competitive elements (Clark, 1988:319), learner-paced instruction (Ornstein, 1991:115), the absence of social distractors (Chernick, 1990:695), and maximum time-on-task (Thomas, 1980:214 has cited McDonald, 1976, Medley, 1977, Stallings and Kaskowitz, 1974, and Harnischfeger and Wiley, 1976).

7.3.2 The teacher as evaluator, should guide learners towards the standards congruent with their potential.

Goals and standards, agreeable to the learner, are key dimensions in the self-regulated process (Schutz, 1991:55). Continuous assessment of learner activities, their use of instructional materials, thinking processes, and the holding to accountability of contracts by learners regarding selected grades, represent the evaluation of the process of learning, rather than the product. Such continuity in assessment is consonant with self-regulation.

7.2.3 The teacher as instructor considers pupils to be unique learners.

The intentions, memories, attitudes, and feelings brought by the learner into the learning situation may influence understanding considerably (Rhetts, 1974:339). Learners tend to learn and remember information which they actively construct mentally during instruction (Wittrock, 1981: 12), seeking learning which is inextricably linked to their own world of meaning (Burns, 1989:34; Hurd, 1991:33).

New information is given meaning as the brain processes it, recreating unique patterns of its own (Caine and Caine, 1990:67). Because the brain actively enters into the construction of meaning, learners and teachers have differentiated responsibilities for learning (Wittrock, 1981:13; Novak, 1985).

7.3.4 The teacher as trainer should be a role model for self-regulation.

Modeling is a major component of instructional processes deemed expedient for teaching self-regulation (Henderson, 1986:412). It has included verbalisation of thought processes, demonstrations, and role-play (Schunk, 1991:216). Skills associated with self-regulation, such as planning, self-monitoring (Wang and Peverly, 1986:392), and goal-setting (Schunk, 1983:93; Bandura and Schunk, 1981; Schunk, 1991:213) can be successfully demonstrated through modeling (Zimmerman, 1989:335). The ability to be a successful model stems from an innate desire on the part of the teacher to be self-regulatory. As such, ...

"The teacher of integrity works constantly to improve him/her self as a person and as a member of the profession by maintaining high standards of personal conduct, by continuing to grow professionally ... by cultivating an appreciation for the best in our culture, and by continuous self-evaluation."

- (Alcorn, et al., 1979:14)

7.3.5 The teacher as educator should empower learners to pursue life-long learning.

When learners begin to accept responsibility for learning outcomes, the ideal of lifelong learning is attainable.

Novak (1985:202), citing Gowin (1981), points out that the misconception that teaching causes learning is widespread; learning is a responsibility that cannot be shared, and learners should be guided to the realisation that sustained effort and overcoming failure are connected (Stipek and Weisz, 1981:130).

7.3.6 The teacher as counsellor must attend to the whole learner: self, metacognitive, cognitive, affective, behavioural, social and spiritual.

A learning environment fostering self-regulation must recognise the centrality of the interpersonal atmosphere existing between learners and adult (Ryan and Powelson, 1991:64). Teachers should exhibit respect, non-contingent regard, care, and acceptance in their socio-emotional support for learners.

Whisler (1991:22) has cited observations of Stewart (1984) that when learners were in a relaxed, positive state of mind, information processing occurred objectively, problem-solving skills were evident, and sound judgement was exercised. It is recommended that persistent attempts be made (by the teacher) to reduce anxiety, and learner stress (Womack, 1989:208; Caine and Caine, 1990:69).

### 7.3.7 The teacher as **subject specialist**

The teacher as subject specialist should be a learner-for-life. Some examples, selected from Degenaar (1986:7-8), that the biology teacher, as subject specialist should consider include,

- (a) Expansion of personal subject knowledge;
- (b) Consolidation and reinforcement of personal knowledge;
- (c) New teaching methods;
- (d) Self-development;
- (e) Self-evaluation;
- (f) Self-determination;
- (g) Curriculum development.

### 7.3.8 The teacher as both **resource**, and **resource mediator**

Resource-based learning is an imperative for self-regulation (Haycock, 1991:16). Resource-based learning has been shown to maximise learner involvement, and to facilitate the use of metacognitive strategies, student-centred activities, and cooperative learning (Gee and Rakow, 1991:109). Consequently, as learners are supported in adopting greater responsibility in previewing, analysing, and organising information, they become more autonomous (Grossnickle, 1989:4).

### 7.3.9 The teacher as facilitator of self-regulation

It has been mooted that teaching processes which develop abilities to learn independently have represented an important aim in teaching (Isaacs, 1990:85). Part of this learning has involved the development of self-motivational, and self-controlled, behaviours by learners which can be learned, or developed with practice, experience, and guided instruction (Stipek and Weisz, 1981:101; Grossnickle, 1989:4).

## 7.4 Conclusion

Whilst locus of control has been implicated in improved academic performance, the opportunity afforded learners to engage actively in learning may have been more important for improved performance. More empirical support is needed. Self-regulated instruction needs to be less a state of the art, and more a state of the practice, in classroom teaching. The findings have alluded to the educational value of developing the will and the skill for learning in an intentional way. Yet without a commitment on the part of educators, in particular teachers, to implementing such instructional practices, the implications of these findings will remain largely of academic interest.

## CHAPTER 8

### RECOMMENDATIONS

An apparent paucity of extant research on self-regulation under naturalised conditions within the South African context suggests a fertile field for further exploration. Suggestions for future research areas are now listed.

- (a) Since learners differ in the degree to which they assume, or are able to assume, responsibility for their learning, effort should be devoted to identifying the affective characteristics of successful self-regulators. Broader knowledge of the nature of these attributes is needed to facilitate a competent diagnosis of aspects of learner ineptitude regarding self-regulation.
  
- (b) The extent to which self-regulated behaviour represents a **developmental task**, is unknown. For example, is mental age a significant predictor of successful self-regulatory behaviour? Is there a lower age limit for the emergence of effective self-regulated behaviour? Can the teaching of self-regulatory skills begin with entry into primary school? Is self-regulated instruction limited to academic achievers? Prudent decisions regarding the implementation of self-regulated instructional designs earlier in the life of the school child can be based on answers to these questions.

- (c) Identification of possible educator resistance to the promotion of self-regulation is required. Reactionary attitudes could negate efforts to implement self-regulation, if such attitudes are not understood.
  
- (d) Since self-regulated behaviour is consonant with the attributes needed for successful scientific endeavour, further explorations on the application of self-regulated instruction to other scientific disciplines such as Physical Science and Mathematics are recommended.
  
- (e) As locus of control appears to be a variable which significantly impacts on self-regulated instruction, the need for a more refined, validated, and internally reliable instrument than the IAR is needed to assist in confirming the provisional findings of this study.
  
- (f) The findings, and those by Singh (1992), suggest promising possibilities for the investigation of self-regulated instruction during team teaching, accelerated learning, or large groups.

- (g) Weiner (1974) proposed that locus of control would be more correlated with factors such as attitudes, ability, effort, task difficulty, and luck, than with academic performance (Keller, et al., 1978:415). The Intellectual Achievement Responsibility Questionnaire did not examine such beliefs. Consequently, research on the relationship between locus of control and these beliefs within the context of self-regulated instruction is needed.
- (h) Research on brain function during learning suggests that sequential teaching may impede understanding (Hart, 1978; Nummela and Rosengren, 1986; Caine and Caine, 1990). In the present study, the random attending of learning centres by pupils in the experimental groups made the linear delivery of content impossible, i.e., the sequence of lessons for the duration of the intervention were "haphazard" in that they did not follow the sequence of the textbook. Yet, this did not appear to disadvantage comprehension of the overall content. This variable may have been advantageous for some pupils, but not for others. The possibilities for further exploration are exciting.
- (i) More confirmatory work is required to substantiate beliefs that self-regulators are more internal in control locus, and more effective learners when engaging in self-regulated instruction.

- (j) By specifically measuring perceived control, feelings of autonomy, and relatedness, and subjecting them to multivariate and regression analyses, greater insights into how these variables impact on self-regulated instruction can be gained.
  
- (k) Discrepancies between what respondents report they do, and what they actually do, confound attempts to use self-reports as measures in assessing learner beliefs. The use of credits as a quantifiable measure of learner-volition and effort suggests a pragmatic solution to this problem. It is therefore recommended that this variable be evaluated in conjunction with self-reports of learner beliefs, and academic performance.

Finally, the value of the intervention rests in its potential application to a variety of research problems regarding self-regulated instruction.

## **CHAPTER 9**

### **CONCLUSION**

This investigation has in part, been a practical response to recommendations by other workers in the area of self-regulated learning. A short-list of the specific recommendations which this study addressed, with a brief account of the pertinent findings in each case, is presented. Key points regarding self-regulated instruction are listed, and serve to conclude this work.

- 9.1 (a) "The overall goal ... involving instructional design experimentations is to build a research base for creating supportive school environments and identifying effective intervention strategies to foster the development and use of self-instructive skills by students as a way of maximising their chances for success in school learning."

- (Wang and Peverly, 1986:396)

and ...

- (b) "... what may be required is an instructional procedure (self-regulated learning) replete with tasks for which strategies have some payoff, and ... a deliberate attempt to teach and/or allow for the discovery of varieties of cognitive strategies appropriate to the use of these tasks."

- (Thomas, 1981:236)

This thesis has responded to the research recommendations of the writers cited above by implementing, and testing, an instructional design that ensured opportunities for learners to develop the necessary will and skill in using self-regulatory learning strategies during classroom time.

The findings support the value of the intervention regarding self-regulated instruction and enhanced academic performance. However, more work to validate this design's contribution to self-regulation is recommended by applying the intervention with other samples in populations different from this study, i.e., disadvantaged learners, younger learners, or multicultural groupings.

Furthermore: -

9.2 (a) "... the affective dimension must be addressed if we hope to have a more comprehensive picture of studying and self-regulated learning."

- (Nist, Simpson, Olejnik and Mealey, 1991:871)

and ...

(b) "Future research into learner control should attempt to determine student perceptions toward their feelings of control over instruction ... "

- (Klein and Keller, 1990:145)

The construct locus of control, as the affective variable, was addressed within the instructional context of self-regulated learning. Learner perceptions towards their feelings of control in an academic environment were assessed using the Intellectual Achievement Responsibility Questionnaire. These procedures enabled the writer to ...

(c) ... investigate the relationship(s) between these (control) perceptions and ... performance in actual instructional settings. Future studies ... should continue to delineate specific aspects of control, using them ... in combination, to determine the critical features of control that influence performance..."

- (Klein and Keller, 1990:145)

Relationships were evaluated between these perceptions, as determined by the measured control locus, and academic performance within an actual (authentic) setting. Learners with an internal locus of control significantly outperformed their coevals receiving traditional instruction. Internals also significantly outperformed externals when instruction was self-regulated. No significant differences in academic performance between internal and external locus of control learners during traditional instruction was evident.

A combination of features believed to be critical antecedents to self-regulation were employed to reinforce learner perceptions of control.

Choice, self-pacing, self-management, self-monitoring, and self-evaluation were sub-elements considered necessary for promoting learner perceptions of control. It is recommended that the multivariate effects of these on academic performance be explored further. The present intervention appears promising in supporting such analyses.

Finally: -

9.3 "... the ecological validity of current findings concerning children's perceptions of control and academic achievement needs to be tested."

- (Stipek and Weisz, 1981:131)

In this regard, the findings have indicated that percepts of control, reinforced by choice, are part of the equation for increased academic achievement.

Earlier evidence of enhanced performance by internal control locus learners in a learner-controlled environment has been substantiated. The demonstration of increased performances by externals in a self-regulated environment has endorsed the belief that giving control to such learners will not be detrimental to their academic progress.

This study is believed to be particularly useful by affording researchers the opportunity to begin to explore self-regulation within an authentic setting. It has also contributed to classroom teaching practice by providing the necessary "scaffolding" for fostering self-regulated instruction.

Finally, it has provided ecologically valid findings on self-regulated performance in classroom settings, and thereby eliminated the artificiality of laboratory-generated results that so frequently undermine external validity (Slavin, 1984:117).

The outcomes of this study have questioned the need for overt teacher control of instruction regarding senior biology pupils.

Pupils in this investigation appeared sufficiently competent to self-manage their learning, given the necessary self-regulated instructional support.

Biology teachers, who feel dissonant with the prescriptive nature of formalism and verbalism are advised to direct their expertise towards developing the skills and abilities required for independence and initiative, critical observation, objective reporting, and justified conclusions which characterise both scientific enquiry and autonomous learning.

Such considerations also include:

1. The relinquishing of overt teacher control;
2. The creation of a challenging, but unthreatening learning environment;
3. The teaching of skills enabling independent study to occur;
4. The presentation of opportunities to choose tasks and thereby develop decision-making skills;
5. The due regard for the free flow of information, rather than unilateral flow; and
6. The maintenance of an emotional climate of relaxed alertness.

In the final analysis, it is what happens "inside the head" - integrating the mind, body, heart, will, spirit and desires of the learner - that determines instructional success. Instruction which supports young learners, in their desire for autonomy and academic independence, is believed to be instrumental in preparing motivated lifelong-learners to become the productive and competent citizens required by this country in the 21st century.

The following observation captures the spirit of instruction that this thesis research has attempted to bring into special prominence:

"The things taught in colleges and schools are not an education, but the means of education."

- Emerson, 1831 -

(quoted from Tripp, 1970)

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## **APPENDIX A**

**RAW DATA: (SCORES)**

**Posttests; Credits;  
Aptitude; IQ; Locus of Control;  
Motivational Variables; Cognitive and  
Self-Regulatory Strategy Use**

FOR SUBJECTS

	X	Y	LOC	IQ	APT	PT1	PT2	CREO	SE	IV	TA	CS	SIR	Σ
NANDES	29	32	109	49	77	40	81		34	47	7	65	50	49
ZLY	30	32	112	51	57	43	83		39	41	15	67	37	46
ILLIS	29	30	106	60	74	37	86		47	49	15	72	51	55
TRICK	29	28	107	58	47	31	69		43	41	13	57	27	42
AZEWSKI	28	28	103	51	49	51	71		32	42	7	42	38	39
ZETHLING	30	28	101	30	46	34	73		29	44	23	71	43	47
MITH, J		28	104	66	80	54	90		46	48	14	63	34	48
SMWELL	21	27	111	61	89	66	100		46	59	19	74	49	58
ARKWOOD	25	27	116	72	77	69	84		55	55	4	71	45	57
ALLD		27	117	66	74	71	88		46	45	10	66	42	50
OCKERILL *	25	26	112	54	49	23	50		absent					
OTES	25	26	107	47	60	57	73		26	27	25	53	32	35
		28,3	112,5	55,4	65,1	48	79							
		8,0	11,1	15,0	15,8	12,8								
		25	111	71	60	66	74		51	47	9	57	45	50

X  
SD

ALDION	22	25	109	62	57	51	75		48	48	5	64	37	49
ARCHETTI	25	25	112	43	49	37	82		29	29	12	44	31	33
DEWIG	23	25	113	47	51	29	71		34	54	16	72	34	49
NDERSON	26	25	109	65	37	40	52		25	37	4	40	31	33
ERRE	26	24	100	47	49	31	46		32	31	12	48	36	37
JALSH	27	24	110	55	54	60	93		41	50	19	58	39	47
APHAM	26	23	120	58	69	54	76		41	46	9	64	36	47
LAASSENS	21	23	115	52	71	40	72		29	37	10	71	36	43
OMEWOOD	25	23	101	54	43	51	88		25	35	19	71	45	46
HITEHORN	24	22	136	71	77	67	91		44	38	13	63	41	47
MITH, D	23	20	110	55	71	37	89		38	41	11	53	39	43
E YRIES		23,6	112,5	55,0	57,7	47,1	75,7							
		9,2	9,3	12,5	13,4	14,7								

X  
SD

MINOR SUBJECTS

	LOC	IQ	APT	PT1	PT2	CREO	SE	IV	TA	CS	SIR	
M V/GRAVEN <sup>26</sup>	27	122	92	77	66		48	49	9	76	48	55
N WARD	29	29	155	72	57	54	55	38	6	67	54	54
O PERSSON	25	27	100	59	46	51	40	55	6	73	46	54
P HARRIS	27	118	54	43	37		35	42	17	71	49	47
MM SMEDLEY	26	25	102	44	49	23	30	32	25	61	42	41

m KOK, N	29	27	122	87	71	77	59	53	4	74	51	54
mm SMITH, N	24	25	110	40	43	43	42	52	11	59	43	
* TANNER							15	34	28	64	36	

SELF-REGULATED POSTTEST PERFORMANCES

\* ABSENTEEISM

X  
SD

## **APPENDIX B**

### **INSTRUMENTATION:**

- 1. INTELLECTUAL ACHIEVEMENT RESPONSIBILITY  
QUESTIONNAIRE (IAR)**
  
- 2. MOTIVATED STRATEGIES FOR LEARNING QUESTIONNAIRE  
(MSL)**

EXPLANATION

A NEW TYPE OF TEACHING APPROACH IS BEING TESTED AND YOUR ASSISTANCE IN THIS REGARD WILL BE APPRECIATED.

THE INFORMATION COLLECTED THROUGH THIS QUESTIONNAIRE WILL BE USED TO IMPROVE THIS TEACHING APPROACH.

\* THE RESPONSES WHICH YOU PROVIDE IN THIS QUESTIONNAIRE WILL BE TREATED COMPLETELY CONFIDENTIALLY.

INSTRUCTIONS

THE STATEMENTS ON THE NEXT PAGE WILL DESCRIBE EVENTS WHICH OCCUR ROUTINELY IN SCHOOL.

EACH STATEMENT INTRODUCES AN IDEA WHICH CAN BE COMPLETED BY SELECTING ONE OF TWO ALTERNATIVES.

READ THE STEM SENTENCE AND CHOOSE EITHER PHRASE (a), OR PHRASE (b), TO COMPLETE THE SENTENCE WHICH BEST DESCRIBES YOURSELF.

AN ALTERNATIVE MUST BE SELECTED FOR EACH QUESTION. DO NOT LEAVE ANY STATEMENTS OUT.

CIRCLE THE ALTERNATIVE OF YOUR CHOICE ON THE RESPONSE SHEET.

DO NOT WRITE ON, OR MARK, THIS QUESTIONNAIRE IN ANY WAY.

\* \* \*

THANK YOU FOR YOUR ASSISTANCE

\* \* \*

WAIT FOR THE SIGNAL FROM THE TEACHER TO START.

1. If a teacher passes you to the next standard, would it probably be
  - a. because he/she liked you, or
  - b. because of the work you did?
2. When you do well on a test at school, is it more likely to be
  - a. because you studied for it, or
  - b. because the test was especially easy?
3. When you have trouble understanding something in school, is it usually
  - a. because the teacher didn't explain it clearly, or
  - b. because you didn't listen carefully?
4. When you read a story and can't remember much of it, is it usually
  - a. because the story wasn't well-written, or
  - b. because you weren't interested in the story?
5. Suppose your parents say you are doing well in school. Is this likely to happen
  - a. because your school work is good, or
  - b. because they are in a good mood?
6. Suppose you did better in a subject at school. Would it probably happen
  - a. because you tried harder, or
  - b. because someone helped you?
7. When you lose at a game of cards or checkers (draughts), does it usually happen
  - a. because the other player is good at the game, or
  - b. because you don't play well?
8. Suppose another person doesn't think that you are bright or clever.
  - a. Can you make him/her change his mind if you try to, or
  - b. are there some people who will think you're not very bright no matter what you do?
9. If you solve a puzzle quickly, is it
  - a. because it wasn't a very hard puzzle, or
  - b. because you worked on it carefully?

10. If a boy or girl tells you that you are stupid, is it more likely that they say it
  - a. because they are cross with you, or
  - b. because what you did was not really very clever?
11. Suppose you study to become a teacher, scientist, or doctor and you fail. Do you think this would happen
  - a. because you didn't work hard enough, or
  - b. because you needed some help, and other people didn't give it to you?
12. When you learn something quickly in school, is it usually
  - a. because you paid close attention, or
  - b. because the teacher explained it carefully?
13. If a teacher says to you, "Your work is fine," is it
  - a. something teachers usually say to encourage pupils, or
  - b. because you did a good job?
14. When you find it hard to do Biology questions at school, is it
  - a. because you didn't study well enough before you tried them, or
  - b. because the teacher gave problems that were too hard?
15. When you forget something you heard in class, is it
  - a. because the teacher didn't explain it very well, or
  - b. because you didn't try very hard to remember?
16. Suppose you weren't sure about the answer to a question your teacher asked you, but your answer turned out to be right. Is it likely to happen
  - a. because she/he wasn't as particular as usual, or
  - b. because you gave the best answer you could think of?
17. When you read a story and remember most of it, is it usually
  - a. because you were interested in the story, or
  - b. because the story was well written?

18. If your parents tell you you're acting silly and not thinking clearly, is it more likely to be
- a. because of something you did, or
  - b. because they happen to be in a bad mood?
19. When you don't do well on a test at school, is it
- a. because the test was especially hard, or
  - b. because you didn't study for it?
20. When you win at a game of cards or checkers (draughts), does it happen
- a. because you play real well, or
  - b. because the other person doesn't play well?
21. If people think you're bright or clever, is it
- a. because they happen to like you, or
  - b. because you usually act that way?
22. If a teacher didn't pass you to the next grade, would it probably be
- a. because he/he "had it in for you", or
  - b. because your school work wasn't good enough?
23. Suppose you don't do as well as usual in a subject at school. Would this probably happen
- a. because you weren't as careful as usual, or
  - b. because somebody bothered you and kept you from working?
24. If a boy or girl tells you that you are bright, is it usually
- a. because you thought up a good idea, or
  - b. because they like you?
25. Suppose you became a famous teacher, scientist or doctor. Do you think this would happen
- a. because other people helped you when you needed it, or
  - b. because you worked very hard?
26. Suppose your parents say you aren't doing well in your school work. Is this likely to happen more
- a. because your work isn't very good, or
  - b. because they are in a bad mood?

27. Suppose you are showing a friend how to play a game and he has trouble with it. Would that happen
- a. because he wasn't able to understand how to play, or
  - b. because you couldn't explain it well?
28. When you find it easy to do Biology questions at school, is it usually
- a. because the teacher gave you especially easy problems, or
  - b. because you studied your book well before you tried them?
29. When you remember something you heard in class, is it usually
- a. because you tried hard to remember, or
  - b. because the teacher explained it well?
30. If you can't work a puzzle, is it more likely to happen
- a. because you are not especially good at working puzzles, or
  - b. because the instructions weren't written clearly enough?
31. If your parents tell you that you are bright or clever, is it more likely
- a. because they are feeling good, or
  - b. because of something you did?
32. Suppose you are explaining how to play a game to a friend and he learns quickly. Would that happen more often
- a. because you explained it well, or
  - b. because he was able to understand it?
33. Suppose you're not sure about the answer to a question your teacher asks you and the answer you give turns out to be wrong. Is it likely to happen
- a. because he/she was more particular than usual, or
  - b. because you answered too quickly?
34. If a teacher says to you, "Try to do better," would it be
- a. because this is something she/he might say to get pupils to try harder, or
  - b. because your work wasn't as good as usual?

**REPONSE FORM**

YOUR NAME? .....

**CLEARLY CIRCLE THE LETTER CORRESPONDING TO THE NUMBER OF THE STATEMENT WHICH BEST DESCRIBES YOUR RESPONSE.**  
**DO NOT WRITE IN THE COLUMNS.**

			E	I	T
1.	a	b			
2.	a	b			
3.	a	b			
4.	a	b			
5.	a	b			
6.	a	b			
7.	a	b			
8.	a	b			
9.	a	b			
10.	a	b			
11.	a	b			
12.	a	b			
13.	a	b			
14.	a	b			
15.	a	b			
16.	a	b			
17.	a	b			

			E	I	T
18.	a	b			
19.	a	b			
20.	a	b			
21.	a	b			
22.	a	b			
23.	a	b			
24.	a	b			
25.	a	b			
26.	a	b			
27.	a	b			
28.	a	b			
29.	a	b			
30.	a	b			
31.	a	b			
32.	a	b			
33.	a	b			
34.	a	b			

MSLQ

EXPLANATION

OUR THOUGHTS INFLUENCE OUR ACTIONS. SIMILARLY, THE WAY YOU THINK DURING CLASSROOM ACTIVITIES IMPACTS ON YOUR LEARNING AND CONSEQUENTLY, ON TEST/EXAMINATION PERFORMANCE. THIS SELF-REPORT QUESTIONNAIRE HAS LED TO IMPROVED UNDERSTANDING OF INDIVIDUAL PUPILS' LEARNING NEEDS AND CONTRIBUTED TO GREATER CLASSROOM SUPPORT FOR SUCH PUPILS.

YOUR RESPONSES TO THE STATEMENTS MAY PROVIDE USEFUL INFORMATION ABOUT HOW YOU THINK DURING CLASSROOM ACTIVITIES, AND MAY INDICATE ASPECTS THAT UNDERMINE YOUR PERFORMANCE IN TESTS/EXAMINATIONS.

INSTRUCTIONS

YOU NEED TO RESPOND TO THE STATEMENTS USING THE 7-POINT SCALE:

1	2	3	4	5	6	7
not true of me			partially true of me	very true of me		

SELECT THE NUMBER ON THE SCALE INDICATING YOUR LEVEL OF AGREEMENT WITH THE STATEMENT AND WRITE THIS DOWN ON THE RESPONSE SHEET PROVIDED.

AFTERWARDS, YOUR RESPONSES WILL BE SCORED AND AVAILABLE FOR INTERPRETATION.

NATURALLY, ITS IN YOUR INTEREST TO RESPOND AS HONESTLY AS YOU CAN!

WORK AS QUICKLY AS POSSIBLE.

1. I prefer challenging classwork so I can learn new things.
2. Compared with other pupils in this class, I expect to do well.
3. I am so nervous during tests that I forget facts I have learned.
4. I learn hard to get a good mark even when I don't like the work.
5. It is important for me to learn what is being taught in this class.
6. I like what I'm learning in Biology.
7. I'm certain I can understand the facts taught in Biology.
8. I underline the work in my book to help me study.
9. I think I can use what I learn in Biology in other subjects.
10. I expect to do very well in Biology in the examinations.
11. Compared with others in this class, I think I'm a good pupil.
12. I often choose topics I will learn something from, even if it means more work.
13. I am certain that I can do an excellent job on the work assigned in this class.
14. I have an uneasy, sick feeling when I'm about to write a test.
15. I believe I will achieve a good mark in Biology.
16. When learning Biology facts, I say them over and over to myself to help me remember.
17. Even when I do badly in a test, I try to learn from my mistakes.
18. I think that what I learn in Biology is useful to know.
19. When I'm reading Biology notes I stop occasionally and go over what I've read.
20. My study skills are much better than others in this class.
21. I think that the work in Biology is interesting.
22. Compared with other pupils in this class, I think I know a lot about the subject.
23. I know that I will be able to learn the work for this class.
24. I have major worries when it comes to writing tests.
25. Understanding Biology is important to me.
26. When I'm studying a chapter of Biology, I try to link the ideas with those in other chapters.
27. When writing a test, I think about how badly I'm doing.

28. I find that when the teacher is talking, I think of other things, and don't really pay attention to what is being said.
29. I often read over my work for class, but don't really understand what it's all about.
30. When learning for a test, I try to link the information from class notes with those of the textbook.
31. When answering questions for homework, I try to remember what the teacher said in class, in order to answer the questions.
32. I ask myself questions to check whether I know the facts I have been studying.
33. I find it difficult to decide what the main ideas are, in what I read.
34. When the work is hard, I either give up, or just study the easy parts.
35. When studying, I put important ideas in my own words.
36. I always keep trying to understand what the teacher is saying even if it doesn't seem to make sense.
37. I find using facts learnt in earlier chapters useful in completing problems in more recent work.
38. When studying for a test, I try to remember as many facts as possible.
39. By copying my notes over I find it helps me remember more.
40. I practice old examination papers even when I don't have to.
41. Even when the work is boring, I keep going until I'm finished.
42. When studying, I practice saying the important facts over and over.
43. Before studying, I reflect on the things I need to do to learn.
44. When reading new work, I try and connect it with things I know.

## **APPENDIX C**

### **POSTTESTS:**

#### **1. EXCRETION**

**(Questions and Memorandum)**

#### **2. GASEOUS EXCHANGE**

**(Questions and Memorandum)**

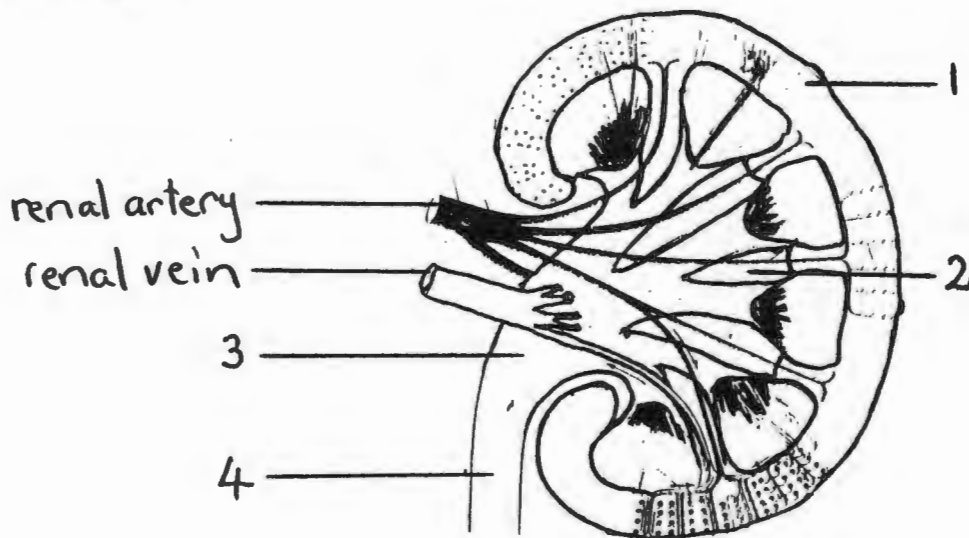
- 
1. READ THE INSTRUCTIONS CAREFULLY BEFORE STARTING EACH QUESTION.
  2. COMPLETE ALL ANSWERS ON THE ANSWER SHEET PROVIDED.
  3. USE A PENCIL AND MARK ONLY ONE ALTERNATIVE EACH TIME.
  4. ENSURE ALL QUESTIONS ARE ANSWERED.
  5. MISTAKES MUST BE COMPLETELY ERASED.
  6. ALL QUESTIONS HAVE THE SAME MARK VALUE ie., ONE MARK EACH.
- 

SECTION A

Each of the statements below has one correct answer. Select the correct alternative amongst those provided and SHADE the letter corresponding to it on the ANSWER SHEET.

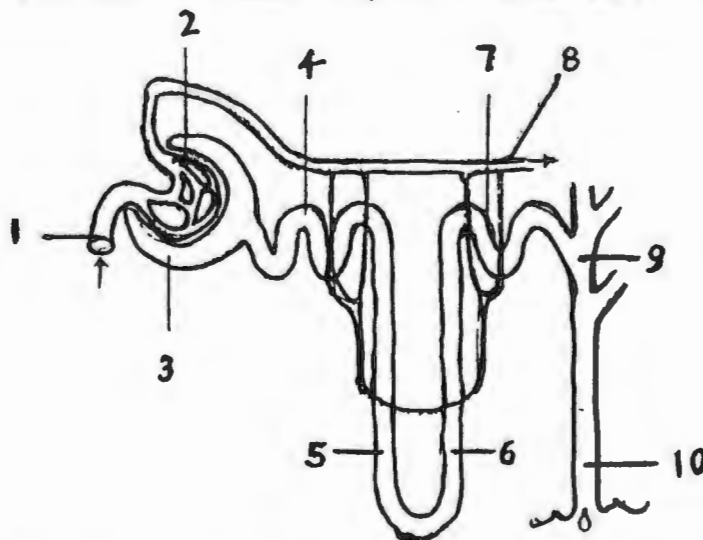
1. Which one of the following is not a function of the mammalian kidney?
  - (a) maintenance of a normal ionic balance
  - (b) removal of urea from the body
  - (c) production of renin
  - (d) maintenance of a normal water content of blood plasma
  - (e) production of ADH (vasopressin)
2. The glomerulus is situated between the...
  - (a) renal artery and afferent arteriole
  - (b) descending and ascending loop of Henle
  - (c) afferent and efferent arteriole
  - (d) Bowman's capsule and renal tubule
  - (e) peritubular capillaries and the renal vein
3. Blood enters the renal artery from the ...
  - (a) posterior vena cava
  - (b) aorta
  - (c) hepatic artery
  - (d) arcuate artery
  - (e) peritubular capillaries
4. The composition of blood in the renal artery differs from that in the renal vein in that the blood in the renal artery has a ...
  - (a) higher concentration of glucose and a lower concentration of urea.
  - (b) lower concentration of glucose and a higher concentration of urea.
  - (c) higher concentration of glucose and a higher concentration of urea.
  - (d) lower concentration of glucose and a lower concentration of urea.
  - (e) consistently lower ionic balance.

5. If the accompanying kidney belongs to a rabbit, how would the kidney of a sand rat (desert animal) differ in structure from that of the rabbit?



- (a) Region 2 would form a greater portion of the kidney.  
 (b) Region 3 would be broader.  
 (c) The renal vein would be narrower.  
 (d) Structure 4 would be absent.  
 (e) The renal artery would be narrower.
6. Heavy beer drinkers urinate very frequently during their consumption. This fact suggests that alcohol ...
- (a) dilates the sphincter muscle of the bladder.  
 (b) by-passes the loop of Henle in the medulla.  
 (c) reduces the tendency for reabsorption of water in the kidneys.  
 (d) decreases the capacity of the bladder.  
 (e) is more easily absorbed than water.

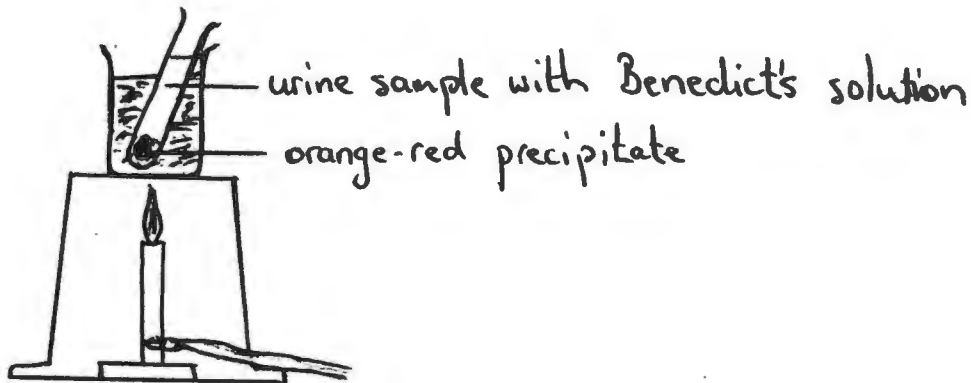
This sketch represents a human nephron. Questions 7 - 11 are based on it.



7. The lowest concentration of glucose will be found at point ...
- (a) 1  
 (b) 3  
 (c) 4  
 (d) 5  
 (e) 8

8. A "pump" which actively pumps chlorine ions from the filtrate into the body fluids of the kidney medulla, mainly occurs in the part numbered ...
- (a) 3
  - (b) 4
  - (c) 5
  - (d) 6
  - (e) 7
9. The anti-diuretic hormone (ADH), is actively involved at part ...
- (a) 1
  - (b) 3
  - (c) 5
  - (d) 7
  - (e) 9
10. The part numbered 10 is mainly concerned with the ...
- (a) absorption of a small amount of water and nearly all glucose.
  - (b) synthesis of uric acid and urea.
  - (c) transport of concentrated urine.
  - (d) passive absorption of large amounts of water.
  - (e) active absorption of sodium ions.
11. Reabsorption of most glucose and amino acids takes place mainly when the filtrate passes through part ...
- (a) 2
  - (b) 4
  - (c) 6
  - (d) 8
  - (e) 10
12. Blood flow into the kidney follows the sequence of blood vessels...
- (a) renal artery - arcuate artery - interlobular artery - interlobar artery - afferent arteriole
  - (b) renal vein - arcuate vein - interlobar vein - interlobular vein - efferent vein
  - (c) renal artery - interlobular artery - arcuate artery - interlobar artery - afferent arteriole
  - (d) renal artery - interlobar artery - arcuate artery - interlobular artery - efferent arteriole
  - (e) renal artery - interlobar artery - arcuate artery - interlobular artery - afferent arteriole
13. Which one of the following is a passive transport process in urine formation?
- (a) secretion of hydrogen ions.
  - (b) reabsorption of glucose.
  - (c) filtration of plasma.
  - (d) secretion of creatinine and penicillin
  - (e) reabsorption of amino acids

14. The following diagram demonstrates the result of a test conducted on a urine sample.



This result indicates that the person's body probably has ...

- (a) too much ADH
  - (b) too little aldosterone
  - (c) too much urea
  - (d) too much glucose
  - (e) too much protein
15. The most suitable description of excretion is the removal of ...
- (a) undigested faeces
  - (b) excess water
  - (c) chemical waste
  - (d) undigested food
  - (e) excess salts
16. A reservoir for urine in the body is the ...
- (a) kidney
  - (b) ureter
  - (c) urethra
  - (d) bladder
  - (e) adrenal gland
17. A very concentrated urine is made possible when ...
- (a) the loop of Henle is very long.
  - (b) blood pressure is very high.
  - (c) ADH is produced in large amounts.
  - (d) large quantities of water are ingested.
  - (e) one kidney is removed.
18. Reabsorption in kidney function means ...
- (a) the movement of useful substances from the blood plasma into Bowman's capsule.
  - (b) the movement of useful substances through the walls of the glomerulus.
  - (c) the transport of urea and creatinine into the collecting ducts.
  - (d) movement of glucose and amino acids into Bowman's capsule.
  - (e) the transport of useful substances into the peritubular capillaries.

19. Two important functions of the distal convoluted tubule include...
- (a) the regulation of water and pH balance
  - (b) the absorption of glucose and amino acids.
  - (c) the regulation of glucose and pH balance.
  - (d) the excretion of urea and uric acid.
  - (e) the secretion of aldosterone and ADH.
20. The blood pH is controlled by the kidneys ...
- (a) by secreting excess hydrogen ions and absorbing carbonate ions.
  - (b) by absorbing excess hydrogen ions and secreting carbonate ions.
  - (c) by secreting sodium and chlorine ions.
  - (d) by monitoring the water balance of the body.
  - (e) by acting as a buffer organ.

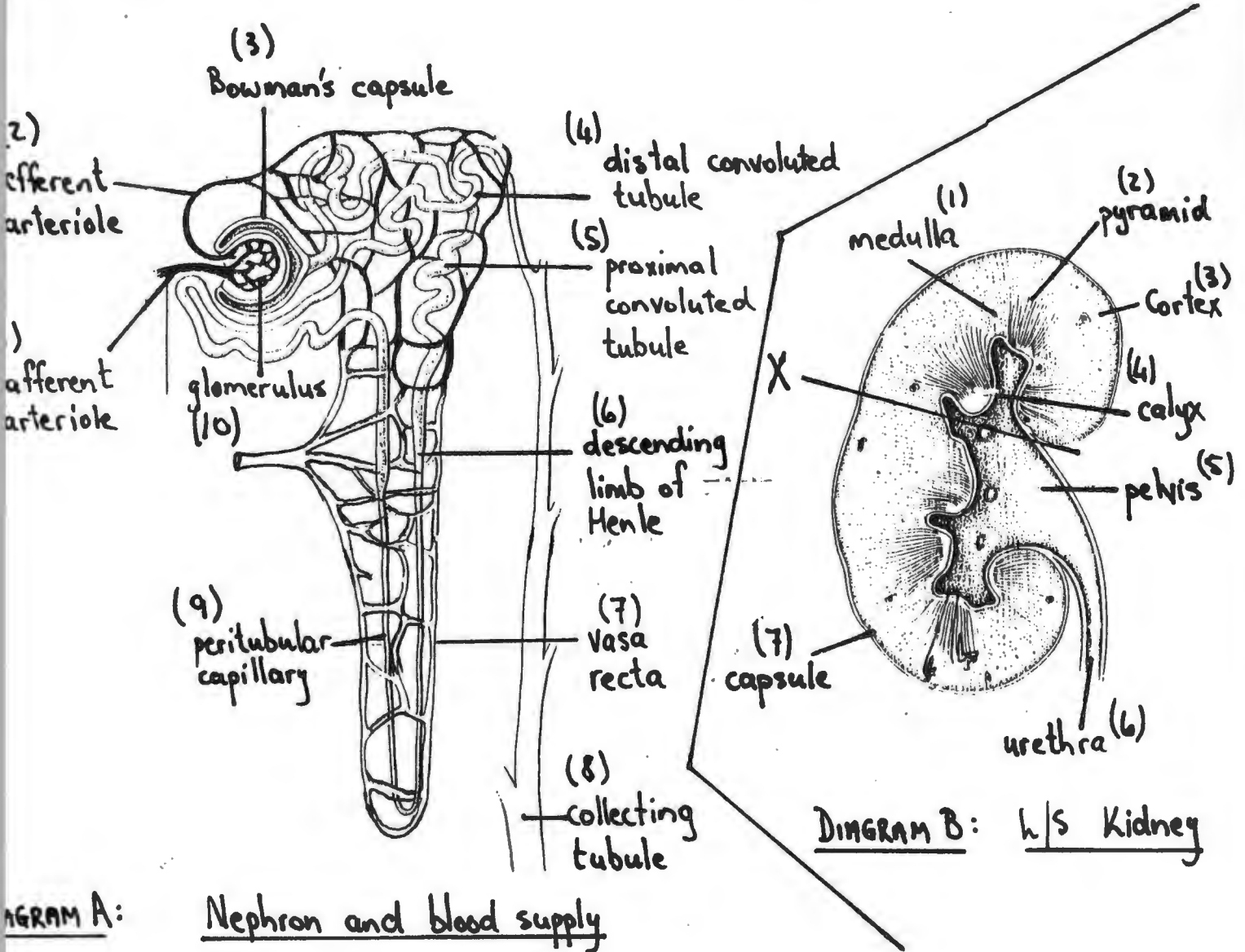
### SECTION B

Each of the following statements contains an error which has been underlined. Correct each statement by writing the CORRECT word(s) on the ANSWER SHEET.

21. The upper portion of the ureter widens forming the renal tubule.
22. The glomerular capillaries reunite to form the renal vein.
23. The widened portion inside the kidney that surrounds the point of a pyramid is called the capsular space.
24. Filtration refers to the active transport of glucose and amino acids into the capillaries.
25. Renin is responsible for the formation and development of red blood cells.
26. The proximal convoluted tubule has the responsibility of creating a hyperosmotic tissue fluid in the region of the medulla.
27. The unit formed by the glomerulus and Bowman's capsule is called a nephron.
28. The adrenal gland produces ADH.
29. The term osmoregulation refers to the maintenance of an constant internal environment.
30. The blood vessel that enters the glomerulus is known as the vasa recta.

SECTION C

In each of the labelled diagrams (A and B) below, ONE label is INCORRECT. Study the sketches carefully and decide which labels are incorrect. Then answer the questions which follow.



31. Identify the incorrect label in DIAGRAM A by writing down its NUMBER IN BRACKETS, corresponding to the INCORRECT label.
32. Write down the CORRECT ANSWER for the label identified as INCORRECT in question 31.
33. Identify the incorrect label in DIAGRAM B by writing down its NUMBER IN BRACKETS, corresponding to the INCORRECT label.
34. Write down the CORRECT ANSWER for the label identified as INCORRECT in question 33.
35. Name label X.

ANSWER SHEET : EXCRETION

SECTION A

SHADE THE LETTER OF YOUR CHOICE  
USE PENCIL  
ERASE ALL MISTAKES/CHANGES COMPLETELY

- |     |                                  |                                  |                                  |                                  |                                  |     |                                  |                                  |                                  |                                  |                                  |
|-----|----------------------------------|----------------------------------|----------------------------------|----------------------------------|----------------------------------|-----|----------------------------------|----------------------------------|----------------------------------|----------------------------------|----------------------------------|
| 1.  | A                                | B                                | C                                | D                                | <input checked="" type="radio"/> | 11. | A                                | <input checked="" type="radio"/> | C                                | D                                | E                                |
| 2.  | A                                | B                                | <input checked="" type="radio"/> | D                                | E                                | 12. | A                                | B                                | C                                | D                                | <input checked="" type="radio"/> |
| 3.  | A                                | <input checked="" type="radio"/> | C                                | D                                | E                                | 13. | A                                | B                                | <input checked="" type="radio"/> | D                                | E                                |
| 4.  | A                                | B                                | C                                | D                                | <input checked="" type="radio"/> | 14. | A                                | B                                | C                                | <input checked="" type="radio"/> | E                                |
| 5.  | <input checked="" type="radio"/> | B                                | C                                | D                                | E                                | 15. | A                                | B                                | <input checked="" type="radio"/> | D                                | E                                |
| 6.  | A                                | B                                | <input checked="" type="radio"/> | D                                | E                                | 16. | A                                | B                                | C                                | <input checked="" type="radio"/> | E                                |
| 7.  | A                                | B                                | C                                | <input checked="" type="radio"/> | E                                | 17. | <input checked="" type="radio"/> | B                                | C                                | D                                | E                                |
| 8.  | A                                | B                                | C                                | <input checked="" type="radio"/> | E                                | 18. | A                                | B                                | C                                | D                                | <input checked="" type="radio"/> |
| 9.  | A                                | B                                | C                                | D                                | <input checked="" type="radio"/> | 19. | <input checked="" type="radio"/> | B                                | C                                | D                                | E                                |
| 10. | A                                | B                                | <input checked="" type="radio"/> | D                                | E                                | 20. | <input checked="" type="radio"/> | B                                | C                                | D                                | E                                |

SECTION B

- |     |                           |     |                        |
|-----|---------------------------|-----|------------------------|
| 21. | pelvis                    | 26. | loop of Henle          |
| 22. | peritubular               | 27. | Malpighian body        |
| 23. | calyces / calyx           | 28. | pituitary / hypophysis |
| 24. | Reabsorption / resorption | 29. | homeostasis            |
| 25. | erythropoietin            | 30. | afferent               |

SECTION C

31. 9
32. ascending limb of Henle
33. 6
34. ureter
35. hilum / hilus

1. READ THE INSTRUCTIONS CAREFULLY BEFORE STARTING EACH QUESTION.
2. COMPLETE ALL ANSWERS ON THE ANSWER SHEET PROVIDED.
3. USE A PENCIL AND MARK ONLY ONE ALTERNATIVE.
4. ENSURE ALL QUESTIONS ARE ANSWERED.
5. MISTAKES MUST BE CAREFULLY ERASED.
6. ALL QUESTIONS HAVE THE SAME MARK VALUE ie., ONE MARK EACH.

SECTION A

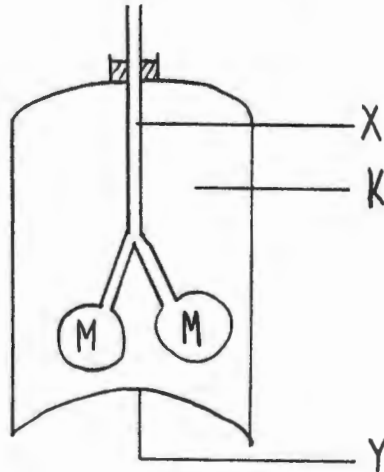
Various possibilities are suggested as answers to the following questions. Indicate the correct answer by SHADING the appropriate letter on the ANSWER SHEET.

ITEMS 1 TO 3 ARE BASED ON THE ACCOMPANYING SKETCH.



1. The blood vessel numbered 1, is a branch of the ...
  - (a) pulmonary veins
  - (b) aorta
  - (c) pulmonary arteries
  - (d) bronchial artery
  - (e) capillary network
  
2. The volume in number 2 increases when the ...
  - (a) external intercostal muscles relax
  - (b) diaphragm becomes more convex
  - (c) ribs move downward
  - (d) external intercostal muscles contract
  - (e) motor stimulus is inhibited

3. The internal surface area of number 3 is lined with ...
- (a) ciliated epithelium
  - (b) squamous epithelium
  - (c) columnar epithelium
  - (d) cuboidal epithelium
  - (e) none of the above
4. Oxygen is carried by the blood mainly ...
- (a) in combination with haemoglobin
  - (b) as oxygen in solution
  - (c) as a carbonate
  - (d) as an organic acid
  - (e) dissolved in blood plasma
5. Which of the following requirement(s), concerning an effective gaseous exchange surface area, is not applicable to both flowering plants and vertebrates?
- (i) Active transport of gases to and from the surface.
  - (ii) A thin surface for faster diffusion.
  - (iii) A moist surface wherein gases can dissolve.
- (a) (i) only
  - (b) (ii) only
  - (c) (i) and (ii)
  - (d) (i) and (iii)
  - (e) (ii) and (iii)
6. The balloons will enlarge when structure Y in the sketch is pulled downwards. This is as a result of a/an ...



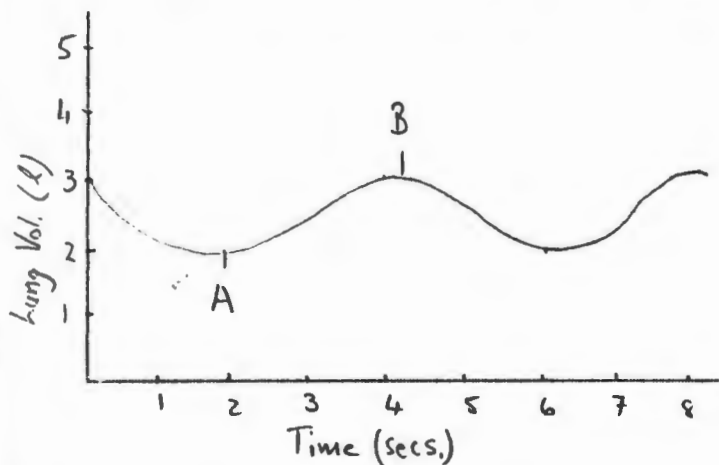
- (a) increase in pressure on M and a decrease in the volume of K.
- (b) increase in pressure in K and an increase in the volume of M.
- (c) decrease in pressure on M and a decrease in the volume of K.
- (d) increase in the volume of K and a decrease of the pressure on M.
- (e) decrease in pressure in K and an increase in pressure in M.

7. The respiratory centre in the brain is sensitive to a/an ... in the extracellular fluid.
- (a) increased alkalinity
  - (b) decrease in the carbon dioxide concentration
  - (c) decrease in  $\text{HCO}_3^-$  (bicarbonate) ions
  - (d) decrease in pH
  - (e) increase in oxygen
8. The presence of buffers in the bloodstream prevent the build-up of ...
- (a) hydrochloric acid as a result of oxygen transport
  - (b) carbamino-haemoglobin during carbon dioxide transport
  - (c) an alkaline medium as a result of oxygen transport
  - (d) carbonic acid during carbon dioxide transport
  - (e) hydrogen ions during oxygen transport
9. Which one of the following statements is incorrect?
- (a) a high partial pressure of carbon dioxide increases the affinity of haemoglobin for oxygen.
  - (b) when the partial pressure of carbon dioxide is increased, oxyhaemoglobin releases oxygen.
  - (c) slow breathing rates indicate low carbon dioxide blood concentrations.
  - (d) the partial pressure of carbon dioxide in the arterial blood reaching the lungs is in the order of 40 mm Hg.
  - (e) the haemoglobin dissociation curve is not a straight line.
10. Cartilaginous support is found in the walls of the ...
- (a) trachea and bronchi
  - (b) trachea, bronchi, and bronchioli
  - (c) bronchi and bronchioli
  - (d) bronchi, bronchioli, and alveoli
  - (e) only the trachea
11. To be effective, a gaseous exchange organ should have a moist surface so that
- (a) the walls can be more elastic
  - (b) oxygen can dissolve more rapidly
  - (c) carbon dioxide does not influence diffusion rates.
  - (d) minimal friction between gaseous exchange surfaces occurs.
  - (e) none of the above
12. The partial pressure of oxygen in the atmosphere is dependent on the ...
- (a) partial pressure of the carbon dioxide
  - (b) atmospheric pressure
  - (c) pressures of other gases in the air
  - (d) moisture in the air
  - (e) ozone thickness

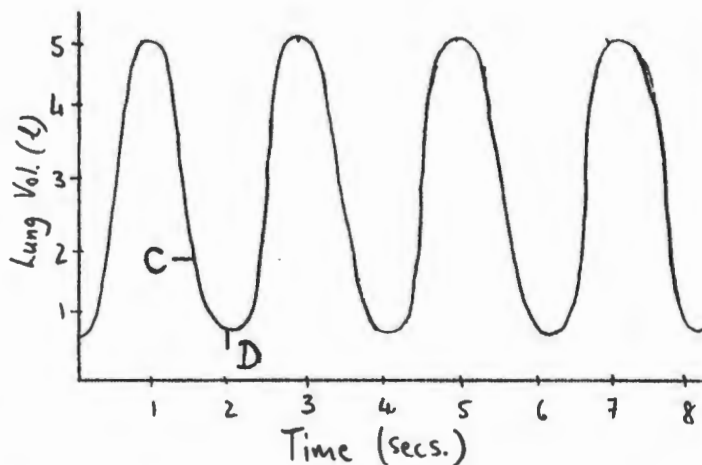
13. The most important respiratory defense mechanism of the air passages is ...
- (a) macrophages in the alveoli
  - (b) coughing
  - (c) swallowing of dust particles
  - (d) cilia clearance of mucus
  - (e) narrowing of the bronchioles
14. A rightward shift of the oxyhaemoglobin dissociation curve indicates that ...
- (a) oxygen release at tissue level is interfered with
  - (b) oxygen will have a greater affinity for haemoglobin
  - (c) oxygen release is facilitated at tissue level
  - (d) increased blood oxygen levels are present
  - (e) oxygen uptake at alveolar level is facilitated
15. One action which the diaphragm does not assist with, is ...
- (a) vomiting
  - (b) sneezing
  - (c) coughing
  - (d) defaecation
  - (e) swallowing

Questions 16 - 19 are based on the two graphs below.

These graphs show the change in volume of a man's lungs in two different circumstances. Graph 1 was made when the man was sitting quietly, graph 2 when he was running.



Graph 1.



Graph 2.

16. The approximate Tidal Air volume (lung volume) of the man is ...
- (a) 1 litre
  - (b) 1,5 litres
  - (c) 2 litres
  - (d) 4,5 litres
  - (e) impossible to determine from the graphs.
17. What is the man's Vital Capacity (maximum volume)?
- (a) 1 litre
  - (b) 2 litres
  - (c) 2,5 litres
  - (d) 4 litres
  - (e) 4,5 litres

18. Which breathing muscle(s) is/are contracting between points A and B?
- (a) internal intercostal muscles
  - (b) diaphragm
  - (c) thoracic
  - (d) pectoral muscles
  - (e) smooth muscles
19. Which breathing muscle(s) is/are contracting between points C and D?
- (a) external intercostal muscles
  - (b) diaphragm
  - (c) internal intercostal muscles
  - (d) pectoral muscles
  - (e) smooth muscles
20. Cilia are lacking in the ...
- (a) nasal cavity
  - (b) trachea
  - (c) bronchus
  - (d) bronchiole
  - (e) alveolus

SECTION B

Each of the following statements contains an error which has been underlined. Correct each statement by writing the CORRECT word(s) on the ANSWER SHEET.

21. The respiratory pigment haemoglobin contains four atoms of copper in each molecule.
22. The bony rings of the trachea help support it.
23. The space between the lungs which accommodates the heart, oesophagus, and major blood vessels is termed the thoracic cavity.
24. The hormone carbonic anhydrase increases the rate of carbonic acid formation in the erythrocytes.
25. The space within the lungs where air pressure is equal to atmospheric pressure is called the alveolar space.
26. The structure found at the end of a bronchiolus which resembles a bunch of grapes is called an alveolus.
27. The pressure exerted by a single gas within a mixture of gases is known as the tension pressure of that gas.
28. The process of gaseous diffusion across membranes is known as respiration.
29. Most of the carbon dioxide is carried by the erythrocytes as carbaminohaemoglobin.
30. The ability of oxyhaemoglobin to dissociate more readily when carbon dioxide concentrations are high is known as the Hamburger Effect.

SECTION C

In each of the labelled diagrams (A and B) below, ONE label is INCORRECT. Study the sketches carefully and decide which labels are incorrect. Then answer the questions which follow.

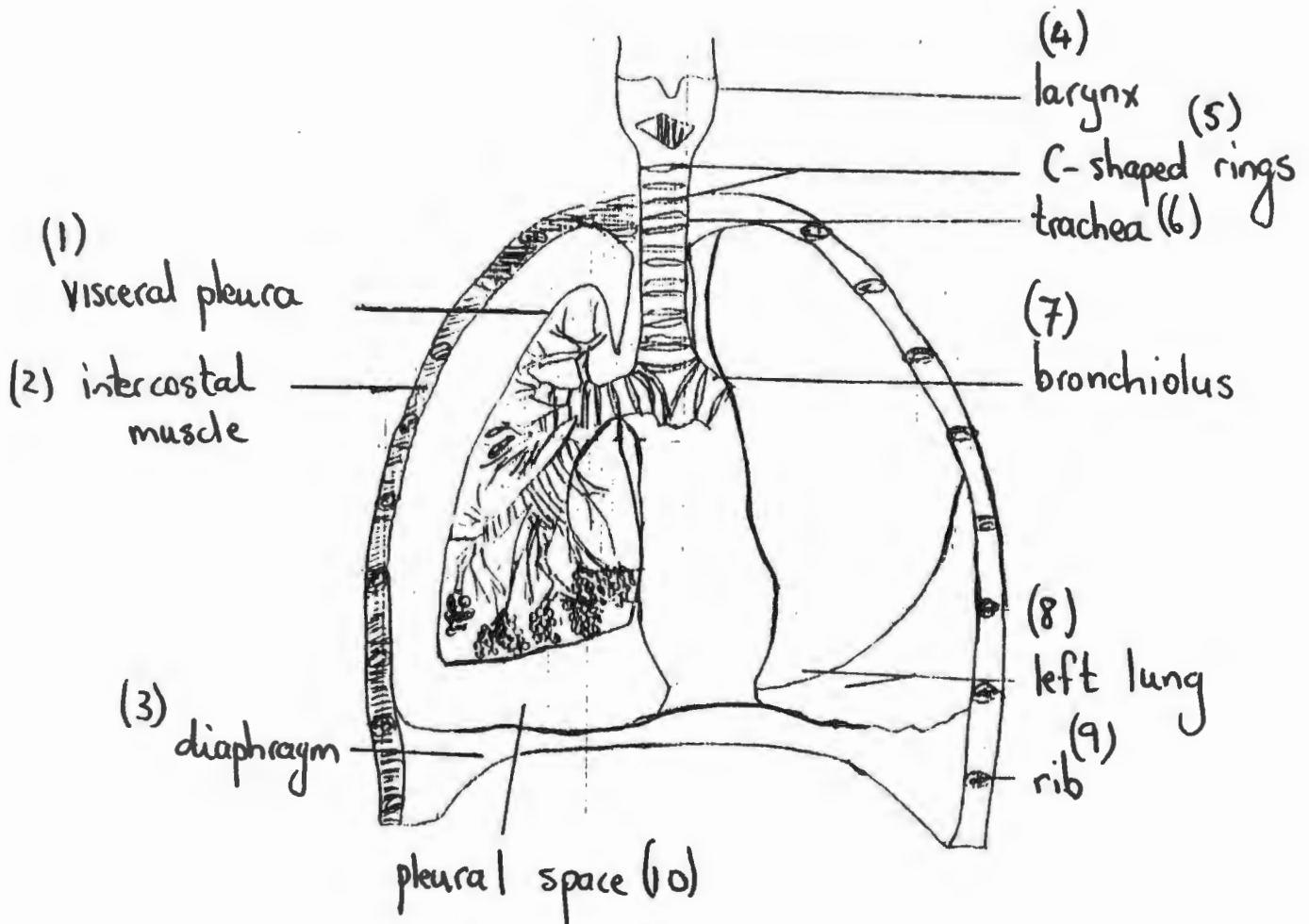


DIAGRAM A.

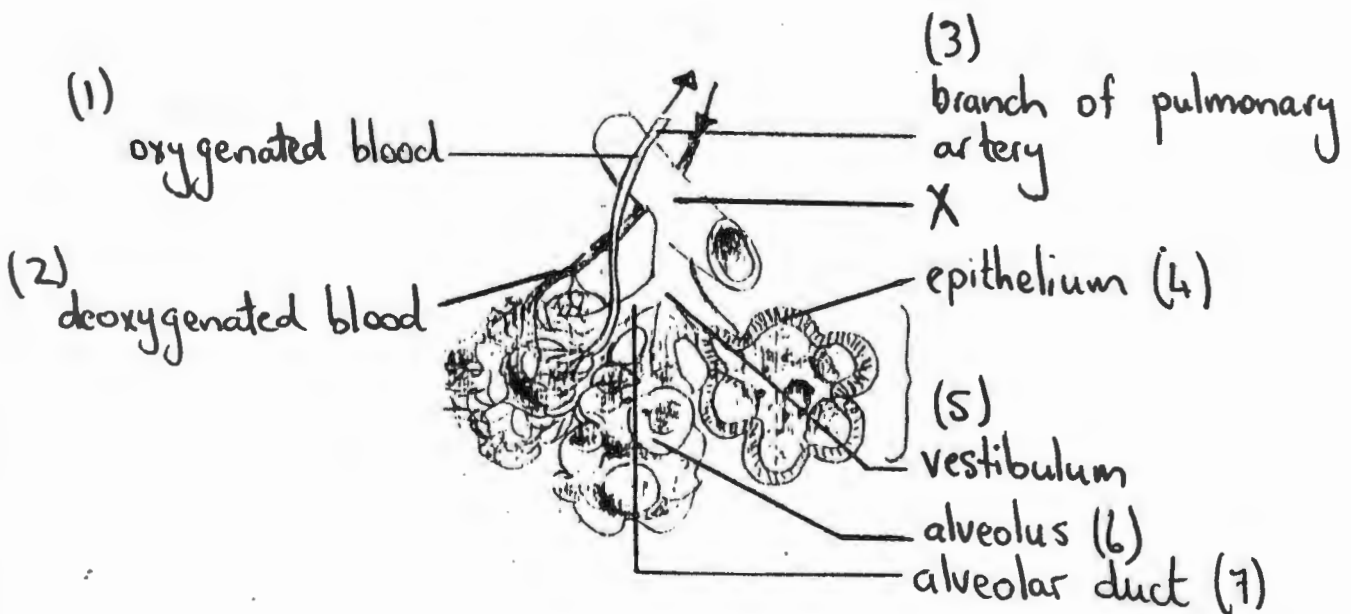


DIAGRAM B

31. Identify the incorrect label in DIAGRAM A by writing down its NUMBER IN BRACKETS.
32. Write down the CORRECT ANSWER for the label identified as INCORRECT in question 31.
33. Identify the incorrect label in DIAGRAM B by writing down its NUMBER IN BRACKETS.
34. Write down the CORRECT ANSWER for the label identified as INCORRECT in question 33.
35. Name label X

ANSWER SHEET : GASEOUS EXCHANGE

SECTION A

SHADE THE LETTER OF YOUR CHOICE  
USE PENCIL

ERASE ALL MISTAKES/CHANGES COMPLETELY

- 1. A B  D E
- 2. A B C  E
- 3. A  C D E
- 4.  B C D E
- 5.  B C D E
- 6. A B C  E
- 7. A B C  E
- 8. A B C D
- 9. A B C  E
- 10. A  C D E

- 11. A  C D E
- 12. A B  D E
- 13. A B C  E
- 14. A B  D E
- 15. A B C D
- 16.  B C D E
- 17. A B C D
- 18. A  C D E
- 19. A B  D E
- 20. A B C D

SECTION B

- 21. iron .....
- 22. cartilage .....
- 23. mediastinum .....
- 24. enzyme .....
- 25. intrapulmonic .....

- 26. infundibulum .....
- 27. partial .....
- 28. gaseous exchange .....
- 29. bicarbonate ions .....
- 30. Bohr .....

SECTION C

- 31. 7 .....
- 32. bronchus .....
- 33. 3 .....

- 34. Vein (pulmonary) .....
- 35. <sup>terminates</sup> bronchiolus (bronchial duct)

## **APPENDIX D**

### **LEARNER PROTOCOLS**

- 1. PROGRAMME INFORMATION BROCHURE**
- 2. BOOKING SCHEDULES**
- 3. CREDIT SCORE SHEETS (Group one and two)**

## AN INTRODUCTION TO THIS PROGRAMME.

The teaching approach used for the next five periods is probably different to that you have encountered in the past. Nevertheless, the aim is to help you make more of your learning opportunities.

The most obvious difference between this teaching method, and the more familiar one is that you have far greater freedom and control over your own learning. The catch is ...

that you must assume greater responsibility for your own learning than in the past.

It is the task of the teacher to create the environment for learning, and support the learning process. However, in this design he is not a dispenser of information, i.e., he may choose not to answer questions with direct answers. Instead he may redirect you to other potential sources of information e.g., books, pupils etc. This may produce frustration on your part, but the intention is to make you more self-dependent in your learning.

One way of assisting you to achieve this goal, is through the use of a credit system.

The system works as follows:

Every time you opt for a particular section of work, you earn credits. A "score-sheet" is available to keep a record of credits earned.

You will need to contract IN ADVANCE (before commencing that day's work) the number of credits you wish to earn for the kind of assignment offered at a particular LEARNING CENTRE (LC). Assuming successful completion of the work (the teacher will monitor this), the stated number of credits will be awarded and placed on the score-sheet.

At the end of the programme the total number of credits earned is converted to a percentage which is then combined with your TEST RESULT. Should the aggregate exceed 100%, the "surplus" will be passed onto the next test result so that it's not lost.

Because a limited amount of space is available at any LC (usually only 7 places per day), you will need to book yourself in, in advance, if you have any special preference order. This is likely as the work load (homework) differs between LC's and you may prefer to opt for a heavier, or lighter, work load on a particular afternoon, whichever is your preference.

You may also 'scout around' and find out what each LC entails. That way your 'Booking' will be based on an informed choice.

Use the necessary form to book your preference. It is available in the classroom.

In some cases, it is possible to prepare work in advance (e.g., the research LC). You are encouraged to do this wherever possible to avoid an accumulation of work.

### HOW THE PROGRAMME IS ORGANIZED

**DURATION:** The duration of the programme will be five consecutive 55-minute periods. A content-specific test will be administered after completion of the programme

**STRUCTURE:** The classroom will be divided into five learning centres.

1. TUTORIAL - feed-back and orally administered questions on the contents of the reading material.
2. DESIGN - involves designing models of plasticine and mastery learning of diagrams of biological structures.
3. PRACTICAL - an assortment of materials with instructions will be available. These include:  
  
specimens for dissection; microscopy; medicinal/pathogenic aspects.
4. COMPREHENSION - a selection of reading matter followed by a series of questions.
5. RESEARCH - selected topics are discussed in an essay format and completed during visitation of the relevant LC.
6. TEST - The test will be written by all participants simultaneously.

### HOW THE CREDIT SYSTEM WORKS!

Every assignment that you may select is worth a specific number of credits.

Before starting work at a particular Learning Centre, consider the different assignment options on the 'menu' in the light of:

your ability,  
the amount of effort required,  
the time you have available,  
how many CREDITS you need, or want to, score.

Once you have decided on your option, write down the potential worth of the credits in the relevant space on the CLASS SCORE SHEET. (This will be placed at some accessible point in the classroom).

When you successfully complete the assignment, the teacher will sign the score sheet and you will have earned the number of credits you chose. Should the assignment, in the teacher's opinion, not be satisfactorily completed, it will need to be reworked before a credit rating is confirmed.

When the programme is finished i.e., after the prescribed number of days, the total number of credits is totalled, and then converted to a GRADE. The grade represents a percentage which is then added (as a BONUS) to the result obtained in the test at the end of the programme.

If the test result, and allocated percentage exceed 100%, the surplus percentage is carried over to the next test.

AN EXAMPLE:

Suppose you opt for an assignment at LEARNING CENTRE 2 that is worth 70 credits and you complete this work to the teacher's satisfaction, you earn 70 credits for that learning centre.

On a different day, you opt for an assignment at a LEARNING CENTRE that is worth 100 credits, and this is also successfully completed, your total number of credits is now, 170

Assuming that another LEARNING CENTRE is too challenging, and you opt for an assignment worth only 40 credits, this is added to the total of 170 bringing it to 210 credits.

At the end of the programme (after 5 LC's), your aggregate is 380 credits. This value is converted to a GRADE (see below).

For the purposes of the example you are awarded a 'D-GRADE. This GRADE has a percentage value of 6% which is added to your test mark.

GRADE VALUES:

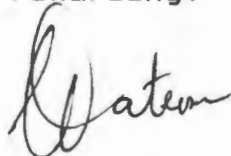
A MAXIMUM OF 500 CREDITS EARNS YOU AN	'A GRADE'	REPRESENTING	15%
A MAXIMUM OF 450	"	"	12%
A MAXIMUM OF 410	"	"	9%
A MAXIMUM OF 360	"	"	6%
A MAXIMUM OF 300	"	"	3%
LESS THAN 250	"	"	'ALL-EXPENSES-PAID' VISIT
TO YOUR STANDARD HEAD!!			

The following represent some of the actions you could use to assist you in becoming more self-reliant and responsible in learning.

- |                           |  |
|---------------------------|--|
| Self-evaluation           | - Ensure that you have completed all work according to the instructions.   |
| Organization              | - Prepare learning materials that will assist your learning.   |
| Goal-setting and planning | - Set a target % for the next test. Design a programme that will enable you to meet dead-lines.                          |
| Keeping records           | - Ensure that all class and home work is completed in the appropriate note book.   |
| Environmental structuring | - Organise your work area so that you are comfortable and relaxed.   |
| Information seeking       | - Establish what you must accomplish and how to go about it.   |
| Rehearsing and memorising | - Practice new learning until you have mastered it.  |
| Assistance seeking        | - Establish which persons may be able and ready to assist you (peers, teacher, adults) inside and outside the classroom. |
| Self-consequences         | - Decide how you will reward yourself for achieving your goal, or for working well.                                      |

Should you encounter any problems, or wish to point out flaws in the programme, I would value your objectivity. Please feel welcome to draw my attention to them.

I trust that you will find this approach both interesting and rewarding!



(COURSE DESIGNER)

BOOKING SCHEDULE

DAY NUMBER: ..... ① .....

1. LEARNING CENTRE 1: TUTORIAL

~~Andre Meade~~ **Liz M**

~~Megan Cox~~ C SMIL

~~Richard Wicht~~

~~C. Crocker~~

~~STEPH A. LAWSON~~

C. Crocker

2. LEARNING CENTRE 2: DESIGN

~~Megan Cox~~

~~Richard Wicht~~

L. Lieberman

N. Smith

R. Gordon Davis

D. Elliott

3. LEARNING CENTRE 3: PRACTICAL

~~Megan Cox~~ P Fuchs

~~Andre Meade~~ T. ...

~~Richard Wicht~~

N. ...

T. ...

T. du Toit

4. LEARNING CENTRE 4: COMPREHENSION

N. Kirk

V. ...

V. Krugh

J. ...

K. Sullivan

Ledley Tucker

5. LEARNING CENTRE 5: RESEARCH

Megan Cox

Theres Parewan

Richard Wicht

Archi ...

B. Cowell

Andre Meade

C. ...

	LC 1 Tutorial	LC 2 Design	LC 3 Practical	LC 4 Comprehension	LC 5 Research
Anderson, C	100 ✓	60 ✓	50 ✓	75 ✓	70 ✓
Bates, A	✓	80 ✓	✓	75 ✓	55 ✓
<del>...</del>	<del>100</del>	100 ✓	<del>100</del>	100 ✓	100 ✓
Classens, M.	60 ✓	60 ✓	85 ✓	80 ✓	95 ✓
<del>...</del>	100 ✓	80 ✓	100 ✓	100 ✓	65 ✓
Dockerill, D.	70 ✓	60 ✓	85 ✓	absent	35 ✓
<del>...</del>	100 ✓	70 ✓	85 ✓	100 ✓	52 ✓
Haahrett, A.	100 ✓	80 ✓	85 ✓	100 ✓	35 ✓
<del>...</del>	70 ✓	70 ✓	85 ✓	75 ✓	60 ✓
Herre, W.	70 ✓	80 ✓	0	70 ✓	35 ✓
Kelly, T.	100 ✓	80 ✓	50 ✓	100 ✓	85 ✓
<del>...</del>	100 ✓	100 ✓	85 ✓	100 ✓	35 ✓
Hadewig, M.	100 ✓	60 ✓	80 ✓	100 ✓	70 ✓
Mapham, K.	100 ✓	100 ✓	100 ✓	80 ✓	60 ✓
Masse, M.	100 ✓	70 ✓	85 ✓	80 ✓	65 ✓
Marchetti, C.	50 ✓	50 ✓	50 ✓	50 ✓	65 ✓
Mazewski	50 ✓	80 ✓	50 ✓	65 ✓	60 ✓
Patrick	50 ✓	50 ✓	50 ✓	85 ✓	65 ✓
Pesson, K.	100 ✓	60 ✓	50 ✓	100 ✓	100 ✓
Smedley, J.	70 ✓	80 ✓	0	75 ✓	45 ✓
Walsh, A.	70 ✓	60 ✓	40 ✓	65 ✓	0
Willis, V.	100 ✓	80 ✓	100 ✓	80 ✓	70 ✓
Van Greunen, T.	100 ✓	100 ✓	85 ✓	100 ✓	35 ✓
Whitchorn, N.	100 ✓	80 ✓	85 ✓	100 ✓	75 ✓
Ward, S.	100 ✓	100 ✓	85 ✓	100 ✓	0 ✓
Smith, D.	100 ✓	100 ✓	85 ✓	100 ✓	70 ✓
Waldron, J.	100 ✓	80 ✓	50 ✓	75 ✓	65 ✓
<del>...</del>	100 ✓	100 ✓	50 ✓	100 ✓	100 ✓
Gould, L.	50 ✓	50 ✓	50 ✓	90 ✓	100 ✓
NEETHLING	100 ✓	60 ✓	85 ✓	65 ✓	35 ✓

PLACE CREDIT TOTAL IN COLUMN AT START OF LESSON	5 options LC 1 TUT	3 options LC 2 DESIGN	LC 3 PRAC	6 options LC 4 COMP	6 options LC 5 RESEARCH	TOTAL	
CAWOOD, T. Dk	✓	60 ✓	70 ✓	70 ✓	<del>50</del> 30 ✓	330	6%
COWELL, B. Dk	<del>20</del> 70 ✓	100 ✓	50 ✓	75 ✓	<del>100</del> 95 ✓	390	9%
COX, M.	70	80 ✓	70	35	<del>25</del> 30 ✓	210	
CROCKER, C.	100	100 ✓	<del>60</del> 70	100	100 ✓	470	15%
DONOVAN, T.	100 ✓	80 ✓	100 ✓	100 ✓	<del>120</del> 100 ✓	450	12%
DU TOIT, T.	<del>100</del> 70 ✓	60 ✓	80 ✓	70 ✓	<del>90</del> 70 ✓	330	6%
ELLIOT, D. Dk	<del>100</del> 70 ✓	80 ✓	<del>100</del> 70	70	30	300	7%
FUCHS, P.	<del>30</del> 30 ✓	80 ✓	50 ✓	70	<del>80</del> 100 ✓	360	6%
GORDON-DAVIS, R. Dk		absent		70			X
GREEN, N.	<del>100</del> 30 ✓	70 ✓	45 ✓	65 ✓	<del>80</del> 30 ✓	245	0%
HAMMOND, N.	100 ✓	80 ✓	70	100 ✓	80 ✓	400	9%
KOK, N.	100 ✓	80 ✓	70 ✓	100 ✓	80 ✓	430	12%
<del>REED, J.</del>	30 ✓	80 ✓	15 ✓	65	<del>100</del> 45 ✓	295	8%
LEWARNE, A.	100 ✓	60 ✓	70 ✓	70 ✓	100 ✓	380	9%
LIEBENBERG, L.	<del>100</del> 70 ✓	80 ✓	<del>50</del> 70 ✓	70 ✓	<del>25</del> 25 ✓	325	X 6%
MADER, A.	70	80 ✓	70	70	<del>70</del> 10 ✓	380	6%
MILLER, L. Dk	100 ✓	<del>50</del> 50 ✓	70 ✓	70 ✓	100 ✓	390	9%
PRESSLY, C.	100 ✓	80 ✓	70 ✓	70 ✓	<del>100</del> 51 ✓	371	9%
REEVES, J. Dk	100 ✓	80 ✓	55	70 ✓	100 ✓	405	X 9%
SMITH, C.	<del>100</del> 70 ✓	60 ✓	<del>50</del> 50 ✓	100 ✓	80 ✓	390	9%
SMITH, N. Dk	70 ✓	50 ✓	50 ✓	70 ✓	30 ✓	270	X 3%
SULLIVAN, R. Dk	70 ✓	60 ✓			30 ✓	310	6%
TURNER, L. Dk	<del>100</del> 70 ✓	50 ✓	absent	70 ✓	30 ✓	220	0%
VILJOEN, D.	70 ✓	80 ✓	15	100	80 ✓	395	9%
WATHEN, T.	30 ✓	40 ✓	70 ✓	35 ✓	<del>100</del> 10 ✓	195	X 0%
WICHT, R.	50 ✓	80 ✓	70 ✓	70 ✓	80 ✓	350	6%

## **APPENDIX E**

### **RATING FORMS:**

- 1. INDEPENDENT OBSERVERS (Adults)**
- 2. LEARNERS**

INDEPENDENT OBSERVER RATING FORM

TYPE OF PROGRAMME: TEACHER-DIRECTED / PUPIL-REGULATED

This evaluation form will be used to assess the effectiveness of the programme processes observed by an independent observer.

Please mark the number in the RHS margin according to the following key:

1 = SELDOM      2 = SOMETIMES      3 = USUALLY      4 = ALL THE TIME

1.0 REponsive LEARNING ENVIRONMENT

- |      |  |   |   |    |   |
|------|--|---|---|----|---|
| 1.1  | The physical position of furniture and seating of pupils are deliberately planned to support learning.           | 1 | 2 | 3  | ④ |
| 1.2  | The environment provides simultaneous access to several learning activities.                                     | 1 | 2 | 3  | ④ |
| 1.3  | The environment is like a workshop or laboratory with emphasis placed on experimentation and involvement.        | 1 | 2 | 3  | ④ |
| 1.4  | The environment is highly structured presenting a complex, flexible organization to meet the needs of the pupil. | 1 | 2 | 3  | ④ |
| 1.5  | Assessment, contracting and evaluation are all used as tools to aid in the growth of the pupil.                  | 1 | 2 | 3  | ④ |
| 1.6  | The pupil is an active participant in the learning process.  | 1 | 2 | 3  | ④ |
| 1.7  | Movement, decision-making/taking self-directed learning, invention and inquiry are encouraged.                   | 1 | 2 | 3  | ④ |
| 1.8  | There is a minimum of total group lessons with most instruction occurring in small groups, or individually.      | 1 | 2 | 3  | ④ |
| 1.9  | The atmosphere is one of trust, respect and cooperation.   | 1 | 2 | ③  | 4 |
| 1.10 | The ambience is productive, supportive, and positive.  | 1 | 2 | ③? | 4 |

2.0 CHOICE AND PERCEIVED CONTROL

- 2.1 There are choices of activities, timing, and/or ways to learn. 1 2 3 (4)
- 2.2 The choices are real with no hidden preference on the part of the teacher. 1 2 3 (4)
- 2.3 The teacher avoids giving excessive help and praise for easy work that is poorly done. 1 2 3 (4)
- 2.4 An emphasis is placed on pupil-directed learning. 1 2 3 (4)
- 2.5 Pupils are given opportunity to select alternatives, and plan their learning experiences. 1 2 3 (4)
- 2.6 The pupil shares the responsibility for learning. 1 2 3 (4)
- 2.7 The pupils appear to experience a sense of perceived control and achievement. 1 2 3 (4)
- 2.8 The pupils can choose to learn on a level appropriate to their abilities. 1 2 3 (4)
- 2.9 Pupils are graded in terms of their own choice. 1 2 3 (4)
- 2.10 The completion, order, and timing of pupils' work is under their control. 1 2 3 (4)

3.0 OBJECTIVES ATTAINMENT

- 3.1 This programme ensured maximum time-on-task activity. 1 2 3 (4)
- 3.2 This programme facilitated responsible learning. 1 2 3 (4)
- 3.3 Mastery of content was facilitated. 1 2 3 (4)
- 3.4 This programme facilitated pupil-perceived control behaviour. 1 2 3 (4)
- 3.5 This programme facilitated self-pacing by pupils. 1 2 3 (4)
- 3.6 This programme required minimum teacher-directed behaviour. 1 2 3 (4)
- 3.7 Discipline was as good, or better, compared to the 'traditional' classroom. 1 2 3 (4)

There was a worthwhile, interesting experience in all ways

INDEPENDENT OBSERVER RATING FORMTYPE OF PROGRAMME: TEACHER-DIRECTED / PUPIL-REGULATED

This evaluation form will be used to assess the effectiveness of the programme processes observed by an independent observer.

Please mark the number in the RHS margin according to the following key:

1 = SELDOM      2 = SOMETIMES      3 = USUALLY      4 = ALL THE TIME

## 1.0 REONSIVE LEARNING ENVIRONMENT

- |      |  |   |   |   |   |
|------|--|---|---|---|---|
| 1.1  | The physical position of furniture and seating of pupils are deliberately planned to support learning.           | 1 | 2 | 3 | 4 |
| 1.2  | The environment provides simultaneous access to several learning activities.                                     | 1 | 2 | 3 | 4 |
| 1.3  | The environment is like a workshop or laboratory with emphasis placed on experimentation and involvement.        | 1 | 2 | 3 | 4 |
| 1.4  | The environment is highly structured presenting a complex, flexible organization to meet the needs of the pupil. | 1 | 2 | 3 | 4 |
| 1.5  | Assessment, contracting and evaluation are all used as tools to aid in the growth of the pupil.                  | 1 | 2 | 3 | 4 |
| 1.6  | The pupil is an active participant in the learning process.  | 1 | 2 | 3 | 4 |
| 1.7  | Movement, decision-making/taking self-directed learning, invention and inquiry are encouraged.                   | 1 | 2 | 3 | 4 |
| 1.8  | There is a minimum of total group lessons with most instruction occurring in small groups, or individually.      | 1 | 2 | 3 | 4 |
| 1.9  | The atmosphere is one of trust, respect and cooperation.   | 1 | 2 | 3 | 4 |
| 1.10 | The ambience is productive, supportive, and positive.  | 1 | 2 | 3 | 4 |

2.0 CHOICE AND PERCEIVED CONTROL

- 2.1 There are choices of activities, timing, and/or ways to learn. 1 2 3 (4)
- 2.2 The choices are real with no hidden preference on the part of the teacher. 1 2 3 (4)
- 2.3 The teacher avoids giving excessive help and praise for easy work that is poorly done. 1 2 3 (4)
- 2.4 An emphasis is placed on pupil-directed learning. 1 2 3 (4) →
- 2.5 Pupils are given opportunity to select alternatives, and plan their learning experiences. 1 2 3 (4)
- 2.6 The pupil shares the responsibility for learning. 1 2 3 (4)
- 2.7 The pupils appear to experience a sense of perceived control and achievement. 1 2 3 (4)
- 2.8 The pupils can choose to learn on a level appropriate to their abilities. 1 2 3 (4)
- 2.9 Pupils are graded in terms of their own choice. 1 2 3 (4)
- 2.10 The completion, order, and timing of pupils' work is under their control. 1 2 3 (4)

3.0 OBJECTIVES ATTAINMENT

- 3.1 This programme ensured maximum time-on-task activity. 1 2 (3) <sup>4</sup>
- 3.2 This programme facilitated responsible learning. 1 2 3 (4)
- 3.3 Mastery of content was facilitated. 1 2 3 (4)
- 3.4 This programme facilitated pupil-perceived control behaviour. 1 2 3 (4)
- 3.5 This programme facilitated self-pacing by pupils. 1 2 3 (4)
- 3.6 This programme required minimum teacher-directed behaviour. 1 2 3 (4)
- 3.7 Discipline was as good, or better, compared to the 'traditional' classroom. 1 2 (3) 4

Mr Wigg  
Day 3 Period 2

TYPE OF PROGRAMME: TEACHER-DIRECTED / PUPIL-REGULATED

This evaluation form will be used to assess the effectiveness of the programme processes observed by an independent observer.

Please mark the number in the RHS margin according to the following key:

1 = SELDOM      2 = SOMETIMES      3 = USUALLY      4 = ALL THE TIME

1.0      **REPONSIVE LEARNING ENVIRONMENT**

- |      |  |   |   |   |   |
|------|--|---|---|---|---|
| 1.1  | The physical position of furniture and seating of pupils are deliberately planned to support learning.           | 1 | 2 | 3 | ④ |
| 1.2  | The environment provides simultaneous access to several learning activities.                                     | 1 | 2 | 3 | ④ |
| 1.3  | The environment is like a workshop or laboratory with emphasis placed on experimentation and involvement.        | 1 | 2 | 3 | ④ |
| 1.4  | The environment is highly structured presenting a complex, flexible organization to meet the needs of the pupil. | 1 | 2 | 3 | ④ |
| 1.5  | Assessment, contracting and evaluation are all used as tools to aid in the growth of the pupil.                  | 1 | 2 | ③ | 4 |
| 1.6  | The pupil is an active participant in the learning process.  | 1 | 2 | 3 | ④ |
| 1.7  | Movement, decision-making/taking self-directed learning, invention and inquiry are encouraged.                   | 1 | 2 | ③ | 4 |
| 1.8  | There is a minimum of total group lessons with most instruction occurring in small groups, or individually.      | 1 | 2 | 3 | ④ |
| 1.9  | The atmosphere is one of trust, respect and cooperation.   | 1 | 2 | ③ | 4 |
| 1.10 | The ambience is productive, supportive, and positive.  | 1 | 2 | 3 | ④ |

2.0 CHOICE AND PERCEIVED CONTROL

- |      |   |   |   |   |   |
|------|---|---|---|---|---|
| 2.1  | There are choices of activities, timing, and/or ways to learn.                            | 1 | 2 | 3 | ④ |
| 2.2  | The choices are real with no hidden preference on the part of the teacher.                | 1 | 2 | 3 | ④ |
| 2.3  | The teacher avoids giving excessive help and praise for easy work that is poorly done.    | 1 | 2 | ③ | 4 |
| 2.4  | An emphasis is placed on pupil-directed learning.   | 1 | 2 | 3 | ④ |
| 2.5  | Pupils are given opportunity to select alternatives, and plan their learning experiences. | 1 | 2 | ③ | 4 |
| 2.6  | The pupil shares the responsibility for learning.   | 1 | 2 | 3 | ④ |
| 2.7  | The pupils appear to experience a sense of perceived control and achievement.             | 1 | 2 | ③ | 4 |
| 2.8  | The pupils can choose to learn on a level appropriate to their abilities.                 | 1 | 2 | 3 | ④ |
| 2.9  | Pupils are graded in terms of their own choice.   | 1 | 2 | 3 | ④ |
| 2.10 | The completion, order, and timing of pupils' work is under their control.                 | 1 | 2 | ③ | 4 |

3.0 OBJECTIVES ATTAINMENT

- |     |  |   |   |   |   |
|-----|--|---|---|---|---|
| 3.1 | This programme ensured maximum time-on-task activity.                        | 1 | 2 | 3 | ④ |
| 3.2 | This programme facilitated responsible learning.                             | 1 | 2 | ③ | 4 |
| 3.3 | Mastery of content was facilitated.  | 1 | 2 | ③ | 4 |
| 3.4 | This programme facilitated pupil-perceived control behaviour.                | 1 | 2 | ③ | 4 |
| 3.5 | This programme facilitated self-pacing by pupils.                            | 1 | 2 | ③ | 4 |
| 3.6 | This programme required minimum teacher-directed behaviour.                  | 1 | 2 | 3 | ④ |
| 3.7 | Discipline was as good, or better, compared to the 'traditional' classroom.. | 1 | 2 | 3 | ④ |

TYPE OF PROGRAMME: TEACHER-DIRECTED / PUPIL-REGULATED

This evaluation form will be used to assess the effectiveness of the programme processes observed by an independent observer.

Please mark the number in the RHS margin according to the following key:

1 = SELDOM      2 = SOMETIMES      3 = USUALLY      4 = ALL THE TIME

1.0 REPOSIVE LEARNING ENVIRONMENT

- |      |  |   |   |     |     |
|------|--|---|---|-----|-----|
| 1.1  | The physical position of furniture and seating of pupils are deliberately planned to support learning.           | 1 | 2 | 3   | (4) |
| 1.2  | The environment provides simultaneous access to several learning activities.                                     | 1 | 2 | 3   | (4) |
| 1.3  | The environment is like a workshop or laboratory with emphasis placed on experimentation and involvement.        | 1 | 2 | 3   | (4) |
| 1.4  | The environment is highly structured presenting a complex, flexible organization to meet the needs of the pupil. | 1 | 2 | (3) | 4   |
| 1.5  | Assessment, contracting and evaluation are all used as tools to aid in the growth of the pupil.                  | 1 | 2 | (3) | 4   |
| 1.6  | The pupil is an active participant in the learning process.  | 1 | 2 | 3   | (4) |
| 1.7  | Movement, decision-making/taking self-directed learning, invention and inquiry are encouraged.                   | 1 | 2 | (3) | 4   |
| 1.8  | There is a minimum of total group lessons with most instruction occurring in small groups, or individually.      | 1 | 2 | 3   | (4) |
| 1.9  | The atmosphere is one of trust, <del>respect</del> and cooperation.  | 1 | 2 | 3   | (4) |
| 1.10 | The ambience is productive, supportive, and positive.  | 1 | 2 | (3) | 4   |

2.0 CHOICE AND PERCEIVED CONTROL

2.1	There are choices of activities, timing, and/or ways to learn.	1	2	3	4
2.2	The choices are real <del>with no hidden preference on the part of the teacher.</del>	1	2	3	4
2.3	The teacher avoids giving excessive help and praise for easy work that is poorly done.	1	2	3	4
2.4	An emphasis is placed on pupil-directed learning.	1	2	3	4
2.5	Pupils are given opportunity to select alternatives, and plan their learning experiences.	1	2	3	4
2.6	The pupil shares the responsibility for learning.	1	2	3	4
2.7	The pupils appear to experience a sense of perceived control and achievement.	1	2	3	4
2.8	The pupils can choose to learn on a level appropriate to their abilities.	1	2	3	4
2.9	Pupils are graded in terms of their own choice.	1	2	3	4
2.10	The completion, order, and timing of pupils' work is under their control.	1	2	3	4

N/A

3.0 OBJECTIVES ATTAINMENT

3.1	This programme ensured maximum time-on-task activity.	1	2	3	4
3.2	This programme facilitated responsible learning.	1	2	3	4
3.3	Mastery of content was facilitated.	1	2	3	4
3.4	This programme facilitated pupil-perceived control behaviour.	1	2	3	4
3.5	This programme facilitated self-pacing by pupils.	1	2	3	4
3.6	This programme required minimum teacher-directed behaviour.	1	2	3	4
3.7	Discipline was as good, or better, compared to the 'traditional' classroom.	1	2	3	4

PUPIL-CONTROLLED LEARNING PROGRAMME (PLP)

EXPLANATION

This is not a test, but a questionnaire to discover the utility (usefulness) of the teaching programme you were involved in.

There are no right or wrong answers.

Before responding to a statement, reflect on your experiences at the LEARNING CENTRES.

Answer the questions as accurately, and honestly, as you can.

INSTRUCTIONS

1. Read each item carefully; do not leave any item out.
2. For each item, indicate with an X on the ANSWER SHEET the extent to which you agree with the statements.

Use the key below to answer all sections i.e., Sections A - C.

- 1 = none of the time
- 2 = a little of the time
- 3 = most of the time
- 4 = all of the time

3. Work as quickly as possible.
4. If you are unsure about an item, ask the supervisor to explain it to you.

SECTION A

A. IN YOUR OPINION, DID THIS PROGRAMME ...

1. ... make you feel more responsible concerning your class work?
2. ... motivate you (to perform better) in class?
3. ... give you opportunities to work autonomously (alone)?
4. ... help you to feel more confident about working alone, (without the teacher's direct supervision)?
5. ... expect you to use your initiative (to solve problems you encountered)?
6. ... expect you to manage (control) the learning yourself?
7. ... make you take more responsibility for your work?
8. ... keep you involved (in completing the chosen work) for the whole period?
9. ... expect you to prepare for class work in advance?
10. ... make you feel that you have mastered (understood) the work?

DURING THE TIME YOU SPENT AT THE LEARNING CENTRES, DID YOU ...

11. ... work at your own pace?
12. ... use all the time at your disposal?
13. ... select work in line with your ability?
14. ... select work in line with your interest(s)?
15. ... maintain your concentration for the whole time?
16. ... produce written work every period?
17. ... feel in control of your learning?
18. ... feel that you were working hard?
19. ... complete the all the assignments you opted for?
20. ... find the assignments interesting?

SECTION C

AS A PARTICIPANT IN THIS PROGRAMME, DID YOU ...

21. ... check that your work was completed according to the instructions given?
22. ... check that the quality of your work was good?
23. ... set goals in terms of how much work to do?
24. ... manage to complete all assignments opted for?
25. ... plan your work to avoid getting behind.
26. ... find that you ran out of time?
27. ... record (in writing) all work completed, ?
28. ... have a means of easily locating previous work?
29. ... have a method of locating information needed to complete assignments?
30. ... easily find the answers to assignments?
31. ... memorise work until you mastered it?
32. ... find you remembered the work when writing a test?
33. ... look for assistance when you needed it?
34. ... resist the temptation to ask others for help?
35. ... feel responsible for your academic successes and/or failures.
36. ... consider the consequences (outcomes) of your decisions before making them?

1 11 9 1





## **APPENDIX F**

### **SAMPLES: LEARNER NOTES**

**Selected Extracts of Learners' Notes  
Completed During Self-Regulated Instruction.**

# Tutorial questions

Q. Study the diagram of an alveolus and associated capillaries. Answer the questions.

(a) Which type of blood enters the blood capillary at A?  
 (b) By which physical process does oxygen move from D to C?  
 (c) B is a red blood corpuscle. Which pigment that aids with the transport of oxygen is found in this blood cell?  
 (d) Which kind of epithelium is Z composed?  
 (e) Name the features of the alveoli which make them well suited for gaseous exchange.  
 (f) Which muscles are involved in the movement of air from the lungs during forced breathing?



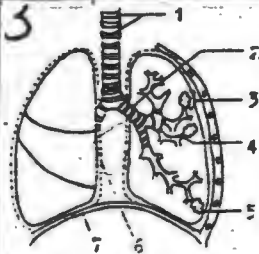
- a) deoxygenated ✓
- b) diffusion ✓
- c) haemoglobin ✓
- d) squamous epithelium ✓
- e) alveoli: so many as to make large surface area for gaseous exchange; walls of alveoli only 1 cell thick. ✓
- f) internal intercostal muscles; ✓  
 respiratory muscles X diaphragm, abdominal muscles.

Q. Study the diagram and answer the questions.

(a) Which respiratory gas will move as indicated by:  
 (1) X, and (2) Y?  
 (b) In which various states is the gas mentioned in (a), transported by blood?  
 (c) Which protein plays an important part in the transport of the gas mentioned in (a). (2). in blood?  
 (d) Which protein acts as a buffer when the  $H^+$  concentration in blood increases?  
 (e) Which enzyme catalyses the following reaction?  

$$H_2O + CO_2 \rightleftharpoons H_2CO_3$$
  
 (f) Mention two other gases which are involved in air pollution and inhibit the transport of respiratory gases.

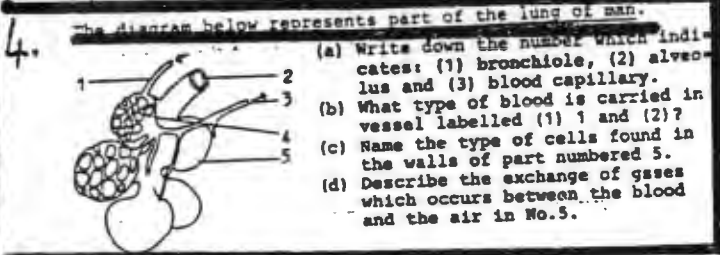
- a) x deoxygenated y: oxygen ✓
- b) in blood plasma and with haemoglobin ✓
- c) haemoglobin → globulin (protein) ✓
- d) plasma ✓
- e) carbonic anhydrase ✓
- f) carbon monoxide ✓  
 nitrogen dioxide ✓



3. The diagram represents part of the respiratory apparatus in man.
- Identify the parts numbered 1 to 7.
  - What type of blood: (i) enters the lungs, and (ii) leaves the lungs?
  - In the lungs is a high diffusion gradient favouring the passage of oxygen from No.4 into the blood.
    - Explain the term diffusion gradient
    - How is the diffusion gradient between No.4 and the blood maintained?
  - Why is it dangerous to inhale motor vehicle exhaust gases?
  - The blood of a person living at sea level, contains approximately 5 million red blood corpuscles per  $\text{mm}^3$ , while the blood of a person living at 5 000m above sea level contains approximately 7 million per  $\text{mm}^3$ .

2. ✓

- e-shaped rings of hyaline cartilage
- 1) cartilage rings 2) bronchus ✓ 3) trachea ✓ 4) vestibulum ✓  
5) alveoli (terminal) 6) heart x pleural membrane) diaphragm ✓
  - i) deoxygenated ✓ ii) oxygenated ✓
  - i) diffusion gradient:  $\text{CO}_2$  diffuses from blood in capillaries to air in alveoli till equilibrium is reached.  
ii)  $\text{CO}_2$  added / taken away.
  - contain carbon monoxide which is a poisonous gas.
  - number of  $\text{O}_2$  tension ↓  
less  $\text{O}_2$  combines with haemoglobin  
more RBCs combine with  $\text{O}_2$



- Write down the number which indicates: (1) bronchiole, (2) alveolus and (3) blood capillary.
- What type of blood is carried in vessel labelled (1) 1 and (2) 2?
- Name the type of cells found in the walls of part numbered 5.
- Describe the exchange of gases which occurs between the blood and the air in No.3.

- 1) 2 ✓ 2) 5 ✓ 3) 4 ✓
- 1) oxygenated (artery) 2) oxygenated
- squamous epithelial cells ✓
-

5. Differentiate between the terms: (i) respiration, (ii) gaseous exchange, and (iii) breathing in man.

- F3 -

3.

- i) Respiration controlled combustion, energy released;  $O_2$  taken in,  $CO_2$  released
- ii) gaseous exchange: exchange of  $CO_2$  and  $O_2$  from alveoli
- iii) Breathing: the mechanic ventilation; mechanism applied to transport  $O_2$

6. Name the features of the lungs which make it an efficient respiratory organ.

- spongy, elastic
- surrounded by double membrane
- bronchial have involuntary muscle and mucus.
- alveolus has 1 cell layer, capillaries have 1 cell.
- many capillaries.
- moist
- large surface area.

7. Write down the correct term for each of the following statements.

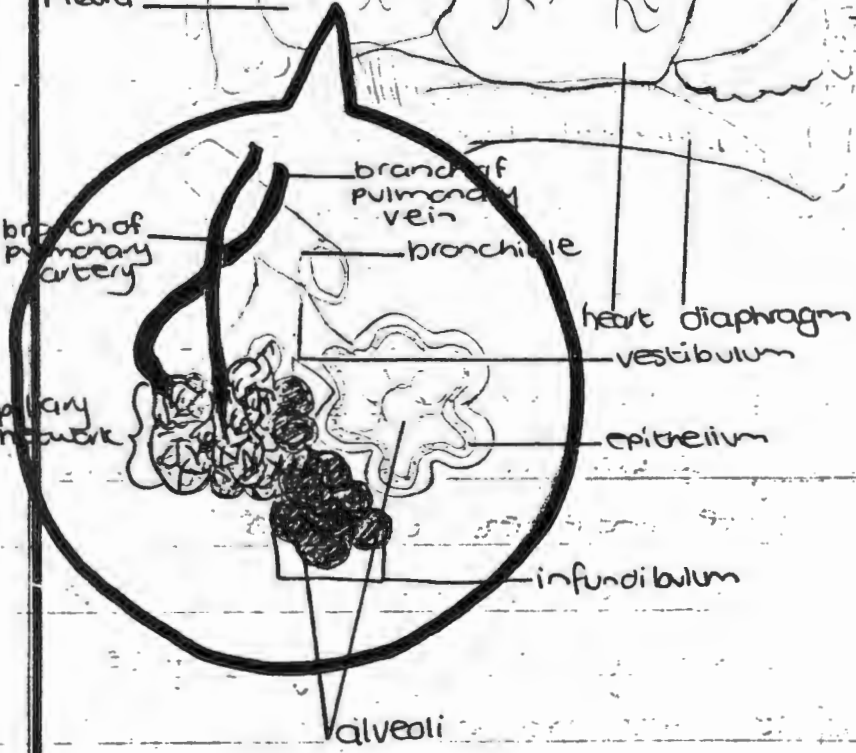
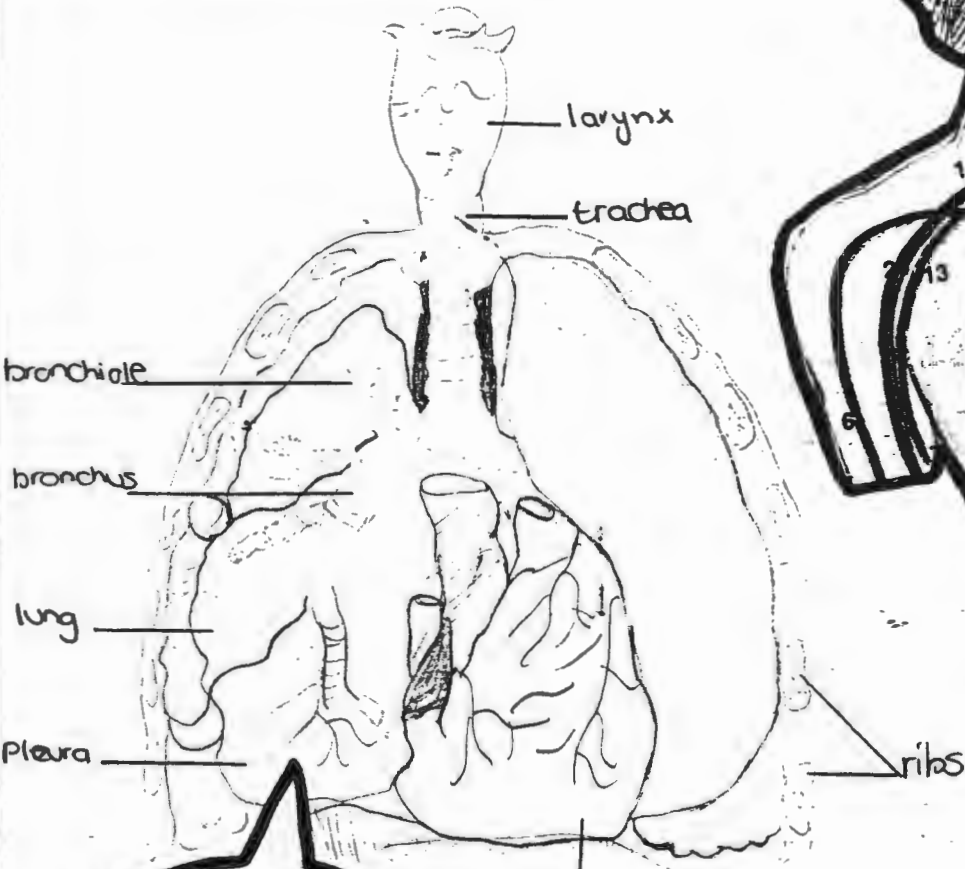
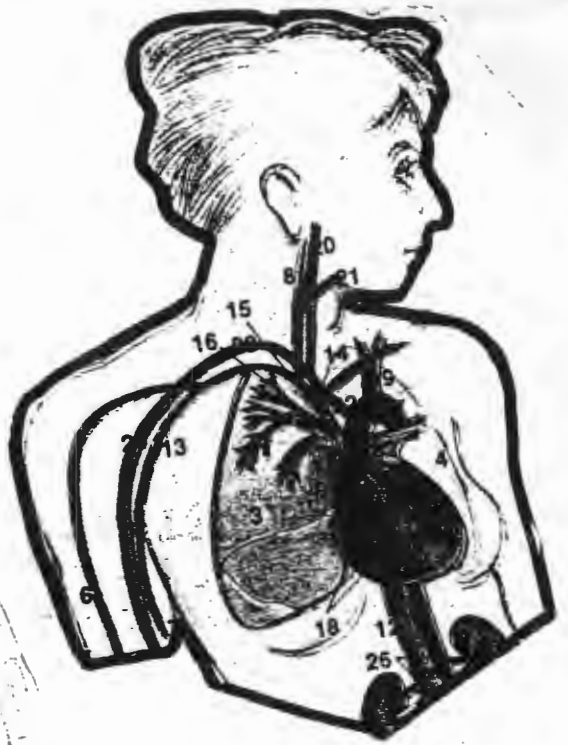
1. The muscular plate which separates the thoracic cavity from the abdominal cavity in man
2. The compound containing iron, that carries oxygen in the blood of a human being
3. The part of the lungs where exchanges of gases takes place
4. The metal element in haemoglobin which is essential for the transport of oxygen
5. The type of epithelium on the inside of the trachea and bronchi
6. The tissue lining the air passages in man
7. The space between the lungs where the heart occurs
8. A membrane lining the entire interior of the thoracic cavity and covering the lungs
9. (HG) The volume of air entering and leaving the lungs during a single breath during any state of respiratory activity
10. (HG) The maximum volume of air which can be inhaled and then forced out of the lungs
11. (HG) The region of the brain concerned with regulating breathing
12. (HG) The type of epithelium lining the aveoli of the lung

- 1) diaphragm ✓
- 2) haemoglobin ✓
- 3) alveoli ✓
- 4) iron ✓
- 5) ciliated columnar

- 6) columnar epithelium ✓
- 7) mediastinum ✓
- 8) pleura ✓
- 9) PO 40mm Hg ✓
- 10) 100mm  $(CO_2)$  ✓

- 11) medulla ✓
  - 12) squamous ✓
- air Good work!

Answers to objectives

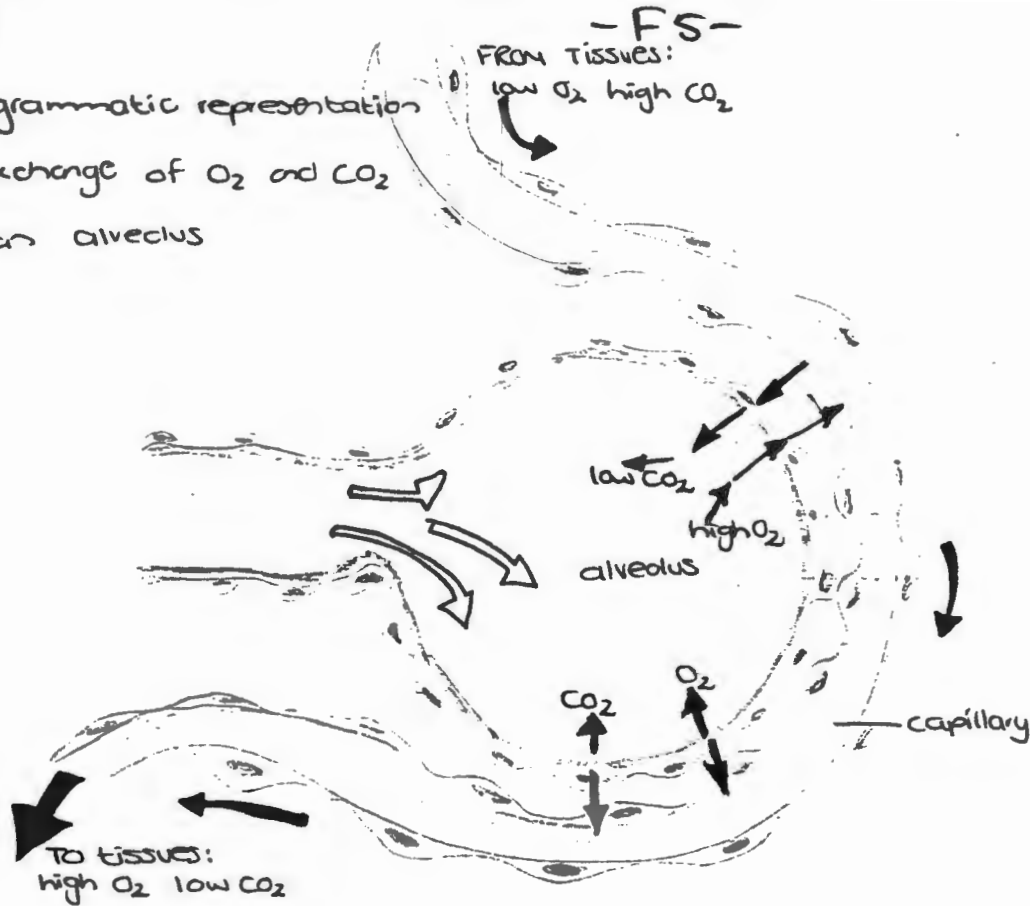


Internal structure of lungs



diagrammatic representation  
of exchange of  $O_2$  and  $CO_2$   
in an alveolus

2.



- 3) • large gaseous exchange surface: to take sufficient  $O_2$  from surroundings to satisfy requirements of active cells in large body.
- efficient transporting medium: transport respiratory gases between gaseous exchange surface and cells.
- close to external environment:
- surface must be thin: facilitate exchange of gases gases dissolve in  $H_2O$
- kept moist continuously: to keep it intact and preserve living cells, not accelerate movement of gases.
- Mechanism to regulate composition of external environment: this is in contact with gaseous exchange surface.
- gaseous exchange surface must be protected

- 4) • mucous in mucous membrane moistens inflowing air. This membranes must be prevented from drying out: goblet cells
- mucous is antiseptic and prevents inhaled germs from multiplying in air passages and lungs: goblet cells.
- dust particles from incoming air are caught in mucous and conveyed to exterior by sweeping movements: cilia

# Practical

effects of CO<sub>2</sub> on an indicator solution



Trial	Breaths/min	Pulse/min
1	18	68
2	16	60
3	28	74
4	22	80

## COLOUR CHANGE

	Beaker 1	Beaker 2	Beaker 3
5	yellow	light blue	yellow



- 1) First trial: breathing and pulse rate before exercise
- 2) Cells need lots of oxygen, quickly  $\therefore$  pulse rate is quicker; the heart pumps faster  $\therefore$  you breathe more often, and breathe in more oxygen.
- 3) faster
- 4) First: lots of  $\text{CO}_2$   
second: less  $\text{CO}_2$  (cell activity decreases)  
third: very little  $\text{CO}_2$  (hardly any cell activity; the cell returns to normal.)

# The Heimlich manoeuvre

1) dyspnoea: difficulty in breathing

respiratory distress: difficulty in respiration

respiratory failure: lungs stop functioning

bronchial obstruction: object obstructing airway

bronchoscope: instrument used in examining bronchus.

foreign body: object swallowed which obstructs airway.  
(pertaining to text)

percussion: act of tapping the body so as to determine the condition of an internal organ.

fluoroscopic examination of thorax: instrument with an eye is fitted with a fluorescent screen to look at x-rays. (of thorax)

Auscultation: method of listening to the heart and lungs.

⊖ atelectasis: irregularity of body functions due to defective muscles.

2) bronchoscope

3) p	(children's doctor)
radiologist	(x-rayer)
bronchoscopist	(lungs)

4) air enters lung because bronchus expands during inspiration, but the caliber of bronchus becomes less during expiration, bronchial wall closes on objects trapping air distal it.

5) the right lung is bigger.

# Spirometer

1) Formula for formulae calculated v.c.

$$\frac{[(0.041 \times \text{height in cm}) - (0.018 \times 17^{\text{age}}) - 2.69] \times 1000}{\text{calculated v.c.}} = \% \text{ lung capacity}$$

$$= \frac{[(0.041 \times 161 \text{ cm}) - (0.018 \times 17) - 2.69] \times 1000}{\text{calculated v.c.}}$$

$$= \frac{2000}{3605}$$

$$= 55.47\%$$

2) Lungs are diseased ∴ decrease in lung capacity.

# COMPREHENSION

13 May 1992

## Section A

- 4.1.1
- 1) A large surface area is essential.
  - 2) The surface area must be exposed to the source of oxygen.
  - 3) There must be a short distance over which the oxygen has to diffuse.

4.1.2. Partial pressure refers to the amount of oxygen in a particular region which results in the diffusion gradient.

4.1.3 Gaseous Exchange.

4.1.4 Haemoglobin, a respiratory pigment, increases the oxygen-carrying capacity of the blood and it has a high affinity for oxygen.

- 4.1.5
- 1) across the alveolar walls
  - 2) between the blood and the cells of the body.

4.1.6 The diaphragm and the external intercostal muscles

4.1.7 Inspiration is the active phase of breathing. It is associated with the contraction of muscles, which increases the volume of the thoracic cavity.

The diaphragm, which is normally convex from above, becomes less convex as a result of muscular contraction. This increases the length of the thoracic cavity from top to bottom. In

Synchronously the abdominal muscles relax to accommodate the internal organs, which have been pushed down.

Simultaneously, the external intercostal muscles contract and slightly lift the ends of the ribs, together with the breastbone.

Because of the shape and arrangement of the ribs the thoracic cavity is enlarged from side to side and from front to back.

The increase in size causes a decrease in pressure in the interpleural space and air flows into the lungs.

Section B

4.4.1 A carcinogen is a cancer-causing substance ~~in tumors~~

4.4.2 Group A carcinogen is more harmful than any other carcinogen

- 4.4.3
- 1) lung cancer
  - 2) bronchitis
  - 3) pneumonia
  - 4) tracheitis
  - 5) laryngitis
  - 6) middle-ear infections
  - 7) asthma
  - 8) tobacco-related heart and respiratory diseases
  - 9) heart disease
  - 10) ulcers
  - 11) hardened arteries
  - 12) strokes
  - 13) spasms in coronary arteries
  - 14) headaches
  - 15) smoke affects blood clotting

- 4.4.4
- 1) carcinogens
  - 2) carbon monoxide
  - 3) hydrogen cyanide
  - 4) formaldehyde
  - 5) nicotine

4.4.5 ?

4.4.6 A nonsmoker is more likely to get cancer from environmental tobacco smoke than from all the hazardous outdoor air pollutants regulated by the Environmental Protection Agency - including asbestos, arsenic and radio-activity combined

- 4.4.7
- 1) miscarriages
  - 2) premature births
  - 3) birth defects
  - 4) children can be 1 cm shorter and three to five months behind in reading and arithmetic
  - 5) they can suffer from respiratory infections
  - 6) they may develop pneumonia
  - 7) they may develop bronchitis

4.4.8. The main reason for the slow progress in introducing such regulations is the lobbying power of big business. The Provincial Administrator vetoed the council's decision to demarcate areas for nonsmokers in restaurants following pressure from tobacco companies and the Federated Hotel, Liquor and Catering Association of South Africa. They insisted that restaurateurs should be able to make their own rules and that official restrictions would be an invasion of their rights.

4.4.9. Through the clubs, unions and other associations, the non-smoker should press for adequate protection, including a ban on smoking at meetings. A smoke-control campaign could be organised and non-smokers must demand more from their legislators

4.4.10 I am prepared to make the smokers more aware of the dangers of smoking, not only to themselves but to non-smokers. Articles on smoking should be placed regularly in the local newspaper and posters on the dangers of passive smoking should be handed out in shopping centres or displayed on notice boards in shops. An anti-smoking week should be created to make smokers aware of their actions.

## **APPENDIX G**

### **COURSE MATERIALS:**

- 1. EXCRETION**
- 2. GASEOUS EXCHANGE**

LEARNING CENTRE 1

TUTORIAL

POINTER'S !

1. This LC stresses the LEARNING OBJECTIVES (syllabus requirements) of EXCRETION.

It also requires that you do some reading around the subject to make you more familiar with the content. The reading material will be available at least 24 hours before you choose to attend this LC.

It is suggested that you read the material sooner as this will give you more time to discover which areas need special attention during the tutorial.

The teacher and other pupils in your group will discuss the reading you have done and you will need to participate in such a discussion, and answer questions on the work. It is essential that you are thoroughly prepared for this period, therefore!

You will also be able to select some examination problems to solve. These should be completed during the remainder of the period, and at home. The number of problems you select will be directly linked to the CREDIT RATING you are contracting for.

ONCE YOU HAVE DECIDED ON THE CREDIT VALUE FOR THIS LC, RECORD IT ON THE CLASS SCORE SHEET.

You are reminded that the teacher is a valuable resource and you should use this opportunity to query any aspects of the work.

- 
2. The material comprises the following:

- 2.1 the LEARNING OBJECTIVES
- 2.2 the READING MATERIAL
- 2.3 the PROBLEMS to solve

3. The CREDIT RATING is structured as follows:

- 3.1 FOR 30 CREDITS - An ability to successfully answer questions during the tutorial on the Learning Objectives marked with an (\*), and complete a minimum of 2 examination questions from the worksheet.

- 3.2 FOR 50 CREDITS - An ability to answer questions on the Learning Objectives as in (3.1) above, and PAGE 1 of the notes. A minimum of 3 examination questions should be completed.

- 3.3 FOR 70 CREDITS - An ability to complete the requirements for (3.2) above, and answer questions on PAGE 2 of the notes. A minimum of 4 examination questions should be completed for homework.

- 3.4 FOR 100 CREDITS - Complete all requirements of (3.3) and complete 5 examination questions from the worksheet.

Module 4: The Anatomy and Physiology of Man  
Unit 3: Excretion

1. Structure of the urinary system
2. Function of the urinary system
3. Homeostatic control of the excretory products of the urinary system
4. Other forms and mechanisms of excretion in man.

Unit Objectives

At the end of this section of work you should be able to:

- \*1. Explain the meaning of the term homeostasis in your own words;
- \*2. List three factors which should be maintained at a constant concentration in the body fluids;
- \*3. Name four organs in man which play a part in the excretion of waste products;
- \*4. Name the most common waste products excreted by each of the following organs:
  - \* Lungs (one product);
  - \* Skin (one product);
  - \* Alimentary canal (one product);
  - \* Kidney (three products);
- \*5. Name at least one other product excreted by each of the organs listed.
- \*6. List two reasons for the process of excretion living organisms;
7. Make a labelled drawing to show the position of the major organs of the urinary system and associated structures in relation to the outline of the body.
- \*8. Name and describe the relative position of the major organs of the urinary system and associated structures;
9. Make a labelled diagram to show the visible internal structure of the kidney in longitudinal section.
10. Indicate on a labelled diagram of a kidney the position of the blood vessels which connect the renal artery to the renal vein
11. Name the blood vessels between the renal artery and the renal vein in the correct sequence and identify those which form part of the renal portal system.
12. Label a diagram of a nephron and associated blood vessels.
13. Recall that the nephron is the functional unit of the kidney.

14. Explain the process of glomerula filtration by:
  - 14.1 naming the parts of the malpighian body;
  - 14.2 recalling that:
    - \* the afferent arteriole has a wider bore than the efferent arteriole;
    - \* this difference in bore produces a high pressure in the capillaries of the glomerulus;
    - \* the epithelial cells of Bowman's capsule are called podocytes and that they form a layer containing many small pores;
    - \* the podocytes and the endothelial cells lining the capillaries of the glomerulus together act as a filter;
    - \* all components of the blood plasma except plasma proteins can pass through this filter system and a major portion of these components form the filtrate which enters the cavity of the Bowman's capsule.

15. List two factors which contribute to the effectiveness of glomerula filtration:

16. Explain the process of renal reabsorption and secretion by:
  - 16.1 naming three mechanisms by which substances useful to the body are reabsorbed from the glomerula filtrate;
  - 16.2 naming:
    - \* one substance reabsorbed by osmosis;
    - \* four substances reabsorbed actively;
    - \* one substance reabsorbed passively;
  - 16.3 recalling the names of the different regions of the renal tubules and giving the major function of each region;
  - 16.4 naming three substances which are actively secreted into the renal tubules;

- \*17. Name four of the main components of urine and give the approximate percentage composition of urine.

18. Recall that antidiuretic hormone (ADH or vasopressin) controls the degree of water reabsorption by the kidney and that:
  - 18.1 it is secreted by the hypothalamus in response to stimulation of osmoreceptors in the hypothalamus;
  - 18.2 the osmoreceptors respond to the concentration of sodium chloride in the blood;
  - 18.3 ADH secretion increases the permeability of the walls of the distal convoluted tubule and collecting ducts to water and more water is reabsorbed into the blood.

# URINARY SYSTEM: STRUCTURES AND FUNCTIONS

-G3-

## Kidneys

### Macrostructure

The two kidneys are bean-shaped organs that are retroperitoneal (behind the peritoneum) on either side of the vertebral column. Each kidney weighs 120 to 170 g (4 to 6 ounces) and is usually about 12 cm (5 inches) long. The right kidney, with the liver above it, is lower than the left. The right kidney is at the level of the 12th rib. An adrenal gland lies on top of each kidney.



Figure 36-1 Organs of the male urinary system.

Each kidney is surrounded by a considerable amount of fat and connective tissue that serves to support and maintain it in position. The surface of the kidney is covered by a thin, smooth layer of fibrous membrane called the *capsule*. The *hilus* serves as the entry site for the renal artery and nerves and the exit site for the vein and ureter.

On a longitudinal section of the kidney (Fig. 36-2), the internal structure can be visualized. The outer layer is referred to as the *cortex*, and the inner layer is called the *medulla*. The medulla consists of a number of *pyramids*. The apices of these pyramids are called *papillae*. They enter *calyces*. Minor calyces merge to form major calyces. These, in turn, form a funnel-shaped sac called the *renal pelvis*. The lumen of the pelvis decreases to form the *ureter*.

### Microstructure

The functional unit of the kidney is the *nephron*. Each kidney has over 1 million nephrons. A nephron is composed of a *glomerulus*, *Bowman's capsule*, and a *tubular system*. The tubular system consists of the *proximal convoluted tubule*, the *loop of Henle*, and the *distal convoluted tubule* (Fig. 36-3). Several nephrons converge into a collecting duct; which eventually merges into a minor calyx.

## Ureters

The ureters are tubes 25 to 35 cm (10 to 12 inches) long and 1 cm (0.4 inch) in diameter that convey urine to the bladder from the kidneys. One to five peristaltic contractions per minute aid in the transportation of urine from the kidneys to the bladder. The ureters receive a nerve supply from the sympathetic vasoconstriction fibers. The afferent fibers from the ureters play an important role in the formation of *renal colic*, which is associated with the lodging and passing of ureteral calculi.

Where the ureters enter the bladder, a fold of mucous membrane serves as a *ureterovesical valve*, which prevents the backflow of urine into the ureters when the bladder contracts. Since the renal pelvis holds only 3 to 5 mL of urine, damage to the kidneys can result from a backflow of urine.

## Bladder

The urinary bladder is a collapsible storage bag composed of muscular elastic tissue which is capable of considerable distension. Its primary function is to serve as a reservoir for urine.

On the average, 200 to 250 mL of urine in the bladder will cause moderate distension and the urge to void. When the quantity of urine reaches 400 mL, the person will feel uncomfortable. The bladder's capacity varies with the individual, ranging from 1000 to 1800 mL.

The distension of the bladder stimulates stretch receptors in the bladder wall, causing reflex contraction of the bladder and simultaneous relaxation of the internal sphincter. This is followed by relaxation of the external sphincter and emptying of the bladder.

Voluntary contraction of the external sphincter, which is composed of skeletal muscle, is a learned response. It is dependent on proper neurological function. Injury to the nerves supplying the bladder, urethra, spinal cord, or motor area of the cortex may lead to *incontinence*.

The mucous membrane of the bladder wall has phagocytic ability. The unidirectional flow of urine from the kidney to the bladder also guards against infection.

Normal urine output is approximately 1500 mL/day, which varies with food and fluid intake. The volume of urine produced at night is less than one-half that formed during the day due to hormonal influences. This diurnal pattern of urination is normal. Most people void 5 to 6 times per day and occasionally at night.

## Urethra

The urethra is a small tube that leads from the bladder to the exterior of the body. Its primary function is to discharge urine. In the female it is 3 to 5 cm (1 to 2 inches) long and lies behind the symphysis pubis and anterior to the vagina. The male urethra, which is about 20 cm (8 inches) long, originates at the bladder and extends the length of the penis. It serves as the passageway for urine as well as semen.

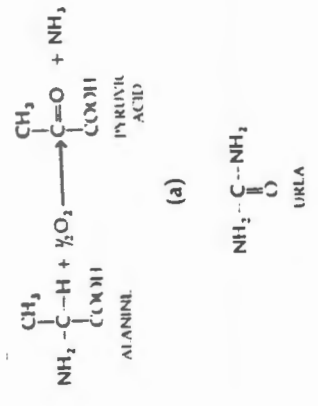
Normally, the urethra contains some bacteria. The turbulent flow of urine through the urethra flushes it free of debris and bacteria. The mucous membrane lining the urethra secretes mucus that is bacteriostatic.

The kidneys can be viewed as excretory organs. The two chief metabolic wastes that cells release into the bloodstream are carbon dioxide and the nitrogen compounds, such as ammonia, produced by the breakdown of amino acids. Carbon dioxide is eliminated from the lungs, or it diffuses out into water through the skin or gills. Animals that have unlimited access to water most often excrete nitrogenous wastes in the form of ammonia through the body surface, the gills, or the kidneys. In land-dwelling organisms, which do not have this unlimited water supply, nitrogenous wastes must be converted to some other form since ammonia is highly toxic, even in low concentrations.

Many birds, terrestrial reptiles, and insects eliminate waste nitrogen in the form of uric acid or uric acid salts (urates), which can be excreted as crystals. In birds, the uric acid and urates are mixed with the undigested wastes in the cloaca (the common exit chamber for the digestive and urinary tracts), and the combination is dropped as a semisolid paste, familiar to frequenters of public parks and admirers of outdoor statuary. This nitrogen-laden substance forms a rich natural fertilizer. Guano, the excreta of seabirds, accumulates in such quantities on the small islands where the birds gather in great numbers that at one time it was harvested commercially. Mammals excrete nitrogenous wastes mostly in the form of urea, which is produced by deamination of amino acids in the liver (Figure 38-2).

In a broader view, however, kidneys are also regulatory organs. Excretion is highly selective. For instance, although most of the urea in the blood that enters a normal mammalian kidney is usually excreted, almost all the amino acids are retained. Glucose is not excreted unless it is present in high amounts, as in diabetes mellitus. The presence of sugar in the urine is, in fact, a basis for the diagnosis of this form of diabetes and the evaluation of its treatment. Chemical regulation also involves maintaining closely controlled concentrations of ions such as  $\text{Na}^+$ ,  $\text{K}^+$ ,  $\text{H}^+$ ,  $\text{Mg}^{2+}$ ,  $\text{Ca}^{2+}$ ,  $\text{Cl}^-$ , and  $\text{HCO}_3^-$ . These ions are important for their specific roles in various chemical processes, such as maintenance of protein structure, membrane permeability, action potentials, and muscle contraction. Some are important in the regulation of the pH of the blood, which is also monitored by the kidneys.

(a) Deamination—the removal of the amino group—is the first step in the breakdown of amino acids. The products of the reaction are ammonia and a carbon skeleton, which can be broken down for energy or converted to sugar or starch. (b) Urea, the principal form in which nitrogen is excreted in most mammals. It is formed in the liver by the combination of two molecules of ammonia with one of carbon dioxide through a complex series of energy-requiring reactions. What would be the other product of this reaction?



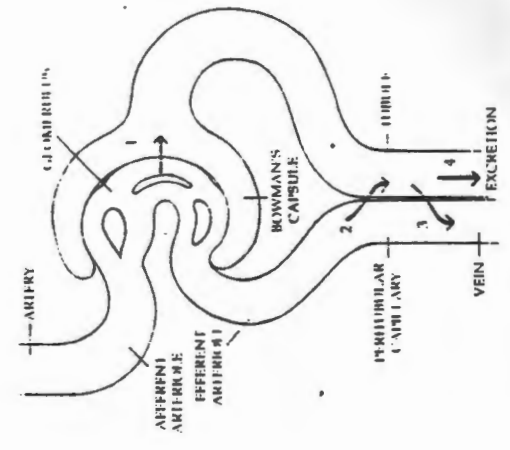
Blood enters the kidney through the renal artery, which divides into progressively smaller branches, the arterioles, which each lead, in turn, to a glomerulus. Unlike other capillary beds, a glomerulus lies between two arterioles. The efferent arteriole—the one leading out—then divides again into capillaries, the peritubular ("around-the-tubules") capillaries, that then merge to form the renal vein.

The efferent vessel—the one leading out of the glomerulus—constricts, keeping the blood within the glomerulus at a pressure about twice that in other capillaries. As a consequence, fluid is forced out of the glomerular capillaries into Bowman's capsule. About one-fifth of the blood plasma that enters the kidney is thus forced into the nephron through the capillary walls of the glomerulus. This crucial first stage of kidney function is called *filtration*, and the fluid entering the capsule is referred to as the *filtrate* (Figure 38-4). Except for the absence of large molecules, the filtrate has the same chemical composition as the plasma.

The second stage in formation of the urine is secretion, in which molecules left in the plasma are selectively removed and actively secreted by the cells of the tubular walls into the filtrate. Penicillin, for example, is removed from the circulation in this way.

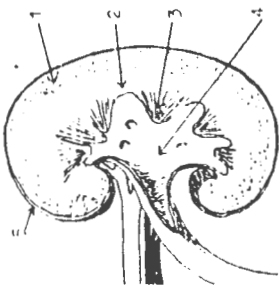
Another major step that occurs simultaneously with secretion is resorption. During the passage through the renal tubule, most of the water and solutes that entered the tubule in the first place are transported back into the bloodstream by the cells of the tubular walls through the capillary walls (Figure 38-5). Secretion and resorption of most solutes take place by active transport. As a consequence, the kidney has a high energy requirement, higher on a per-gram basis than even the heart.

Finally, the remaining fluid leaves the nephron; it is now the urine. You will note that excretion by the kidney is quite different from elimination by the intestinal tract. In the latter, the residue that is eliminated consists almost entirely of material that never entered the body.



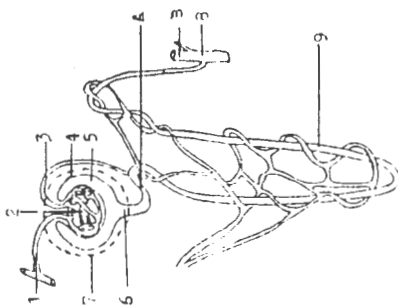
38-4 The four basic components of renal function: (1) filtration through the glomerular capillaries into Bowman's capsule; (2) secretion from the peritubular capillary into the tubule; (3) resorption from the tubule to the peritubular capillary; (4) excretion. The pressure in the glomerular capillaries is regulated by constriction of the efferent arteriole.

- C. Study the diagram of a kidney and answer the questions.
- Identify the parts numbered 1 to 6
  - Write down the numbers of those parts in which the numbers of those structures are found:
    - interlobar arteries;
    - arcuate arteries;
    - interlobular veins;
    - Malpighian bodies; and
    - ducts of Bellini.
  - State two structural characteristics of the glomeruli which promote filtration.
  - Mention two non-filterable constituents of plasma.
  - Mention two other important functions of the kidney except secretion.
  - What is understood by the concept homeostasis?



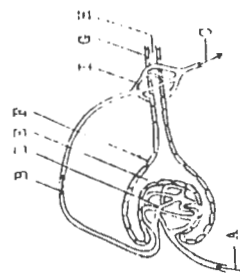
- Q. The diagram below represents a nephron of a kidney. Answer the following questions using numbers and names.

- In what ways are the parts making up the ringed portion numbered 7, well suited for their function(s)?
- A study of the functioning of a kidney shows that it is largely concerned with conserving water and useful solutes rather than getting rid of them. Show how this is true by describing what happens in the nephron from Point A on the diagram to point B.

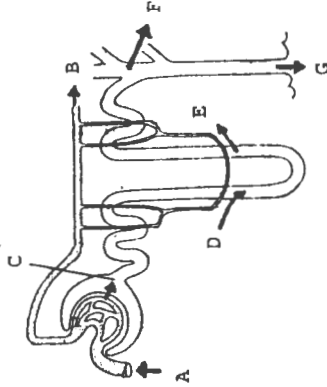


- Study the diagram of part of a nephron of a mammal. The arrows A, B and C indicate the direction of flow of the blood.

- Blood capillaries are represented by \_\_\_\_\_ and \_\_\_\_\_.
- Of the blood vessels shown, the highest blood pressure is at \_\_\_\_\_ and is caused by \_\_\_\_\_.
- Fluid passes from D to E by a \_\_\_\_\_.
- The fluid at E consists of \_\_\_\_\_ and \_\_\_\_\_.
- The cells at G are \_\_\_\_\_ epithelium.
- The cells at G absorb \_\_\_\_\_ and synthesize \_\_\_\_\_, which is added to the filtrate.
- The structure shown in the diagram is situated in the \_\_\_\_\_ of the \_\_\_\_\_ in man.



4. The diagram below represents a nephron of a mammal.

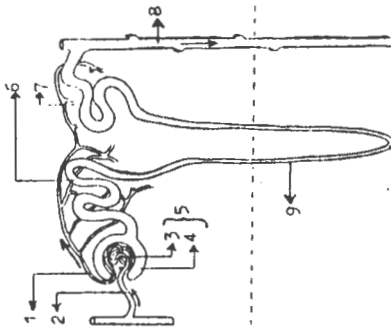


- Which letter indicates the largest passive diffusion of water?
- Name the process indicated by C.
- Which letter represents the active transport of sodium ions.
- Between which two letters do you expect to find dilute urine?
- Which letter indicates the flow of concentrated urine?
- Write down the letter(s) of the parts of the nephron which are situated in the medulla of the kidney.
- Which letter represents the passive diffusion of sodium ions?

5.

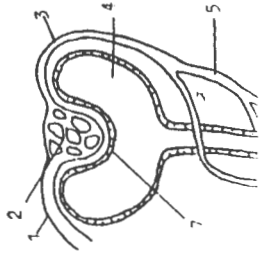
This diagram represents the functional unit of a kidney.

- What is the name of this unit?
- Identify the part of the kidney:
  - beneath the dotted line, and
  - above the dotted line.
- Why is blood at no.3 under high pressure?
- List three substances which pass into structure numbered 4. What name is given to the process whereby substances pass into 4 from the structure numbered 3?
- Identify the parts numbered 5 to 9.
- Mention two functions of the kidney.
- What is the collective name of the fluid waste product in the part numbered 5?
- Name three substances which are reabsorbed into the blood from the part numbered 7.
- Name the epithelium lining the part numbered 9.



- The diagram represents a nephron.
- Write down the letter of the tube which brings wastes to the nephron.
  - Why is blood in 2 under pressure?

- Name three substances likely to be found in structure indicated by 4.
- Name two substances which are reabsorbed from 6 into the blood.
- Name the liquid which will drain out of the tube labelled 6 into the pelvis of the kidney.
- Write down the number of the part





LEARNING CENTRE 2

DESIGN

POINTER'S

This LC is creative in nature and you will be required to build a model and study a drawing involving the kidney. At the same time you will need to learn the names of the different renal structures.

The learning of ALL structures and their associated labels is an important feature of this LC. You are advised to pay close attention to this work as it is definitely examinable!

Once you believe you are ready to test your learning, move to a TEST CUBICLE and follow the instructions there. You are required to leave the test in the box for checking by the teacher.

Credits are selected by choosing a test you believe is in line with your ability, and understanding, of the work at this LC. You will mark the test yourself. No credits are confirmed unless a marked test has been received by the teacher.

---

INSTRUCTIONS

1. Read EXTRACT A and quickly build a model depicting the structure described in the extract. Check the accuracy of your interpretation with the diagram in ENVELOPE A (20 mins).
  2. Learn the drawing and labels of diagram 2.2 (15 mins).
  3. Now proceed to the TEST CUBICLE (20 mins).
-

EXTRACT A: HUMAN NEPHRON

READ THE EXTRACT BELOW THROUGH CAREFULLY.

USING THE MODELLING CLAY PROVIDED, MAKE A SMALL MODEL MATCHING THE DESCRIPTION OF THE NEPHRON IN THE EXTRACT BELOW.

WORK QUICKLY (20 MINUTES).

THE MODEL SHOULD APPEAR RESPECTABLE, BUT NOT RESEMBLE A MASTERPIECE!

CONCENTRATE ON LEARNING THE NAMES OF THE DIFFERENT PARTS AS YOU PROCEED.

---

---

The functional unit of the kidney is the nephron. It comprises three portions: a cluster of capillaries looking like a ball of wool, called the glomerulus; an invaginated, hollow socket, comprising a double envelope of membrane called Bowman's capsule; and a long, narrow tube named the renal tubule which extends out of the back of the capsule.

THE GLOMERULUS AND BOWMAN'S CAPSULE

The cluster of capillaries fit inside Bowman's Capsule much resembling a ball-and-socket joint. The capsule and glomerulus together form the structure named the Malpighian body. The blood vessel entering the ball is called the afferent arteriole. It narrows to form the ball of capillaries and finally emerges out of the "socket" (Bowman's Capsule) as an efferent arteriole. This blood vessel is wider than the capillaries, but narrower than the afferent arteriole.

The efferent arteriole soon branches into many finer capillaries that resemble a spider's web. These capillaries are called the peritubular capillaries. Eventually these capillaries re-unite to form the renal vein.

The capsule, which appears like a horseshoe when seen in transverse section, has a tube coiling out of the rear of it.

THE RENAL TUBULE

Leading from the rear of the capsule is a convoluted (twisting) tube, the proximal convoluted tubule. After several turns it narrows, and dips down into the "spider-web" of peritubular capillaries. It then turns back upwards very sharply closely resembling a hairpin.

The tubule running downward is named the descending loop of Henle, the turn is the loop of Henle, and the portion moving upwards is the ascending limb of Henle. The ascending limb widens into another convoluted tubule, the distal convoluted tubule.

The distal tubule then widens into a larger vessel called the collecting duct. This duct dips down, running parallel to the limbs of Henle. The peritubular capillaries closely surround the limb of Henle, but do not enclose the collecting duct.

The collecting duct leads downward into the centre of the kidney.

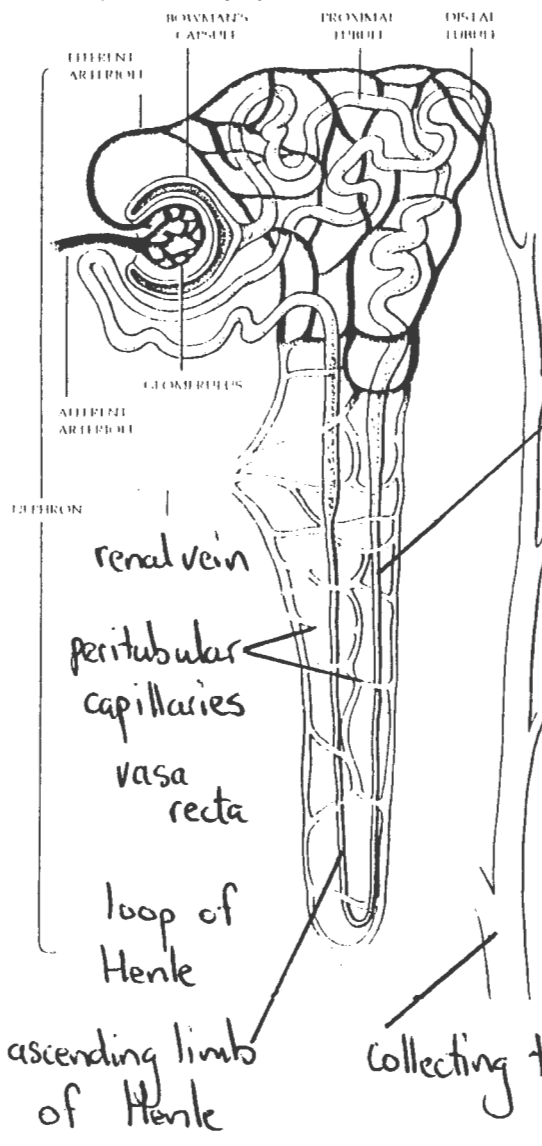
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CHECK YOUR ACCURACY BY COMPARING YOUR EFFORTS WITH A PICTURE OF A NEPHRON CONTAINED IN THE ENVELOPE.

In humans and other mammals, the functional unit of the kidney is the *nephron*. It consists of a cluster of capillaries known as the *glomerulus*, a bulb called *Bowman's capsule*, and a long, narrow tube, the *renal tubule* (Figure 38-3). Each of the two human kidneys contains about a million *nephrons* with a total length of some 80 kilometers (50 miles) in an adult male.

Urine is formed in the nephrons and passed into the renal pelvis, which is, in essence, a funnel. From this funnel, the urine trickles continuously through the ureters to the bladder, which stores the urine until it is excreted through the urethra. (The urinary system is shown in Figure 31-14, on page 579.)



Note: Bowman's capsule + glomerulus → Malpighian body.

descending limb of Henle

(b) The nephron is the functional unit of the kidney. Blood enters the nephron through the afferent arteriole leading into the glomerulus. Fluid is forced out by the pressure of the blood through the thin capillary walls of the glomerulus into Bowman's capsule. The capsule connects with the long renal tubule, which loops down into the medulla and up again. As the fluid travels through the tubule, almost all the water, ions, and other useful substances are resorbed into the bloodstream through the capillaries surrounding the tubule. Other substances are secreted from the capillaries into the tubules. Waste materials and some water pass along the entire length of the tubules into the collecting duct and are excreted from the body.

renal vein  
peritubular capillaries  
vasa recta  
loop of Henle  
ascending limb of Henle  
collecting tubule

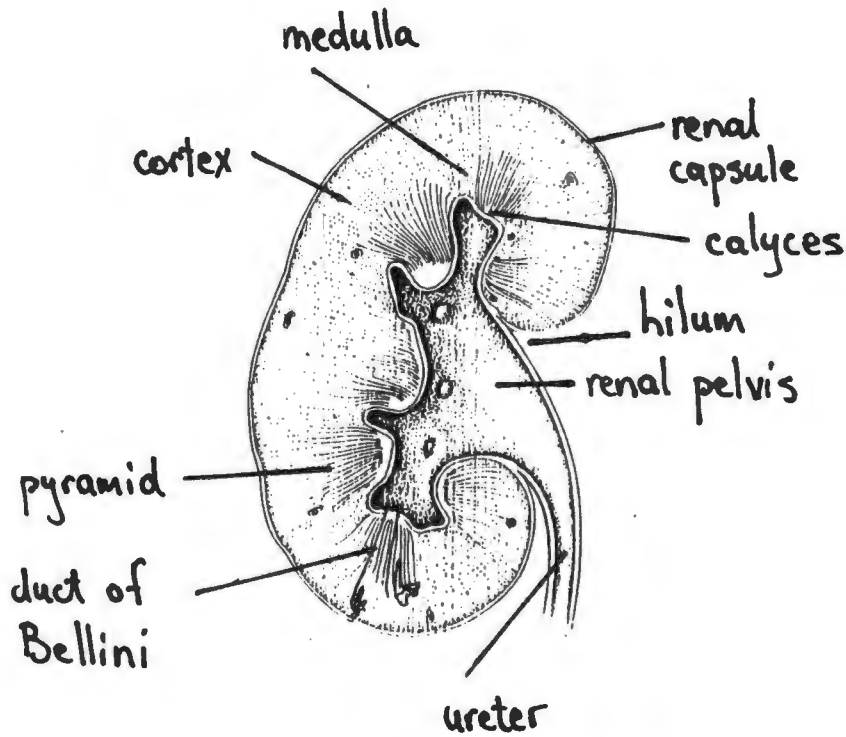
Nephron of kidney

FIG.2.2: T/S OF HUMAN KIDNEY

STUDY THE DIAGRAM BELOW AND LEARN THE LABELS AS QUICKLY AS POSSIBLE.

ONCE YOU FEEL YOU KNOW THE LABELS, MOVE TO A TEST CUBICLE AND SELECT A TEST TO WRITE THAT MATCHES THE CREDITS YOU WANT.

REMEMBER, THE GREATER THE CREDIT RATING THE MORE DIFFICULT AND LONGER THE TEST!



L/S of human kidney

(a) In longitudinal section, the human kidney is seen to be made up of an outer region, the cortex, which contains the fluid-filtering mechanisms, and an inner region, the medulla, through which collecting ducts carrying the urine merge and empty into the funnel-shaped renal pelvis, which enters into the ureter.

RATIONALE FOR THE TEST CUBICLE

Three tests are provided in specific envelopes numbered TEST A, TEST B, and TEST C.

All examine the same work, but each varies in difficulty and length. The credit value of each is indicated on the envelope. You should select a test based on:

- \* the number of credits you desire;
- \* the amount of time still available this period (you must both write and mark the test);
- \* how well you think you learnt the material at the LC.

NB! A test result of 80 - 100% earns you the number of credits you aimed for.

A test result of 60 - 79% means you forfeit 20 of your indicated credits.

A test result of 40 - 59% means you forfeit 40 of your indicated credits.

THIS IS TO ENSURE THAT YOU MASTER THE WORK BEFORE ATTEMPTING THE TEST. THIS WORK IS TO BE REGARDED AS VERY IMPORTANT FOR EXAMINATION PURPOSES!

PROCEDURES

1. YOU MAY NOT VIEW THE ACTUAL TEST UNTIL YOU HAVE SELECTED THE CREDIT VALUE.
2. ENTER THE APPROPRIATE NUMBER OF CREDITS ON THE CLASS SCORE SHEET!
3. Select the test representing the number of credits you need from the envelope.
4. Write the test on the paper provided
5. Mark the test.
6. Place the marked test in the box named TESTS.

INSTRUCTIONS: TEST A

This test is worth a total of 60 CREDITS.

It requires that you do two drawings with the labels.

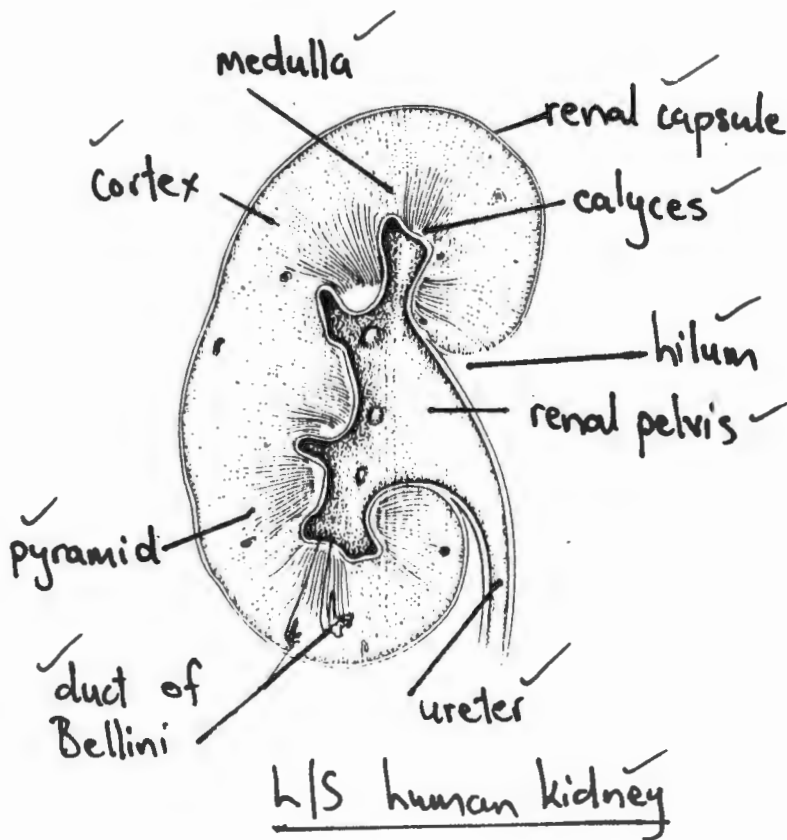
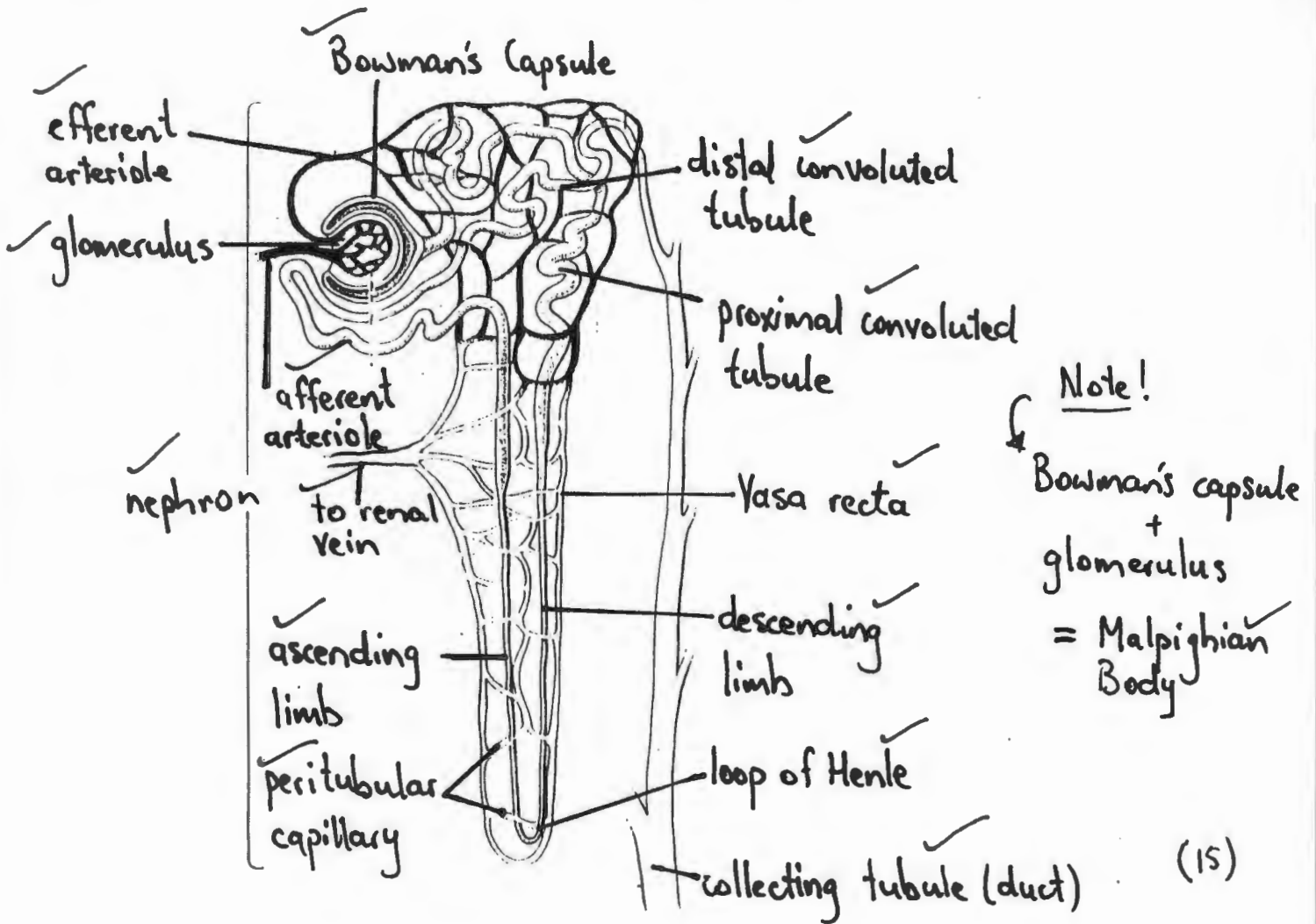
---

1. DRAW THE NEPHRON AS IT APPEARS IN THE DIAGRAM AT THE LC.  
INCLUDE ALL LABELS.  
(15 MARKS)
  
  2. DRAW A L/S OF THE KIDNEY AS SEEN AT THE LC.  
INCLUDE ALL LABELS.  
(10 MARKS)
- 

THE ANSWER TO THIS TEST IS IN ENVELOPE MARKED : ANSWER / A

ANSWERS TO TEST A

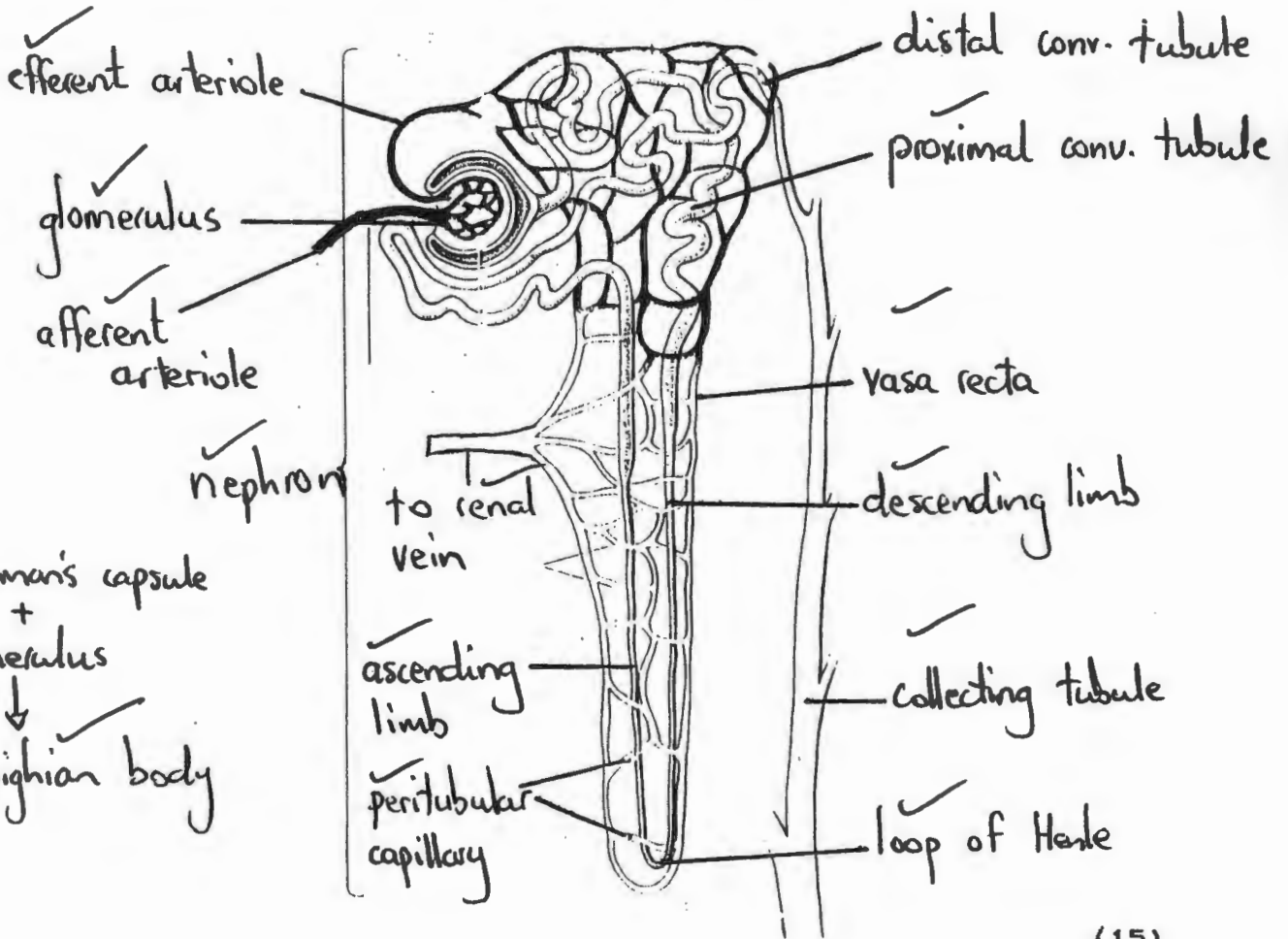
The following labels should appear in your answer.



ANSWERS TO TEST B

1. The following labels should appear in your diagram of the nephron.

Bowman's Capsule



(15)

- 2.1
- 2.1.1 glomerulus
- 2.1.3 renal / proximal convoluted tubule
- 2.1.5 afferent
- 2.1.8 ascending limb of Henle
- 2.1.10 collecting duct
- 2.1.2) Bowman's Capsule
- 2.1.6) peritubular
- 2.1.7) Henle
- 2.1.9) distal
- 2.1.4) efferent

(10)

TOTAL: (25)

INSTRUCTIONS : TEST B

This test is worth a total of 80 CREDITS if passed successfully (80 - 100%).

It requires that you draw and label a nephron and complete the sentences below by writing down the missing words ONLY on the answer sheet.

---

1. DRAW AND LABEL A NEPHRON. (15 MARKS)
2. SUBSTITUTE THE MISSING WORDS WITH THE CORRECT ONES IN THE SENTENCES BELOW.
  - 2.1 Each 2.1.1 is made up of a coiled arteriole resembling a ball of wool, invaginated into a hollow balloon, 2.1.2, whose stem forms the start of the 2.1.3 tubule. The 2.1.4 arteriole is narrower than the 2.1.5 arteriole. The former arteriole divides into a complex network of 2.1.6 capillaries which surround the limb of 2.1.7. The 2.1.8 moves upwards into the cortex of the kidney and widens forming the 2.1.9 convoluted tubule. This finally descends back into the medulla of the kidney and is known as the 2.1.10.

(10 MARKS)

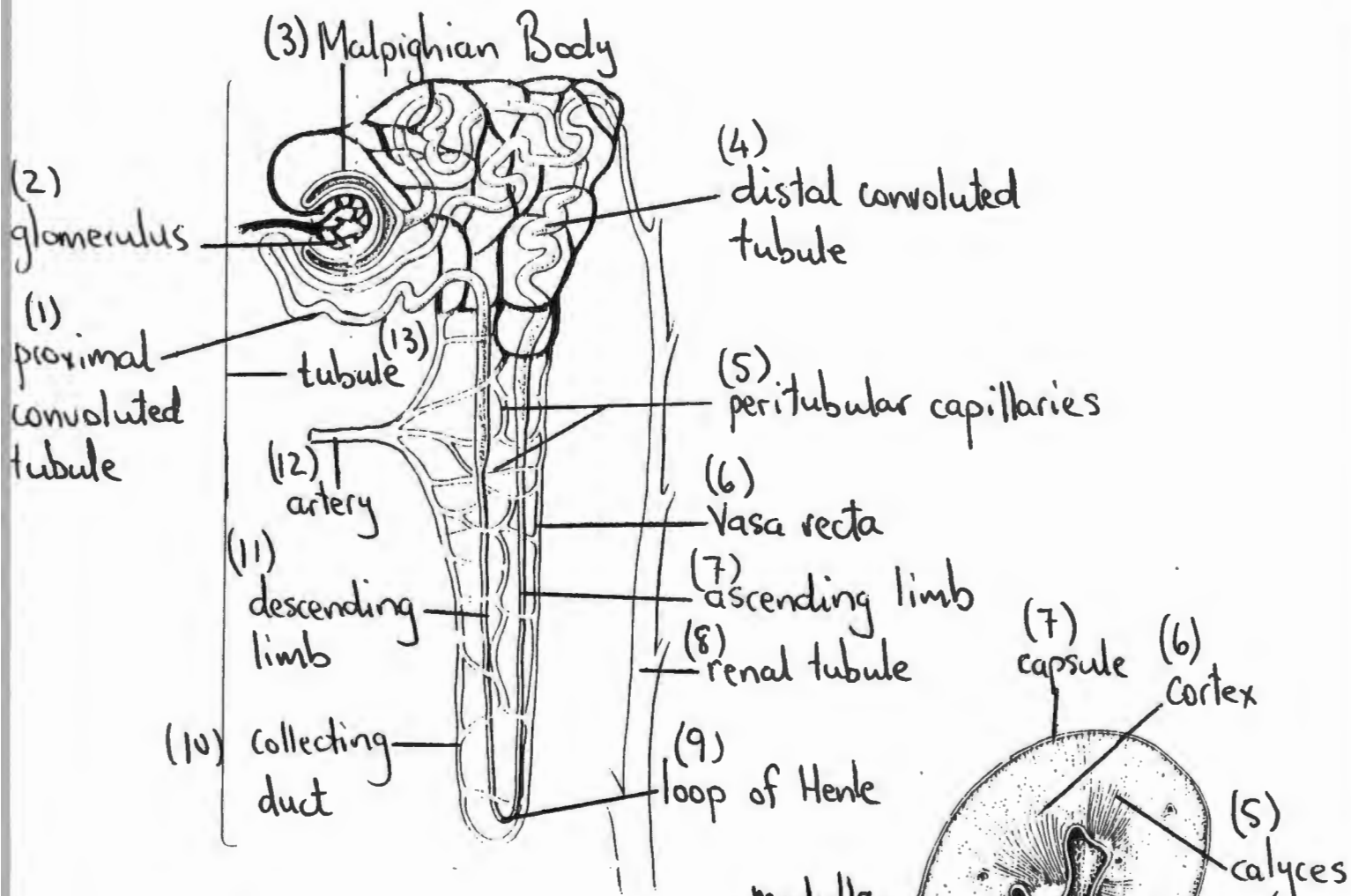
TOTAL : (25)

THE ANSWER TO THIS TEST IS IN ENVELOPE MARKED: ANSWER / B

INSTRUCTIONS: TEST C

This test is worth a total of 100 CREDITS if passed successfully (80-100%). It requires that you identify the errors in the labels and replace these with the correct labels. In the second part of the test you need to correct the incorrect statements by changing the underlined word(s). Write only the corrected word(s) down.

1. SELECT THE LABELS THAT ARE INCORRECT ON THE DRAWINGS BELOW. WRITE DOWN THE NUMBER OF THE INCORRECT LABEL AND ALONGSIDE IT THE CORRECT VERSION OF THE LABEL.



(A) Nephron

(B) L/S human kidney

2. CORRECT EACH OF THE FOLLOWING STATEMENTS BY WRITING THE CORRECT WORD(S) ON THE ANSWER PAPER.
- 2.1. The outer region of the kidney is termed the nephron.
  - 2.2 The ureter, upon entering the glomerulus, widens to form the renal tubule.
  - 2.3 The proximal convoluted tubule leads from the ascending limb of Henle into the collecting duct.
  - 2.4 The glomerular capillaries reunite to form the renal vein.
  - 2.5 The Malpighian body is made up of a double layer of membranes two cells thick.
  - 2.6 The cortex is the part of the kidney through which the collecting ducts lead.
  - 2.7 The conical sections inside the kidney are called pyramids.
  - 2.8 The bloodvessel supplying the kidney with blood is the renal vein.
  - 2.9 The wider of the two arterioles that enter the Bowman's capsule is known as the peritubular arteriole.

(10 MARKS)

TOTAL : (40 MARKS)

---

THE ANSWER TO THIS TEST IS IN ENVELOPE MARKED: ANSWER / C

ANSWERS TO TEST C

**(A) Nephron**

- 1. (1) distal conv. tubule ✓
- (3) Bowman's Capsule ✓
- (4) proximal conv. tubule ✓
- (7) descending limb ✓
- (8) collecting tubule/duct ✓
- (10) Vasa recta ✓
- (11) ascending limb ✓
- (12) vein ✓
- (13) nephron ✓

**(B) Kidney**

- (1) cortex ✓
- (2) calyces ✓
- (3) ureter ✓
- (4) renal pelvis ✓
- (5) pyramids ✓
- (6) medulla ✓

Note: ✓ for correct number, and...  
 ✓ for correct label

(30)

- 2.
- 2.1 cortex ✓
- 2.3 distal ✓
- 2.5 Bowman's Capsule ✓
- 2.7 calyces ✓
- 2.9 afferent ✓

- 2.2) hilum / pelvis ✓
- 2.4) peritubular ✓
- 2.6) medulla ✓
- 2.8) renal artery ✓

(10)

TOTAL: (40)

LEARNING CENTRE 3

PRACTICAL

POINTER'S !

Part of the Biology syllabus requires that you do practical work. This LC provides an opportunity to do so.

Available credits are indicated in brackets.

AFTER DECIDING WHICH OPTIONS YOU INTEND SELECTING, RECORD THEIR TOTAL CREDIT VALUE ON THE CLASS SCORE SHEET.

---

3. The following activities are offered by this LEARNING CENTRE.
- 3.1 A dissection of the RAT to view the internal position of the kidneys and associated organs. (50)
- 3.2 A dissection of a sheep's kidney to view the internal structure. (35)
- 3.3 To conduct various tests on urine samples and thereby attempt to identify any irregularities in the urine. (50)

### 3.1 INTERNAL ARRANGEMENT OF URINARY ORGANS: RATTUS

This component of the LC involves a dissection of the lower abdominal region of a rat.

Follow the instructions of the practical sheet carefully.

Be VERY careful of the dissecting instruments. Report any cuts etc. to the teacher. Wash your hands well after completion of the dissection.

---

ONCE YOU HAVE EXPOSED THE KIDNEYS, URETERS, BLADDER AND URETHRA, DRAW AND LABEL THESE ORGANS AS SEEN IN THE DISSECTION. YOU MAY NOT COPY A DRAWING DIRECTLY FROM A BOOK.

---

### 3.2 INTERNAL STRUCTURE OF A SHEEP KIDNEY

This component of the LC involves a dissection of a sheep kidney.

Follow the instructions below carefully.

Be VERY careful of the dissecting instruments. These are sharp. Report any cuts etc. to the teacher immediately.

---

#### EXTERNAL STRUCTURE:

Note the general shape, colour and size.

Start at the convex side and remove any fat that may be present. What is the function of this fat?

Expose the thin renal capsule by pushing in the scalpal blade diagonally at the convex side and lift. The capsule can be removed.

#### INTERNAL STRUCTURE:

Cut the kidney into equal halves along the convex side to the hilum. Separate the two halves and examine the interior.

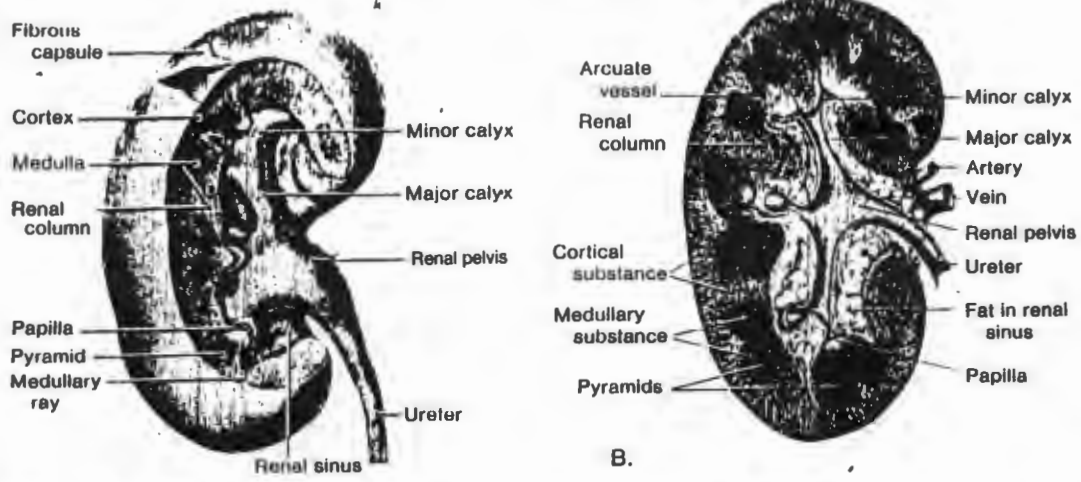
Note the difference in colour between the cortex and medulla. To what do you attribute the darker colour of the cortex?

Try and see the Malpighian bodies in the cortex using a hand-lens or dissecting microscope.

Identify where the pyramids open into the calyces. Use a dissecting needle and find the fine tubules in the pyramids.

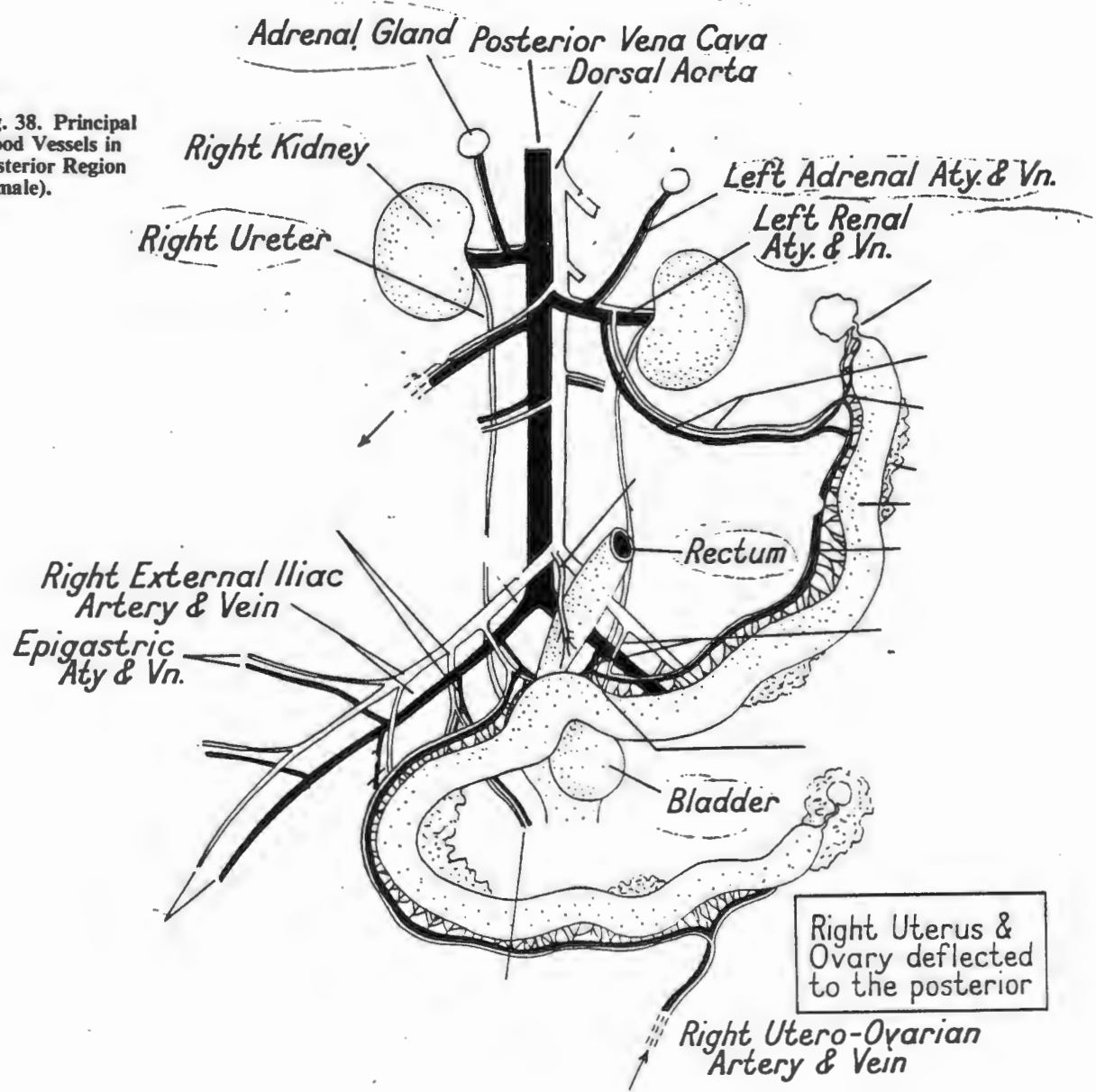
MAKE A SIMPLE DRAWING WITH LABELS SHOWING THE AREAS YOU MANAGED TO IDENTIFY.

DO NOT COPY SUCH A DIAGRAM FROM A BOOK.



**Figure 2-104.** A, drawing of a right kidney from which the anterior lip of the renal sinus is cut away to show the structure of the kidney. B, longitudinal section of the kidney. In these drawings observe that the outer one-third of the renal substance is cortex and the inner two-thirds is medulla. Note that the cortical tissue (composed of glomeruli and convoluted tubules) is granular on section and extends as renal columns through the medulla to the renal sinus. The medulla contains 7 to 14 pyramids which are striated because of the collecting tubules they contain. Each pyramid ends as a papilla on which a dozen or more of the largest collecting tubules open. One to four papillae project into each minor calyx. Usually there are from 8 to 18 renal papillae and 7 to 15 minor calyces. Several minor calyces unite to form a major calyx. There are usually two major calyces which are directed toward the superior and inferior parts of the kidney. Occasionally there is a third major calyx.

**Fig. 38.** Principal Blood Vessels in Posterior Region (female).



3.3

URINE TESTING

The exercises of this option seek to determine the nature of the urine samples in the different test tubes.

Each sample represents a patient who is potentially sick. You need to use the test dops and universal indicator paper supplied and, together with one or two other pupils do a protein (biuret) and sugar (Benedicts) test, to confirm the accuracy of the test strips and hence establish any abnormalities in the urine.

Once you have proven what the irregularities are, you should indicate what disease(s) the patient has. To do this, you may need to research some of the literature supplied (the reading extract at the COMPREHENSION LC contains some information you may find helpful).

Finally, briefly indicate which part of the kidney may be malfunctioning.

---

STEP 1: Test each of the test tubes of urine with the test papers. Compare the colour of the dip with that on the container supplied. Note your findings.

(Due to a shortage of dops, you should share results with each other).

STEP 2: In partnerships, do a biuret and Benedict's test on the appropriate samples.

STEP 3: Check the available literature to establish the disease causing the abnormality in the urine. Note it for each urine sample.

STEP 4: Mention (where applicable) the specific part of the kidney which may be malfunctioning.

WORK QUICKLY !!



### Summary of nephron function

The basic function of nephrons is to clean or clear blood plasma of unwanted substances. After the glomerulus has filtered the blood, the tubules separate the unwanted from the wanted portions of tubular fluid. The wanted portions are returned to the blood, and the unwanted portions pass into urine.<sup>2</sup> Of every 125 mL filtered, about 1 mL becomes urine; 124 mL is returned to the blood.

### Physiology of Urine Formation

#### Glomerulus

Urine formation starts at the glomerulus, where blood is filtered. The blood flow to the glomeruli of both kidneys is about 1200 mL/minute. A semipermeable membrane surrounding the outer surface of the glomerulus allows for filtration. The filtration pressure is supplied by the heart. Filtration in the glomerulus is more rapid than in ordinary tissue capillaries because of the porosity of the glomerular membrane. The ultrafiltrate is similar in composition to blood except that it lacks blood cells, platelets, and large plasma proteins.

The amount of blood filtered by the glomeruli in a given time is referred to as the *glomerular filtration rate (GFR)*. The normal GFR is about 125 mL/minute. However, on the average only 1 mL/minute leaves as urine.

#### Tubular function

Since the glomerular membrane functions to filter substances chiefly by size, provision is made for the reabsorption of essential materials and the excretion of nonessential ones (Table 36-1). The tubules and collecting ducts carry out these functions by means of *reabsorption* and *secretion* (Fig. 36-5). Reabsorption refers to the passage of a substance from the lumen of the tubules through the tubule cells and into the capillaries. It involves both active and passive transport. Tubular secretion refers to the passage of a substance from the capillaries through the tubular cells into the lumen of the tubule.

In the proximal convoluted tubule, about 80 percent of the electrolytes are reabsorbed. Normally, all the glucose, amino acids, and protein are reabsorbed.

Hydrogen (H<sup>+</sup>) and creatinine are secreted into the filtrate.

In the loop of Henle, reabsorption continues. In the ascending limb, chloride is actively reabsorbed, followed passively by sodium. About 25 percent of the filtered sodium is reabsorbed here. Henle's loop is also very important in conserving water.

Two important functions of the distal convoluted tubule are final regulation of water balance and acid-base balance. In the distal tubule, the role of certain hormones becomes important. *Antidiuretic hormone (ADH)* released by the posterior pituitary is required for water reabsorption. In the presence of ADH, the tubules become more permeable to water, allowing it to return to circulation. In the absence of ADH, the tubules are practically impermeable to water, and any water in them leaves the body as urine.

In the presence of *aldosterone* (released from the adrenal cortex) at the distal tubule, sodium is reabsorbed, followed by water. In exchange for sodium, potassium is excreted.

*Parathormone* is released from the parathyroid gland. It is secreted in the presence of low serum calcium levels. It causes increased tubular reabsorption of calcium and decreased tubular reabsorption of phosphate. Therefore, serum calcium levels are increased.

Acid-base regulation involves reabsorbing and conserving most of the bicarbonate (HCO<sub>3</sub><sup>-</sup>) and secreting excess hydrogen ions (H<sup>+</sup>). The distal tubule functions in different ways to maintain the pH of ECF within a range of 7.35 to 7.45 (see Chap. 12). In the distal tubule, potassium ions are also secreted into the filtrate.

When the filtrate leaves the distal tubule and enters the collecting duct, it is called *urine*. Final concentration of water may occur in the collecting duct.

- 4.1.1 In which ways is the glomerular filtrate different to blood plasma?
- 4.1.2 Suggest three means by which filtrate formation is enhanced. Two these are mentioned in the reading.
- 4.1.3 What do the terms reabsorption and excretion mean in terms of kidney function?
- 4.1.4 Mention the essential differences in function between the proximal and distal convoluted tubules.
- 4.1.5 In which ways is the functioning of aldosterone and ADH different? In which ways are they the same?
- 4.1.6 How is the pH of extra-cellular fluid maintained by the kidney?
- 4.1.7 How, in a chemical sense, can the urine concentration be increased?
- 4.1.8 The kangaroo rat, a desert animal, has the ability to super concentrate its urine thereby conserving water. What structural difference do you think exists between the nephron of this animal and that of a human?
- 4.1.9 Assuming both kidneys are suddenly removed, consider which symptoms could be anticipated as the person begins to deteriorate.

THE WORK OF THE KIDNEYS : VIDEO VD/UA-208

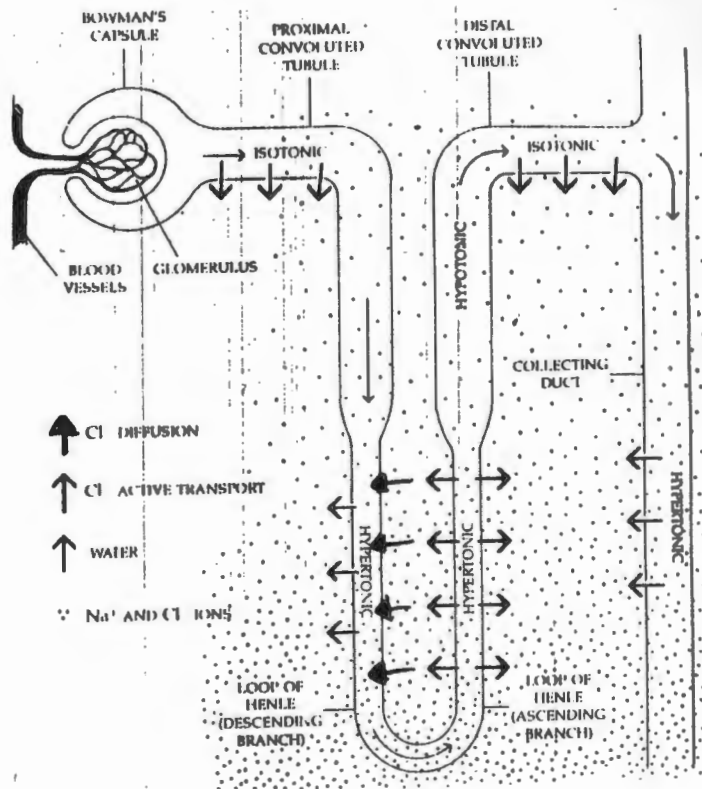
WATCH THE VIDEO AND MAKE NOTES. THEN, USING THESE NOTES ANSWER THE FOLLOWING QUESTIONS.

1. What is the prime work of the kidneys?
2. Name the three areas into which the kidney is divided.
3. Name the basic working unit of the kidney.
4. In which region do the collecting ducts unite?
5. Name one factor which contributes to the possibility of filtration by the glomerulus.
6. name the first part of the nephron where 80% of the fluids are reabsorbed.
7. Which ions are actively pumped out of the tubule?
8. This is called ACTIVE TRANSPORT. Why is it given this name?
9. What controls the reabsorbtion of water?
10. What is the function of ADH?
11. Name the gland producing ADH.

TUBULAR ACTIVITY

- 4.3.1 How does the filtrate first enter the nephron?
- 4.3.2 What does the term hypertonic mean, and why is urine described as hypertonic?
- 4.3.3 Study the paragraph "FUNCTION OF THE COMPONENTS OF THE NEPHRON" and name the substances that will be present in the filtrate when it arrives at the lower end of the loop of Henle.
- 4.3.4 What effect does the recirculation of chlorine ions have on the concentration of the solution surrounding the loop of Henle.
- 4.3.5 How does this influence water movement in the medulla region of the kidney?
- 4.3.6 Therefore, what is the purpose of a hypertonic solution in the region of the kidney?
- 4.3.7 The hormone ADH (antidiuretic hormone, also called vasopressin) influences the removal of water from the collecting tubule. How does it do this?
- 4.3.8 The kidney controls the amount of water that re-enters the blood after extraction by the glomerulus. What term identifies this homeostatic activity?
- 4.3.9 Suggest two ways in which a very concentrated urine could be produced.
- 4.3.10 If amino acids and glucose appeared in the urine, a doctor would know that a portion of the nephron is defective. Name this portion.

The formation of hypertonic urine in the human nephron. As the urine passes up the ascending branch of the loop of Henle, the cells lining the tubule pump out chloride ( $\text{Cl}^-$ ) into the surrounding fluid. The chloride ions diffuse passively into the descending branch and are recirculated in the urine to the ascending branch, where they are pumped out again. Sodium ions ( $\text{Na}^+$ ) follow passively, maintaining the balance of positive and negative charges. As a consequence of this recirculation of chloride, the loop of Henle and the lower section of the collecting duct are constantly bathed in a salty fluid. The cells of the ascending loop are impermeable to water, so it does not diffuse out when the chloride is pumped out. The membrane of the collecting duct, however, is permeable to water if ADH is present, so water diffuses out into the surrounding salty fluid, and a hypertonic urine is passed down the duct to the renal pelvis, the ureter, the bladder, and finally out the urethra.



**Functions of the Components of the Nephron**

Component	Function
Glomerulus	Filtration
Proximal tubule	Reabsorption of 80% of electrolytes and water Reabsorption of all glucose and amino acids Reabsorption of $\text{HCO}_3^-$
Loop of Henle	Secretion of $\text{H}^+$ and creatinine $\text{Na}^+$ and $\text{Cl}^-$ reabsorbed in ascending limb
Distal tubule	Conservation of water Secretion of $\text{K}^+$ , $\text{H}^+$ , $\text{NH}_3$ Reabsorption of $\text{H}_2\text{O}$ (regulated by ADH) Reabsorption of $\text{HCO}_3^-$ Regulation of $\text{Ca}^{2+}$ and $\text{HPO}_4^-$ by parathormone Regulation of $\text{Na}^+$ and $\text{K}^+$ by aldosterone
Collecting duct	Reabsorption of $\text{H}_2\text{O}$ (ADH required)

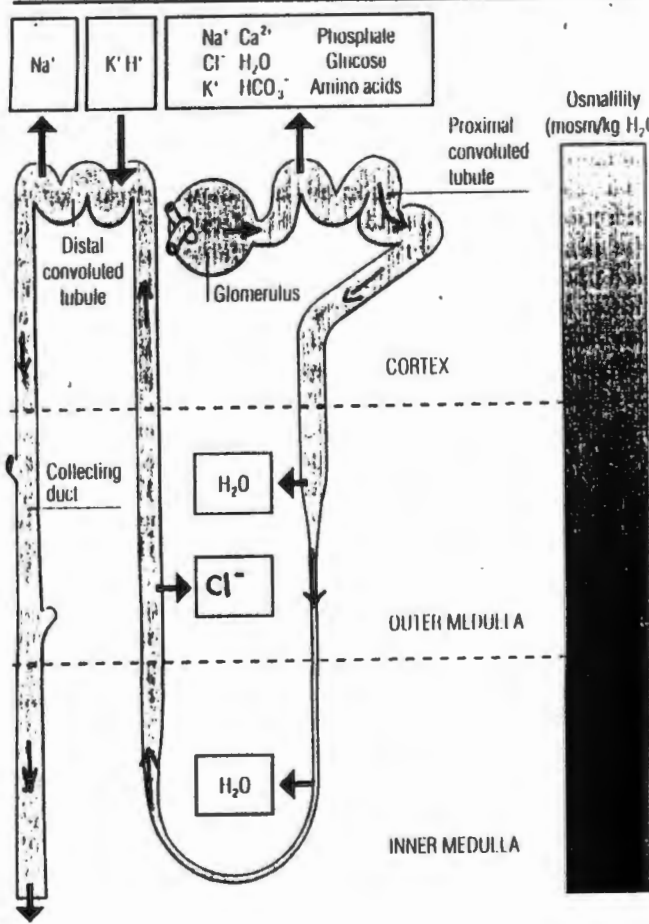


Fig. 21.2 Modification of the glomerular filtrate by tubular action.

Arrows (↓) indicate direction of filtrate movement.

This is how these findings are explained: Water diffuses freely through the cells of the walls of the nephron, with the exception of the ascending branch of the loop of Henle, and, in the absence of ADH, the collecting duct. Chloride ions are actively pumped from the ascending loop of Henle back to the interstitial fluid with sodium ions following passively after, thus maintaining electrical balance. The ions pumped out of the ascending loop pass back into the descending loop by simple diffusion since the fluids surrounding the descending loop are more concentrated than those within it. Thus the salt recirculates to the ascending loop, where the chloride is pumped out again. This recirculation of  $\text{NaCl}$  has two consequences: (1) as the urine passes through the loop of Henle, much salt but little water is reabsorbed, and (2) the lower part of the loop of Henle and also the lower part of the collecting duct are bathed in a fluid containing many times the level of salt normally found in tissue or blood. The urine—which has become isotonic again by the time it leaves the distal tubule—then descends through the collecting duct, which crosses the zone of high salt concentration. If ADH is present, water is removed from the collecting duct by osmosis, leaving within the duct a urine that is isotonic to the surrounding briny fluid but hypertonic in relation to the body fluids as a whole. In this way, the body is able to excrete a fluid, the urine, far more concentrated than the plasma from which it is derived, and water is extracted from the urine and returned to the bloodstream.

ADEQUATE WATER INTAKE

- 4.4.1 Why is water so essential to normal kidney function?
- 4.4.2 Suggest five uses of water as listed in the article.
- 4.4.3 What is the logic behind drinking more water to retain less?
- 4.4.4 What is the name given to a doctor who specialises in treating fat people?
- 4.4.5 Write a short paragraph on how water balance in the body is maintained by the renal tubules in the kidney. Also mention the two hormones that assist in this task.
- 4.4.6 Mention some of the negative effects of not drinking sufficient water.

## Think You're Drinking Enough Water?

If you're not, you could end up with excess body fat, poor muscle tone, digestive complications, muscle soreness — even water-retention problems

BY LEROY PERRY

**N**EXT TO air, water is the element most necessary for survival. A normal adult is 60 to 70 per cent water. We can go without food for almost two months, but without water for only a few days. Yet most people have no idea how much water they should drink. In fact, many live in a dehydrated state.

Without water, we would be poisoned to death by our own waste products. When the kidneys remove uric acid and urea, these must be dissolved in water. If there isn't enough water, wastes are not removed as ef-

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fectively and may build up as kidney stones. Water is also vital for chemical reactions in digestion and metabolism. It carries nutrients and oxygen to the cells through the blood, and helps to cool the body through perspiration. Water also lubricates our joints.

We even need water to breathe: our lungs must be moist to take in oxygen and excrete carbon dioxide. It is possible to lose half a litre of liquid each day just exhaling.

So, if you don't drink sufficient water, you can impair every aspect of your physiology. Dr Howard Flaks, a bariatric (obesity) specialist in Beverly Hills, California, says, "By not drinking enough water, many people incur excess body fat, poor muscle tone and size, decreased digestive efficiency and organ function, increased toxicity in the body, joint and muscle soreness and water retention."

Water retention? If you're not drinking enough, your body may retain water to compensate. Paradoxically, fluid retention can sometimes be eliminated by drinking *more* water, not less.

"Proper water intake is a key to weight loss," says bariatric specialist Dr Donald Robertson. "If people who

are trying to lose weight don't drink enough water, the body can't metabolize the fat adequately. Retaining fluid also keeps weight up."

"The minimum for a healthy person is eight to ten glasses a day," says Dr Flaks. "You need more if you exercise a lot or live in a hot climate. And overweight people should drink an extra glass for every 11 kilograms that they exceed their ideal weight. Consult your own doctor for his recommendations."

At the International Sports Medicine Institute, the experts have a formula for daily water intake: 30 millilitres per kilogram of body weight if you're not active (that's ten glasses if you weigh 72 kilograms), and 35 millilitres per kilogram if you're athletic (13 to 14 glasses a day, at the same weight). Your water intake should be consumed throughout the day and evening.

You may wonder: If I drink this much, won't I constantly be running to the bathroom? Yes. But after a few weeks, your bladder tends to adjust and you will urinate less frequently but in larger amounts.

And by consuming those eight to ten glasses of water throughout the day, you could be on your way to a healthier, leaner body.

KIDNEY BLOOD SUPPLY

USE THE PLASTICINE (RED AND BLUE) TO ASSEMBLE A SERIES OF BLOODVESSELS DEPICTING BLOOD FLOW THROUGH THE KIDNEY.

THE VESSELS SHOULD VARY IN DIAMETER TO INDICATE THE DIFFERENCE BETWEEN ARTERIES, ARTERIOLES AND CAPILLARIES.

USE RED PLASTICINE FOR ARTERIAL FLOW AND BLUE FOR VENOUS FLOW.

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ARTERIAL BLOOD SUPPLY

The renal artery leaves the descending aorta and enters the kidney through the hilum. It immediately branches into several interlobar arteries. These spread through the medulla (inner region of kidney) towards the cortex (outer layer of kidney) like a fan. At the boundary of medulla and cortex, the interlobar arteries divide into arcuate arteries. From these a large number of interlobular arteries develop and pass into the cortex. These divide into afferent arterioles, each of which enters a Bowman's Capsule and divides into capillaries becoming as glomerulus.

The capillaries of the glomerulus eventually reunite into the efferent arteriole. Soon after leaving the glomerulus, the efferent arteriole branches into a network of capillaries, the peritubular capillaries. These unite to form interlobular veins, then arcuate veins, and finally, interlobar veins. These unite as the renal vein which leaves the kidney at the hilum and enters the inferior vena cava.

NOTE THE DIFFERENCE IN SPELLING OF INTERLOBAR (LOBE) AND INTERLOBULAR (LOBULE).

LEAVE THE MODEL INTACT.

COMPARE YOUR MODEL WITH THAT OF A DRAWING PROVIDED BY THE TEACHER.

### RENAL FUNCTION

The glomerulus filters off the contents of the plasma. The tubules then reabsorb certain solutes, excrete others, and reabsorb most of the filtered water. Renal failure is associated with destruction of the glomeruli. This leads to a reduction in overall glomerular filtration rate. Flow of urine through the tubules increases, which overloads the concentrating and diluting mechanisms at the distal ends of the tubes. The result is a progressive reduction in kidney ability to concentrate or dilute urine. Eventually, no difference will exist between the urine produced and the plasma filtered by the glomeruli, signifying total renal failure.

#### QUANTITY

Healthy people show a urine output varying between 700 and 2500 ml. Polyuria, the copious production of urine is associated with diseases like diabetes. Anuria, the inability to micturate (urinate), is associated with obstruction and is rare. Abnormally low urine output may be due to salt and water depletion, low blood pressure, extensive burns, and vomiting of diarrhoea.

#### COLOUR AND TRANSPARENCY

Small quantities of blood give urine a smoky appearance; larger amounts, a brownish or red colour. Haemoglobin from burst cells colours it dark red to almost black. Bile pigments make it brown. Various drugs also colour urine from yellow to pink, through to grey, green and orange. Freshly passed urine is often quite transparent.

#### pH

Normal fresh urine is nearly always acidic.

#### PROTEINS

Normally less than 150 mg of protein is excreted in urine over 24 hr period. One third of protein in urine is albumin. Two thirds consist of globulins. Persistent protein presence in the urine usually implies renal disease.

#### BLOOD

Menstrual contamination is the most common cause for blood in the urine. Otherwise this is due to disease of kidney, ureter, bladder or urethra. Severe exercise may also cause the appearance of blood in the urine.

#### SUGARS

In normal people glucose appears in amounts too small to be detected by normal methods. Glycosuria may be due to diabetes or renal failure.

#### BILE

Bilirubin is the end-product of haem metabolism. It is transported in plasma strongly bound to protein and in a fat soluble form. It is therefore seldom found in urine of healthy people. People with jaundice may have bilirubenuria, an indication that liver cell damage has occurred.

QUESTIONS ON RENAL FUNCTION

- 4.6.1 Indicate the functions of the glomerulus and tubules.
- 4.6.2 When the glomeruli are destroyed their ability to filter selectively disappears, but the flow rate of urine increases. Explain this.
- 4.6.3 Suggest one reason for urine flow being obstructed.
- 4.6.4 Why do you think that the following would cause low urine output?
- extensive burns  
low blood pressure  
vomiting
- 4.6.5 Why is a large protein presence or a persistent one indicative of renal failure?
- 4.6.6 What does the term glycosuria mean?
- 4.6.7 What does bilirubenuria mean?
- 4.6.8 Normally, commercial paper strips are used for testing for glucose in the urine. Suggest another means of testing if such strips are not available.

LEARNING CENTRE 5
RESEARCH

POINTER'S

This LC is a particularly challenging one. It requires that you select a subject from those offered below, and conduct a literature review on it. Consult as many reference sources as possible. Try not to exceed the total number of words.

ONCE YOU HAVE DECIDED ON A TOPIC, OR TOPICS, ENTER THE TOTAL NUMBER OF CREDITS SELECTED ON THE CLASS SCORE SHEET.

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5. COMPULSORY:

Write a short essay (350 words) on water regulation by the loop of Henle. Explain how this structure is able to produce a urine that is hyperosmotic (more concentrated) than the blood plasma.

(35)

5.2 OPTIONAL: Essay(s) on any of the following may be written.

5.2.1 Discuss the formation of kidney stones. Mention the causes, symptoms, diagnostic procedures, curative procedures, and suggest what could be done by a person to limit the formation of stones.

(350 words)

(35)

5.2.2 A urinalysis, a test of urine, is a common medical procedure. What information could be gained by studying a urine sample?

(300 words)

(30)

5.2.3 Relate each of the following to kidney function.

Why does a high-protein diet require an increased intake of water?

Why does a person lose some weight after shifting to a low-salt diet even without reducing calorie intake?

Given the fact that amino acids in excess of the body's requirements are broken down by the liver, not stored, what is the advantage of a high protein diet? What might be a disadvantage?

Why could increased intake of salt lead to hypertension (high blood pressure)?

(350 words)

(40)

5.2.4 Establish the functions of the following substances/structures in the course of kidney regulatory activities.

vasopressin (ADH)  
erythropoetin  
renin  
aldosterone  
loop of Henle

(200 words) (20)

5.2.5 Explain the following terms in relation to kidney function:

filtration  
secretion  
resorbtion  
excretion

(500 words) (50)

5.2.6 Provide some details on the following diseases.

diabetes mellitus  
cystitus  
alcaptonuria  
incontinence

(400 words)

(40)

LEARNING CENTRE 1

TUTORIAL

POINTER'S !

This LC stresses the LEARNING OBJECTIVES (syllabus requirements) of GASEOUS EXCHANGE.

It also requires that you do some reading around the subject to make you more familiar with the content.

The teacher and other pupils in your group will discuss the reading and you will be required to answer some questions on it. You should ensure, therefore, that you are thoroughly prepared for this period!

The reading material will be available at least 24 hours before you choose to attend this LC.

It is suggested that you read the material sooner as this will give you time to discover which areas need special attention during the tutorial.

You will also be able to select some examination problems to solve. These should be completed during the remainder of the period, and at home. The number of problems you select will be directly linked to the CREDIT RATING you are contracting for.

ONCE YOU HAVE DECIDED ON THE CREDIT VALUE FOR THIS LC, RECORD IT ON THE CLASS SCORE SHEET.

You are reminded that the teacher is a valuable resource and you should use this opportunity to query any aspects of the work.

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2. The material comprises the following:

- 2.1 the OBJECTIVES
- 2.2 the reading material.
- 2.3 the selected problems to solve

3. The CREDIT RATING is structured as follows:

- 3.1 FOR 30 CREDITS - An ability to successfully answer questions during the Tutorial on the Learning Objectives marked with an (\*), and complete a minimum of 2 examination questions from the work sheet.
- 3.2 FOR 50 CREDITS - An ability to answer questions on the Learning Objectives as in (3.1) above, and PAGE 1 of the notes. A minimum of 3 examination questions should be completed for homework.
- 3.3 FOR 70 CREDITS - An ability to complete the requirements for (3.2) above, and answer questions on PAGE 2 of the notes. A minimum of 4 examination questions should be completed for homework.
- 3.4 FOR 100 CREDITS - Complete all requirements of (3.3) and complete 5 examination questions from the worksheet.

Several chemical reactions are involved in the transport and exchange of oxygen and carbon dioxide and occur continuously with great speed in the blood throughout all the tissues. A brief summary of the reactions follows and, since the reactions of oxygen and carbon dioxide are interrelated, they are considered together.

**IN THE TISSUES.** Potassium oxyhemoglobin (KHbO<sub>2</sub>) in red blood cells dissociates in the systemic capillaries to release O<sub>2</sub> which diffuses through the plasma into the interstitial fluid and on into the cells:



Carbon dioxide diffuses from the tissues into the plasma and on into red blood cells where the enzyme carbonic anhydrase promotes a reaction with water to form carbonic acid:



This is a very unstable acid and readily ionizes to hydrogen (H<sup>+</sup>) and bicarbonate (HCO<sub>3</sub><sup>-</sup>) ions. Some of the HCO<sub>3</sub><sup>-</sup> ions move out into the plasma and form sodium bicarbonate (NaHCO<sub>3</sub>). The H<sup>+</sup> ions unite with the hemoglobin (HHb):



Chloride (Cl<sup>-</sup>) ions released by dissociation of NaCl move into red blood cells from the plasma to replace the HCO<sub>3</sub><sup>-</sup> ions to maintain ionic equilibrium. They react with potassium hemoglobin (KHb) and form potassium chloride (KCl) and hemoglobin (Hb):



Some bicarbonate (HCO<sub>3</sub><sup>-</sup>) ions which remain within the red blood cells also react

with KHb when it gives up O<sub>2</sub> to form potassium bicarbonate:



Some of the CO<sub>2</sub> entering the red blood cells unites with Hb, forming carbaminohemoglobin (HbCO<sub>2</sub>):



The above reactions at tissue level result in:

1. O<sub>2</sub> being released from Hb
2. The formation of NaHCO<sub>3</sub> and KHCO<sub>3</sub>
3. The formation of HbCO<sub>2</sub>

**IN THE LUNG CAPILLARIES.** The O<sub>2</sub> diffuses from the plasma into the red blood cells where it combines with HHb to form oxyhemoglobin (HHbO<sub>2</sub>). The H<sup>+</sup> ion makes this compound acidic, so it reacts with KHCO<sub>3</sub>, yielding potassium hemoglobin (KHbO<sub>2</sub>) and carbonic acid (H<sub>2</sub>CO<sub>3</sub>):



Dissociation of H<sub>2</sub>CO<sub>3</sub> is promoted by carbonic anhydrase, and CO<sub>2</sub> and H<sub>2</sub>O are produced. The CO<sub>2</sub> diffuses out of the red blood cell through the plasma into the alveolar air because of the pressure gradient.



With the loss of HCO<sub>3</sub><sup>-</sup> ions in these reactions the ionic equilibrium is disturbed so dissociated Cl<sup>-</sup> ions move out of the red blood cells into the plasma where they react with NaHCO<sub>3</sub> to form NaCl and bicarbonate (HCO<sub>3</sub><sup>-</sup>):



Much of the HCO<sub>3</sub><sup>-</sup> diffuses into the red blood cells and combines with the KHb to form KHCO<sub>3</sub>.

As cited above, KHCO<sub>3</sub> reacts with the acidic oxyhemoglobin (HHbO<sub>2</sub>) to yield carbonic acid (H<sub>2</sub>CO<sub>3</sub>).

The spaces between the visceral and parietal pleurae form the intrapleural or pleural cavities. (Each lung has its own closed pleural cavity.) Each pleural cavity is only a potential space since the visceral and parietal pleurae are separated normally by just a thin film of fluid that moistens the surfaces. The surfaces of the lungs are in close apposition with the chest walls. The pressure within the pleural cavities is approximately 5 mm. Hg less than atmospheric pressure, which is 760 mm. Hg at sea level. It may also be expressed as a negative pressure equal to that exerted by a column of water 10 cm. in depth.

The intrapulmonic cavity is the space within the lungs and, since it communicates with atmosphere, the intrapulmonic pressure varies above and below atmospheric pressure during expiration and inspiration, respectively. Between expiration and inspiration, when there is no movement of air, the intrapulmonic pressure is the same as that of the atmosphere.

The space in between the two lungs and their pleurae is known as the *mediastinum*. It contains the large blood vessels, heart, esophagus, trachea, bronchi, and lymphatic ducts and nodes.

### Respiratory Muscles

The muscles used in normal breathing are principally the diaphragm and the intercostal muscles. The *diaphragm* is a dome-shaped muscular partition between the thoracic and abdominal cavities and is the most important respiratory muscle. When the diaphragm is relaxed, its thoracic surface is convex. On contraction, the convexity is reduced and the thoracic cavity is lengthened. The diaphragm also functions in coughing and sneezing and, in conjunction with the abdominal muscles, is used in defecation, vomiting and parturition.

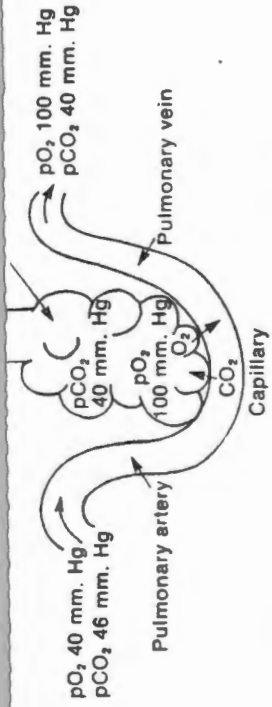
The *external intercostal muscles* increase the lateral and anteroposterior diameters of the thoracic cavity by elevating the sternum and moving the ribs into a more horizontal position.

**Diffusion and Transportation of Respiratory Gases**

**DIFFUSION.** The diffusion component of pulmonary respiration is the interchange of oxygen and carbon dioxide across the alveolar and capillary membranes. Gases move rapidly from areas of higher to lower pressure. A pressure differential occurs between the oxygen in the alveolar air and that in the blood in the pulmonary capillaries and, as a result, oxygen moves from the alveoli into the blood. Carbon dioxide moves in the opposite direction for the same reason.

Blood enters the vast number of pulmonary capillaries with the  $pO_2$  at about 40 mm. Hg and the  $pCO_2$  at approximately 46 mm. Hg. Alveolar air has a  $pO_2$  of approximately 100 mm. Hg and a  $pCO_2$  of about 40 mm. Hg. As a result of the diffusion exchange that quickly takes place as the blood flows through the pulmonary capillaries, blood enters the pulmonary veins with a  $pO_2$  of 95 to 100 mm. Hg and a  $pCO_2$  of approximately 40 mm. Hg (see Table 15-2 and Fig. 15-3).

**TRANSPORTATION OF RESPIRATORY GASES BY THE BLOOD.** Oxygen is transported by the blood in solution in plasma and as a chemical compound in the red blood cells. The amount of gas that can be carried in solution is very limited; in order to meet the needs of the cells, most of the gas that enters the blood in the alveoli diffuses from the plasma into the red blood cells where it combines loosely with the hemoglobin to form the compound oxyhemoglobin. If the hemoglobin has its normal complement of iron, each gram can carry 1.34 ml. of oxygen and is completely saturated. The chemical process that produces oxyhemoglobin is reversible so that as the oxygen in solution is used up by the tissues, more is made available by the dissociation of the unstable oxyhemoglobin ( $Hb - O_2 \rightleftharpoons HbO_2$ ). Of the 20 volumes per cent of oxygen in the arterial blood, only about 0.5 volume per cent remains in solution in plasma; the remaining 19.5 volumes per cent is carried as oxyhemoglobin.



The rate at which hemoglobin combines with oxygen and the rate of dissociation of oxyhemoglobin is influenced by the  $pO_2$  and  $pCO_2$  of the plasma. An increase in the  $pO_2$  and a decrease in the  $pCO_2$  hasten the formation of oxyhemoglobin. Conversely, a decrease in the  $pO_2$  and an increase in the  $pCO_2$ , as occurs in the systemic capillaries, promote the release of oxygen from hemoglobin; the saturation of hemoglobin declines. The pH of the blood has a significant effect on the dissociation of oxygen and hemoglobin. A decrease in the alkalinity below the normal (i.e., a decrease in the pH) promotes release of oxygen from the hemoglobin molecule. Body temperature also influences oxygen-hemoglobin dissociation. An elevated temperature also promotes the release of oxygen from oxyhemoglobin.

Carbon dioxide is produced within the body by cellular metabolism and diffuses out of the cells through the tissue fluid into the blood, where it is carried in several forms. Only a very limited amount remains in solution in plasma; the larger proportion is carried in the form of bicarbonate ( $HCO_3^-$ ) and in combination with hemoglobin and plasma proteins (carbamin compounds). About two-thirds of the total blood carbon dioxide is carried as sodium bicarbonate ( $NaHCO_3$ ) in the plasma and serves to maintain the normal blood alkalinity (pH 7.4). A small, essential amount of potassium bicarbonate ( $KHCO_3$ ) is found in the erythrocytes.

The chemical compounds are unstable and tend to dissociate with changes in the pressures of the gases in the blood. As the blood is circulated through the tissues, the increasing  $pCO_2$  and decreasing  $pO_2$  promote the formation of the compounds. A

**TABLE 15-2 PARTIAL PRESSURES OF RESPIRATORY GASES**

	$pO_2$ (mm. Hg)	$pCO_2$ (mm. Hg)
Alveolar air	100	40
Venous blood	40	46
Arterial blood	95	40

motes dissociation of the compounds. In the pulmonary capillaries, where the  $pO_2$  increases and  $pCO_2$  decreases, a rapid dissociation takes place to release some of the  $CO_2$ .

**TISSUE RESPIRATION.** The exchange of carbon dioxide and oxygen which takes place between the cells and the blood in the systemic capillaries throughout the body comprises tissue or internal respiration. The basis of the gaseous exchange is the pressure gradient of each of the respiratory gases between the cells and the tissue fluid, and between the tissue fluid and the blood. The  $pO_2$  of the arterial blood when it enters the systemic capillaries is approximately 95 mm. Hg (20 volumes per cent) and is much higher than that of the interstitial fluid, so oxygen diffuses from the plasma into the tissue fluid. Continuous cell activity uses oxygen, so the higher  $pO_2$  of the tissue fluid results in a movement of the oxygen into the cells. As the oxygen tension is reduced in the plasma, the loosely combined oxyhemoglobin dissociates to free oxygen. By the time the blood again reaches the pulmonary capillaries the oxyhemoglobin has given up considerable oxygen.

The chemical activities of the cells (metabolism) produce carbon dioxide. Its concentration in the cell produces a pressure gradient that results in its movement into the tissue fluid. From here, because of the pressure difference, it moves into the capillary blood and gradually accumulates a higher concentration in the venous blood than that of alveolar air. This promotes the diffusion of carbon dioxide from the pulmonary capillary blood into alveolar air.

Module 4: Unit 1: Gaseous Exchange

11. identify the following structures on a fresh specimen of a lung: epiglottis, larynx, trachea, bronchus, bronchiolus, lung.

HG ONLY

12. draw a sketch graph to illustrate the relationship between the partial pressure of oxygen and the % saturation of haemoglobin resulting from the partial pressure;
13. use the graph to determine the % saturation if given the partial pressure of oxygen;
14. determine the effect of the partial pressure of carbon dioxide on the % oxygen saturation of haemoglobin if given two oxygen dissociation curves of haemoglobin for different partial pressures of carbon dioxide.
15. use these graphs to produce data to illustrate how the partial pressure of carbon dioxide affects the effectiveness of the transport of oxygen by the blood.

Module 4: Unit 1: Gaseous Exchange

Unit 1: Gaseous Exchange

1. Structure of the respiratory organs
2. Effectiveness as a gaseous exchange system
3. Mechanism of inhalation and exhalation
4. Processes at gaseous exchange surface
5. Transport of oxygen
6. Transport of carbon dioxide
6. Homeostatic control of gaseous exchange
7. Gaseous exchange as excretion

Unit Objectives

At the end of this section of work you should be able to:

1. make a labelled sketch to show the macro-structure of the lungs and associated air passages. (18 labels);
2. make a labelled sketch to show the micro-structure of an alveolus (8 labels).

- \* 3. list seven requirements for an efficient gaseous exchange surface and state how these requirements are met by the organs of gaseous exchange in man;
- \* 4. list three ways in which the air is purified prior to entering the lungs and identify those structures and regions responsible for the purification of the air;

5. recall the names of the structures responsible for the processes of inspiration and expiration and give the function of each;

6. describe the process of inspiration by:
  - recalling that inspiration is an active process;
  - naming the structures and muscles responsible for the process;
  - listing in order the events which produce inspiration;

7. describe the process of expiration by:
  - recalling that expiration is mostly a passive process;
  - naming the structures and forces which produce expiration;
  - listing in order the events which produce expiration;

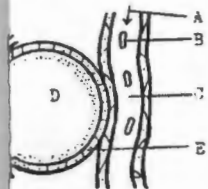
- \* 8. list two methods by which oxygen is transported by the blood;

- \* 9. list three methods by which carbon dioxide is transported by the blood;

- \* 10. list three factors which influence the affinity of haemoglobin for oxygen and describe how these factors contribute to the effective uptake, transport and release of oxygen by the blood.

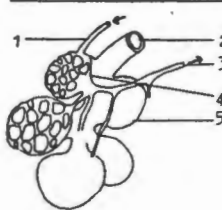
Q. Study the diagram of an alveolus and associated capillary.

- Which type of blood enters the blood capillary at A?
- By which physical process does oxygen move from D to C?
- B is a red blood corpuscle. Which pigment that aids with the transport of oxygen is found in this blood cell?
- Which kind of epithelium is E composed?
- Name the features of the alveoli which make them well suited for gaseous exchange.
- Which muscles are involved in the movement of air from the lungs during forced breathing?



G38-

The diagram below represents part of the lung of man.



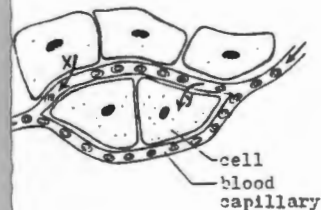
- Write down the number which indicates: (1) bronchiole, (2) alveolus and (3) blood capillary.
- What type of blood is carried in vessel labelled (1) 1 and (2)?
- Name the type of cells found in the walls of part numbered 5.
- Describe the exchange of gases which occurs between the blood and the air in No.5.

Q. Study the diagram and answer the questions in connection with the transport of gases.

- Which respiratory gas will move as indicated by: (1) X, and (2) Y?
- In which various states is the gas mentioned in (a), transported by blood?
- Which protein plays an important part in the transport of the gas mentioned in (a) (2), in blood?
- Which protein acts as a buffer when the  $H^+$  concentration in blood increases?
- Which enzyme catalyses the following reaction?



- Mention two other gases which are involved in air pollution and inhibit the transport of respiratory gases.



5.

Differentiate between the terms: (i) respiration, (ii) gaseous exchange, and (iii) breathing as it occurs in man.

6

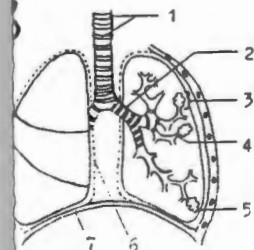
Name the features of the lungs which make it an efficient gaseous exchange organ.

Q. The diagram represents part of the respiratory apparatus in man.

- Identify the parts numbered 1 to 7.
- What type of blood: (i) enters the lungs, and (ii) leaves the lungs?
- In the lungs is a high diffusion gradient favouring the passage of oxygen from No.4 into the blood.
  - Explain the term diffusion gradient
  - How is the diffusion gradient between No.4 and the blood maintained

(d) Why is it dangerous to inhale motor vehicle exhaust gases?

(e) The blood of a person living at sea level, contains approximately 5 million red blood corpuscles per  $mm^3$ , while the blood of a person living at 5 000m above sea level contains approximately 7 million per  $mm^3$ . How do you account for this difference?



7.

Write down the correct term for each of the following statements.

- The muscular plate which separates the thoracic cavity from the abdominal cavity in man
- The compound containing iron, that carries oxygen in the blood of a human being
- The part of the lungs where exchanges of gases takes place
- The metal element in haemoglobin which is essential for the transport of oxygen
- The type of epithelium on the inside of the trachea and bronchi
- The tissue lining the air passages in man
- The space between the lungs where the heart occurs
- A membrane lining the entire interior of the thoracic cavity and covering the lungs
- (HG) The volume of air entering and leaving the lungs during a single breath during any state of respiratory activity
- (HG) The maximum volume of air which can be inhaled and then forced out of the lungs
- (HG) The region of the brain concerned with regulating breathing
- (HG) The type of epithelium lining the aveoli of the lung

# MEMO: GASEOUS EXCHANGE: TUTORIAL

- (a) deoxygenated (b) diffusion (c) haemoglobin (d) squamous
- (e) large surface area; thin walled; moist walls; transport medium is available
- (f) intercostal muscles; diaphragm; abdominal muscles

- (a) (1)  $\text{CO}_2$  (2)  $\text{O}_2$  (b)  $\text{H}_2\text{CO}_3$ ; carbamino-haemoglobin; bicarbonate ions (c) haemoglobin (d) haemoglobin/plasma proteins (e) carbonic anhydrase (f) carbon monoxide; nitrogen oxide;  $\text{SO}_2$

- (a) 1 C-shaped rings of hyaline cartilage 2 bronchus 3 alveolar sac 4 bronchiole 5 alveolus 6 pleural membrane 7 diaphragm
- (b) (i) deoxygenated (ii) oxygenated
- (c) 1 concentration of oxygen is always higher in alveolus; than in blood surrounding alveolus; oxygen diffuses down its concentration gradient; from air in alveolus into blood of lung capillaries; and rate of diffusion increases
- 2 by inhaled oxygen; and deoxygenated blood which reached alveolus; blood reaching alveolus has lower oxygen pressure than alveolar air
- (d) haemoglobin has greater affinity to CO than to  $\text{O}_2$ ; affinity is more or less 250 times greater to CO than to  $\text{O}_2$ ; carboxyhaemoglobin forms; the oxygen binding force of blood decreases; tissues experience an oxygen deficit; victim becomes dizzy and paralysis sets in; death follows due to tissue suffocation
- (e) - with increased altitude the oxygen tension decreases
- less oxygen combines with haemoglobin
- hence more red blood corpuscles are required
- to transport sufficient oxygen to tissue cells

- (a) (1) 2 (2) 5 (3) 4 (b) (1) deoxygenated (2) oxygenated
- (c) squamous epithelium
- (d)  $\text{O}_2$ : - blood entering capillaries of lung is deoxygenated
- most of oxygen blood carried was released from oxyhaemoglobin in tissues
- air breathed in is rich in oxygen
- due to differences in concentration oxygen diffuses continually down its concentration gradient
- oxygen dissolves in moisture lining alveolar wall.
- and diffuses in solution through squamous epithelium of alveolus and capillary
- into the blood plasma and from there into erythrocytes
- blood leaving lungs is oxygenated
- $\text{CO}_2$ : - blood entering capillaries of lung is rich in  $\text{CO}_2$
- concentration of  $\text{CO}_2$  in alveolar air is very low
- most of  $\text{CO}_2$  is carried in blood plasma as carbonic acid or bicarbonate ions
- in capillaries of lung carbonic anhydrase catalyses reactions
- which releases  $\text{CO}_2$  from sodium bicarbonate and carbamino-

- (i) - stepwise breaking down of organic fuel molecule (glucose)
- in cells into carbon dioxide and water
- with the liberation of metabolic usable energy in form of ATP
- (ii) - diffusion of carbon dioxide from tissue fluid into blood and from blood into alveoli of lungs down its diffusion gradient
- and diffusion of oxygen from alveoli into blood and from blood into tissue fluid and cells down diffusion gradient
- (iii) - mechanism which is applied to transport oxygen
- from the external atmosphere to lungs
- and carbon dioxide from the lungs to external atmosphere
- thus air in lungs is exchanged for fresh air from outside

- provide a large gaseous exchange surface; of about  $1000\text{m}^2$
- inner surface is kept moist by film of moisture; to facilitate diffusion of oxygen and carbon dioxide in dissolved state
- lining of lungs is thin; and only one cell layer thick for rapid diffusion of gases
- is richly supplied with blood capillaries; blood contains haemoglobin which acts as oxygen carrier
- lungs are situated in air-tight chest cavity; with air passages which are kept open to outside atmosphere
- efficient ventilation mechanism is present; which draws in fresh air and forced out old air
- gaseous exchange surface is well protected by thoracic cavity and pleura; which protect lungs against mechanical injury, desiccation and atmospheric pressure

- 1 diaphragm 2 haemoglobin 3 alveoli 4 iron 5 ciliated
- 6 epithelium 7 mediastinum 8 pleura 9 tidal air
- 10 vital capacity 11 medulla oblongata 12 squamous epithelium

LEARNING CENTRE 2

DESIGN

POINTER'S !

This LC is creative in nature and you will be required to build a model and learn a drawing. At the same time you will learn the names of the different lung structures.

The learning of ALL structures and their associated labels is an important feature of this LC. You are therefore advised to pay close attention to this work as it is definitely examinable!

Once you believe you are ready to test your learning, move to a TEST CUBICLE and follow the instructions there. You are required to leave the test in the box for checking by the teacher.

Credits are selected by choosing a test you believe is in line with your ability, and understanding, of the work at this LC. You will mark this test yourself. No credits are confirmed unless a marked test has been received by the teacher.

---

INSTRUCTIONS

1. Read EXTRACT A and quickly build a model depicting the structure described in the extract. Check the accuracy of your interpretation with the diagram in ENVELOPE A. (approx 10 mins)
  2. Proceed with EXTRACT B. Read this, and learn the drawing AND labels (10 mins).
  3. Now proceed to the TEST CUBICLE.
-

EXTRACT A

The actual exchange of gases occurs in small air sacs called alveoli. These are clustered around the ends of the smallest bronchioles called terminal bronchioles, much like a bunch of grapes. Such a grouping is called an infundibulum.

The terminal bronchioles branch in different directions much like one's fingers point outwards from the palm. In this case the "fingers" are called alveolar ducts and the point at which they join is called the vestibulum.

Each alveolus is about 1 or 2 mm in diameter and each is surrounded by capillaries. A pulmonary arteriole brings deoxygenated blood to the alveolar capillary and the oxygenated blood leaves the alveolar capillaries via a pulmonary venule.

The walls of the capillaries and of the alveoli each consist of only a single layer of flattened squamous epithelial cells. The barrier between an alveolus and its capillaries is only about 0,3 mm. Alveoli are inter-connected by pores of Kohn which allow for air movement between adjacent alveoli.

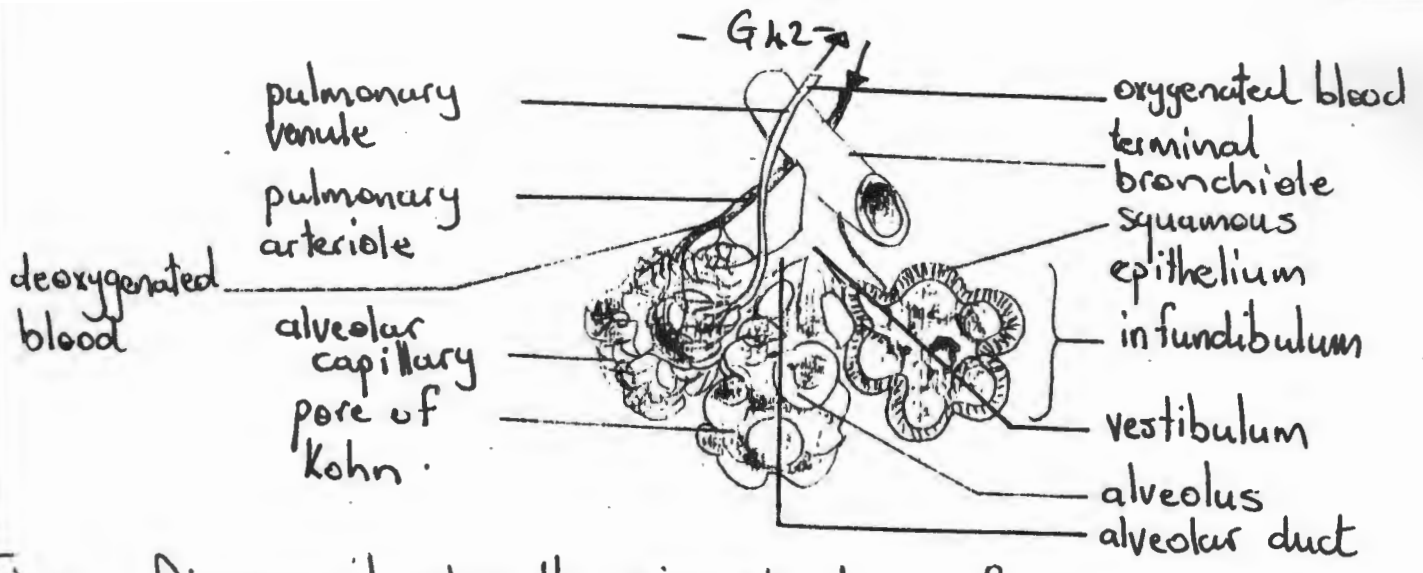


Fig 2. Diagram showing the microstructure of human lung tissue.

EXTRACT B

The trachea is a cylindrical tube strengthened with rings of cartilage. It leads from the larynx (voice box) and branches into two bronchi. each bronchus sub-divides several times eventually forming thin tubes called bronchioli. The most distant bronchioli lead into the alveolar ducts and alveoli.

The chest wall structures include the rib cage, intercostal muscles and diaphragm. The chest cavity is lined with a membrane called the parietal pleura and the lungs covered with a membrane called the visceral pleura. The parietal and visceral pleura are joined and form a closed, double-walled sac. Fluid is secreted into the inter-pleural space as a lubricant allowing the layers of pleura to slide over each other during breathing. The space in between the lungs is known as the mediastinum. It contains the large blood vessels, heart, oesophagus, bronchi, etc.

The major muscle of breathing is the diaphragm. This is assisted by the external intercostal muscles which enlarge the thoracic cavity during inspiration.

The lungs are divided into three lobes on the right and two lobes on the left.

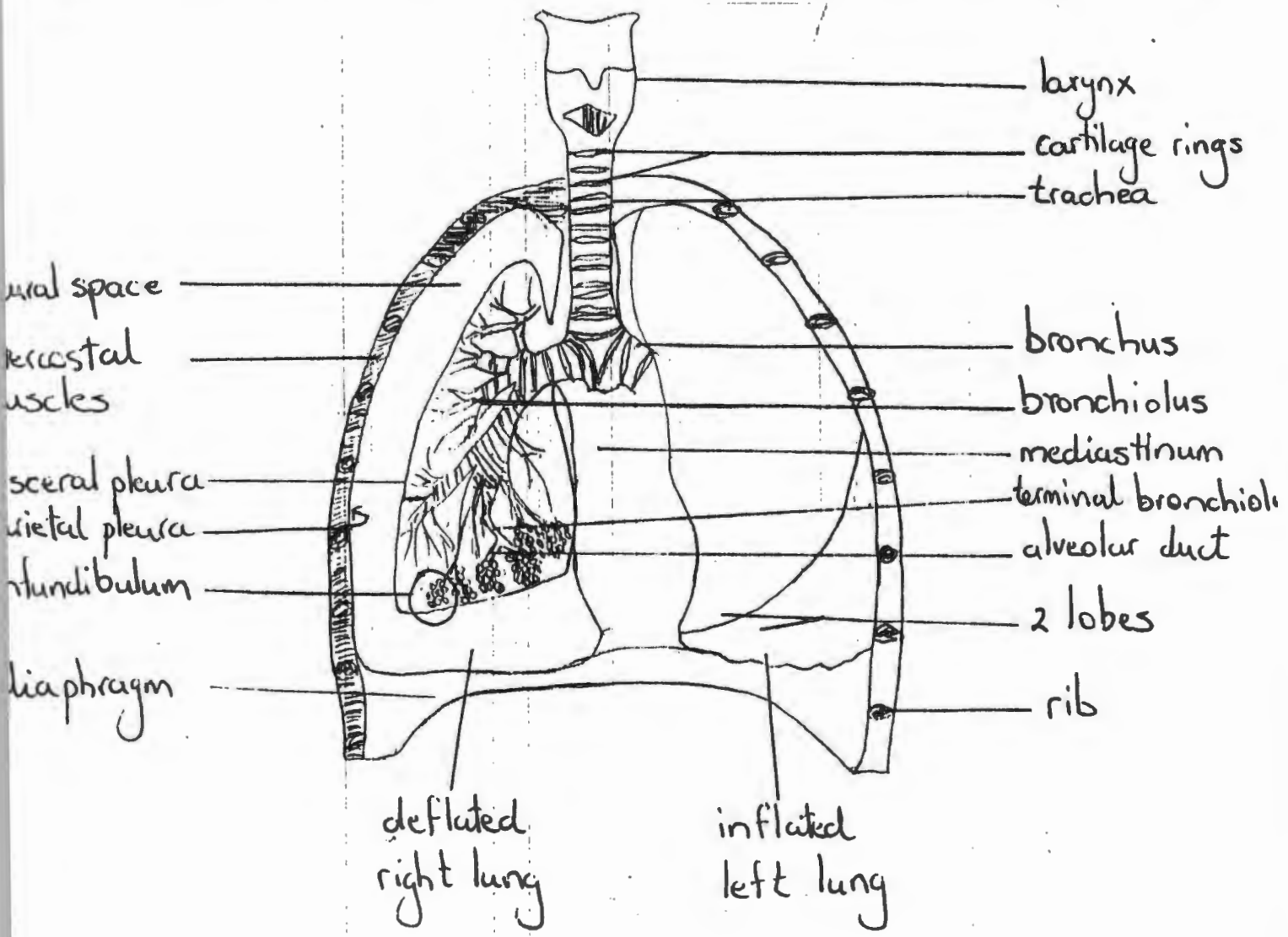


Diagram showing the macrostructure of the human thoracic cavity.

RATIONALE FOR THE TEST CUBICLE

Three tests are provided in specific envelopes numbered TEST A, TEST B, and TEST C.

All examine the same work, but each varies in difficulty and length. The credit value of each is indicated on the envelope. You should select a test based on:

- \* the number of credits you desire;
- \* the amount of time still available this period (you must both write and mark the test);
- \* how well you think you learnt the material at the LC.

NB! A test result of 80 - 100% earns you the number of credits you aimed for.  
A test result of 60 - 79% means you forfeit 20 of your indicated credits.  
A test result of 40 - 59% means you forfeit 40 of your indicated credits.

THIS IS TO ENSURE THAT YOU MASTER THE WORK BEFORE ATTEMPTING THE TEST. THIS WORK IS TO BE REGARDED AS VERY IMPORTANT FOR EXAMINATION PURPOSES!

PROCEDURES

1. YOU MAY NOT VIEW THE ACTUAL TEST UNTIL YOU HAVE SELECTED THE CREDIT VALUE.
2. ENTER THE APPROPRIATE NUMBER OF CREDITS ON THE CLASS SCORE SHEET!
3. Select the test representing the number of credits you need from the envelope.
4. Write the test on the paper provided
5. Mark the test.
6. Place the marked test in the box named TESTS.

INSTRUCTIONS: TEST A

This test is worth a total of 60 CREDITS.

It requires that you do a drawing and label it.

The drawing must be done with a sharp pencil and marked in a different colour afterwards.

- 
1. Draw a longitudinal section (L/S) through the thoracic cavity of the organs and associated structures involved in gaseous exchange in man. Label fully, i.e. 15 labels.

15 MARKS

2. Draw a portion of the part of the lung, as seen under high magnification, where gaseous diffusion between the air and blood occurs. Label fully, i.e. 10 labels.

10 MARKS

---

THE ANSWER TO THIS TEST IS IN ENVELOPE MARKED: ANSWER / A

ANSWERS TO TEST A.

- 1. cartilage ring(s) ✓
- trachea ✓
- larynx ✓
- bronchi(us) ✓
- bronchioli ✓
- alveolar ducts ✓
- pleural space ✓
- intercostal muscles ✓
- diaphragm ✓
- parietal pleura ✓
- visceral pleura ✓
- mediastinum ✓
- rib ✓
- 2-lobes ✓
- infundibulum ✓



The following should appear

as labels to your diagram,

The diagram is the same as

the one at the h.c.

(15 marks)

- 2. alveolus ✓
- terminal bronchiole ✓
- infundibulum ✓
- pulmonary arteriole ✓
- deoxygenated blood ✓
- alveolar capillary ✓
- oxygenated blood ✓
- pulmonary venule ✓
- squamous epithelium ✓
- pores of Kohn ✓



These are the labels

for the diagram, a

copy of which was

available at h.c. to

check the accuracy of your

model

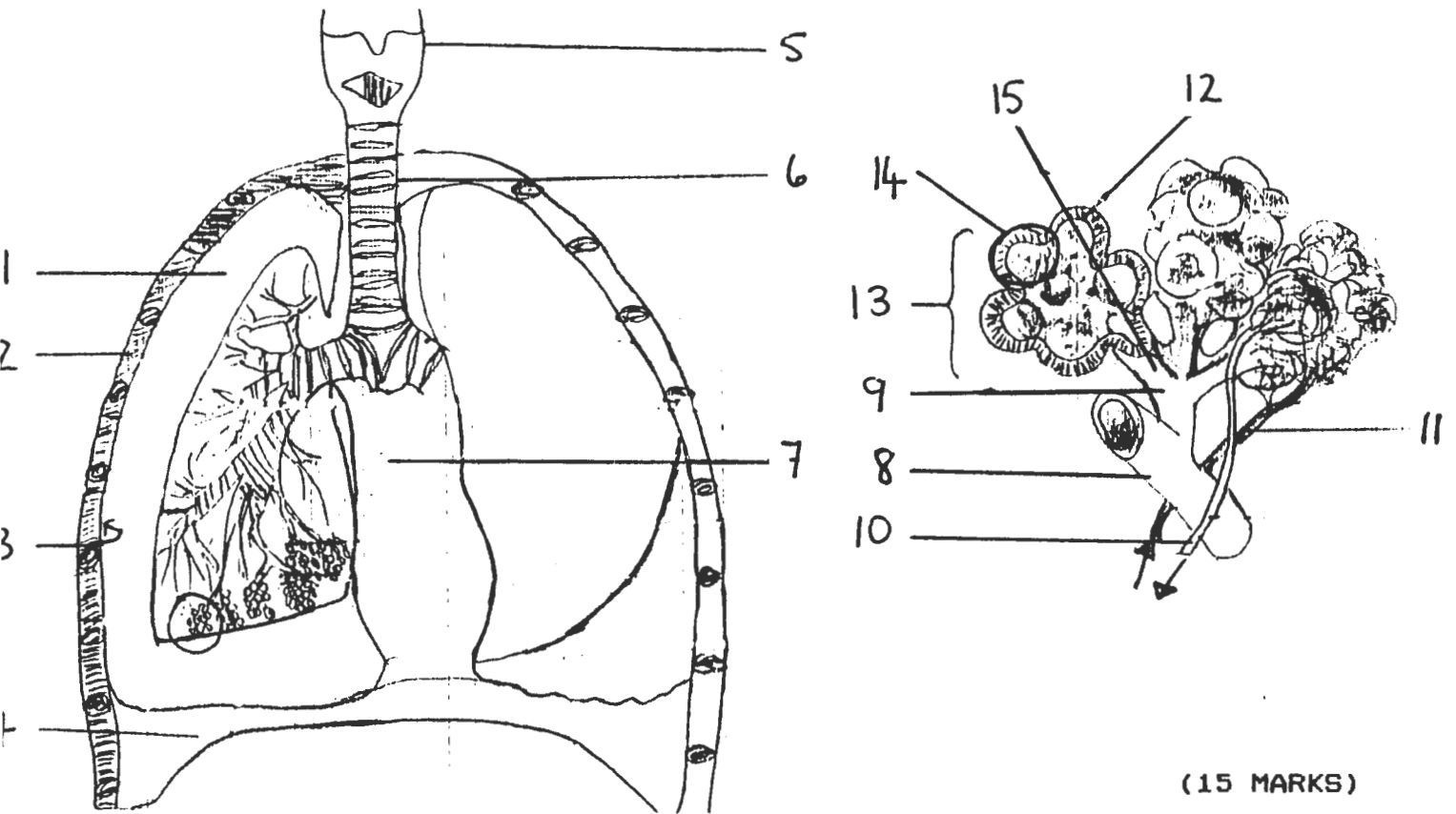
(10 marks)

INSTRUCTIONS : TEST B

This test is worth a total of 80 CREDITS if passed successfully (80 - 100%).

It requires that you label the drawings, and complete the sentences, by writing down the appropriate words ONLY on the paper provided.

1. INDICATE THE CORRECT LABELS OF THE DRAWINGS BELOW BY WRITING THE WORDS ONLY ON THE PAPER.



(15 MARKS)

2. DEDUCE THE WORDS THAT SHOULD APPEAR IN THE SPACES BELOW THAT WILL COMPLETE THE SENTENCES BELOW. WRITE THE WORDS ON THE PAPER PROVIDED.

Gaseous exchange occurs in small air sacs called (2.1). A grouping of these structures is termed a/n (2.2). A (2.3) arteriole brings (2.4) blood to the (2.5) capillary.

The type of epithelium comprising these small air sacs is called (2.6). These sacs are interconnected by the pores of (2.7).

The space within the thoracic cavity into which the thoracic organs fit is called the (2.8). A double-walled membrane called the (2.9) membrane is located within the chest cavity. The inner layer is attached directly to the lung surface and is termed the (2.10).

(10 MARKS)

TOTAL : (25 MARKS)

THE ANSWER TO THIS TEST IS IN ENVELOPE MARKED: ANSWER / B

- 1.501 - 1.502
- |    |                         |                         |                           |
|----|-------------------------|-------------------------|---------------------------|
| 1. | 1 - pleural space ✓     | 6 - trachea ✓           | 11 - deoxygenated blood ✓ |
|    | 2 - intercostal musc. ✓ | 7 - mediastinum ✓       | 12 - squamous epith ✓     |
|    | 3 - parietal pleura ✓   | 8 - term. bronchiole ✓  | 13 - infundibulum ✓       |
|    | 4 - diaphragm ✓         | 9 - vestibulum ✓        | 14 - alveolus ✓           |
|    | 5 - larynx ✓            | 10 - pulmonary venule ✓ | 15 - alveolar duct ✓      |

(15)

- |     |                |      |                   |
|-----|----------------|------|-------------------|
| 2.1 | alveoli ✓      | 2.6  | squamous ✓        |
| 2.2 | infundibulum ✓ | 2.7  | Kohn ✓            |
| 2.3 | pulmonary ✓    | 2.8  | mediastinum ✓     |
| 2.4 | deoxygenated ✓ | 2.9  | pleural ✓         |
| 2.5 | alveolar ✓     | 2.10 | visceral pleura ✓ |

(10)

/25/

INSTRUCTIONS: TEST C

This test is worth a total of 100 credits if passed successfully (80 - 100%).

It requires that you identify the errors in the labels and replace these with the correct labels. In the second part you need to correct each of the incorrect statements by replacing the underlined word(s). Write only the word(s) on the paper provided.

1. STUDY THE DIAGRAMS BELOW AND SELECT THE INCORRECT LABELS. WRITE DOWN THE NUMBER OF EACH INCORRECT LABEL. ALONGSIDE IT WRITE DOWN THE CORRECT VERSION.

DIAGRAM A.

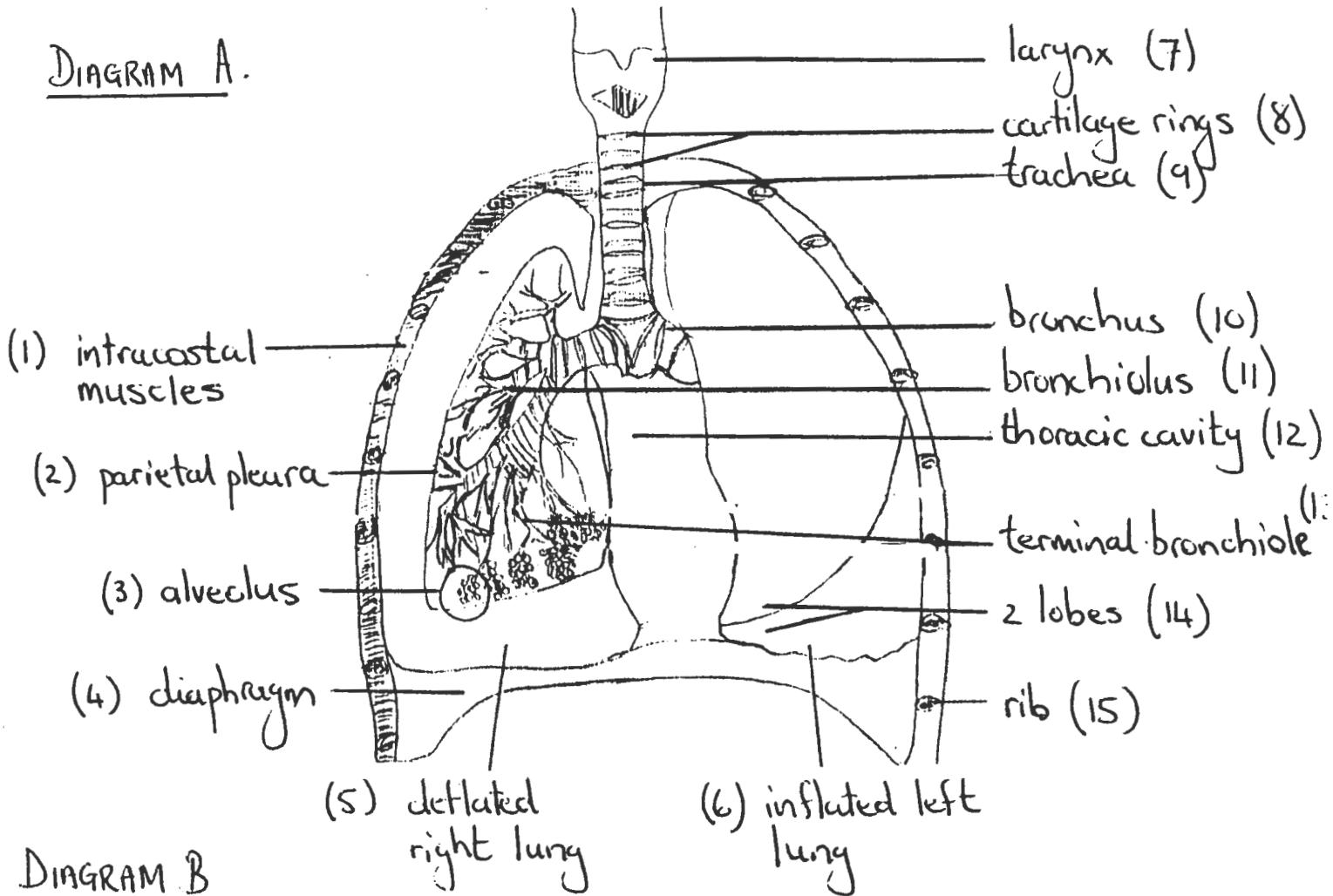
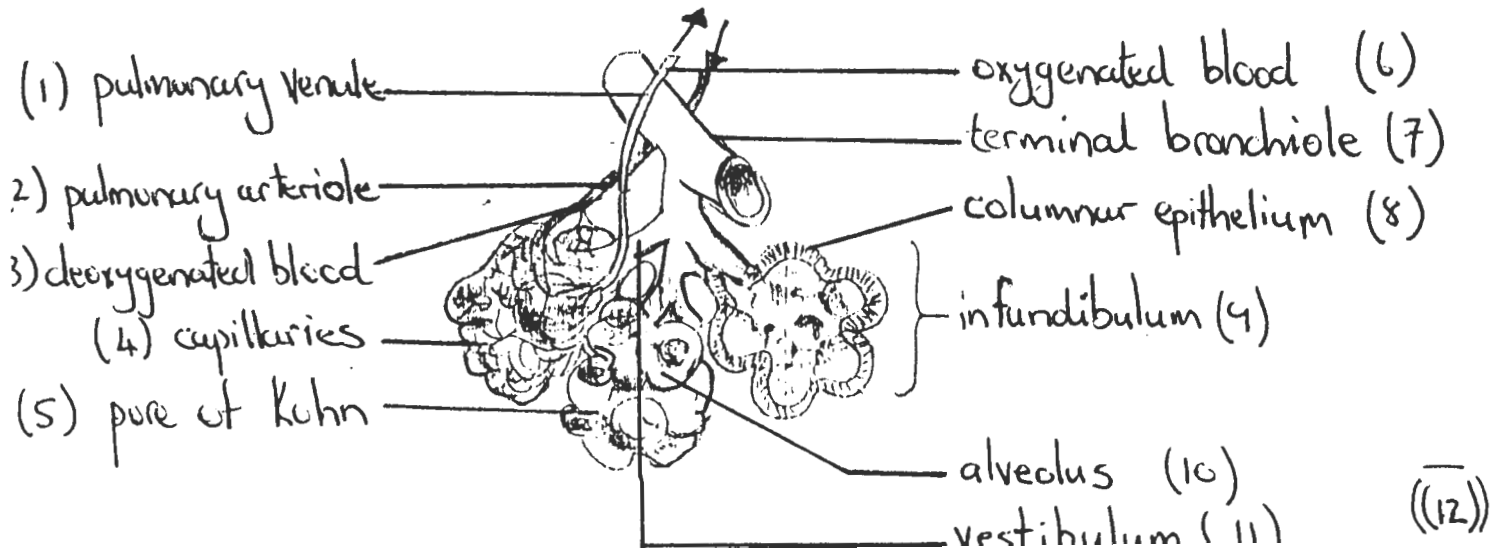


DIAGRAM B



(12)

2. CORRECT EACH OF THE FOLLOWING INCORRECT STATEMENTS. WRITE ONLY THE CORRECT WORD(S) ON THE PAPER PROVIDED.
- 2.1. The internal intercostal muscles are the main breathing muscles.
- 2.2. The chest cavity is lined with a membrane called the double-walled sac.
- 2.3. The walls of the alveoli are composed of ciliated epithelium.
- 2.4. The structure at the end of a terminal bronchus which resembles a bunch of grapes is called an alveolus.
- 2.5. The space between the lungs which accommodates the heart, oesophagus and major vessels is termed the thoracic cavity.
- 2.6. The capillaries bring oxygenated blood from the alveolar capillaries.
- 2.7. The two continuous membranes around the lungs and chest wall enclose a cavity called the thoracic cavity.

((8 MARKS))

TOTAL :(20 MARKS)

THE ANSWER TO THIS TEST IS IN ENVELOPE MARKED ANSWER / C

- 951 -  
TEST 3 ANSWERS (100 CREDITS)

1. DIAGRAM A:

- (1) ✓ intercostal ✓
- (2) ✓ visceral ✓
- (3) ✓ infundibulum ✓
- (12) mediastinum ✓

DIAGRAM B:

- (8) ✓ squamous ✓
- (11) ✓ alveolar duct ✓

(12)

2. 2.1 DIAPHRAGM ✓  
2.2 PARIETAL PLEURA ✓  
2.3 SQUAMOUS ✓  
2.4 BRONCHIOLUS ✓ & INFUNDIBULUM ✓  
2.5 MEDIASTINUM ✓  
2.6 PULMONARY VENULES ✓  
2.7 PLEURAL SPACE ✓

(8)

/20/

LEARNING CENTRE 3

PRACTICAL

POINTER'S !

Part of the Biology syllabus requires that you do practical work. This LC provides an opportunity to do so.

Credits are indicated in brackets.

AFTER DECIDING WHICH OPTIONS YOU WISH TO TRY, RECORD THEIR TOTAL CREDIT VALUE ON THE CLASS SCORE SHEET.

---

3. The following activities are offered by this LEARNING CENTRE.
- 3.1 A dissection of the thorax of the rat or frog (if available) showing the internal arrangement of the breathing organs. (50)
- 3.2 A demonstration of the Heimlich manoeuvre to clear a blocked windpipe. After the demonstration, you will need to complete a worksheet. (30)
- 3.3 The calculation of your lung volume using a spirometer. (20)
- 3.4 A demonstration of the lung ventilation system using balloons and a bell jar. A short worksheet will also have to be completed after this demonstration. (25)
- 3.5 A demonstration of a mammalian lung and the completion of a worksheet. (15)
- 3.6 The effects of carbon dioxide on indicator solution. (20)

WORKSHEET 3.2 : AIRWAY OBSTRUCTION

READ THE EXTRACT BELOW AND ANSWER THE QUESTIONS WHICH FOLLOW.

**Case 1-6**

A 16-month-old boy was "helping" his mother clean up the morning after a cocktail party when he *suddenly started to choke and cough*. Thinking he must have something in his throat, she straddled him over her forearm and gave him several back blows. Although he seemed to be somewhat better after this, it was not long before he began coughing again. When she observed that he was having difficulty breathing (*dyspnea*), she called her pediatrician who arranged to meet her at the hospital.

When asked what the child had been eating when he began to choke, the mother replied, "Nothing! But he could have picked up something that had been dropped onto the floor such as an hors d'oeuvre or a peanut."

On examination it was obvious that the child was in *respiratory distress* which was characterized by coughing and *dyspnea*. On subsequent examination, the pediatrician noted limited movement of the right side of the chest.

*Auscultation* disclosed reduced breath sounds over the right lung anteriorly and posteriorly. On *percussion* he thought there was slight hyperresonance over the right lung. He requested a *fluoroscopic examination of the thorax* and inspiration and expiration chest films.

The radiologist reported that there was *overinflation (hyperinflation) of the middle and inferior lobes of the right lung, with a shift of the heart and mediastinal structures to the left which decreased on inspiration.*

In view of these observations, the radiologist suggested that there was likely a **foreign body** lodged in the right middle lobe bronchus, inferior to the origin of the superior lobe bronchus (Fig. 1-39).

Under general anesthesia, the interior of the tracheobronchial tree was examined with a **bronchoscope**. A peanut was observed in the right principal bronchus at the site suggested by the radiologist. The **bronchoscopist** removed the peanut with some difficulty, using forceps passed through the bronchoscope.

Speaking to the mother later, the pediatrician urged her to keep small objects out of the reach of her child. He explained that inhalation of nuts, beans, and dry watermelon seeds was harmful because they rapidly swell to several times their usual size, causing **bronchial obstruction**.

When asked for details about this condition, the pediatrician made simple sketches (Fig. 1-85) showing how some air can usually go into the lung because the bronchus expands during inspiration. However, because the caliber of the bronchus becomes less during expiration, the bronchial wall closes on the peanut, trapping the air distal to it. He further explained that aspiration of certain materials such as peanuts may cause both a local and a systemic reaction.

The pediatrician later explained to an intern that *overinflation of a sizeable portion of a lung may be progressive and compress the rest of the lung, and even the other lung (by displacement of the mediastinum), to the point of respiratory failure and death. In some cases, the peanut swells so much that it completely obstructs the bronchus, producing atelectasis (collapse) of the lung distal to the peanut. In addition, peanuts release substances that induce a chemical bronchitis and pneumonitis.*

- 3.2.1 Briefly explain the terms printed in bold print and which have been highlighted for you.
- 3.2.2 Name the instrument used to examine the internal structures of the lung.
- 3.3.3 Three medical specialists were involved in this case. Name them by giving their professional titles.
- 3.3.4 Explain why air may enter the lung during inspiration, but be unable to leave (expiration) when the bronchiole is blocked by a peanut or similar obstruction.
- 3.3.5 Foreign bodies pass more frequently into the right bronchus rather than the left. Suggest a reason for this.

**WORKSHEET 3.3 : LUNG VOLUMES**

Read the extracts and follow the instructions below AFTER you have measured your VITAL CAPACITY (VC).

*Lung Capacity and the Spirometer*

Measurements of lung capacity are good indicators of an individual's respiratory health; a lowered volume of air exchange with the atmosphere may indicate diseased tissues which decrease the ability of the lungs to fully expand or a weakening of the muscles associated with the respiratory mechanism. A subject, expelling from his lungs all of the air of which he is capable (a residual air volume of about 1 to 1½ liters remains in the lungs to prevent their collapse) with one complete expiration, exhales this air into the free end of the tubing equipped with a mouthpiece, and can observe the volume of water in the graduated jar which it displaces. Hence, the Vital Capacity, generally ranging from 3000 to 5800 ml. among high school students, can be measured, and the rationale of the method employed in its measurement established.

For a more accurate measurement of Vital Capacity, a Spirometer, which reads V.C. volumes that can be read on a metered scale, is preferable. Individuals tested should also calculate their Vital Capacity based on considerations of age, sex, and height, using the formulas

- FORMULA 1:**  
 Male V.C. =  $\{[.052H(\text{cm.}) - .022A(\text{yrs})] - 3.50\} \times 1000 = \text{V.C. in ml.}$   
 Female V.C. =  $\{[.041H(\text{cm.}) - .018A(\text{yrs})] - 2.69\} \times 1000 = \text{V.C. in ml.}$

On the basis of the data collected, it should be noted that it is the relationship existing between the calculated and the actual Vital Capacity that is significant. Thus, if a boy calculates his Vital Capacity to be 4600 ml. but registers only 4800 ml. with an actual Spirometer measurement, he can compute the relationship

**FORMULA 2:**  

$$\frac{\text{Actual V.C.}}{\text{Calculated V.C.}} = \frac{4600}{5000} = .96 \text{ or } 96\% \text{ of lung capacity being utilized}$$

**Pulmonary Volumes and Capacities**

The volume of air breathed in and out varies with the activity and demands of the body, the age and size of each individual and the condition of the respiratory system. The figure given with each of the following respiratory volumes is the average for normal male adults; for the normal average adult female the volumes are approximately 20 to 25 per cent less.

**TIDAL VOLUME (V<sub>T</sub>).** This represents the volume of air inspired or expired with each breath. During normal, quiet breathing the tidal volume measures about 500 ml.

**MINUTE RESPIRATORY VOLUME (MRV, MV, OR V MIN.).** This is the total volume of air moved in or out of the lungs in 1 minute and is determined by multiplying the tidal volume by the respiratory rate per minute (V<sub>T</sub> × f).

**INSPIRATORY CAPACITY (IC).** This term indicates the maximum amount of air which can be inhaled in one breath. The normal is approximately 3500 ml.

**INSPIRATORY RESERVE VOLUME (IRV).** This is the portion of the inspiratory capacity in excess of the tidal volume and is approximately 3000 ml.

**EXPIRATORY RESERVE VOLUME (ERV).** The maximum quantity of air that can be forcibly exhaled after an ordinary expiration is approximately 1000 to 1100 ml.

**FORCED EXPIRATORY VOLUME (FEV).** This is the maximum volume of air that can be rapidly exhaled following a maximum inspiration. It is usually recorded in liters per second.

**RESIDUAL VOLUME (RV).** The volume of air remaining in the lungs after maximum expiration is referred to as residual air. The average normal volume is approximately 1200 ml. The lungs cannot be completely emptied of air if the chest cavity remains closed.

**VITAL CAPACITY (VC).** This is the maximum volume of air that can be expired after an inspiration of maximum capacity. It equals the tidal volume plus the inspiratory and expiratory reserve volumes. The normal is approximately 4000 to 5000 ml.

**TOTAL LUNG CAPACITY (TLC).** The residual volume plus the vital capacity volume represents the total lung capacity. The normal amounts to approximately 5200 to 6000 ml.

- 3.3.1 Using the equipment supplied, discover what your ACTUAL VITAL CAPACITY (vc) is. Write this figure down.
- 3.3.2 Using the formula (formula 1) for calculating VITAL CAPACITY (VC) establish your own CALCULATED VC. Write this down.
- 3.3.3 Now calculate the % of the lung capacity being utilized by using formula 2.
- 3.3.4 Now establish your total lung capacity (TLC).
- 3.3.5 Why is the on-going monitoring of lung volumes an important feature in preventative medicine?

### WORKSHEET 3.4: LUNG VENTILATION

Having examined the simulation of lung ventilation using the balloon and bell jars, read the extract below and answer the questions which follow.

#### RESPIRATORY FUNCTIONS

##### *Mechanics of Pulmonary Ventilation*

Each respiration involves inspiration and expiration. Inspiration is an active phase during which air moves into the lungs. Expiration, in normal breathing, is a passive phase during which air moves out of the lungs. Pulmonary ventilation is made possible by rhythmic variations in the dimensions of the thoracic and intrapulmonic spaces brought about by the alternating contraction and relaxation of the respiratory muscles.

Gases possess certain physical properties which explain the movement and exchange of respiratory gases. They differ from fluids in that their molecules spread out to fill the space available to them. The molecules of a gas are in a ceaseless movement and strike the walls of the container, creating a pressure. Within a given space, the greater the number of molecules of gas, the higher is the pressure produced. *The pressure of a gas varies inversely with the space in which it is contained if the temperature remains constant* (Boyle's law). If the space in which the volume of gas is confined is reduced, more gas molecules strike a smaller area of the container, increasing the pressure. Conversely, if the space is increased, the pressure of the gas is decreased. *Gas molecules move from an area of higher pressure to one of lower pressure.*

According to Dalton's law of partial pressure, *each gas in a mixture of gases exerts the same pressure that it would exert if it were not in a mixture, and that pressure is proportional to its concentration.* The pressure of the mixture is the sum of the pressures of the constituent gases. The pressure of each gas in the mixture is termed the partial pressure of that gas, and is indicated by a "p" preceding the gas symbol. For example, the pressure of oxygen in a mixture of gases is recorded as  $pO_2$ .

*The amount of a gas absorbed by a fluid (i.e., its solubility) is directly proportional to the partial pressure of the gas.* The fluid will absorb the gas until the pressure of the gas is the same as that at the surface. This is referred to as Henry's law of the solution of gases.

**INSPIRATION.** The diaphragm and external intercostal muscles contract, increasing the closed, airtight thoracic space and resulting in a pressure decrease of approximately 4 to 5 mm. Hg within the cavity. The moist visceral and parietal pleurae are apposed and resist separation in the same way that two pieces of plastic or glass whose surfaces are wet are difficult to separate but slide readily on each other. As the adherent moist parietal pleura moves out with the thoracic walls, the visceral pleura follows because of the cohesion between the two moist serous surfaces. The pressure in the intrapulmonic space is atmospheric and is greater than that of the expanded thoracic cavity. This pressure differential, combined with the cohesion of the pleurae, promotes a stretching of the elastic alveoli, resulting in the expansion of the lungs. The intrapulmonic space is now increased and the pressure of the contained air is reduced. A pressure gradient is produced between the atmospheric air and that in the lungs, so air moves into the respiratory tract, producing an inspiration.

**EXPIRATION.** Relaxation of the respiratory muscles reverses the above process. As the intrathoracic space decreases with the muscular relaxation, the pressure within the cavity increases. The elastic alveoli which were stretched now recoil also, diminishing the intrapulmonic space. The pressure of the air within the lungs is increased then to a level above that of the atmospheric air. This causes air to move out until the intrapulmonic pressure is equal to that of the atmosphere, thus producing an expiration. Normally, this cycle of inspiration and expiration is completed 14 to 18 times per minute in the adult.

- 3.4.1 Explain the term partial pressure.
- 3.4.2 State Henry's Law as it applies to solubility of gases in liquids.
- 3.4.3 What mathematical relationship exists between the pressure and volume of a gas at constant temperature.
- 3.4.4 Explain why, when the rubber disc is pulled down, the balloons inflate.
- 3.4.5 Now relate this phenomenon to that which occurs in human lungs using the information in the extract.

WORKSHEET 3.5 : MAMMALIAN LUNG EXAMINATION

Study the fresh lung specimen provided.

- 3.5.1 Note the following structures: epiglottis; larynx; trachea; bronchus; bronchiolus; lung tissue.
- 3.5.2 Make a microscope slide of a THIN piece of lung tissue and view it using the microscope.
- 3.5.3 Draw (3.5.1) and (3.5.2) with labels.

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**WORKSHEET 3.6: CO<sub>2</sub> CONCENTRATION**

**Purpose**

To determine the effects of different kinds of activities on breathing rate and pulse rate.

**Materials**

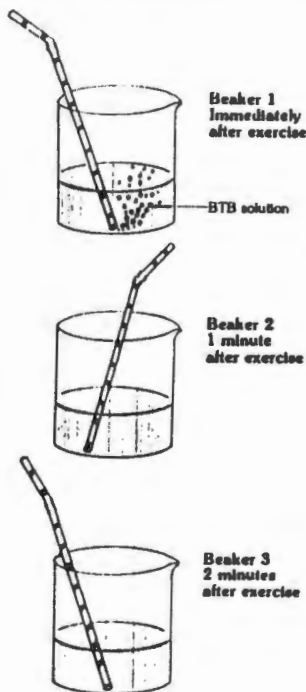
- 3 small beakers with Bromthymol blue (BTB) solution
- 3 straws
- Pencil and paper

**Procedures**

1. In Trial 1, establish your normal breathing rate and pulse rate at rest. Record the data in a chart like the one shown.
2. In Trial 2, do some type of mild exercise such as walking for one minute before taking each reading. Record your data.
3. In Trial 3, do some type of strenuous exercise such as running in place for one minute before taking each reading. Record your data.
4. In Trial 4, take in ten deep breaths before taking each reading. Record your data.

5. In Trial 5, repeat the strenuous exercise for one minute. Then immediately bubble your breath through a straw into the BTB solution in the first beaker. Wait one minute and bubble your breath for ten seconds into the second beaker. Wait one more minute and bubble your breath for ten seconds into the third beaker. Note the resulting color of the solution, as well as its intensity. Record your results.

Trial	Breaths/min	Pulse/min
1		
2		
3		
4		
Color Change		
	Beaker 1	Beaker 2 Beaker 3
5		



**Analysis**

1. Which trial acts as the control for the experiment?
2. Why does the breathing rate change with each trial?
3. How does the pulse rate change with each trial?
4. The color change noted in the BTB solution indicates the presence of carbon dioxide. Explain the differences in the color of the solutions in each of the beakers.

LEARNING CENTRE 4

COMPREHENSION

POINTER'S

This LC offers a series of exercises which assess your ability to process information. Questions will follow. The answers to many of these will be found in the extracts, although other sources may have to be referenced before the exercise is successfully completed.

ONCE YOU HAVE CHOSEN YOUR CREDIT RATING, YOU MUST ENTER THIS ON THE CLASS SCORE SHEET.

4. SECTION A (COMPULSORY)

- 4.1 Read the extract on sheet 4/A and answer the questions which follow. (35)

SECTION B

- 4.2 Read the extract (4.2/B) from the Reader's Digest article "I am Joe's right lung" by J.D.Ratcliff, and follow the instructions which follow. (35)

- 4.3 The extract (4.3/B) discusses carbon dioxide transport by the blood. Carefully assimilate the information and answer the questions which follow. (40)

- 4.4 Read the two articles from the Reader's Digest (April 1988 and May 1991) concerning the effects of passive smoking and answer the questions (see extract 4.4/B) which follow. (65)

- 4.5 The video entitled "Respiration in Man" is available. Watch the video and answer the questions on PAGE 4.5/B.

Only certain sections should be viewed as time is limited and you may wish to complete another reading exercise too.

Using the TIME COUNTER as a guide,

BEGIN at 2:35 and watch until 8:05.

FAST FORWARD until 12:25. Continue watching until 14:45.

FAST FORWARD until 16:30. Continue watching until 23:30.

NOW PROCEED WITH THE QUESTIONS ON THIS VIDEO. (35)

- 4.6 "ONE PUFF OF DEATH" - read EXTRACT 4.6/B and, using the table of data provided, calculate the answer to: "How much does one cigarette shorten a smoker's life?"

(30)

LEARNING CENTRE 5

RESEARCH

POINTER'S !

This LC is a particularly challenging one. It requires that you select a subject from those offered below, and conduct a literature review on it. As many reference sources should be consulted as possible, although you should be careful not to exceed the total number of words.

ONCE YOU HAVE DECIDED ON A TOPIC, OR TOPICS, ENTER THE TOTAL CREDIT RATING ON THE CLASS SCORE SHEET.

5. This LC requires that two essays be written.

5.1 COMPULSORY:

Write a short essay (300 words) explaining the phenomenon known as the Bohr effect. Indicate why you think this phenomenon is so important.

(30)

5.2 OPTIONAL: Essay(s) on any of the following may be written.

5.2.1 Explain HOW:

- |                                  |               |
|----------------------------------|---------------|
| (a) carbon dioxide concentration | (d) altitude  |
| (b) temperature                  | (e) body size |
| (c) fetal haemoglobin            |               |

influence the dissociation curve of oxygen, and WHY.

(600 words) (70)

5.2.2 Write an essay on any TWO of the following diseases. Indicate the symptoms, causes, curative procedures and likelihood of full recovery.

- |                           |                  |
|---------------------------|------------------|
| (a) lung cancers          | (b) emphysema    |
| (c) pneumonia             | (d) tuberculosis |
| (e) occupational diseases | (f) asthma       |

(600 words) (50)

5.2.3 The following quotation has been adapted slightly from that found in a Bible verse (Luke 8:18).

"To haem who has will more be given; but to haem who has not, even that which he thinks he has, will be taken away."

Explain this quote in the light of the affinity of haemoglobin for oxygen.

(400 words) (40)

5.2.4 Investigate, both in the short term and the long term, the effects of cigarette smoke on lung functions.

(400 words) (40)

5.2.5 Research the following questions and briefly explain WHY:

- i) hyperventilation just prior to swimming underwater for long periods can lead to loss of consciousness and therefore drowning;
- ii) smoking reduces the ability of the respiratory passages to fulfil their cleansing functions;
- iii) seals and other marine mammals can remain below the water for long periods (60 minutes or more), whereas man is cannot;
- iv) it is impossible to commit suicide by holding one's breath;
- v) a victim of a car accident survived without brain damage after being trapped underwater for 38 minutes where the water temperature was just above freezing.
- vi) the alveoli do not collapse when oxygen leaves during expiration.

(60)

NOTE: ALL THESE QUESTIONS MUST BE ANSWERED IN ORDER TO RECEIVE THE CREDITS!

**APPENDIX H**

**PHOTOGRAPHS:  
CLASSROOM INTERACTIONS**



Figure H-1: The teacher responding to a pupil's question at the TUTORIAL Learning Centre.

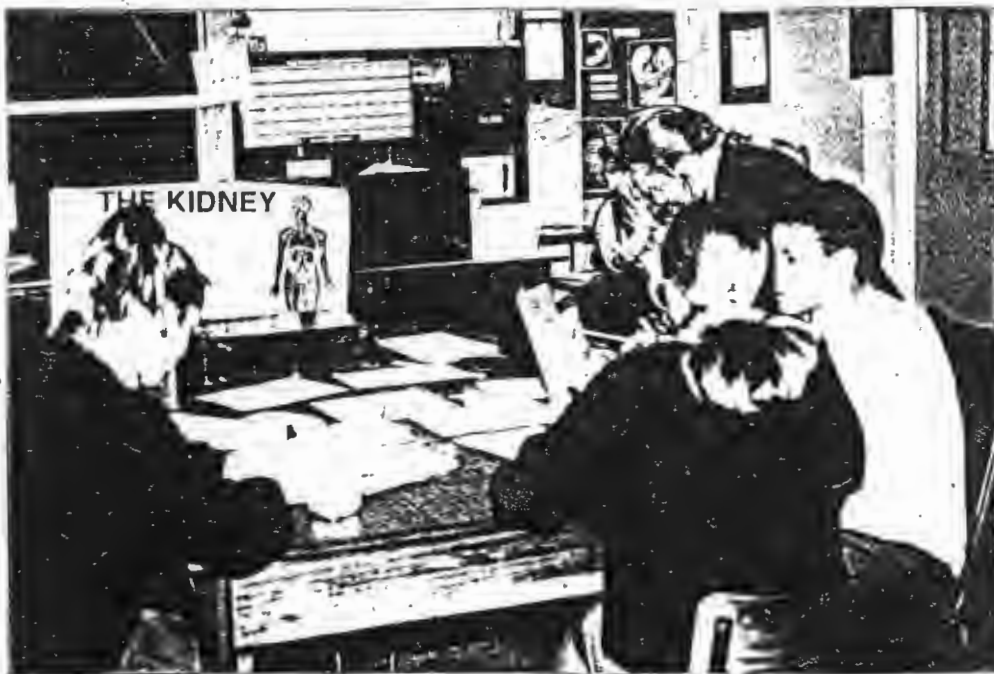


Figure H-2: Pupils engaged in task-related activities at the TUTORIAL Learning Centre.

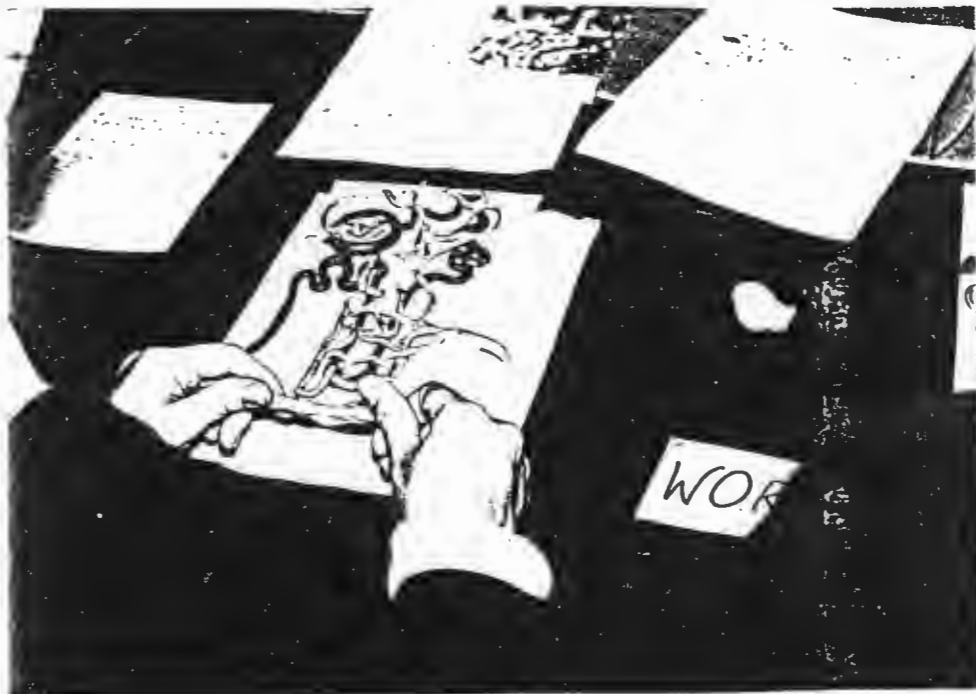


Figure H-3: A display of a plasticine model prepared at the DESIGN Learning Centre.



Figure H-4: Pupils at work writing a mini-test at the Test Zone of the DESIGN Learning Centre.



Figure H-5: A view of a dissection in progress at the PRACTICAL Learning Centre.



Figure H-6: A pupil operating a dissecting microscope situated at the PRACTICAL Learning Centre.



Figure H-7: Work at the PRACTICAL Learning Centre is always a "hands-on" experience. Here a pupil is measuring the glucose concentration of urine samples.



Figure H-8: A view of the COMPREHENSION Learning Centre showing the "cells", each of which accommodates two pupils.



Figure H-9: A view of the RESOURCE Centre with pupils researching topics presented at the RESEARCH Learning Centre.

## **APPENDIX I**

### **PARTICIPANTS' RESPONSE:**

**Some written comments by participants  
regarding aspects of the self-regulated  
instructional programme.**

"The program was helpful, but I found it much more work for it didn't cover all the work in the textbook."

"The programme is effective and enjoyable, but perhaps consider the pressure on pupils from other subjects."

"Very well organised, helpful - could include more theory work and less 'unnecessary' work."

"I feel to some extent that the program helped in its ways, but not to its full extent. The advantage of the program was the fact that the work had to be done by oneself."

"The program was (to me) an easier way of learning. The given work load was sufficient to keep the the pupils busy for the entire lesson. No time is wasted during the lesson and the pupil is compelled to do his/her work. By splitting the chapter into sections like drawings and practicals, a better understanding is obtained of the chapter."

"The program - helped a lot - I understand the work."

"The first program - I chose the sequence of centres poorly. This made understanding the work a little difficult. I think future pupils should be made aware how important choice is and adapt their choice accordingly. I benefitted by the program and it made studying much easier."

"The programme was positive and very helpful."

"Its like doing theory practicals which I think are more useful. One has to get involved and participate which I think is better."

"The program (to me) took time to adjust to. It is definitely a positive procedure of learning and I found it highly motivating and interesting"

"The program is very good (brilliant). I find it easier to learn the sections than any other in the book."

"If the program was run continuously then it would be helpful; but doing certain sections is not helpful at all."

The programs are enjoyable and enable us to think on our own. It is challenging although a lot of hard work is required.

"The program - good, and helps to learn, but don't jump into it, ease in and let the people understand how it works first."

"I would recommend that you incorporate more of the program in your classwork. This would ensure that there would not be a shock to first time pupils doing the program."

"You should try to ensure that the pupils do their notes, so as to prevent them from falling behind."

"The program was helpful in that you get involved in the chapter and are "forced" to concentrate and participate in the work."

"The program was a refreshing break from routine and I felt very comfortable with it. At the start it feels very shaky, but falls into place at the end."

**APPENDIX J**

**HOMOGENEITY OF VARIANCE**

Table J

Calculated F-values to ascertain Homogeneity of Variance for

Parametric Tests :  $H_0 : \mu_1 = \mu_2$

Null Hypothesis No.	d.f.	F-value	Table value (5% level)	Decision
1 : Cycle 1	(23,23)	1,37	2,00	Accept $H_0$
1 : Cycle 2	(23,23)	1,02	2,00	Accept $H_0$
2 : Cycle 1	(11,11)	1,20	2,60	Accept $H_0$
2 : Cycle 2	(11,11)	1,46	2,60	Accept $H_0$
3 : Cycle 1	(11,11)	1,59	2,60	Accept $H_0$
3 : Cycle 2	(11,11)	1,06	2,60	Accept $H_0$
4 : Cycle 1	(11,11)	1,25	2,60	Accept $H_0$
4 : Cycle 2	(11,11)	1,17	2,60	Accept $H_0$
5 : SR vs LOC	(27,25)	1,57	1,95	Accept $H_0$
5 : Anxiety	(26,26)	1,147	1,93	Accept $H_0$

**APPENDIX K**

**CORRESPONDENCE: Cape Education Department**

**Application for permission to conduct  
educational research; the affirmative response**

13 Leslie Crescent  
St Michaels  
Brackenfell  
7560  
17 March 1992

Cape Education Department  
P.O.Box 13  
Cape Town 8000

Dear Sir

**APPLICATION: PROPOSED EDUCATIONAL RESEARCH**

I hereby request permission to conduct educational research towards the fulfilment of the requirements for a Master of Education degree (M.Ed).

I intend registering for this degree at the University of Cape Town in March 1992. All preparations regarding the proposed research have been completed and the research proposal has been accepted by the Academic Heads Committee of the Education Faculty of the university.

The research will be conducted at Fairmont High School, Durbanville, where I am currently a permanent member of staff. The pupils involved in this investigation are all members of two intact standard ten subject (Biology) class groups.

**The research will be undertaken in the following way:**

The teaching of the subject content will occur in April and May (second term);  
the syllabus will be adhered to;  
the total duration of the programme will be approximately 9 hours  
(10 periods) and will occur within the normal constraints of the school timetable. No disruption of existing classes, work schemes, time schedules etc., will therefore, occur.

**The programme will involve the following:**

The administration of the Intellectual Achievement Responsibility Questionnaire (Crandall, Katkovsky, and Crandall, 1965) for a period of 20 minutes;

the teaching of two sections of the Biology syllabus (Gaseous exchange and Excretion) for 10 periods;

the administration of a subject content test (30 minutes) to ascertain the academic performance achieved by the pupils.

The main aspect of this research is to compare the differences in the academic performance results of two classes who have been subjected to two different methods of teaching.

As the results of the two classes will be compared, it is necessary to ensure that both classes are as academically equivalent as possible. To achieve this, each class will be matched with the other, in terms of previous examination performance, and IQ results.

The IQ values will naturally be kept entirely confidential. Once the classes have been successfully matched, they will not be utilised for any other purpose. Pupils will be unaware of the fact that they have been matched as the matching exercise is only relevant once data interpretation begins and the actual teaching programme has been completed.

Being a teacher at this school, I took the liberty of requesting permission from my Principal to undertake this research. He agreed in principle to the idea, subject to Departmental permission.

I enclose a copy of the IAR Questionnaire and a certified letter from the Faculty Officer of the Education Faculty, University of Cape Town.

I trust that the above will receive your favourable attention and I look forward to receiving your response.

A handwritten signature in black ink, appearing to read 'C.C. Paterson', written in a cursive style.

C.C.PATERSON



**Faculty of Education**

Private Bag · Rondebosch 7700 · South Africa  
Telephone: 650-2760  
Fax No: 650-3489

**TO WHOM IT MAY CONCERN**

This is to certify that the Higher Degrees Committee of the Faculty of Education, having considered his dissertation proposal, has recommended approval of Mr C C Paterson (student no PTRCRA001) as a Masters candidate in this Faculty. All formalities concerning Mr Paterson's registration are expected to be cleared by 27 March, and 1992 will count as the first year of his registration for the MEd degree.

Dissertation supervisor:  
Associate Professor K Rochford

*T. Nicolay*

**MRS T NICOLAY**  
**Education Faculty Officer.**

12 March 1992



DEPARTMENT VAN ONDERWYS EN KULTUR  
DEPARTMENT OF EDUCATION AND CULTURE  
KAAPLANDSE ONDERWYSDEPARTEMENT  
CAPE EDUCATION DEPARTMENT

ADMINISTRATIE VOORSKAAD  
ADMINISTRATION - HOUSE OF ASSEMBLY

Navres: Mr G.J. Swanepoel  
Enquines: L.15/73/7  
Vryw.:  
Ref.: 483-3329  
Tel.: (0211)

Provinciale Gebou  
Provincial Building  
Postbus 13  
PO Box 13  
Kaapstad 8000  
Cape Town 8000

25 March 1992

Mr C.C. Paterson  
13 Leslie Crescent  
St Michaels  
BRACKENFELD  
7560

Dear Mr Paterson

SELF-REGULATED LEARNING: EFFECTS OF TYPE OF INSTRUCTIONAL CONTROL  
ON ACADEMIC ACHIEVEMENT IN BIOLOGY: M. ED. DEGREE

1. I refer to your letter of 17 March 1992.
2. Your application to conduct research at Fairmont High School is granted subject to the following conditions:
- 2.1 The principal/teachers/pupils is/are under no obligation to cooperate in the research.
- 2.2 The principal/teachers/schools may not be identifiable in any way, in your research project.
- 2.3 All arrangements in connection with your project must be undertaken by yourself.
- 2.4 The research may be conducted during the second term of 1992 as suggested by you.
- 2.5 The conditions 2.1 - 2.4 above must be quoted in full when you approach the principals/teachers concerned.
- 2.6 Prior to your arrangements with your principal, Mr J.P. Zietsman, Superintendent of Education (Educational Guidance) should be approached and informed about your proposed research.

1  
K  
1

2.7

Being that the Std 10 pupils are approaching the end of a school phase and, therefore, to a large extent are conditioned to a specific learning style, it would appear that a new style may not have the required effect, and doubt may consequently be thrown on the validity of the experiment. To meet this problem it is therefore suggested that the experiment be conducted with Std 8 classes.

2.8

An synopsis (+ 3 pages) of the contents, findings and recommendations in respect of your completed thesis must be placed at the disposal of the department.

2.9

In addition to the synopsis mentioned in par. 2.7 you are requested to submit a copy of your completed thesis to:

The Research Section  
Cape Education Department  
P.O. Box 13  
CAPE TOWN  
8000.

3.

The department wishes you every success with your research.

Yours faithfully

  
EXECUTIVE DIRECTOR: EDUCATION



**APPENDIX L**

**A CRITIQUE ON TRADITIONAL TEACHING**

## Education System

During the earlier part of the century, the need to educate the masses resulted in the imposition of a grade level curriculum (Burns, 1989:32) which sought an orderly and progressive approach in the teaching of basic information and skills (Clark, 1986:6). Learners were taught a standardised body of knowledge, prescribed by a standardised curriculum which, for the majority, equipped them adequately for a standardised job market (Toffler, 1980:61).

Formal schooling isolated learners from the world of reality by removing the child from the social matrix where children learnt tasks in a self-paced manner and participated in joint problem-solving with adults. It also removed the social support provided by relationships with adults who engage metacognitive states of awareness (Mills, 1991:76). Learning largely lost its intrinsic meaning for learners (Ryan and Powelson, 1991:50).

The rationale for such an education system was ostensibly, to sustain industrial growth, promote nationalism and democracy, and preserve the traditional enclaves of the Industrial Age (Burns, 1989:32).

The rapidly diversifying, exponentially increasing, knowledge base (Thompson, 1991:24) of the Information Revolution (Morris, 1991:51; Bierman, 1991:8), and the advent of the Technological Age (Burns, 1989:32) have accelerated the exchange of information (Ornstein, 1989:38).

For learners, information transferred during formal education becomes obsolete within a few years (Hunter, 1989:3; Morris, 1991:51; Hurd, 1991:34). The traditional view of teachers as omniscient, and dispensers of information (Breivik, 1991:4) has also been challenged. In reality, their training, experiences, and knowledge, are rapidly becoming dated and meaningless (Hunter, 1989:3).

Despite the significance of these elements to education, virtually no changes to the academic and physical structure of schooling have occurred during the past 100 years (Burns, 1989:31). For example, the current (1987) standard nine plant biology syllabus for Cape Education Department schools differs little with the Biology course recommended for American high school pupils in 1893 (Novak, 1970:5)!

### Curriculum Planners

Novak (1970:15) has pointed out two central problems of Biology teaching which are particularly relevant. First, biology syllabus requirements are incongruent with current knowledge in biology. Second, the emphasis placed on rote learning and memorisation of facts is contrary to the reality that Biology, as a scientific discipline, which actively promotes inquiry. Industrial-oriented schooling presupposes that traditional, controlling environments, which demand mastery of facts and packages of information through a prescribed curriculum, will prepare learners for the demands of the future.

In contrast, O'Brien (1989: 85) believes that society will highly value "... independence and initiative in the future." Curriculum developers should take cognisance of the importance of developing human resources as a theme in science teaching (Hurd, 1991: 33 cites Carey, 1990). A curriculum should therefore, acknowledge the nature of change in the environment by guiding teachers to teach learners how to learn, think, organize thoughts and systematically devise methods on solving problems (Breivik, 1991:5; Burns, 1989:33).

"Learning to learn" is an imperative in science education which could enable individuals to sustain, and renew, their knowledge throughout life, thereby endowing such learners with an ability to direct their futures. The belief that education is a life-long process, that learners can make their own decisions about what to learn and how they should learn, that people can learn on their own given the necessary skills are possible inclusions of future curricula. Traditional discipline bound, fact-laden curricula cannot facilitate such goals.

Teacher domination has been characterised by excessive teacher-talk that creates illusions of control (Thomas, 1980: 215), but does little to facilitate teacher-learner contact time (Waterhouse, 1985), or improve the use of analytic skills (Boschee, 1990). The importance of detecting bias, differentiating between fact and opinion, and evaluating the authoritativeness of information sources should also be acknowledged by curriculum designers (Morris, 1991:51; Hurd, 1991:34).

Reducing instruction to the rote recall of facts, although convenient for evaluation purposes, is counterproductive (Wittrock, 1981:13; Clark, 1986:149), and is unlikely to develop the abilities required to make sound decisions, abilities vital for survival in a complex, changing environment (Lapierre, 1982:30). The change in emphasis from content to process is likely to compel science educators to move away from teacher-talk dominated teaching strategies to those facilitating enquiry (Haines, 1989: 103).

The formalisation of extrinsic motivators such as positive rewards, or negative detentions, also represent a reliance by educators on external controls which remove control over learning from the natural, motivational bases for learning (Ryan and Powelson, 1991:50).

Researchers have suggested that the excessive reliance on extrinsic rewards, the determination of success and failure by achievement, rather than by effort, and standards which are imposed on learners, result in a breakdown in commitment and self-regulated learning (Covington and Beery, 1976, cited by Thomas, 1980:215; Clark, 1988:318; Deci, 1975, cited by Clark, 1988). Deci et al. (1991:335) pointed out that external motivators which included monetary payments (Deci, 1971), prizes (Harackiewicz, 1979), good-player rewards (Lepper et al., 1973), deadlines (Amabile et al., 1976), imposed goals (Mossholder, 1980), and competition (Deci et al., 1981; Vallerand et al., 1986; Vallerand et al., 1991) served to control behaviour while they were operative.

However, they undermined intrinsic motivation for interesting tasks and restricted the internalisation of regulation for uninteresting tasks. All these events serve a common purpose, to pressure individuals to conform in specific ways. Such external contingencies foster percepts of an external locus of causality perception, diminish intrinsic motivation, and retard internalisation of regulatory processes. Measures counteracting such interventions, often evident in traditional classrooms, should be taken.

In conclusion, McCombs (1991:120) has suggested that several key factors have been instrumental in restricting life-long learning in schools and society.

1. Goals which are socially acceptable and their outcomes have not been personally appropriated as meaningful and relevant by a substantial number of learners.
2. Meaningful personal relationships and supportive climates for learning are largely missing in contemporary classrooms.
3. Attempts to nurture learners' understanding of their psychological processes, so crucial for intrinsic motivation, are not included in current curricula.
4. Although the responsibility for learning lies with the learner, greater personal choice in learning should be provided by the teacher to increase perceptions of control and thereby reinforce learner self-responsibility.

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