CHAPTER ONE

SETTING THE SCENE

1.1 Introduction

Serious preoccupation with environmental problems is a relatively recent phenomenon in contemporary society (Fien 1993: 7, O'Donoghue 1993: 3, Yeld 1993: 19, Cross 1998: 42, De Jager & Bornman 1999: 267). While there have always been certain expressions of concern for issues relating to the environment, only in the last few decades, as a result of extraordinary rapid scientific progress, as well as technological and social changes, have new problems emerged, and others, which have existed before, taken on entirely new dimensions (Beck 1993: 156). It is now recognized that many human activities, collectively, have detrimental and possibly irreversible consequences. Equally new is the realization that some problems, which arise in a variety of specific forms, according to the context of individual countries where they occur, may be affecting humanity as a whole (UNESCO 1977: 11, Clark 1991: 3-14, Cornwell 1996: 81**,** Chenje 1999: 22).

The landmark publication of Rachel Carson's *Silent Spring* in 1967 sounded the alarm for harmful effects of chemicals on wildlife. The 1996 publication of *Our Stolen Future* by Theo Colborn, Dianne Dumanoski, and John Peterson Myers was a clarion call for recognition of similar effects on humans. The authors of *Our Stolen Future* revealed how many of the findings in animals correlate with disturbances in normal reproductive and developmental processes in humans, citing data from decades of research on wildlife that traced birth defects, sexual abnormalities, and reproductive failures to synthetic chemicals that mimic natural hormones. There is increasing evidence that environmental hormones may be linked to increases in hormone-related cancers, endometriosis, certain behavioural aberrations, and reproductive effects such as an alarming apparent drop in male sperm counts worldwide in recent years (Eubanks 1997: 1).

Recent advances in technologies have extended our ability to detect minuscule

amounts of chemicals in the body and the environment, and have enabled scientists to decipher biochemical processes at the molecular level. These advances are opening new doors to understanding the complex roles endogenous and exogenous chemicals play in human health. New molecular tools are enabling researchers to study the basic mechanisms of reproductive hormones, how damaged or mutated genetic systems interact with synthetic and naturally occurring hormones, and the role such hormones play in initiating tumorigenesis, causing developmental abnormalities, and impairing reproduction. Knowledge gained from this basic research will provide critical information for developing new clinical applications, therapies, and prevention strategies (Eubanks 1997: 1).

Many compounds that are in daily use in industry, agriculture and in households have Endocrine Disrupting (ED) effects. These include the alhylphenols, polychlorinated biphenyls, dioxins and furans, and organochlorines, which are used in different forms as plasticizers, lubricants, packaging material, pesticides and insecticides (De Jager, Bornman & Oosthuizen 1999: 107). Dichloro-diphenyl-trichloroethane (DDT) and organochlorine pesticides are well-known for their ED effects. The limited water sources of South Africa, the limited health budget, the likelihood of significant pollution by industry, the lack of proper waste control, the need to use DDT for malaria vector control, emphasize the need for timely measures to be taken as these EDCs pose a health risk (De Jager & Bornman 1999: 267).

Endocrine Disrupting Chemicals (EDCs) are defined as chemicals that interfere with the structure, or function of hormone-receptor complexes. They can cause endocrinal or hormonal disruptive effects at exposure levels up to a million times lower than carcinogen exposure levels of concern. Internationally, the impact of EDCs on health is evident and no longer an issue of dispute (EDSTAC 1998: 2; http://ehp.niehs.nih.gov/who/). Examples include the increase of testicular and prostatic cancer, the higher incidence of undescended testes and hypospadia, the decline in male reproductive health and fertility, and the very likely causal effect on the cognitive and immunological development of children. Female reproductive health and fertility, particularly

conditions like endometriosis and adenomyosis, breast and reproductive tract cancer and possibly polycystic ovarian syndrome, seem to be mediated by EDCs. Fetal exposure to EDCs was found to influence reproductive and general health. It also seems that environmental EDCs probably contribute to declines in some wildlife populations (Toppari *et al.* 1996: 747; Lee 2002: ix). Changes in male reproduction in wildlife involve such issues as feminization, demasculinization, reduced hatchability, reduced viability of offspring, impaired hormone secretion or activity, and altered sexual behaviour (Colborn, Vom Saal, Soto 1993: 379).

Humans, like other forms of life on earth, are dependent on the capability of both of local ecosystems and the global ecosphere for maintaining health. Many different measurement techniques show that current global patterns of human activity (over-consumption, population growth and inappropriate use of technology) are unsustainable and are likely to have profound consequences for human health. Major changes in policies that govern society are to be brought about if emerging trends in the ecosystem degradation, resulting from human activities, are to be arrested. Rational changes in policy will require the availability of scientific information appropriate to measuring global changes (De Jager & Bornman 1999: 267).

In South Africa, at national level, the focus of health authorities is on acute conditions and infectious diseases. Most of the environmental risk research over the last 30 years has attempted to establish causal links between putative contaminants and cancers of all kinds. In all of these instances, the major problems were to obtain sufficient individual exposure and outcome data to provide decisive answers. It is, however, becoming increasingly obvious, in both developed and developing nations, that chronic conditions, especially those caused by exposure to environmental chemicals, will constitute a greater threat to human health in the future (De Jager & Bornman 1999: 267).

As the lag time of the health effects of environmental pollutants is often long, it is important to realize that the environmental health problems should be addressed as a matter of urgency. The environmental health and educational

initiative will aim to address exposure to environmental chemicals and the risks to health in rural and urban populations. This will also provide the essential building blocks for public awareness campaigns in the future. The approach will therefore be to include the assessment and management of environmental exposure to toxins and their health effects on an informative basis (De Jager 2003, Personal Communication).

It has been said that human beings are the only animals not bound by their environment, so they can change it. Not only should they protect it, but they should also improve it. Science and technology can without doubt provide, or contribute to solve the problems which they may, in fact, have helped to cause. Nevertheless, the solutions sought, should not be short-term ones, nor too narrowly conceived. In many cases, solutions have to take into account the social and cultural factors which are so often at the root of such problems. Environmental Education has an evident role to play if the issues at stake are to be grasped and if all concerned are to be provided with the knowledge, skills and attitudes which can modify the existing situation for the better (UNESCO 1977: 11 - 12).

Today, educators face a compelling responsibility to serve society by fostering the transformations needed to set us on the path to sustainable development. The time has come to ensure that the concepts of education for sustainability, in the broadest sense, are discussed and woven into a framework upon which the current and future educational policy is based (US Government 1994: 1).

Education is probably the single most important step on our staircase to a better future. The solutions to many of our environmental problems are known, but they are often not acted upon because people and politicians do not understand them, or have other priorities. By learning something about our environmental problems, we can contribute to creating a sustainable world. A sustainable world is a world in which human populations can continue to exist indefinitely maintaining with a high standard of living and health (Arms 1994: 3). The Brundtland Commission defined sustainable development as follows: "Sustainable development is development that meets the needs of the present

without compromising the ability of future generations to meet their own needs" (The World Commission on Environment and Development 1987: 43). Fien (1993: 19) stated that the promotion of both values of ecological sustainability and social justice underscores education for sustainable living. Jickling (1999: 62) felt that sustainability and sustainable development are part of the evolutionary process of Environmental Education.

Environmental Education has the capacity to reform and transform education in many respects and will, it is hoped, cultivate environmentally literate citizens who have learned to live and work in harmony with the environment (Bornman 1997a: 58).

It can be accepted that if people are properly informed, if they are educated, they will make intelligent choices to reduce their health risks. For most toxic environmental pollutants, the greatest reduction in public health risks can be achieved by reducing exposure at the personal level - by changing personal activities, habits, and lifestyles (Ott & Roberts 1998: 86).

The development of new curricula for education in South Africa offers opportunities for the integration of Environmental Education (see Chapter 3). Teachers in formal education should regard the integration of Environmental Education into the curriculum as a challenge. It should also be viewed as an opportunity to contribute to the protection of the environment and to improve the quality of life in all our communities in South Africa (Bornman 1997a: 56 - 57).

The purpose of this study is to develop a programme on EDCs that would give learners the necessary knowledge, skills and attitudes which can modify the existing situation for the better.

1.2 Formulation of the problem

Can a Life Sciences programme, integrating Environmental Education, on environmental endocrine disruptors, in the teaching of the Life Sciences Curriculum for Grades 10 to 12, be successfully developed?

The sub-problems of the study are:

- What is the extent of the problems regarding EDCs?
- Is the inclusion of Environmental Education in the teaching of the Life Sciences Curriculum feasible?
- How successful is the programme?
- Can Environmental Education provide a solution to the problems we are facing with regard to EDCs?

1.3 Aims of the study

To develop a Life Sciences programme, integrating Environmental Education, on environmental endocrine disruptors, in the teaching of the Life Sciences Curriculum for Grades 10 to 12.

The sub-aims of the study are:

(a) to establish the need for a Life Sciences programme on EDCs,
(b) to investigate the inclusion of Environmental Education in the Life Sciences Curriculum for grades 10 - 12,
(c) to evaluate the developed programme on EDCs.
(d) to investigate whether Environmental Education can provide a solution to the problems we are facing with regard to EDCs?

1.4 Hypothesis

A Life Sciences programme, integrating Environmental Education, on environmental endocrine disruptors, in the teaching of the Life Sciences Curriculum for Grades 10 to 12, can be successfully developed.

1.5 Environmental Education and Outcomes-Based Education

Outcomes-Based Education (OBE) forms the foundation of the curricula in South Africa (Department of Education 2002: 1). Transformation, redress,

equity and participation are of major importance and Environmental Education can be an important facilitation vehicle in achieving these goals (Le Grange & Reddy 1997: 12).

OBE and Environmental Education have many common areas. Both focus on the relevance to the needs of society as well as the relevance to learners' present and future needs. Both ideas also take a holistic approach to the curriculum and emphasize the importance of integration and cross-curricular approaches. Both are learner-centered and encourage active learning on the part of learners, involving them in real and simulated action, and both also emphasize the importance of life-long learning. Critical thinking is also an integral part of both these approaches to education (Le Grange & Reddy 1997: 15).

The ideal is that in courses, such as the natural sciences, Biology, geography, languages, art, history and technology, Environmental Education could become a cross-curricular, multi-disciplinary learning experience for learners in the primary and secondary school phases (Bornman 1997a: 60).

Environmentalists and environmental educators accept that Environmental Education is inter-disciplinary and holistic in nature and application, and spreads its influence across the whole school management. As a cross-curricular "theme" it is concerned with learning about the environment, learning in and through the environment and also learning for the environment (Tilbury 1995: 195). In South Africa this approach has also been followed (Bornman 1997a: 60).

In 1995 the Environmental Education Policy Initiative (EEPI) identified four main policy options for Environmental Education in formal education in South Africa:

1. Environmental Education as local, problem-solving curriculum action;
2. Environmental Education as an integrated approach to environmental education (an environmental perspective within separate subjects);

3. Environmental Education as a separate subject:
4. Environmental Education as a component within a subject (EEPI 1995: 2).

A key outcome of the workings of the EEPI was the establishment of the principle in the 1995 *White Paper on Education and Training* that stated that Environmental Education must be a vital element of all levels and programmes of the education and training system (Department of Education, 1995: 18). This principle in turn set the scene for ongoing Environmental Education curriculum developmental work. Following this, the EEPI changed focus to become the Environmental Education Curriculum Initiative (EECI) which had a great impact on the curriculum development process of Curriculum 2005 through participation in resource development and research and also attempting to strengthen curriculum development activities at colleges and universities (Sguazzin 2002: 2).

The "environment" was defined as a phase organizer in Curriculum 2005. With the revision of Curriculum 2005 and the development of a *National Curriculum Statement for General Education and Training* phase organizers were dropped. Environmental Education processes are still integral to all of the learning areas in the formal curriculum, each learning area having a particular environmental focus embedded within it. The principle of the *National Curriculum Statement* encompasses Environmental Education since it recognizes the relationship between human rights, inclusivity, a healthy environment and social justice (Lotz-Sisitka & Raven 2001: 67 & 101).

Wagiet (2002: 27) felt that our country would benefit from our education system, which now holds the environment as a mainstream education issue. She stated that the learners who will learn about their environment, its problems and how to be a part of the solution, will eventually move into the workforce and, in many cases, into positions of responsibility. The insights gained through EE processes should influence their decision-making in favour of a sustainable future (Wagiet 2002: 27).

1.6 The National Environmental Education Programme (NEEP)

In South Africa, the most recent development in the field of Environmental Education is the establishment of the National Environmental Education Programme (NEEP) by the Minister of Education to facilitate the Environmental Educational processes as important educational priorities within the curricula. The aim of NEEP-GET is to provide an integrated educational framework for environmental enhancement, and sustainable development through co-operative governance. The developmental objective of the NEEP-GET is to enhance the capacity of teachers in South Africa, and to enable them to implement environmental learning at compulsory school level, integrated in the OBE curriculum (Wagiet 2002: 27).

1.7 Summary

Environmental pollution has far reaching effects on human health, especially EDCs used in the plastic industry, various pesticides and also those present in food and products used in everyday life. Oestrogenic contamination in these harmful chemicals may occur through food, water and in the workplace. Elimination of agents with hormone disrupting properties from the environment is probably not a realistic approach to prevent the problem, due to the immense mass of agents in the environment and their persistence. The goal aimed at is to prevent humans from absorbing large amounts of these substances. Measures must also be taken to stop the production and diffusion of hormone disruptors.

Most people know very little about EDCs and the ways in which these chemicals affect humans and animals. If people are properly informed and if they are educated, they will make intelligent choices to reduce their health risks. For most toxic environmental pollutants, the greatest reduction in public health risks can be achieved by reducing exposure at the personal level - by changing personal activities, habits, and lifestyles.

The development of a Life Sciences programme, integrating Environmental Education, on EDCs, would possibly make learners in the Further Education

and Training Phase at school aware of the problems we are facing in this regard - an issue that cannot be ignored anymore. Presently, the system of Outcomes-Based Education offers many opportunities for integration of Environmental Education into Life Sciences. This study will contribute to the process of including Environmental Education in the Life Sciences Curriculum.

CHAPTER TWO
ENVIRONMENTAL ENDOCRINE DISRUPTING CHEMICALS (EDCs): A LITERATURE REVIEW

2.1 Introduction

Certain chemical compounds can act like hormones once they get inside our bodies. This means our health is influenced by hormonal factors that come from outside our bodies. Certain manmade chemicals, many of which are found in the household products we use regularly and in the foods we consume each day, are under suspicion. Humans are exposed to these compounds through the air we breathe as well as the food and water we ingest or absorb through our skins. These particular compounds, environmental endocrine disrupting chemicals (EDCs), can mimic our natural hormones, creating an imbalance, or they can alter the way our natural hormones are supposed to work in the body (Berkson 2000: xxiii).

Concerns regarding exposure to EDCs are due primarily to

1) adverse effects observed in certain wildlife, fish, and ecosystems;
2) the increased incidence of certain endocrine-related human diseases; and
3) endocrine disruption, resulting from exposure to certain environmental chemicals observed in laboratory experimental animals (Berkson 2000: 19**;** <http://ehp.niehs.nih.gov/who/>, 2001: 2).

Evidence of increasing levels of oestrogens during the past half-century comes from several sources. Probably the most important has been the overall

change in diet and the increasing use of environmental chemicals, many of which are weak oestrogens. Humans are exposed to environmental endocrine disruptors and toxins in multiple ways. Diet, drinking water, air, and skin are the routes through which xenoestrogens (environmental chemicals known to possess oestrogenic activity) enter the body. The major groups of environmental chemicals are the organochlorine pesticides, poly-chlorinated bi-phenyls, dioxins, alkylphenol polyethoxylates, phyto-oestrogens, and other xenoestrogens. Xenoestrogens are also implicated as possible factors involved in the pathogenesis of breast cancer in women (Toppari *et al.* 1996: 756 - 768).

While exposure levels to oestrogenic chemicals are not at all well-known to humans, the large number of chemicals in numerous environmental categories suggests adequate availability. For example, environmental chemicals reported to be oestrogenic include, but are not limited to, some ubiquitous chlorinated hydrocarbons such as poly-chlorinated biphenyls (PCBs) and DDT, some products of detergent and surfactant manufacture, such as the alkylphenols, and some products released from plastics, such as bisphenol A and some phthalates (Toppari *et al.* 1996: 756 - 768).

Natural oestrogens (particularly 17ß-oestradiol) play pivotal roles, not only in controlling reproduction in females but also to a lesser degree, in males. These are also implicated in the development and growth of some forms of cancer. This accounts for the growing concern that exposure to oestrogenic chemicals may results in deleterious physiological effects on both wildlife and humans. With shorter generation periods than humans, wildlife could provide clues, concerning the invisible, long-term effects of transgenerational exposure to endocrine disruptors before the effects become pervasive and are manifested in human populations. Recent concern has focused not so much on the incidence of considerable exposure, but rather on whether unavoidable chronic exposure to lower concentrations of an array of endocrine disrupting chemicals may produce less immediately obvious, but nevertheless important, effects (De Jager 2003: Personal communication).

2.2 What are EDCs?

Collectively, chemicals with the potential to interfere with the function of endocrine systems (hormonal systems) are called endocrine disrupting chemicals (EDCs) (Kavlock, 1999: 1227). The working definition used in the final report of the United States Environmental Protection Agency's (US EPA) Endocrine Disruptor Screening and Testing Advisory Committee (EDSTAC) is: *'An endocrine disruptor is an exogenous substance or mixture that alters function(s) of the endocrine system and causes adverse effects at the level of the organism, its progeny, populations or subpopulations of organisms, based on scientific principles, data, weight-of-evidence, and the precautionary principle'* (EDSTAC 1998: 2; http://ehp.niehs.nih.gov/who/).

Research has clearly shown that EDCs can act at multiple sites via multiple mechanisms of action. Receptor-mediated mechanisms have received the most attention, but other mechanisms (e.g. hormone synthesis, transport, and metabolism) have shown to be equally important. Dose-response relationships are likely to vary for different chemicals and endocrine mechanisms. Timing of exposure is absolutely critical to the understanding of dose-response relationships for EDCs (<http://ehp.niehs.nih.gov/who/> 2001: 5).

The following is a short summary of some groups of chemicals known to be endocrine disruptors.

2.2.1 Organochlorine pesticides

Organochlorine pesticides include dichlorodiphenylethanes (DDT, DDD, DDE, dicofol, perthane, methoxychlor), cyclodienes [chlordanes (chlordane, oxychlordane, trans-nonachlor, heptachlor, heptachlorepoxide, aldrin and dieldrin), hexachlorobenzene, and hexachlorocyclohexanes (Toppari *et al.* 1996: 756; De Jager & Bornman 1999: 269).

Persistence is a particular problem with chlorinated hydro-carbon pesticides such as DDT with a half-life of 2 - 5 years. DDT is broken down extremely slowly only by decomposers. DDT and its breakdown products DDD and DDE remain in the environment indefinitely. As a result, each use of this pesticide increases the amount in the biosphere. DDT can now be detected everywhere in the world: from the Antarctic ice to our own bodies (Arms 1994: 466).

2.2.2 Polychlorinated biphenyls (PCBs)

PCBs are industrial chemicals used since 1929 as heat transfer and hydraulic fluids, adhesives, flame-retardants, dielectric fluids for capacitators and transformers and waxes. PCBs in various concentrations were found in a study of South African water in the Kruger National Park, Northwest Province and Gauteng (De Jager *et. al.* 2002).

2.2.3 Dioxins and Furans

These compounds are formed as unwanted by-products in the manufacturin of chlorinated hydrocarbons. Other sources include incinerated processes, paper and pulp bleaching, as well as emissions from steel foundries and motor vehicles. The mechanism of action of dioxins and furans may not be primarily oestrogenic or anti-oestrogenic, but it certainly has a hormonelike effect (Toppari *et al.* 1996: 758).

2.2.4 Alkylphenol polyethoxalates (APEs)

Alkylphenols

Alkylphenols have considerable industrial applications and they also appear as pollutants in the environment. They are used as plastic additives and surfactants. p-Alkylphenol polyethoxylates are widely used non-ionic surfactants. Their degradation during aerobic treatment of wastewater by activated sludge leads to the formation of p-alkylphenol mono- and di-ethoxylates, which have been found in major refractory constituents of treated wastewater effluents and river water. In addition, alkylphenol polyethoxy carboxylic acids have been detected in biologically treated domestic wastewater. There is great concern about the degradation of p-nonylphenol (p-

Np) ethoxylates during sludge treatment and, in particular, the high concentrations of the toxic compound p-NP in anaerobic stabilized sewage sludge (De Jager & Bornman 1999: 270).

p- Nonylphenol

p-NP is used in the preparation of lubricating oil additives, resins, plasticizers and surface active agents. It is also used as anti-oxidants in the manufacturing of plastics such as polyvinyl chloride (PVC) and polystyrene. p-NP may leach from plastic and is reported to contaminate water flowing through PVC pipes and food wrapped in cling plastics. It was even reported that polystyrene tubes used in routine laboratory procedures released oestrogenic properties that affected the results (De Jager & Bornman 1999: 270). p-NP has been found at a concentration of 5.0 μg/l in South African river water as well as drinking water in Pretoria (De Jager *et al.* 2000: 73).

2.2.5 Phthalates

The main human exposure to phthalates is believed to be from foods that have absorbed the chemical from their packaging, or from manufacturing processes. In the UK they are no longer used in the manufacturing of cling film or most other food contact plastics. The ink used to print on plastic, board and foil-packed products frequently contains phthalates, as do some of the adhesives used in packaging. They are found in products such as cheese, margarine and chips (crisps), as well as in vinyl flooring and emulsion paint (Toppari *et al.* 1996: 758; De Jager 2003: Personal Communication).

2.2.6 Phyto-oestrogens

Large amounts (hundreds of milligrams) of phyto-oestrogens such as isoflavones can be ingested daily by humans, especially in a vegetarian diet (Toparri *et al.* 1996: 758). Phyto-oestrogens are naturally occurring plant compounds that may be defined on the basis of their structural and functional similarity to 17β-estradiol or their ability to elicit oestrogenic and/or anti-oestrogenic effects in animals (Aneck-Hahn 2003: 14). Some of the food products rich in phyto-oestrogens include rye, wheat, cabbage, sprouts, spinach and soybean. Soybean is the richest source of plant oestrogens and

is used ubiquitously in the food industry as a protein source (Toparri *et al.* 1996: 758). Phyto-oestrogens combined with synthetic oestrogens, could have an additive or synergistic effect (De Jager *et al.* 2001).

2.2.7 Other xenoestrogens:

Bisphenol-A (BPA)

BPA is a plasticizer, used in epoxy resins, that line various food and beverage cans and in polycarbonate resins which are used in microwave ovenware, returnable water and milk containers, refrigerator crisp drawers and other food storage applications, including baby bottles (Aneck-Hahn 2003: 17).

2.3 The effects of EDCs on human health

2.3.1 Neurological effects

Studies done by Jacobson & Jacobson (1996: 788) indicate that *in utero* and lactational exposure to poly-chlorinated biphenyls (PCBs) impairs mental and motor abilities, including a lowering of intelligence. In a study done in the Yaqui Valley of North Western Mexico, children exposed to pesticides demonstrated decreases in stamina, gross and fine eye-hand co-ordination, 30-minute memory, and the ability to draw a person (Guillette *et al.* 1998: 347). *In utero* exposure to PCBs resulted in adverse effects on the neurological and intellectual functions (memory and attention) in young children born to women who had eaten PCB contaminated fish in the USA (Jacobson & Jacobson 2002: 1).

2.3.2 Testicular cancer

Germ cell-derived cancer of the testes is one of the most common malignancies in young males (Giwercman *et al.* 1993: 65). It is obvious that there is a worldwide trend towards an increased incidence of testicular cancer (Toppari *et al.* 1996: 743).

2.3.3 Cryptochidism and hypospadia

Birth data from several reports have indicated a substantial increase in the incidence of cryptorchidism (maldescent of the testes) and in the prevalence of hypospadias (Toppari *et al.* 1996: 744).

2.3.4 Semen quality

A number of studies over the past 10-20 years have suggested that sperm counts in men have declined (De Jager & Bornman 1999: 266; De Jager *et al*. 2001).

2.3.5 Female breast cancer

Although improved detection may be partly responsible, there has been an upward trend of about 1% per year since 1940. A number of factors that increase breast cancer risk have been identified, including diet, calorie intake and alcohol consumption. However, a lifetime exposure to oestrogens (age at menarche and menopause, use of contraceptive pill) is of major importance and environmental oestrogens might contribute to overall exposure and thereby to the rising incidence of the disease (Phillips & Harrison 1999: 24).

2.3.6 Female reproductive health

Female reproductive health and fertility, particularly conditions such as endometriosis and adenomyosis, breast and reproductive tract cancer and possibly polycystic ovarian syndrome, seem to be mediated by EDCs (Toppari *et al.* 1996: 747; Lee 2002: ix).

2.4 The effects of EDCs on wildlife

Trends in the reproductive health of species, other than man also raise the possibility of environmental factors as partial etiological contributors to a decline noted in the male reproductive health of wildlife. Wild panthers in the United States have been reported to have an increase in undescended testes and a decrease in semen quality, whereas male alligators in some lakes in Florida have shown abnormalities in their sex hormone levels (tending toward femaleness) and to have smaller than normal genitalia. Male fish in some parts

of the United Kingdom have expressed a female-like response. Added together, this growing evidence suggests that environmental factors that resemble female sex hormones may be having an adverse effect on the reproductive capacity and well-being of diverse species (Toppari *et al.* 1996: 769).

Persistent pesticides eventually reach waterways. Birds that eat fish were the worst sufferers from DDT because DDT interferes with calcium metabolism. Birds laid thin eggs that broke when they sat on them. Penguins, pelicans, peregrines, and eagles were all endangered, or eliminated, from some areas as a result (Arms 1994: 466).

2.5 Exposure to EDCs

Oestrogenic effects are not only restricted to a small group of therapeutic agents, but also appear in several groups of compounds that are in daily use in industry, agriculture or in the home. Routes of human exposure to oestrogens have changed in the past half-century. The potential routes of human exposure are listed in Table I (Toppari *et al.* 1996: 760; De Jager 2003: Personal Communication).

Table 2.1: Some routes of human exposure to oestrogens.

SOURCES OF OESTROGEN		**FACTORS THAT MAY HAVE ALTERED EXPOSURE**
		SOURCES
Endogenous	Changes in diet	Low fibre diet Recycled excreted oestrogens
	Increased body fat	Increased bioavailable oestrogens
Synthetic	Oral contraceptives	Recycled drinking water
	Orally active anabolic oestrogens in livestock	Important route: 1950s - 1970s
Plant	Changes in diet	Many plants, e.g. soya
Other dietary sources		Increased consumption of dairy

products Cow's milk

Environmental o	estrogenic chemicals	Production started 1930s / 1950s

Includes organochlorine compounds (e.g. DDT); products of combustion; distribution range from rainwater to breastmilk

Human exposure to these chemicals may be occurring through the following routes:

- Contaminated drinking water, extracted from polluted rivers and dams.
- Absorption through skin from shampoos, cosmetics, spermicidal lubricants and domestic and industrial detergents.
- Inhalation and ingestion from pesticide sprays.
- Contamination of food from fields spread with sewage sludge containing alkylphenols.
- Contamination of food from packaging materials.
- In some countries sewage sludge can also be spread on grazing land, potentially contaminating milk (De Jager & Bornman 1999: 271).

2.6 The EDC situation in South Africa

In South Africa, very little data is currently available on the levels of oestrogenic contamination in aquatic systems (Aneck-Hahn 2003: 2). A pilot study to determine the presence of specific chemicals (p-NP, PCBs) and organochlorine pesticides) known to have oestrogenic activity was performed on water samples from certain rivers and dams during the summer of 1998/99. The results indicated that there was oestrogenic contamination in a number of areas. With the limited resources in South Africa this is disturbing, as many humans and animals are dependent on these sources for drinking water (De

Jager *et al.* 2000: 73).

In South Africa the environment in rural and urbanized areas are often contaminated with a complex mixture of toxic compounds originating from industries, agriculture and private households. Many of these pollutants end up in surface waters, such as dams, rivers and eventually the sea. Toxic contaminants may disturb the biological condition of aquatic ecosystems and be harmful to humans, if they are transported to human food or drinking water. In the rural areas the only access that the communities have to water for drinking and household purposes are boreholes, natural springs and rivers in their area. As water is a scarce and valuable resource in South Africa it is important to examine the oestrogenic activity in the water sources as it could impact detrimentally on the general health of the population (Aneck-Hahn 2003: 44).

Humans are dependent on water for basic survival and the quality of the water they consume falls under the banner of primary health care. Studies performed thus far (Meintjies *et al*., 1995, Meintjies *et al.*, 2000; de Jager *et al.* 2002) indicate that there are EDCs with oestrogenic activity contaminating the water sources in South Africa (Aneck-Hahn 2003: 45).

South Africa recently took a decision to phase out DDT and to switch to pyrethroids in the 1996/97 season, being completed by the beginning of 1999. During this phase-in it became apparent that the number of malaria cases were on the increase and by the end of 1999 the number was 50 000 for South Africa. A mosquito species eradicated by DDT has also returned. This species is pyrethroid resistant and transmits throughout the year. Initially it was only in Kwazulu Natal, but is also found now in Mphumalanga and Limpopo Province. The decision was taken that all provinces will use DDT (an estimated 215 tons) in an effort to combat this species (Bouwman 2000: 1).

There is growing international concern about the persistent bio-accumulative chemicals, bio-magnification and synergistic/additive effects of EDCs. In South Africa, this process may be associated with pollution, the production and

uncontrolled disposal of high volumes of industrial chemicals, and unmonitored occupational exposure, which also applies to some existing industries. Current South African legislation does not require that chemicals be screened for endocrine disruptor chemical (EDC) effects before being used as packaging material, detergents or lubricants in food, cosmetics, household, industrial, agricultural and pharmaceutical products. These sources, as well as land-fill sites, sewage treatment works and industrial effluents, contribute to the contamination of the aquatic environment, and soil. Toxic dumping in Africa is notoriously uncontrolled, contributing further to the exposure of both man and nature. The scientific and public awareness of the possible implications to EDC exposure in South Africa is nearly non-existent, and the research capacity on EDCs is very limited. Few of the exposure routes and potential EDCs, and hardly any of the suspected health effects have been investigated. Extensive research is urgently needed if we are to prevent future generations from falling victim to the effects of exposure to chemicals which act as EDCs. Further studies are essential to find the sources of oestrogenic contamination so that further action can be taken to limit exposure (Aneck-Hahn 2003: 148).

2.7 Summary

Endocrine Disrupting Chemicals (EDCs) are defined as chemicals that interfere with the structure, or function of hormone-receptor complexes. Many compounds that are in daily use in industry, agriculture and in households have ED effects. These include the alhylphenols, polychlorinated biphenyls, dioxins and furans, and organochlorines, which are used in different forms as plasticizers, lubricants, packaging material, pesticides and insecticides. The limited water sources of South Africa, the limited health budget, the likelihood of significant pollution by industry, the lack of proper waste control, the need to use DDT for malaria vector control, emphasize the need for timely measures to be taken as these EDCs pose a health risk.

Examples include the increase of testicular and prostatic cancer, the higher incidence of undescended testes and hypospadia, the decline in male

reproductive health and fertility, and the very likely causal effect on the cognitive and immunological development of children. Female reproductive health and fertility, particularly conditions like endometriosis and adenomyosis, breast and reproductive tract cancer and possibly polycystic ovarian syndrome, seem to be mediated by EDCs. Human exposure to these chemicals may be occurring via various routes, namely contaminated drinking water, food, absorption through the skin, inhalation and ingestion from pesticide sprays.

It also seems that environmental ED probably contributes to declines in some wildlife populations. Exposure to certain EDCs have contributed to adverse effects in some wildlife species and populations. These effects vary from subtle changes to the physiological and sexual behaviour of wildlife species, to permanently altered sexual differentiation.

The evidence that exposure to EDCs impacts on both humans and wildlife requires our full attention to ensure the sustainability of populations and communities. The scientific and public awareness of the possible implications to EDC exposure in South Africa needs urgent attention.

CHAPTER THREE
INCLUSION OF ENVIRONMENTAL EDUCATION IN THE TEACHING OF THE LIFE SCIENCES CURRICULUM

3.1 Introduction

Environmental Education has developed from Nature and Outdoor education and was originally included, amongst others, in programmes of the natural sciences (Geography, Biology and Chemistry) (Disinger 1986: 1; Irwin 1990: 3, Bornman 1997b: 2). The twelve Tbilisi principles state that Environmental Education should be a lifelong, holistic and multi-disciplinary process (Unesco 1980: 69 - 70). Although Environmental Education is holistic in nature and multidisciplinary in approach, the important role that subjects such as Biology play in teaching about Nature's pivotal role in Environmental Education, should not be ignored (Loubser 1996: 3).

The inclusion of Environmental Education content, concepts, and processes into curricula, particularly in the science (Life Sciences) and the social studies is in many ways still the most practical, sensible way to enhance Environmental Education, and may eventually be Environmental Education's most significant contribution to the educational enterprise and to environmental quality (Disinger 1986: 3).

The newly proposed Life Sciences Curriculum for the Further Education and Training Phase in the system of Outcomes-Based Education offers many opportunities for integration of Environmental Education into the curriculum document. Bornman (1997: 56) indicated that the development of new curricula for education in South Africa offers opportunities for the integration of Environmental Education. This was later strengthened by, amongst others, Asmal, Wagiet and the NEEP (Asmal 2000, Department of Education 2001: 5, Wagiet 2002: 27)

3.2 Environmental Education through the teaching of Biology

The current Biology syllabus for Grade 10 (the previous Standard 8) of the National Educational system provides for Environmental Education under the topic “Ecology” (Degenaar 1988: 45). In 1996 Loubser (1996: 3) suggested, that, although there is room in the existing Biology syllabi for teaching about the environment in a holistic and multidisciplinary way and that topics such as ecology, genetics, nutrition etc, lend themselves to such approaches, a complete new Biology curriculum might be more suitable for satisfying the principles of Environmental Education - and human life. Changes to this effect have also been suggested by Dekker and Van der Merwe (1990: 105), Watson (1990: 45) and others. Loubser (1996: 3) recommended that Biology as a school subject should reconsider its boundaries, rethink its role in the context of everyday life and change its content to be relevant. In such a process of change, Environmental Education could play a crucial role in linking Biology to everyday life and in improving the understanding of the problems of everyday life.

3.3 Outcomes-Based Education and Environmental Education

Outcomes-Based Education (OBE) forms the foundation of the present curricula in South Africa. By setting the outcomes to be achieved at the end of the educational process, OBE strives to enable learners to reach their maximum learning potential. The outcomes encourage a learner-centered and activity based approach to education. The National Curriculum Statement (NCS) builds its learning Outcomes for the Grades 10-12 (Schools) on the Critical and Developmental Outcomes that were inspired by the Constitution and developed in a democratic process (Department of Education 2002: 8).

The Critical Outcomes require learners to be able to:

1. identify and solve problems and make decisions using critical and creative thinking
2. work effectively with others as members of a team, group, organisation and community
3. organize and manage themselves and their activities responsibly and effectively

4. collect, analyse, organize and critically evaluate information
5. communicate effectively, using visual, symbolic and/or language skills in various modes
6. use science and technology effectively and critically showing responsibility towards the environment and the health of others, as well as
7. demonstrate an understanding of the world as a set of related systems by recognizing that problem solving contexts do not exist in isolation (Department of Education 2002: 9).

The Developmental Outcomes require learners to be able to:

1. reflect on and explore a variety of strategies to learn more effectively
2. participate as responsible citizens in the life of local, national, and global communities
3. be culturally and aesthetically sensitive across a range of social contexts
4. explore education and career opportunities
5. develop entrepreneurial opportunities

(Department of Education 2002: 9).

Environmental Education processes are integral to most of these outcomes, having a particular environmental focus embedded within it.

What is "Environmental Education"?

The influential 'classic' definition of Environmental Education was formulated in 1970 at the IUCN/UNESCO 'International Working Meeting on Environmental Education in the School Curriculum':

Environmental Education is the process of recognizing values and clarifying concepts in order to develop skills and attitudes necessary to understand and appreciate the inter-relatedness among man, his culture,and his biophysical surroundings. Environmental Education also entails practice in decision-making
and self-formulation of a code of behaviour about issues concerning

environmental quality. (Palmer 1998: 7)

The objectives for Environmental Education were defined by the 1977 Tbilisi Inter-governmental Conference on Environmental Education (UNESCO 1977: 26). These objectives are as follow:

- *Awareness* - to help social groups and individuals acquire an awareness of and sensitivity for the total environment and its allied problems (and/or issues)
- *Sensitivity* - to help social groups and individuals gain a variety of experiences in, and acquire a basic understanding of the environment and its associated problems (and/or issues)
- *Attitudes* - to help social groups and individuals acquire a set of values and feelings of concern for the environment and motivation for actively participating in environmental improvement and protection
- *Skills* - to help social groups and individuals acquire skills for identifying and solving environmental problems (and/or issues)
- *Participation* - to provide social groups and individuals with an opportunity to be actively involved at all levels in working towards the resolution of environmental problems (and/or issues) (UNESCO 1977: 26).

Twelve guiding principles for Environmental Education were formulated.

Environmental Education should:

1. consider the environment in its totality - natural and built, technological and

social (economic, political, technological, cultural-historical, moral, aesthetic);

2. be a continuous lifelong process, beginning at the pre-school level and continuing through all formal and non-formal stages;
3. be inter-disciplinary in its approach, drawing on the specific content of each discipline in making a holistic and balanced perspective possible;
4. examine major environmental issues from local, national, regional and international point of view so that learners receive insights into environmental conditions in other geographical areas;
5. focus on current and potential environmental situations, while taking into account the historical perspective;
6. promote the values and necessity of local, national and international co-operation in the prevention and solution of environmental problems;
7. explicitly consider environmental aspects in plans for development and growth;
8. enable learners to have a role in planning their learning experiences and provide an opportunity for making decisions and accepting their consequences;
9. relate environmental sensitivity, knowledge, problem-solving skills and values clarification to every age, but with special emphasis on environmental sensitivity to the learner's own community in early years;
10. help learners discover the symptoms and real causes of environmental problems;
11. emphasize the complexity of environmental problems and thus the need to develop critical thinking and problem-solving skills;
12. utilize diverse learning environments and a broad array of educational approaches to teaching-learning about and from the environment with due stress on practical activities and first-hand experience (UNESCO 1977: 26 - 27).

In the opinion of the researcher, these objectives and principles are still appropriate. Environmentalists and environmental educators accept that Environmental Education is inter-disciplinary and holistic in nature and application, and spreads its influence across the whole school management

(EEPI 1995: 2-3). As a cross-curricular "theme" it is concerned with learning about environment, learning in and through an environment, as well as learning for an environment (United Nations Conference on Environment and Development 1992: ; Tilbury 1995: 195).

OBE and Environmental Education have many common areas. Both focus on the relevance to the needs of society, as well as relevance to learners' present and future needs. Both ideas also take a holistic approach to the curricula and emphasize the importance of integration and cross-curricular approaches. Both are learner-centered and encourage active learning on the part of learners, involving them in real and simulated action, and both also emphasize the importance of life-long learning. Critical thinking is also a central part of both these approaches to education. (Le Grange & Reddy 1997: 15).

3.4 The Proposed Life Sciences Curriculum and Environmental Education

The learning area *Life Sciences* involves a systematic study of life in the natural and human-made environment of the earth's biosphere and beyond, where there are human-made (sub)systems which support life. It involves the understanding of concepts and the analyses of processes and their related biological and ecological systems. Through systematic and critical inquiry, *Life Sciences* reflects on life processes and systems of the past and the present with the aim of sustaining life in the future. The desire to study *Life Sciences* is deeply rooted in human existence and awareness of the environment (Department of Education 2002: 7).

The study of *Life Sciences* enables learners to understand biological and ecological processes that impact on the environment. These include food production, food consumption, equitable food distribution, health promotion, conservation, sustainable eco-systems, bio-diversity, biotechnology and genetic engineering (Department of Education 2002: 7). Aspects of Environmental Education are integrated into the Life Sciences Curriculum as recommended by Degenaar (1988: 45) and Loubser (1996: 3). Therefore it is

feasible to implement an EE programme on Endocrine Disrupting Chemicals (EDCs) into the Life Sciences Curriculum of the Further Education and Training Phase.

The subject *Life Sciences* develops the following competences through addressing skills, knowledge, attitudes and values:

- development of inquiring skills
- construction of Life Sciences knowledge
- the inter-relationship of science, society and the environment
- acknowledgement and understanding of different attitudes and values related to *Life Sciences (*Department of Education 2002: 15).

Life Sciences builds on the foundation laid by the Natural Sciences Learning Area in the General Education and Training Band. *Life Sciences* has four learning outcomes which focus on:

1. scientific investigations,
2. constructing science knowledge,
3. science, society and the environment and
4. science, society, attitudes and values (Department of Education 2002: 16).

Where will a programme on EDCs fit into the Life Sciences Curriculum?

Schools must have the freedom to interpret the guidelines in the various learning areas, according to the school phases (primary or secondary), as long as it is done in a planned and coherent manner (Bornman 1997a: 61). What is of importance is that the presentation of an Environmental Educational programme should ensure continuity and progression. It is important that a variety of approaches to the organization of the curriculum and the methodology for learning in Environmental Education should be followed (Palmer & Neal 1995: 23-33; Bornman 1997a: 61). Learners should also have the necessary

knowledge on the endocrine system and certain concepts regarding pollution and its effect on the environment, wildlife and human health before attempting the programme on EDCs.

The developed learning programme to create increased environmental awareness about EDCs can fit into the proposed core content of the Life Sciences Curriculum of the newly proposed National Curriculum Statement in the following areas:

Cell and molecular study

- Study the reproduction and continuity of life at the cellular level in order to understand and deal with fertility, societal problems and technological developments

Organism structure and function

- Understand the way in which organisms interact with the changes in the environment, which influence their behaviour and social Biology.

Study of the environment

- Study the environment, looking at the bio-physical, social, economic and political systems
- Study the environment, looking at the inter-relationships of science, technology, indigenous knowledge systems and society with management and sustainability of environmental resources and products.

Change, diversity and continuity

- Knowledge of change through contested nature and diverse perceptions of issues such as diseases, evolution, reproduction, genetically engineered organisms *(*Department of Education 2002: 15).

3.5 Education for Sustainability and the Life Sciences Curriculum

The Brundtland Commission defined sustainable development: "Sustainable development is development that meets the needs of the present without compromising the ability of future generations to meet their own needs" (World

Commission on Environment and Development 1987: 43).

Education for sustainability is a lifelong learning process that leads to an informed and involved citizenry, having the creative problem-solving skills, scientific and social literacy, and commitment to engage in responsible individual and co-operative actions. These actions will help ensure an environmentally sound and economically prosperous future (Fien 1993: 17; US Government 1994: 2; Cross 1998: 43). Contrary to the above-metioned statements, Jickling (1994: 23) argued that we should not educate *for* sustainable development. He thinks educating *for* sustainable development is "contrary to the spirit of education". It would be better to educate learners than to condition them to believe that 'sustainable development' constitutes a constellation of correct environmental views or that hidden beneath its current obscurity lies an environmental panacea. In the opinion of Jickling (1999: 62), 'sustainability' is a steppingstone for future visions. Education should be about creating possibilities, and these creative possibilities can arise when we embrace exploration, evaluation, and critique of emerging ideas.

The term education for sustainability is often used as an umbrella term. The term *education for sustainability* or *sustainability education* complements a number of other fields such as Environmental Education, global education, economics education, development education, multi-cultural education, conservation education, outdoor education, global change education, and others. Education for sustainability is considerably broader and encompasses many aspects of these respected and established fields of study. As such, it may embrace components from traditional disciplines such as civics, science, political science, geography, and others (U.S. Government: 1994; Cross 1998: 43). Ideas about the nature and meaning of sustainable development include ecological sustainability, cultural, social, economic and political sustainability. Undoubtedly, Life Sciences will play an important role in fostering the changes needed to set us on a path of sustainability.

3.6 Summary

OBE and Environmental Education have many common areas, namely relevance to the needs of society, relevance to learners' present and future needs, a holistic approach, emphasis on the importance of integration and cross-curricular approaches. Both are learner-centered and both also emphasize the importance of life-long learning and critical thinking.

A new Biology curriculum that is more relevant to everyday life might be more suitable for satisfying the principles of Environmental Education. Aspects of Environmental Education are integrated into the newly proposed Life Sciences Curriculum and in the critical outcomes of OBE. Therefore, it is feasible to implement an EE programme on Endocrine Disrupting Chemicals (EDCs) into the Life Sciences Curriculum of the Further Education and Training Phase. Education for sustainability encompasses the discipline Life Sciences, amongst others.

CHAPTER FOUR

A LIFE SCIENCES PROGRAMME, INTEGRATING ENVIRONMENTAL EDUCATION, ON EDCs: ACTIVITIES, POST ACITIVITIES AND EVALUATION

4.1 Introduction

Learners must be empowered to address environment and development issues in their own lives by implementing programmes of education that inform them about the complexities of the environment in which they are growing up. The course of the future depends on action taken today (Guilette 2000: 323). Such action includes two important segments: that of limiting our exposure to EDCs released into the environment and that of integrating EDC research to present a valid and realistic picture of what is actually happening. The question all of us must face is: Should EDC production and use be restricted? If so, what will the outcome be in terms of the global quality of life and public health? There are no simple answers to these questions. Advances in knowledge,

technology, and policy must provide avenues that will protect both the environment and the people, now and in the future (Guilette 2000: 323, 335).

Knowledge of environmental problems and knowledge of action strategies have been consistently identified as correlates of environmentally responsible behaviour (Hines, Hungerford, & Tomera 1987: 2; McDowell, Sparks, Grindly & Moll 1989: 211, Young & Witer 1994: 27). Knowledge of environmental problems refers to one's understanding of specific environmental issues (Ramsey *et al* 1992: 31). Acting "for the environment" involves decision-making in an attempt to live out personal values through individual or collective behaviour. Environmentally responsible behaviour is behaviour that would lead to sustainable living (Scott & Oulton 1998: 214).

Hungerford and Volk (1990: 8) stated that the ultimate aim of education is shaping human behaviour. Societies throughout the world establish educational systems in order to develop citizens who will behave in desirable ways. Although the behaviourist approach is seen as outdated by some social scientists, it still has some value for education (Von Glaserfeld 1995: xiii). The behaviourist approach may have positive value for Environmental Education if people's destructive behaviour towards the environment can be changed for the better (Engleson & Yockers 1994: 62). This should, however, not be done by manipulating and controlling people.

Attitude is defined as an enduring positive or negative feeling about some person, object, or issue (affective domain) (Newhouse 1990: 26). Beliefs about environmental issues refer to an individual's perspective on an issue. Values refer to the relative word an individual places on issues related to the environment. Values can therefore influence how an individual feels and behaves with respect to these issues (Newhouse 1990: 26; Ramsey 1993: 31).

According to Ramsey (1993: 31), the components of an Environmental Educational methodology designed to focus on the development of responsible environmental behaviour are: knowledge of environmental issues, beliefs concerning environmental issues, values related to the environment, individual

and group locus of control, environmental sensitivity, knowledge and skills of environmental action strategies, and knowledge of ecological concepts.

A learning programme (Appendix A) was developed on EDCs in an attempt to create increased awareness about EDCs and to increase learners' environmental literacy by giving learners the necessary knowledge and skills to limit their exposure to EDCs and to help try finding a long-term solution.

4.2 Data-collection

For the research to be valid and reliable, use was made of a specific scientific method, namely questionnaires, to collect data (Collins et al. 2000: 88). By means of group-administered questionnaires (Appendix B) information was gathered before the programme had commenced. The Lickert scale was used to establish the learners' knowledge, attitudes and values in connection with EDCs and the environment before the programme had commenced. The same questionnaires were used after of the programme was completed to establish the success of the programme (see Chapter 5).

4.3 Objectives of the learning programme to create increased knowledge about EDCs:

The content of environmental courses needs to be matched to the objectives selected, based on perceived local needs (Council for the Environment 1993: 13). While it is not possible to predict items of local significance, the major concepts of Environmental Education must be considered (see Chapter 3). It should be relevant to the lives of the learners and their future (Smyth 1983: 124).

The objectives of the learning programme on EDCs are:

1. To inform the learners about the effects of EDCs on human health and wildlife.

2. To inform learners about the ways contamination of EDCs may occur.
3. To inform learners about ways exposure to EDCs can be limited.
4. To help learners make informed decisions about issues concerning the use and production of EDCs.
5. To help learners become aware that reduction in public health risks can be achieved by reducing exposure at the personal level - by changing personal activities, habits, and lifestyles.
6. To give learners the necessary problem solving skills in connection with EDCs.

4.4 Target Group

The target group is 24 Grade 10 Biology learners from Iona Convent School, Pretoria. The age of the learners varies between 15 and 16 years. Environmental Education, like all education, should conform to known development patterns of learners. Research regarding the growth and development of children provides a basis for structuring curricula and programmes dealing with Environmental Education. Since Environmental Education is a relatively new concern, it has had the advantage of being able to use the wealth of recent research on learning and behaviour (Engleson & Yockers 1994: 52).

According to the Piagetian Intellectual Development Stages, learners in the age group 14 and up, have the following characteristics:

- Formal abstract though ability begins to develop, marked by appearance of hypothetical-deductive reasoning based upon logic of all possible combinations, development of combinatorial system and unification of operations into a structured whole.
- Ability to perform controlled experimentation develops, keeping all but one factor constant.
- Ability to hypothesize variables before experimentation, to reverse direction between reality and possibility, develops.

- Can use interpropositional operations, combining propositions by conjunction, disjunction, negation, and implication (Engleson & Yockers 1994: 52).

Brain growth at this age level, 15 and older, is particularly noticeable in the intentional system. The functions of this system are closely related to the intellectual abilities and skills namely analysis, synthesis, and evaluation. According to Engleson and Yockers (1994: 75) major emphasis should be on citizen action skills, citizen action experience, and environmental ethic and minor emphasis on perceptual awareness and knowledge.

Activities were chosen to comply with the objectives of the learning programme to create increased literacy about EDCs, the critical and development outcomes of OBE (see Chapter 3), the learning outcomes of the Life Sciences Curriculum (see Chapter 3), as well as the cognitive development of the learners in mind. Table 4.1 serves as a summary of the different activities which are attached as Appendix A.

Table 4.1: A learning programme on EDCs: Activities, Activity Outcomes and Learning Outcomes

Activity	Activity Outcomes	Learning Outcomes
Activity 1.1 Newspaper article	• Read a newspaper article. • Get to know relevant abbreviations and terms. • Learn more about bio-accumulation. • Find out about a toxicologist.	2
Activity 1.2 Bio-accumulation of pesticides	• Understand the meaning of the term “bio-accumulation of pesticides”. • Write a paragraph.	2,3
Activity 2.1 Assessing your exposure risk	• Establish your exposure risks. • Identify various products that may contain EDCs. • Design a concept map on EDCs.	2,3
Activity 2.2 DDT Debate	• Debating issues • Role play • Form opinions	2,3,4
Activity 2.3 Graph - Decline in sperm counts	• Draw a line graph • Draw conclusions from data • Suggest possible reasons for findings • Learn new terms	1,2
Activity 2.4 Interview	• Learn more about Dr Theo Colborn, co-author of the book “Our Stolen Future”. • Learn more about what you can do to change the situation. • Share your ideas with others	2,3
Post activities	• Make posters to promote awareness on EDCs • Analyse views. • Interview teachers. • Prepare a slide show.	1,2,3,4

4.5 Assessment and evaluation

By means of group-administered questionnaires information was gathered before and after the programme had commenced. Lickert scales were used to establish the learners’ knowledge, attitudes and values in connection with EDCs and the environment before and after the learners had followed the programme on EDCs. The Lickert scales were used by formulating a number of statements related to attitude and values, and environmental literacy (Collins et al. 2000:

189).

4.5.1 Evaluating knowledge and the understanding of EDCs

Evaluation of the knowledge and understanding of EDCs were done by means of a written test. Marks were allocated for the graph drawn, paragraph and letters written, construction of the concept map and debating issues. Marking grids were used. The criteria that were used to allocate marks were given beforehand to the learners.

4.5.2 Evaluating attitudes and values

Although evaluating of attitudes and values are difficult, the learners' attitudes and values will be noticeable in the debates and class discussions. This will also be a good indication of the success of the course**.**

4.6 Summary

Learners must be assisted by implementing educational programmes inform them about the complexities of the environment in which they are growing up, empower them to address environmental and developmental issues in their own lives. If people are properly informed and educated, they will make intelligent choices to reduce their health risks. The objectives of the programme developed on EDCs are to inform the learners about the effects of EDCs on human health and wildlife, the ways in which contamination of EDCs may occur, how exposure to EDCs can be limited and to help learners to make informed decisions about issues concerning the use and production of EDCs. The most important objectives of this programme are, however, to make learners aware of the fact that they can make a difference and to help learners become aware that the reduction in public health risks can be achieved by reducing exposure to EDCs at the personal level - by changing personal activities, habits, and lifestyles.

A variety of activities have been included, e.g. writing paragraphs, constructing concept maps, drawing graphs, assessment of exposure risks and debating

issues in order to achieve the objectives of the programme.

CHAPTER FIVE
RESEARCH DESIGN

5.1 Introduction

Evaluation is a fundamental and continuing aspect of Environmental Education programme planning and implementation. In general, evaluation is the means of determining programme effectiveness - the degree to which learners develop perceptual awareness, acquire knowledge, develop a positive environmental ethic, acquire citizen action skills, and gain citizen action experience. It is also the means of determining the programme's

efficiency - how well chosen instructional strategies achieved desired results, the appropriateness of the settings in which the strategies were employed, and the adequacy of time allocations (Thomas 1990: 3; Engleson & Yockers 1994: 142).

Bennett (1989: 15) maintained that there are four readily apparent benefits from evaluating a programme. First, the information obtained will help improve the effectiveness and efficiency of teaching methods, the learning environment, and the use of instructional resources. Secondly, growth in student learning will more likely occur through better diagnosis of student needs and measurements of student achievement. Thirdly, better assessment of the impact of education programmes on environmental protection will be possible. Fourth, educators will be in a better position to gain support for their programmes from student, parents, administrators, and the general public.

Hungerford (1980: 46) recommended that any effort to achieve the goals for EE should be undertaken in a manner that is consistent with the Guiding Principles for EE proposed at the Tbilisi Inter-governmental Conference of 1977. Therefore, the programme should also be evaluated against the following objectives for EE as developed by the representatives at the 1977 Tbilisisi Inter-governmental Conference on Environmental Education (Unesco 1977: 26-27)

- **Awareness:** to help social groups and individuals acquire an awareness and sensitivity to the total environment and its allied problems
- **Knowledge:** to help social groups and individuals gain a variety of experience in, and acquire a basic understanding of, the environment and its associated problems.
- **Attitudes:** to help social groups and individuals acquire a set of values and feelings of concern for the environment and motivation for actively participating in environmental problems.
- **Skills:** to help social groups and individuals acquire the skills for identifying and solving environmental problems

- **Participation:** to provide social groups and individuals with an opportunity to be actively involved at all levels in working towards the resolution of environmental problems.

The concepts, skills and attitudes, expressed in a form suited to the prevailing circumstances, can provide a basis for the construction of a checklist of objectives against which a programme of studies may be arranged and assessed (Smyth 1983: 125).

5.2 The functions of evaluating a Life Science programme, integrating Environmental Educational

Ultimately the purpose of evaluation is to improve the programme so that it will in turn yield greater returns for student learning about the environment. (Bennett 1989: 21). Carl (1995: 118) stated that each curriculum developer should make a values judgement of the success of the design. Evaluation, which is often regarded as synonymous with measurement, endeavours to determine to what extent learning has taken place with learners or how successful the design was. The evaluation may thus be learner or curriculum orientated, in other words the focus may be either on learning outcomes or curriculum development.

According to Carl, the functions of evaluation of a programme are:

- to determine the success of instruction, or the quality of the learning outcomes;
- to determine the suitability of the programme;
- to direct replanning and adjustments;
- to determine whether grading and advancement are possible;
- to monitor progress;
- to timeously identify and correct effects (Carl 1995: 118 - 119).

Engleson and Yockers (1994: 142) stated that the purposes of evaluating Environmental Educational programmes (amongst others) are:

- selecting, appraising, and clarifying goals, sub-goals, and objectives;
- judging the intellectual integrity and sequence of the content of the programme;
- planning, directing, and improving instruction and/or learning experiences;
- determining what learners have learned, both related to and apart from stated objectives;
- determining how learners perceive, react to, and/or have been influenced by their experiences;
- improving a programme once it has been implemented or adopted.

5.3 The quantitative nature of this study

The quantitative approach aims at examining the generally accepted explanation of phenomena, and is therefore more structured and controlled in nature (Collins et al. 2000: 88). A quantitative study was decided upon because scientific knowledge should be factually based on things that can be observed and measured by means of the senses (Neser et al. 1995: 53). In this type of research, preference is given to the following methods and techniques:

1. conceptualization of concepts that can be operationalised through measuring instruments
2. data-collection techniques, such as structured questionnaires and schedules
3. data-analysis techniques, varying form simple cross-tabulation of the data to complex analysis techniques (Collins et al. 2000: 88).

5.4 Questionnaires

The success of the programme on EDCs that was developed and tested was evaluated by means of a quantitative study. Group-administered questionnaires were used to gather information before and after the

programme had commenced. Lickert scales are used to establish the learners' knowledge, attitudes and values in connection with EDCs and the environment before and after the learners had followed the programme on EDCs. The learners could choose whether they "strongly agree", "agree", were "not sure", "disagree" or "strongly disagree" with the different statements (Collins et al. 2000: 189). The questionnaires are attached as Appendix B.

Questionnaire 1 deals with the learner's attitude and values in connection with EDCs and the environment. It is important to take notice that the programme was developed mainly to enhance the learners' knowledge on EDCs and not to change the attitudes and values of the learners, although a positive change will of course be welcomed. The questions were phrased in such a way that "agree" or "strongly agree" would indicate positive attitudes and values towards the environment and "disagree" or "strongly disagree" would indicate a negative attitude towards the environment. Behaviour is not included, since behaviour needs to be observed and cannot be measured by questionnaires. Values, attitudes and behaviour are shortly discussed in the introduction of Chapter 4.

Questionnaire 2 deals with the learners' knowledge in connection with EDCs and the environment. The questions were phrased in such a way that "agree" or "strongly agree" would indicate knowledge about EDCs and "disagree" or "strongly disagree" would indicate that learners do not have knowledge about EDCs.

The target group for this study is 24 Grade 10 Biology learners from Iona Convent School, Pretoria. The age of the learners varies between 15 and 16 years (see Chapter 4).

5.5 Analyses of data

Table 5.1 Results of questionnaires 1 before completion of module: Attitudes and values in connection with EDCs and the environment (responses focusing on attitudes and values towards the environment)

Number of respondents: 24

Number of statements: 10

Total number of answers: 240

Statement	Agree		Unsure		Disagree		
	f	%	f	%	f	%	
1. I tolerate the values of others.	240	100	0	0	0	0	
2. I believe there is seldom one clear right or wrong answer to environmental problems.	14	58,3	5	20,8	5	20,8	
3. I am interested in ways of preventing our exposure to EDCs.	15	62,5	8	33,3	1	4,2	
4. I think we should distinguish between wants and needs.	200	83,3	40	16,7	0	0	
5. I think we should accept responsibility for environmental abuse.	240	100	0	0	0	0	
6. I believe every person deserves good health.	240	100	0	0	0	0	

7. I believe all living creatures are important.	24	100	0	0	0	
8. I believe every person has a right to a clean healthy environment	24	100	0	0	0	
9. I believe every person has a right to clean, unpolluted drinking water.	22	91,7	1	4,2	1	4.2
10. I want to get involved in projects informing people about the dangers concerning EDCs.	18	75	5	20,8	1	4,2
Total	**209**	**87,1**	**23**	**9,6**	**8**	**3,3**

f: frequency

EDCs: Endocrine Disrupting Chemicals

Table 5.2 Results of questionnaire 1 <u>after</u> completion of module: <u>Attitude and values</u> in connection with EDCs and the environment (responses focusing on attitude and values towards the environment)

Number of respondents: 24

Number of statements: 10

Total number of answers: 240

Statement	Agree		Unsure		Disagree	
	f	%	f	%	f	%
1. I tolerate the values of others.	24	100	0	0	0	0
2. I believe there is seldom one clear right or wrong answer to environmental problems.	20	83,3	0	0	4	16,7
3. I am interested in ways of preventing our exposure to EDCs.	17	70,8	2	8,3	5	20,8
4. I think we should distinguish between wants and needs.	20	83,3	0	0	4	16,7
5. I think we should accept responsibility for environmental abuse.	22	91,6	2	8,3	0	0
6. I believe every person deserves good health.	23	95,8	0	0	1	4,1
7. I believe all living creatures are important.	22	91,6	2	8,4	0	0
8. I believe every person has a right to a clean healthy environment	24	100	0	0	0	

	0	0	0			
9. I believe every person has a right to clean, unpolluted drinking water.			23	95,8		
	0	0	1	4,1		
10. I want to get involved in projects informing people about the dangers concerning EDCs.						
	19	79,1	3	12,5		
	2	8,2				
Total	**214**	**89,2**	**9**	**3,8 17**		
	7,0					

f: frequency

EDCs: Endocrine Disrupting Chemicals

Table 5.3 Results of questionnaire 2 before completion of module: Knowledge in connection with EDCs and the environment (responses focusing on environmental literacy)

Number of respondents: 24

Number of statements: 10

Total number of answers: 240

Statement	**Agree**		**Unsure**			
	Disagree					
	f	**%**	**f**	**%f**		
	%					
1. Certain chemical compounds can act like hormones once they get inside our bodies.				22		
	91,7	2	8,3	0 0		
2. Chemicals with the potential to interfere with the function of endocrine systems (hormonal systems) are called endocrine disrupting chemicals (EDCs).	14	58,3	9	37,5		
	1	4,2				
3. We are exposed to EDCs through the air we breathe.	12	50,0	11	45,8		
	1	4,2				
4. EDCs can mimic our natural hormones, creating imbalance.	11	45,8	13	54,2		
	0	0				
5. Chemicals that are EDCs are: organochlorine pesticides, polychlorinated biphenyls, dioxins and furans, alkylphenol, polyethoxalates, phthalates and phyto-oestrogens			6	25,0		
	15	62,5	3	12,5		
6. Exposure to polychlorinated biphenyls (PCBs) impairs mental and motor abilities, including a lowering of intelligence.	11	45,8	13	54,2		
	0	0				

7. There is a worldwide trend towards an increased incidence of testicular cancer.	17	70,8	0	7 29,2 0		
8. Sperm counts in men have declined over the last 10 - 20 years.	70,8	7	29,2	17		
9. The use of DDT for malaria vector control pose a health risk.	7 2	29,2 8,3	15	62,5		
10. A decline in the male reproductive health of wildlife is also noted.	70,8	5 2	20,8 8,3	17		
Total	**102 9**	**42,5 3,8**	**129**	**54,5**		

f: frequency

EDCs: Endocrine Disrupting Chemicals

Table 5.4 Results of questionnaire 2 <u>after</u> completion of module: Knowledge in connection with EDCs and the environment (responses focusing on environmental literacy)

Number of respondents: 24

Number of statements: 10

Total number of answers: 240

Statement	**Agree**		**Unsure**			
	Disagree					
	f	**%**	**f**	**%**	**f**	
	%					
1. Certain chemical compounds can act like hormones once they get inside our bodies.	100	0	0	0	24 0	
2. Chemicals with the potential to interfere with the function of endocrine systems (hormonal systems) are called endocrine disrupting chemicals (EDCs).	23 0	95,8	1	4,1	0	
3. We are exposed to EDCs through the air we breathe.	23 0	95,8	1	4,1	0	
4. EDCs can mimic our natural hormones, creating imbalance.	19 0	79,2 0	5	20,8		
5. Chemicals that are EDCs are: organochlorine pesticides, polychlorinated biphenyls, dioxins and furans, alkylphenol, polyethoxalates, phthalates and phyto-oestrogens	1	4,1	23 0	95,8 0		
6. Exposure to polychlorinated biphenyls (PCBs) impairs mental and motor abilities, including a lowering of intelligence.	16 1	66,7 4,1	7	29,0		
7. There is a worldwide trend towards an increased incidence of testicular cancer.	4	16,7	0	20 0	83,3	
8. Sperm counts in men have declined over the last 10 - 20 years.	0	24 0	100,0 0	0		
9. The use of DDT for malaria vector control pose a health risk.	18 0	75,0 0	6	25,0		

10. A decline in the male reproductive health of wildlife is also noted.	190	79,1	5	20,8		
Total	**2051**	**85,4**	**34**	**14,2**		

f: frequency

EDCs: Endocrine Disrupting Chemicals

Table 5.5 Results of questionnaire 1 before and after completion of the progamme:

Attitude and Values in connection with EDCs and the environment (responses focusing on attitude towards the environment)

Statement	Agree		Unsure		Disagree	
	% Before	% After	% Before	% After	% Before	% After
1.	100	100	0	0	0	0
2.	58,3	83,3	20,8	0	20,8	16,7
3.	62,5	70,8	33,3	8,3	4,2	20,8
4.	83,3	83,3	16,7	0	0	16,7
5.	100	91,6	0	8,3	0	0
6.	100	95,8	0	0	0	4,1
7.	100	91,6	0	8,4	0	0
8.	100	100	0	0	0	0
9.	91,7	95,8	4,2	0	4.2	4,1
10.	75	79,1	20,8	12,5	4,2	8,2
Total	**87,1**	**89,2**	**9,6**	**3,8**	**3,3**	**7,0**

Table 5.6 Results of questionnaire 2 before and after completion of the programme:

<u>Knowledge</u> in connection with EDCs and the environment

(responses focusing on environmental literacy)

Statement	Agree		Unsure		Disagree		
	% Before	% After	% Before	% After	% Before	%	
After							
1.	91,7	100	8,3	0	0 0		
2.	58,3	95,8	37,5	4,1	4,2	0	
3.	50	95,8	45,8	4,1	4,2	0	
4.	45,8	79,2	54,2	20,8	0 0		
5.	25,0	95,8	62,5	4,1	12,5	0	
6.	45,8	66,7	54,2	29,0	0 4,1		
7.	29,2	83,3	70,8	16,7	0 0		
8.	29,2	100,0	70,8	0	0 0		
9.	29,2	75,0	62,5	25,0	8,3	0	
10.	20,8	79,1	70,8	20,8	8,3	0	
Total	**42,5**	**85,4**	**54,5**	**14,2**	**3,8**	**0,4**	

5.6 Graphic representation of results

Figure 5.1: Responses before and after completion of programme.
Attitudes and Values in Connection with EDCs and the Environment

Figure 5.2: Responses before and after completion of programme.
Knowledge in connection with EDCs and the environment.

5.7 Discussion of results

The number of responses to “agree” and “strongly agree” were added together. The number of responses to “disagree” and “strongly disagree” were added together.

5.7.1 Questionnaire 1: Attitudes and values in connection with EDCs and the environment

The questions were phrased in such a way that “agree” or “strongly agree” would indicate positive attitudes and values towards the environment and “disagree” or “strongly disagree” would indicate a negative attitude towards the environment. There was no significant change in the learners’ attitudes and values in connection with EDCs and the environment. This is to be expected, since attitudes and values of people cannot easily be changed in only 10 days. Hungerford & Volk (1990: 13) stated this clearly:

> “Educators must not assume that one course or unit or one year of training will accomplish the task needed even though a number of studies have shown that certain strategies for changing behaviour are successful”.

According to the questionnaire, 87,1 % of the learners had a positive attitude towards the environment. There was a slight increase in a positive attitude after completion of the programme (89,2 %). It must, however, be noted that the population of this study is a small group of learners and that the educator have been teaching this particular group of learners since they have been in Grade 7. The results of this study can therefore not be generalized.

Statement number 3 (“I am interested in ways of preventing our exposure to EDCs) illustrated an increase from 4,2 % to 20,8 % after completion of the programme. According to these values, some learners are not interested in ways of preventing their exposure to EDCs.

5.7.2 Questionnaire 2: Knowledge in connection with EDCs and the environment

There was an increase from 42,5 % to 85,4 % in the “agree” responses that indicate an increase of 42,9 %. The “not sure” section decreased with 40,3 % and the “disagree” section decreased with 3,4 %. Because the questions were phrased in such a way “agree” would indicate knowledge about EDCs and “disagree” would indicate that learners do not have knowledge about EDCs, it can be assumed that the learners’ knowledge in connection with EDCs improved after completion of the programme on EDCs.

5.8 Evaluating the programme

It should be kept in mind that this is a short programme focussing on EDCs that is intended to form part of the Life Sciences Curriculum and that it should be evaluated in this context.

5.8.1 Evaluating the Objectives

The objectives of the programme were clearly indicated in Chapter 4. The activities selected realised the following objectives:

1. To inform the learners about the effects of EDCs on human health and wildlife.
2. To inform learners about the ways contamination of EDCs may occur.
3. To inform learners about ways exposure to EDCs can be limited.
4. To help learners to make informed decisions about issues concerning the use and production of EDCs.
5. To help learners become aware that reduction in public health risks can be achieved by reducing exposure at the personal

level - by changing personal activities, habits, and lifestyles.

During the course of the programme, the researcher concluded that more activities are needed to promote problem solving skills.

6. To give learners the necessary problem solving skills in connection with EDCs.

Although there are no easy answers to the problems we are facing with regard to EDCs (Guilette 2000: 323) (see Chapter 4), the first step in the right direction is to inform people about the dangers of EDCs and hopefully they will make intelligent choices to reduce their health risks. For most toxic environmental pollutants, the greatest reduction in public health risks can be achieved by reducing exposure at the personal level - by changing personal activities, habits, and lifestyles (Ott & Roberts 1998: 86) (see Chapter 1).

5.8.2 Evaluating the Enthusiasm and Participation of Learners

Most learners participated with enthusiasm in the different activities.

5.8.3 Evaluating the Contact Time

Unfortunately the contact time for the completion of this programme was too short (10 hours). Activities had to be rushed. The programme developed was squeezed into a very full curriculum. It is suggested that the contact time should preferably be increased to 12 to 15 hours.

5.9 Summary

There was no significant change in the learners' attitudes and values in connection with EDCs and the environment. According to the questionnaire 89 % of the learners have a positive attitude towards the environment. It is important to take notice that the programme was developed mainly to enhance the learners' literacy on EDCs and not to change the attitudes and values of the learners, although a positive change would of course be welcomed. There was an increase from 42,5 % to 85,4 % in the "agree" responses that indicate an increase of 42,9 % in the questionnaire, testing knowledge of with EDCs and the environment. It should be kept in mind that this is a short programme focussing on EDCs that is intended to form part of the Life Sciences Curriculum and should be evaluated in this context. Evaluation, as part of design, should be based on specific criteria and principles as these may determine the quality of the evaluation to a great extent. The content of environmental courses needs to be matched to the objectives of Environmental Education and also the objectives selected, based on perceived local needs. These objectives may be viewed as a checklist to measure the success of the programme on EDCs.

CHAPTER 6
DISCUSSION OF RESEARCH FINDINGS, CONCLUSIONS AND RECOMMENDATIONS

6.1 Introduction

This chapter serves as conclusion to conclude the research done on the necessity of integrating Environmental Education into the Life Sciences Curriculum of the Further Educational and Training Phase, as well as the utter importance of a Life Sciences programme, integrating Environmental Education, on EDCs. Problems experienced in implementing the programme are discussed and recommendations to overcome these problems are proposed.

6.2 The need for a Life Sciences programme, integrating Environmental Education, on EDCs

Chapter two provides the scientific framework this study was built on. In subsection 2.1 the working definition of an endocrine disruptor is given: *'An endocrine disruptor is an exogenous substance or mixture that alters function(s) of the endocrine system and causes adverse effects at the level of the organism, its progeny, populations or subpopulations of organisms, based on scientific principles, data, weight-of-evidence, and the precautionary principle'.* Different chemicals that are classified as EDCs are also discussed in this subsection.

The last two decades have witnessed growing scientific concerns and public debate on the potential adverse effects as may result of exposure to a group of chemicals that have the potential to alter the normal functioning of the endocrine system in wildlife and humans. The effects EDCs have on humans and wildlife are discussed in subsections 2.3 and 2.4 of this research. Concerns regarding exposure to these EDCs are due primarily to:

1. adverse effects observed in certain wildlife, fish, and ecosystems;
2. the increased incidence of certain endocrine-related human diseases; and
3. endocrine disruption resulting from exposure to certain environmental chemicals observed in laboratory experimental animals (WHO 2002: 1).

The vulnerability of different groups in the population will be affected by lifestyle factors (e.g., subsistence hunting and fishing and avid sportsmen who consume fish and wildlife), genetic factors, special dietary habits, and age (e.g., the types and rates of food consumption in children). There is general agreement that diet would most likely be the major route for exposure to the EDCs. Other routes include dermal, inhalation and ingestion (WHO 2002: 3). Routes of exposure are discussed in subsection 2.5. In subsection 2.6 the EDC-situation in South Africa is evaluated. Studies performed thus far indicate that there are EDCs contaminating the water sources in South Africa.

Advances in knowledge, technology, and policy must provide avenues that will protect both the environment and the people, now and in the future (Guilette 2000: 323, 335). In order to ensure a better future, there must be a change in the way we did things in the past; as a short term solution, to limit our exposure to EDCs and as a long term solution, to reduce the use and production of EDCs.

By using the objectives of Environmental Education as defined by the 1977 Tbilisi Inter-governmental Conference on Environmental Education, an environmental responsible citizen may be defined as one who has
(1) an awareness and sensitivity to the total environment and its allied problems [and/or issues],
(2) a basic understanding of the environment and its allied problems [and/or issues],
(3) feelings of concern for the environment and motivation to actively participate in environmental improvement and protection,
(4) skills for identifying and solving environmental problems [and/or issues], and
(5) active involvement at all levels in working toward the resolution of environmental problems [and/or issues] (Hungerford & Volk 1990: 9).

Hungerford and Volk (1990: 14) identified a number of critical components of a total educational programme for Environmental Education if changes in learner behaviour are desired:

1. teach environmentally significant ecological concepts and the environmental inter-relationships that exist within and between these concepts;
2. provide carefully designed and in-depth opportunities for learners to achieve some level of environmental sensitivity that will promote a desire to behave in appropriate ways;
3. provide a curriculum that will result in an in-depth knowledge of issues;
4. provide a curriculum that will teach learners the skills of issue analysis and investigation, as well as provide the time needed for the application of these skills;
5. provide a curriculum that will teach learners the citizenship skills needed for issue remediation, as well as the time needed for the application of these skills;
6. and provide an instructional setting that increases learners' expectancy of reinforcement for acting in responsible ways, i.e., an attempt to develop an internal focus of control in learners.

Citizenship behaviour can be developed through Environmental Education. The challenge lies in a willingness to do things differently than we have in the past (Hungerford & Volk 1990: 17).

6.3 The inclusion of Environmental Education in the Life Sciences Curriculum for grades 10 - 12

The newly proposed Life Sciences Curriculum for the Further Education and Training Phase in the system of Outcomes-Based Education offers many opportunities for integration of Environmental Education into the curriculum. Although there is room in the existing Biology syllabi for teaching about the environment in a holistic and multidisciplinary way, a complete new Biology curriculum might be more suitable for satisfying the principles of Environmental Education - and human life. The outcomes of the Life Sciences Curriculum

support the inclusion of Environmental Education, as stated in subsection 3.4 of this research.

6.4 Environmental Education: a solution to the problems we are facing with regard to EDCs?

Learners must be assisted by implementing programmes of education that inform them about the complexities of the environment in which they are growing up and empowered to address environmental and developmental issues in their own lives. In subsection 4.1 of this research it is suggested that a short term solution to the problems we are facing with regard to EDCs, would be to limit our exposure to EDCs released into the environment. This programme (Appendix A) on EDCs is an attempt to give learners the necessary knowledge and skills to limit their exposure to EDCs and assist them in finding a long-term solution.

The objectives of the learning programme on EDCs, as stated in subsection 4.2. of this research are:

1. To inform learners about the ways contamination of EDCs may occur.
2. To inform learners about ways exposure to EDCs can be limited.
3. To help learners make informed decisions about issues concerning the use and production of EDCs.
4. To inform the learners about the effects of EDCs on human health and wildlife.
5. To help learners become aware that reduction in public health risks can be achieved by reducing exposure at the personal level - by changing personal activities, habits, and lifestyles.
6. To give learners the necessary problem solving skills in connection with EDCs.

Environmental Education, like all other education, should conform to the known development patterns of learners. In subsection 4.3 of this research

the characteristics of the learners in the age group in the age group 15 to 16 years are discussed. Brain growth at this age level, is particularly noticeable in the intentional system. The functions of this system are closely related to the intellectual abilities and skills namely analysis, synthesis, and evaluation. Major emphasis should be on citizen action skills, citizen action experience, as well as environmental ethic with minor emphasis on perceptual awareness and knowledge. Activities were chosen to comply with the objectives of the awareness progamme on EDCs, the learning outcomes of the Life Sciences Curriclum, as well as the cognitive development of the learners in mind. Table 4.1 serves as a summary of the activities developed for the learning programme on EDCs, the activity outcomes and Learning Outcomes of the Life Sciences Curriculum.

6.5 Evaluating the developed programme on EDCs.

The need for evaluating Environmental Education programmes are discussed in subsection 5.7 of this research. Evaluation is a fundamental and continous aspect of Environmental Education programme planning and implementation. In general, evaluation is the means of determining programme effectiveness - the degree to which learners develop perceptual awareness, acquire knowledge, develop a positive environmental ethic, acquire citizen action skills, and gain citizen action experience. It is also the means of determining the programme's efficiency - how well chosen instructional strategies achieved desired results, the appropriateness of the settings in which the strategies were employed, and the adequacy of time allocations. Ultimately the purpose of evaluation is to improve the programme in such a way that it will yield greater returns for student learning about the environment. The functions of evaluating Environmental Educational programmes are listed in subsection 5.2 of this research. To summarise, the functions of evaluation Environmental Educational programmes are:

- to improve a programme;
- to determine the success of the programme;
- to determine the suitability of the curriculum;

- to clarify goals, sub-goals, and objectives;
- to judge the intellectual integrity and sequence of the content of the curriculum;
- to plan, direct, and improve instruction and/or learning experiences;
- to determine what learners have learned, both related to and apart from stated objectives;
- to determine how learners perceive, react to, and/or have been influenced by their experiences.

The success of the programme on EDCs that was developed and tested was evaluated by means of a quantitative study. With the aid of group-administered questionnaires, information was gathered before and after the programme had commenced. Lickert scales were used to establish the learners' knowledge, attitudes and values in connection with EDCs and the environment before and after the learners had followed the programme on EDCs. The questionnaires are attached as Appendix B. Questionnaire 1 deals with the learner's attitude and values in connection with EDCs and the environment. Questionnaire 2 deals with the learners' knowledge in connection with EDCs and the environment. The questions were phrased in such a way that "agree" or "strongly agree" would indicate that learners have knowledge about EDCs and "disagree" or "strongly disagree" would indicate that learners do not have knowledge about EDCs. In subsection 5.4 of this research the data obtained was analized and subsection 5.5 contains a graphic representation of the results.

As discussed in subsection 5.6 of this research, it is clear that there was no significant change in the learners' attitudes and values in connection with EDCs and the environment. It was, however, also not the aim of this study to change attitudes and values. According to the questionnaire 89 % of the learners have a positive attitude towards the environment. Because the target group was relatively small (24 learners) this result should not be generalized. There was an increase from 42,5 % to 85,4 % in the "agree" responses that indicate an increase of 42,9 % in the questionnaire testing knowledge in connection with EDCs and the environment. It can therefore be concluded that the awareness

programme on EDCs proved to be successful in increasing the literacy of the target group in connection with EDCs.

6.6 The constraints and difficulties experienced in implementing the programme

- Teachers' workloads are very heavy, especially now with the phasing in of the new OBE curriculum.
- A full curriculum. Presently, the programme developed was squeezed in to a very full curriculum.
- Time constraints. Careful planning is necessary.
- Lack of resources. The availability of suitable resource material on EDCs was a hindering factor in the implementation of Environmental Education. The use of resource material is important in any teaching situation and therefore also important in the implementation of the Environmental Education programme on EDCs.
- The programme was too short because of time constraints and a very full curriculum. More activities were needed to develop problem solving skills in connection with EDCs.

6.7 Recommendations

1. It is evidently imperative that learners get in-depth educational experiences over a substantial length of time (Hungerford & Volk 1990: 14). A suggestion, when implementing the programme, is that there should be referred back to EDCs and their effects in different sections of the curriculum:

- water pollution (Grade 10),
- invertebrates (Grade 11),
- vertebrates (Grade 11),
- the reproductive system (Grade 11), and
- chemical coordination (Grade 12).

2. It is recommended that the programme developed should also be tested

with another target group and with another educator to obtain more views and recommendations, preferably in another school.

6.8 Summary

This study set out to develop an Environmental Education programme to promote awareness of EDCs. The intention in developing this programme is for it to form part of the newly proposed Life Sciences (previously known as Biology) Curriculum for the Further Education and Training phase (Grades 10, 11 and 12) of the Outcomes Based System.

The research began with setting the scene by stating the problems we are facing with regard to EDCs and clarifying concepts such as Environmental Education and Outcomes-Based Education and EDCs. A comprehensive literature review was done to establish the extent of the problems with regard to EDCs and the ways humans and wildlife are exposed to EDCs.

The literature review was followed by a discussion of the possibility of including Environmental Education in the teaching of the Life Sciences Curriculum. The relationship between Outcomes-Based Education and Environmental Education was also examined.

The theoretical discussion was followed by the actual developing of the learning programme on EDCs, taking into consideration the objectives of the awareness progamme on EDCs, the learning outcomes of the Life Sciences Curriclum, as well as the cognitive development of the learners in mind. The

programme was then tested in the school situation with a target group of 24 Grade 10 learners. A quantitative study was done to evaluate the programme. The analysis of the data led the researcher to conclude that the programme increased the learners' knowledge on EDCs and was therefore successfully developed. This programme is an attempt to give learners the necessary knowledge and skills to limit their exposure to EDCs and to assist them in trying to find a long term solution. The constraints and difficulties experienced in implementing the programme were discussed and recommendations made.

Learning programmes are essential in providing solutions to the problems we are facing with regard to EDCs. We have a right to know what is happening. We need to take this growing body of information out of the hands of professionals alone and place it in the hands of everyday humans - the people who buy the groceries and feed their families, microwave quick meals, take their kids to dentists, use hormone replacement therapy - the people who need to know how to minimize the risks for breast cancer, the people who understand the heartbreak of not to being able to conceive.

That's you and me.

The researcher sincerely hopes that this study will contribute to the process of including Environmental Education in the Life Sciences Curriculum. A leap forward in the present curriculum planning must occur if today's youth are to be prepared to contribute to sustainable development.

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Appendix A: A learning programme on EDCs

Endocrine Disrupting Chem

FRAMEWORK

Phase: Further Education and Training Phase

Grade: 10

Phase Organiser: The Environment

Programme Organiser: Environmental Pollution - Endocrine Disrupting Chemicals

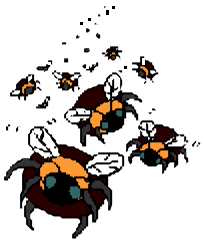
Duration of Programme: 10 School Days

Contact time: 10 Hours

Contents

1.The Endocrine System

Learning Outcome 2: Constructing Science Knowledge



Birds do it.

Bees do it.

Alligators and petunias, fruit flies and polar bears do it. The baby in the womb does it. So do you. Every organism operates through the same mechanism of signal and response that has changed very little over the last 400 to 500 million years or so. One cell sends out a signal and another cell receives the message. All life is based on sending and receiving these signals. The "messages" in humans and animals come from the **endocrine system** and are called **hormones** (Berkson 2000: 6).

The organs in the endocrine system are known as **endocrine glands**. They are unique from other glands, because they release chemicals known as hormones into general circulation. Other glands discharge their secretion into ducts to a particular place. These glands are called **exocrine glands** (Bodyworks 1997).

The organs of the endocrine system are located in widely separated parts of the body.

- in the cranial cavity,
- in the neck,
- in the thoracic cavity,
- in the abdominal cavity,
- in the pelvic cavity,
- and outside the body cavities (Bodyworks).

Hormones integrate all systems in the body and urge the body to regulate, through the action of genes, among other things:

- metabolism
- sexual development and reproduction
- mental processes
- growth and maintenance
- many aspects of our development before birth (Berkson 2000: 11).

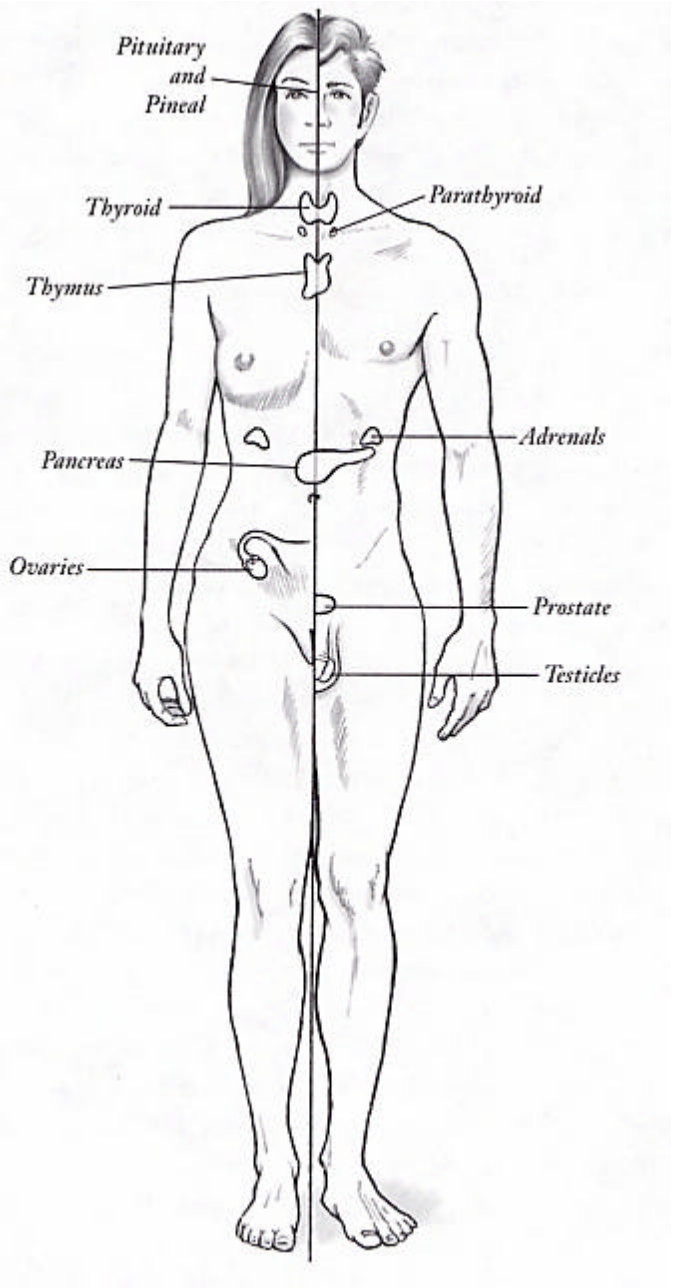


Figure 1: The Endocrine System (Berkson 2000: 10).

Activity 1.1

Newspaper article

Learning Outcome 2: Constructing Science Knowledge

Activity Outcomes:

- Read a newspaper article.
- Get to know relevant abbreviations and terms.
- Learn more about **bio-accumulation.**
- Find out about a **toxicologist.**

Activity

Read through the following newspaper article and answer the questions that follow:

Man-made chemicals are causing serious problems for wild animals
<http://www.guardian.co.uk/life/feature/story/0,13026,965635,00.html>by Alok Jha

It reads like the line-up for some grotesque traveling circus show: female, pseudo-hermaphrodite polar bears with penis-like stumps; panthers with atrophied testicles; male trout and roach with eggs growing in their testes. But all these abnormalities are cropping up in wild animal populations, and opinion as to why is converging: our awesome appetite for artificial chemicals is slowly poisoning the planet.This week the WWF warned that evidence for environmental problems caused by man-made chemicals is mounting fast. A group of 60 scientists from around the world has signed a declaration calling for action.

We humans have designed and made a staggering number of chemicals to help us live our lives. Between 1930 and 2000, the annual production of man-made chemicals increased from 1m to 400m tons a year. The WWF has identified two specific types of chemicals affecting wildlife.

The first are the persistent bio-accumulative chemicals. These can stay in the environment for long periods and do not break down easily. They build up in animal tissue and can pass up the food chain or to successive generations through the placenta or by suckling. Examples include toxic pesticides such as DDT, which has been banned in the USA but lingers in ecosystems.

The second type is the endocrine disrupting chemicals, which interfere with hormonal action. "When you look at the structure of a hormone molecule such as testosterone, they have these circular links of carbon and it's exactly that sort of pattern that's present on a lot of the pesticides like PCBs," says Andrew Derocher, a professor of Biology at the University of Alberta.

Physiologically, an organism cannot tell the difference between a pollutant molecule and, say, one of its own hormone molecules. As a result, the natural mechanisms for dealing with the invading molecules go into overdrive and may break down more than just pollutants. The result is an imbalance and, since hormones regulate things like growth and body development, abnormalities are almost inevitable.

Of course, humans are just another animal at the top of the food chain. "If we were exposing the population to harmful levels of chemicals that can mimic oestrogen and chemicals that can block the action hormones, the effect you'd see is an increase in hormone-related cancers - cancer of the breast, prostate, the testes," says Derocher. "And you would expect to see an increase in birth defects, the reproductive tract, undescended testes. You might also expect girls coming to puberty earlier. All those effects do seem to be happening." A lot of the 300 or so man-made chemicals found in humans are those that have been banned for decades - PCBs and other pesticides like DDT. "You can't turn off the exposure tap overnight," says Lyons. Andreas Kortenkamp, a toxicologist at the University of London School of Pharmacy, agrees more research must be done but adds that it is not too early for action. "In a strict scientific sense, we don't have proof but I firmly believe there are warning signs and if we wanted to we could act on them now."

The Guardian, 29 May 2003, New York

1. Find out what the following abbreviations stand for:

(a) WWF

(b) DDT

(c) PCB

(d) EDC

2. What does “persistent bio-accumulative chemicals” mean?

3. Name a few effects of EDCs on human health.

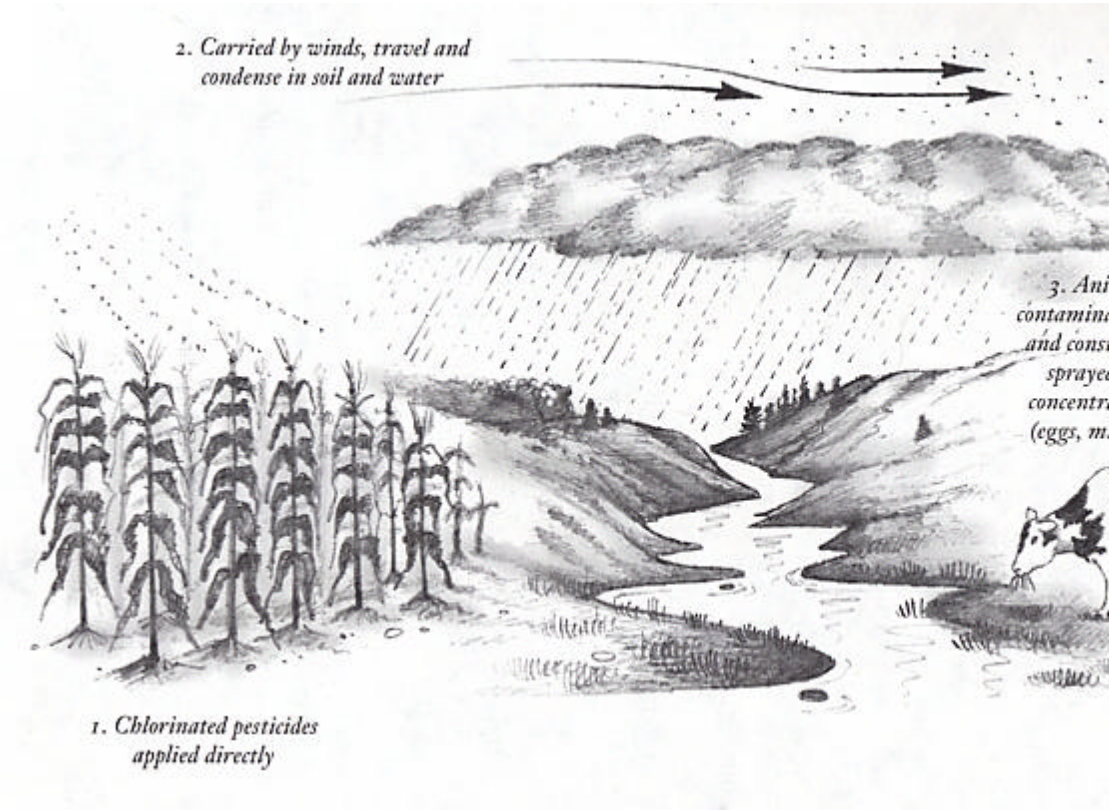
4. Try to find out more about a toxicologist.

(a) What does a toxicologist do?

(b) What qualifications does a toxicologist need?

(c) Which subjects does a person who wants to become a toxicologist need at school in order to qualify?

Activity 1.2



Bio-accumulation

Figure 2: Bio-accumulation of pesticides (Berkson 2000: 92).

Learning Outcome 2: Constructing Science Knowledge

Learning Outcome 3: Science, Society and the Environment

Activity Outcomes:

- Understand the meaning of the term “bio-accumulation of pesticides”.
- Write a paragraph

Activity:

Use the information in figure 2 to write a paragraph explaining how pesticides end up in humans.

2. Facts about EDCs

Endocrine systems are complex mechanisms, coordinating and regulating internal communication among cells. Endocrine systems release hormones that act as chemical messengers. The messengers interact with receptors in cells to trigger responses and prompt normal biological functions such as growth, embryonic development and reproduction.

2.1 Endocrine disruption

Scientists know that endocrine systems can be adversely affected by a wide variety of substances. A substance can interfere with the normal communication between the messenger and the receptor in the cell, so that the chemical message is not interpreted properly. Even very subtle effects on the endocrine system can result in changes in growth, development, reproduction or behaviour that can affect the organism itself, or the next generation. The specific mechanisms by which substances disrupt the endocrine systems are very complex, and not yet completely understood.

Substances can interact with endocrine systems and cause a disruption to normal functions in several ways.

- They can act like a natural hormone and bind to a receptor.

- This causes a similar response by the cell, known as an agonistic response.
- They can bind to a receptor and prevent a normal response, known as an antagonistic response. A substance can interfere with the way natural hormones and receptors are synthesized or controlled.

2.2 Endocrine disrupting chemicals (EDCs)

Given the complexity of endocrine systems, it is not surprising that the range of substances thought to cause endocrine disruption is wide and varied, and includes both natural and manufactured (synthetic) chemicals.

Industrial, agricultural and municipal wastes can expose organisms in the environment to unusually high concentrations of natural substances such as sex hormones, or phyto-oestrogens. Manufactured chemicals may be released intentionally - pesticides, for example; as by-products of industrial processes and waste disposal - dioxins or PCBs; or as discharges from industrial or municipal treatment systems - alkylphenols. The wide variety of sources and substances presents an enormous challenge to environmental managers in industry and government.

(Environment Canada, www.on.ec.gc.ca)

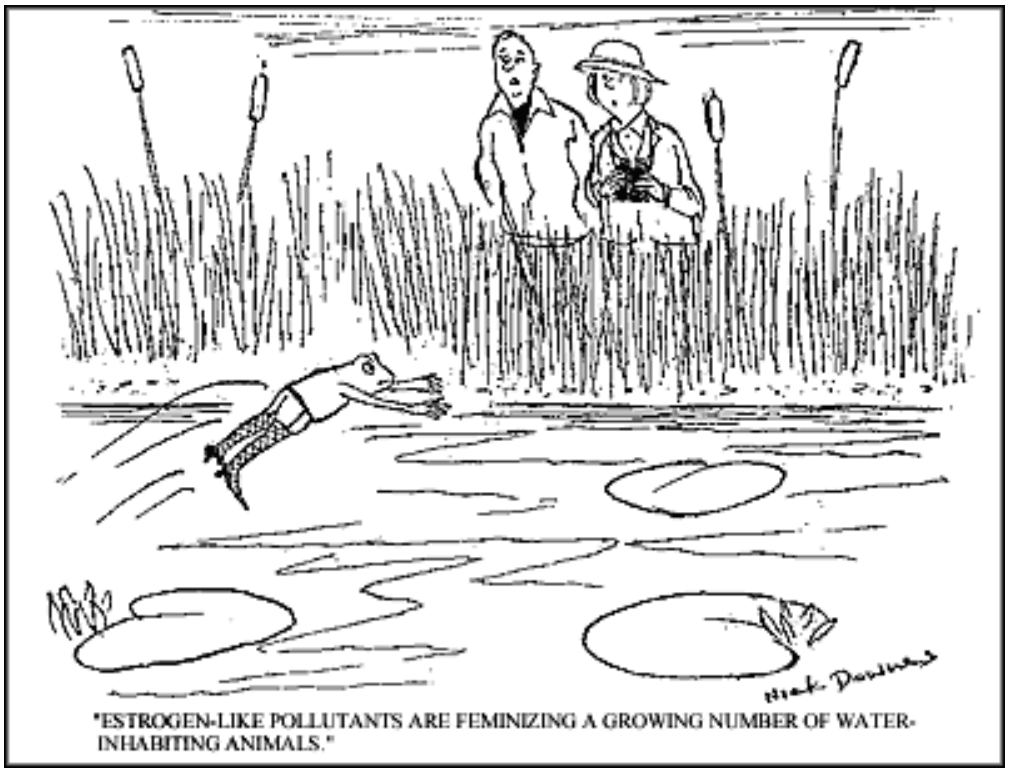
2.3 Effects of EDCs

Some examples of endocrine-related effects in wild populations:

- deformities and embryo mortality in birds and fish caused by exposure to industrial chemicals and organochlorine insecticides;
- impaired reproduction and development in fish exposed to effluents from pulp and paper mills;
- abnormal reproduction in snails exposed to antifouling substances applied to the exteriors of ships;
- depressed thyroid and immune functions in fish-eating birds;
- feminization of fish near municipal effluent outlets.

(Environment Canada, www.on.ec.gc.ca)

Figure 3: Frog abnormalities (WWF-UK website <http://www.wwf.org.uk>)



The effects of EDCs on human health include:

- the increase of testicular and prostatic cancer,
- the higher incidence of undescended testis,
- the decline in male reproductive health and fertility,
- and the very likely causal effect on cognitive and immunological development of children,
- endometriosis,
- breast and reproductive tract cancer and
- possibly polycystic ovarian syndrome (Toppari, Larsen, Christiansen *et al.* 1996: 747; Lee 2002: ix).

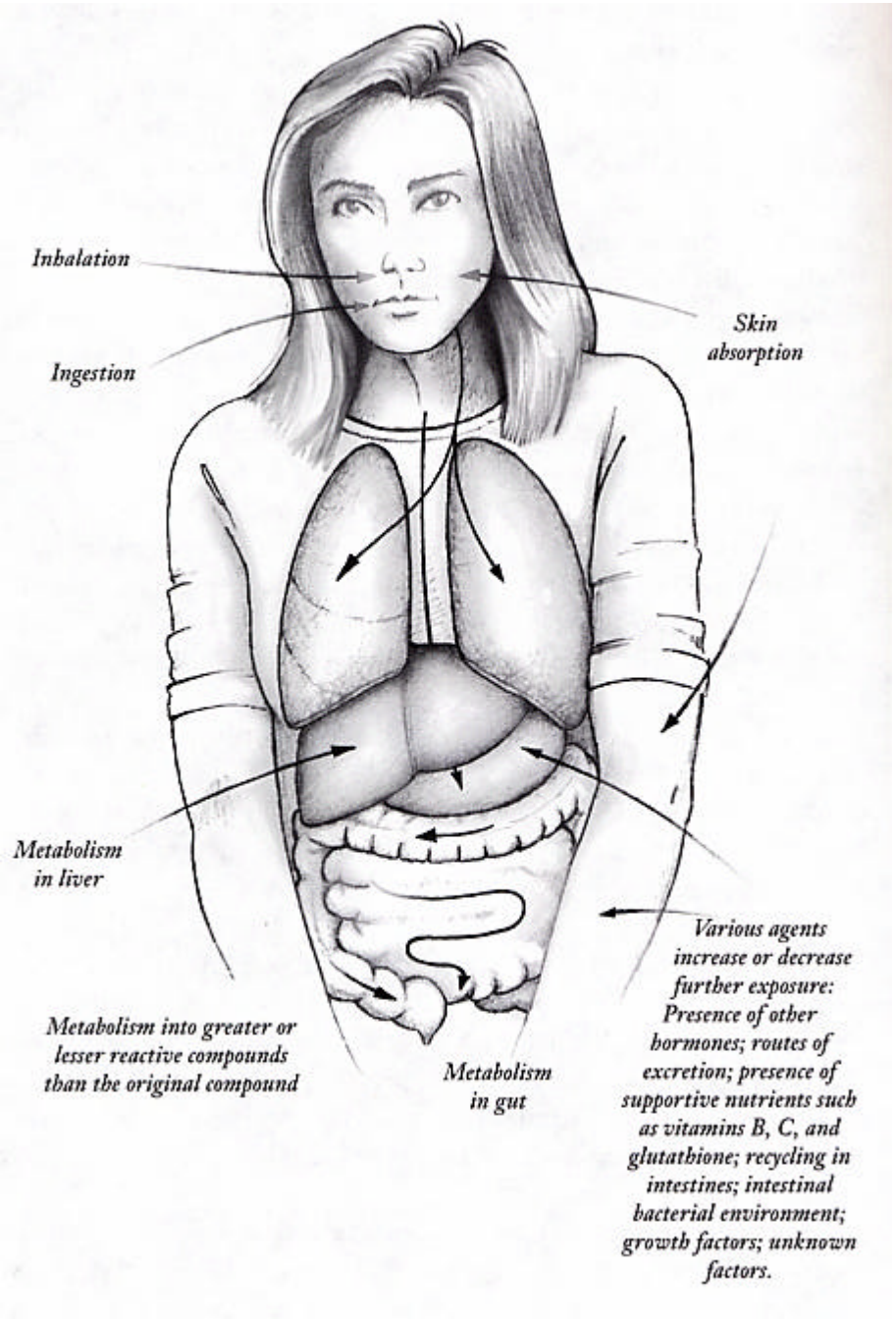

Inhalation
Ingestion
Skin absorption
Metabolism in liver
Metabolism into greater or lesser reactive compounds than the original compound
Metabolism in gut
Various agents increase or decrease further exposure: Presence of other hormones; routes of excretion; presence of supportive nutrients such as vitamins B, C, and glutathione; recycling in intestines; intestinal bacterial environment; growth factors; unknown factors.

Figure 4: Routes of Exposure to EDCs (Berkson, 2000: 214).

Activity 2.1

Assessing your exposure risk

Learning Outcome 2: Constructing Science Knowledge

Learning Outcome 3: Science, Society and the Environment

Activity outcomes:

- Establish your exposure risks.
- Identify various products that may contain EDCs.
- Design a concept map on EDCs.

Activity:

1. Perhaps you think that you already know enough about protecting your

health. You maintain a moderately good diet and exercise regularly. But, are you sure that you are not exposed to EDCs? Read through the following list of questions and see how many pertain to you. Tick the statements that are applicable to you:

- ❑ Did your mother take synthetic hormones when she was pregnant with you?
- ❑ Do you consume a diet high in animal fats?
- ❑ Do you dust and vacuum your home less than twice a week?
- ❑ Do people walk on your carpets with street shoes?
- ❑ Do you hang recently dry-cleaned clothes in your bedroom closet?
- ❑ Do you eat non-organic, commercially grown foods?
- ❑ Do you eat canned food and drinks?
- ❑ Do you microwave food in plastic containers?
- ❑ Do you cover food with plastic cling wrap?
- ❑ Do you use pesticides on your lawn or garden?
- ❑ Do your pets wear flea collars?
- ❑ Do you use clothes-washing detergents?
- ❑ Does your new car have a strong new-car smell?
- ❑ Do you use commercial air fresheners in your home or car?

Changes are you answered yes to at least a few of these questions. Each of these situations can introduce hormone disruptors into your body.

2. Study the given information and design a concept map summarizing the facts on EDCs.

Activity 2.2

DDT Debate

Learning Outcome 2: Constructing Science Knowledge
Learning Outcome 3: Science, Society and the Environment
Learning Outcome 4: Science, society, attitudes and values

Activity Outcomes:

- Debating issues
- Role play
- Form opinions

The facts:

- Malaria causes more than a million deaths each year, particularly in children under five years of age and in pregnant women. Malaria is responsible for one out of every four-childhood deaths in Africa.
- Malaria slows down economic growth in African countries by an estimated 1.3% each year.
- The recent re-introduction of the use of DDT (Dichloro-diphenyl-trichloroethane) for malaria control in KwaZulu-Natal and other parts of South Africa has opened up the debate on the values and options associated with its use. The conflict between the well-known advantages of DDT in malaria prevention, and the disadvantages resulting from the use of DDT in both human and environmental health, presents a paradox: DDT is both good and bad. DDT is an endocrine disrupting chemical and causes many health risks, but, when used for malaria vector control (the *Anopheles spp.* mosquito), has managed to save millions of lives (Bouwman 2000: 1).
- The question is 'To use or not to use DDT'?

DDT DEBATE

Regarding the debate on the use of DDT for mosquito control the question is asked: What use is it if people are 'saved' from malaria only to be slowly

poisoned by dangerous residues in the water and soil? With many toxins, it is the slow (often imperceptible) effects, which cause most harm?

Set up a debate: 'To use or not to use DDT'?

You need to have representatives from both sides on your panel. You should include:

- The Minister of Health who is responsible for the combating of malaria.
- A toxicologist doing research on the effects of EDCs on human health and wildlife.
- The mother of a child who had recently died because of malaria.
- The Minister of Tourism who is well aware of the fact the malaria control will have positive benefits for the development in the areas of Northern KwaZulu-Natal and the Kruger National Park.
- A man who has prostate cancer. His job involves spraying homes with DDT to combat *Anopheles spp.* mosquitoes.

Activity 2.3

Graph - Decline in sperm counts

Learning Outcome 1: Scientific Investigation

Learning Outcome 2: Constructing Science Knowledge

Activity outcomes:

- Draw a line graph
- Draw conclusions from data
- Suggest possible reasons for findings
- Learn new terms

Several reports in the literature have suggested a possible decline in human semen quality during the last 50 to 60 years. A systematic meta-analysis on international data on the sperm counts of 14 947 normal men over the period 1938 to 1990 was done scientists. The following data was obtained:

Year	Sperm count (million/milliliter)
1940	110
1950	100
1960	95
1970	70
1980	65
1990	60

(Toppari, Larsen, Christiansen *et al.* 1996: 742)

1. Study the results in the table. Draw a line graph representing the data.
    - Place “time” (the independent variable) on the x-axis and “sperm count (the dependent variable) on the y-axis).
    - Label the axis.
    - Give the graph a suitable heading.
    - Indicate the scales that you have used.

2. What conclusion can you draw from the graph, concerning semen count over the past few decades?
3. Can you suggest any possible reason(s) for the decline in sperm counts?

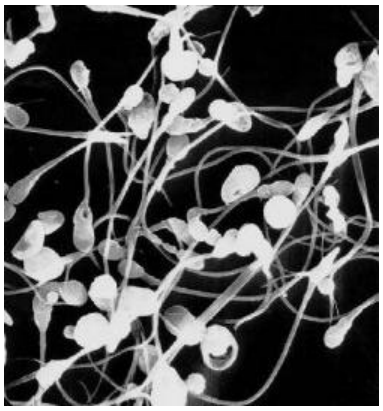


Figure 6: A scanning electron micro-graph of sperm. Courtesy of the University of Utah Andrology Microscopy Lab.(http://science.nasa.gov)

Activity 2.4

Interview

Learning Outcome 2: Constructing Science Knowledge

Learning Outcome 3: Science, Society and the Environment

Learning Outcome 4: Science, society, attitudes and values

Activity Outcomes:

- Learn more about Dr Theo Colborn, co-author of the book "Our Stolen Future".
- Learn more about what you can do to change the situation.
- Share your ideas with others.

The authors of *Our Stolen Future* reveal how many of the findings in animals correlate with disturbances in normal reproductive and developmental processes in humans, citing data from decades of research on wildlife that traced birth defects, sexual abnormalities, and reproductive failures to synthetic chemicals that mimic natural hormones.

Activity:

In your groups, two learners take turns in reading the following interview.

Nikki van der Gaag interviews Dr. Theo Colborn, whose groundbreaking work has unearthed a growing menace.

How did you become involved in this research?

By accident. I was working in Washington on a one-year fellowship that was just ending and I was asked to be the scientist on an American/Canadian team investigating the state of the environment in the Great Lakes area around Michigan. There was little information on the health of people living in that area, that had been known to be heavily polluted. What I found was amazing. We found problems, all of which seemed to be related to hormones. Male animals for example were not reaching sexual maturity. Many species had thyroid problems. Some adults simply abandoned their young or the babies died unexpectedly, in large numbers, for unknown reasons. Birds were born deformed with crossed bills, missing eyes and clubbed feet.

And this is where alarm bells began to ring for me. If babies were being affected then these chemicals must have the ability to cross the placenta. These chemicals were getting through the placenta and reaching fetuses in the womb and the eggs of birds and fish.

We found out that babies of mothers who had eaten fish from the Great Lakes had lower intelligence than those whose mothers had not eaten fish - as well as lower birth weight and a host of other problems. And the mothers didn't have to eat large quantities of fish; two to three meals a month were sufficient to affect the babies in the womb.

So how can you know all this for sure? How can you test for effects on unborn children or on things which might affect two or three generations?

Of course this is difficult to test. But we know that some chemicals bio-accumulate - that is, they build up in the body and can be stored for a long time in body fat. Many other chemicals are very much a part of our daily lives. They include certain pesticides and also some plastics. And the combination of two or more of these can be even stronger.

They can also spread to other places, can't they?

Yes. High levels are found for example in the Arctic in the bodies of Inuit people, polar bears and other wildlife who have never gone near such chemicals.

How about the effects in the developing world?

Well the direct effects of people using some of these chemicals are terrible. It is particularly bad for farm workers in the Third World who don't have the protective clothing or the ability to protect them selves.

So what can be done?

The most important thing is to find alternatives. As a priority there needs to be a crash programme of research for new ways of controlling diseases like malaria and dengue fever because people are still having to use insecticides like DDT to kill mosquitoes.

What about at an individual level?

One of the things I always tell people is to buy organic. This is not only good for the consumer's health but it means that the people growing the food don't have to put up with the chemical doses either. The other thing I tell people is to avoid eating fatty foods because many of the persistent fat-soluble chemicals are found in body fats. Eat more beans!

Our Stolen Future, the book you co-authored on endocrine disruptors, has been hailed as the second Silent Spring. What impact do you think it has had?

Well, it has been translated into 18 languages.

Discuss in your groups:

1. What did Dr. Colborn find in connection with the intelligence of the children of mothers who had eaten fish from the Great Lakes?

2. Brainstorm ideas of what can be done to reduce our risk of being exposed to EDCs.3

3. Compare your suggestions to that of the other groups and the following list and add to your list if necessary.

Practical steps that we can all take to reduce our risk:

Don't use pesticides (e.g. flea powders) on pets.

Don't use pesticides in the garden - try to garden organically.

Don't let children chew on plastic toys.

Don't use plastic containers to store and cook food unless they are specifically designed for the purpose - use glass or ceramic containers instead.

Wash fruit and vegetables before use, and buy organic where possible.

Replace any lead piping in your home.

Use environmentally-friendly cleaning products.

Be aware that certain shampoos (e.g. to control head lice) contain pesticides.

(WWF-UK website <http://www.wwf.org.uk>)

3. Post Activities

Learning Outcome 1: Scientific Investigation
Learning Outcome 2: Constructing Science Knowledge
Learning Outcome 3: Science, Society and the Environment
Learning Outcome 4: Science, society, attitudes and values

1. Learners make posters to promote awareness of EDCs. Put your posters up on the school's notice board and in you communities e.g. the local library, cafe etc.
2. Write to various environmental organisations requesting information about EDCs. Analyse their views. What remedies do they recommend? Do the same for industrial groups like manufacturers of cling wrap plastics, plastic toys, polystyrene packaging etc. Compare and contrast the difference in viewpoints.
3. Interview other teachers in the school to find out what they know about EDCs. Ask them these and other questions:

   - Have you ever heard about endocrine disrupting chemicals?
   - Do you know that cling wrap contains chemicals that can reduce the sperm count in men?
   - Are you aware of the fact that body lotions contain chemicals that can cause breast cancer, amongst other cancers?
   - Are you aware of the fact that EDCs have been found in South African rivers?

4. Prepare a slide show that can be viewed by all learners in the school during assemblies.

4. EDC vocabulary

Bio-accumulation: build up (of chemicals) in the body.

Endocrine disrupting chemical (EDC): exogenous substance or mixture that alters function(s) of the endocrine system and causes adverse effects at the
level of the organism, its progeny, populations or subpopulations of organisms, based on scientific principles, data, weight-of-evidence, and the precautionary principle.

Endocrine glands: release hormones into general circulation.

Endocrine system: coordinating and regulating internal communication among cells

Endometriosis: an abnormal condition in which endometrial tissue occurs in various areas in the pelvic cavity

Exocrine gland: discharge secretion into ducts to a particular place

Hormone: complex chemical substances that are produced in one part of the body that circulate in body fluids and that start or run the activity of an organ or a group of cells in other part of the body

Phyto-oestrogens: natural compounds present in plants

Sperm count: the number of sperm cells per milliliter of semen

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APPENDIX B: QUESTIONAIRES

QUESTIONAIRE 1:

ATTITUDE, VALUES AND BEHAVIOUR IN CONNECTION WITH EDCs AND THE ENVIRONMENT

Statement	Strongly Agree	Agree	Agree		Not Sure
	Disagree	Strongly Disagree			
1. I tolerate the values of others.					
2. I believe there is seldom one clear right or wrong answer to environmental problems.					
3. I am interested in ways of preventing our exposure to EDCs (Endocrine Disrupting Chemicals).					
4. I think we should distinguish between wants and needs.					
5. I think we should accept responsibility for environmental abuse.					
6. I believe every person deserves good health.					
7. I believe all living creatures are important.					
8. I believe every person has a right to a clean healthy environment.					
9. I believe every person has a right to clean, unpolluted drinking water.					
10. I want to get involved in projects to make people aware about the dangers concerning EDCs.					

QUESTIONAIRE 2:

KNOWLEDGE IN CONNECTION WITH EDCS AND THE ENVIRONMENT

Statement	Strongly Agree		Agree	Not Sure	
	Disagree	Strongly Disagree			
1. Certain chemical compounds can act like hormones once they get inside our bodies.					
2. Chemicals with the potential to interfere with the function of endocrine systems (hormonal					

systems) are called endocrine disrupting chemicals (EDCs).

3. We are exposed to EDCs through the air we breathe.
4. EDCs can mimic our natural hormones, creating imbalance.
5. Chemicals that are EDCs are: organochlorine pesticides, polychlorinated biphenyls, dioxins and furans, alkylphenol, polyethoxalates, phthalates and phyto-oestrogens
6. Exposure to polychlorinated biphenyls (PCBs) impairs mental and motor abilities, including a lowering of intelligence.
7. There is a worldwide trend towards an increased incidence of testicular cancer.
8. Sperm counts in men have declined over the last 10 - 20 years.
9. The use of DDT for malaria vector control pose a health risk.
10. A decline in the male reproductive health of wildlife is also noted.