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Teaching evolution in a new curriculum: Life Sciences teachers' concerns and needs.

Ngxola, Nonyameko

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Appendix A

Explanations of the requirements of the new South African curricula

Appendix A: Explanations of the requirements of the new South African curricula

Requirements	Explanations
1. Teaching should focus on outcomes	• Outcomes are defined as *"clear learning results that we want students to demonstrate at the end of significant learning experiences"* (Spady, 1994, 2). • Lessons should be planned in a way that the pre-stated outcomes are achieved. • The outcomes should not only require knowledge from the learners, but should also target skills and attitudes. • The curriculum for the *Life Sciences* has three learning outcomes in which learners should demonstrate competence in the discipline. • Teachers have to develop their own more detailed outcomes, for their lessons as the three outcomes stated in the curriculum are too broad to use to focus lesson plans (Sanders and Nduna, 2007).
2. Learning should be learner-centered	• Teachers should consider diversity of individual learners, including their religious and cultural background, preferred learning styles, learning pace and home language (Sanders and Kasalu, 2004). • Teachers should plan lessons to cater for these differences in their teaching.
3. Learning should be activity-based	Classroom activities should provide the foundation for learning. In this way learners are afforded an opportunity to engage in scientific thinking as they participate in 'hands-on' and 'minds-on' activities which promote the construction of knowledge.
4. The teacher's role should be that of a facilitator	• Teachers are expected to change from being transmitters of knowledge to being facilitators of knowledge. • As facilitators, teachers are required to o bring a balance between explaining concepts and affording learners an opportunity to construct meanings of the world. o plan their lessons in order to achieve the outcomes. This is coupled with a thorough knowledge of the subject matter and suitable teaching strategies to achieve the outcomes. o create a conducive atmosphere for meaningful learning to take place. o provide necessary resources to promote learning for understanding. o monitor and interact with individual learners or groups as the process of learning is unfolding. o consolidate the lessons at the end to ensure adequate coverage of concepts learners need to know, and eradication of misconceptions (Sanders and Kasalu, 2004).
5. Teaching should include skills development	• Skills as competencies to be learned and developed should be stated in teachers' lesson outcomes, and be taught in class. • Learners should be made aware of the skill that is targeted during the lesson. • To master the targeted skill, an on-going practice is required (Sanders and Kasalu, 2004).
6. The curriculum should be relevant	• There are a number of ways in which the curriculum is made relevant, one way could be that learning should: o relate to learners' real-life situations. o relate to learners' prior knowledge. o be relevant to the South African context (Sanders and Kasalu, 2004).
7. Group work should be promoted	• Group work should feature prominently in classroom practice, but not all teaching and learning necessarily has to use this approach. • Group work is advocated as one teaching approach in the new curriculum to develop skills of working with others. • Group work should involve purposeful activities so as to achieve outcomes (Sanders and Kasalu, 2004).
8. Learning should be integrated across learning areas	Topics and skills from one learning area should be incorporated in other learning areas so that links are made.
9. Assessment should be continuous	• The National Curriculum Statement emphasizes that assessment should form an integral part of the teaching and learning process, and should be used as an approach to promote learning, assessment: o should be directed by outcomes as it is a mechanism used to ascertain if the intended outcomes have been met. (Department of Education, 2003). o should be continuous and not only focus on tests and on examinations (Sanders and Nduna, 2007). o should serve a number of purposes: to monitor the progress of the learners, to diagnose their problems and achievements (Sanders and Kasalu, 2004).

Appendix B

A summary of evolution-related concepts covered in different content areas in the *Life Sciences* (Content Framework for *Life Sciences* Grade 10-12, 2007)

Appendix B: A summary of evolution-related concepts covered in different content areas in the revised FET *Life* Sciences curriculum (Content Framework for *Life Sciences* Grade 10 – 12, 2007)

Grade	**Learning outcome 1:** The learner is able to confidently explore and investigate phenomena relevant to *Life Sciences* by using scientific inquiry and problem solving skills.	**Learning outcome 2:** The learner is able to access, interpret, construct and use *Life Sciences* concepts to explain phenomena relevant to *Life Sciences.*	**Learning outcome 3:** The learner is able to demonstrate an understanding of the nature of science, the influence of ethics and biases in the *Life Sciences*, and the interrelationships of science, technology, indigenous knowledge, the environment and society.
Content area: Tissues, cells, and molecular studies			
12	**DNA – the code of life, and RNA**		
		Structure of DNA: double helix with 4 nitrogenous bases adenine (A), thiamine (T), cytosine (C), guanine (G); and deoxyribose sugar and phosphate. Distinguish between pyrimidines and purines. [molecular structure of living organisms has the four bases, links with common ancestry]	*Sequencing of DNA provides evidence of relationships between groups of organisms(link*[s] *with interpreting phylogenies in Grade 10 and 11)*
	Meiosis		
		• *Explain the importance of meiosis.* - *In the reduction of chromosome number from diploid to haploid.* - *Production of gametes* - *As a mechanism to introduce genetic variation (random segregation of chromosomes and crossing over)*	*Biotechnology and polyploidy in agriculture - production of larger flowers, fruits, storage organs*
	Genetics and genetic engineering		
	Investigate individually, …genetic engineering of a particular crop	• *Concepts in inheritance* - *Dominant & recessive genes and alleles* - *Monohybrid crosses (phenotype & genotype, homozygous & heterozygous: pure-bred and hybrid) demonstrating inheritance and variation [Link to natural selection and reproduction.* - *Polygenic inheritance (e.g. skin colour, height)* - *Mutations – harmless and harmful leading to diseases/disorders e.g. albinism, hemophilia, sickle-cell anemia, etc. Differentiate between gene mutations and chromosomal aberrations.*	• *Genetic engineering* - *in medicine, e.g. production of hormones such as insulin and vaccines* - *in agriculture, e.g. genetically modified crops (pest-resistant, drought resistant, improved quality).*
Content area: Diversity, change and continuity			
10	**Biodiversity and classification**		
	Classify organisms into groups based on evidence. [Links to use of keys and identification guides]	*Enormous biodiversity on Earth at present emphasizing the extent of biodiversity and endemism in sourthern Africa*	
	History of life on Earth		
	• *Examine fossils at a museum or fossil site or look at photos of fossils.* • *Construct a timeline showing the history of life on Earth and major events in life's history as you progress through this section. The timeline should emphasize the long history of life.* • *Find out what the earliest amphibians looked like. [Links to coelacanth]* • *Various hypotheses have been proposed for the*	• *Fossil formation and methods of dating e.g. radiometric dating and relative dating.* • *Life's history: Interpret different representations of life's history and its relationship to climatic (e.g. increase in oxygen levels, ice ages) and geological events (e.g. movement of continents) [extension of GET work].* • *Cambrian explosion – origins of early forms of all animal groups.* • *Mass extinctions – there have been five, two of which are particularly important: 250 mya (resulted in the extinctions of about 90% of all life on Earth) and 65 mya (resulted in the extinction of many species, including the dinosaurs).*	• *Scientists use <u>deductive reasoning (inference)</u> to understand fossils and the history of life on Earth.* • *The role of South African scientists in the discovery of the first living coelacanth (sic).* • *Fossil tourism is a source of income and employment in some fossil localities.*

	extinction, 65 million years ago, such as the meteorite impact theory and the volcanic eruptions in India theory. Select at least ONE of these hypotheses and describe the evidence scientist[s]have gathered in supporting it. [Nature of science] • *Research the "missing link" between dinosaurs and birds, Archaeopteryx.*	• *Key events in life's history for which there is evidence from southern Africa (locations should be identified on a map)* - *origins of earliest forms of life (fossilized bacteria from the Barberton district, Mpumalanga)* - *soft-bodied animals in Namibia* - *early land plants in the Grahamstown area* - *forests of primitive plants such as Glossopteris (near Mooi River and Escourt) and which form most of the coal deposits in southern Africa* - *the coelacanth (sic) as a "living fossil", of the group that is ancestral to amphibians* - *mammal-like reptiles in Karoo* - *dinosaurs (Drakensberg and Maluti mountains, Euskylosaurs from Lady Grey in the Eastern Cape) and cone-bearing plants* - *first mammals (Eastern Cape and Lesotho)* - *Humans (Gauteng, Free State, KwaZulu Natal, Western Cape).*	
12	**Origin of an idea about origins**		
		Evolution as scientific theory and not just hypothesis. The difference between hypothesis and theory.	• *The role of Erasmus Darwin, Lamarck, Charles Darwin and Alfred Wallace in the development of the theory of evolution.* • *Beginning of conflict between religion and science with respect to evolution.*
	Evolution by natural selection		
	Demonstration of principles of natural selection through camouflage and avoidance of predation, using e.g. games or models	• *Darwin's theory of evolution by natural selection* - *life forms have evolved from previous life forms by natural selection (link to Genetics). Most species are unable to survive in a new environment, and become extinct, but a few species may successfully adapt to a new environment* - *natural selection only operates on variation in inherited characteristics (link wink with Genetics)* - *artificial selection mimics natural selection. Artificial selection as illustrated by at least one domesticated animal species and one crop species.*	
	Formation of new species		
		• *Speciation as a mechanism for producing new species. Geographic speciation due to isolation e.g. Galapagos finches.* • *Mechanisms of reproductive isolation:* - *breeding at different times of the year* - *species-specific courtship behavior (animals)* - *adaptation to different pollinators (plants)* - *infertile offspring (e.g. mules).*	
	Human evolution		
	Map out the sequence of human evolution from ape-like ancestor around 5 mya to modern Homo sapiens. Emphasize the fossil record found in Africa, and the simultaneous existence of several species at various times in the past	• *Evidence for common ancestors for living primates including humans.* • *Out of Africa hypothesis and evidence for African origins of all modern humans.* • *All modern humans are genetically very closely related.*	*African fossils have made a huge contribution to understanding human evolution e.g. Cradle of Humankind at Sterkfontein, Great Rift Valley.*
	Evolution in present times		

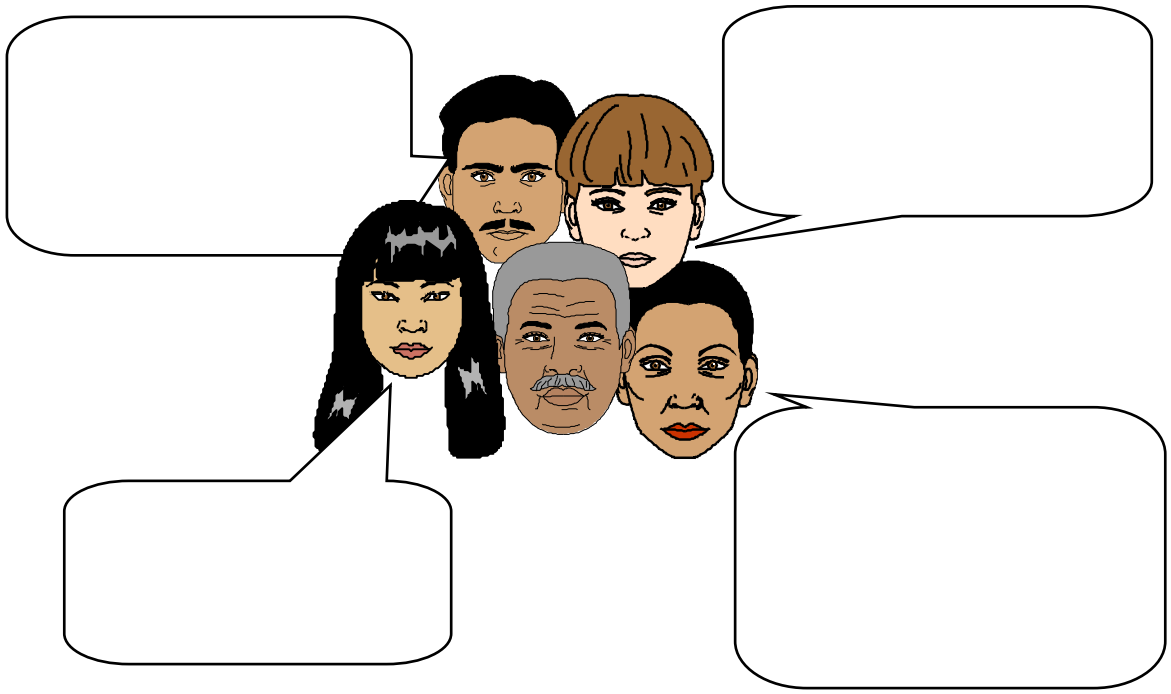
		Examples that evolution is still occurring, e.g. the development of resistance to insecticides in insects; resistance to antibiotics in various bacteria.	• *Use of DDT and consequent resistance to DDT in insects can be explained in terms of natural selection.* • *Development of resistant strains of TB – MDR and, more recently, XDR strains of tuberculosis-causing bacteria.*
	Alternative explanations		
	Investigate and discuss cultural and religious explanations for the origin and development of life on Earth.		<u>Alternatives to Darwin's explanation</u> *People have different ways of understanding the history of life and the place of humans in life. Science has limits: it can explain physical structures and events, but not spiritual or faith-based matters. Both are important to humans, but in different ways.*

Appendix C1

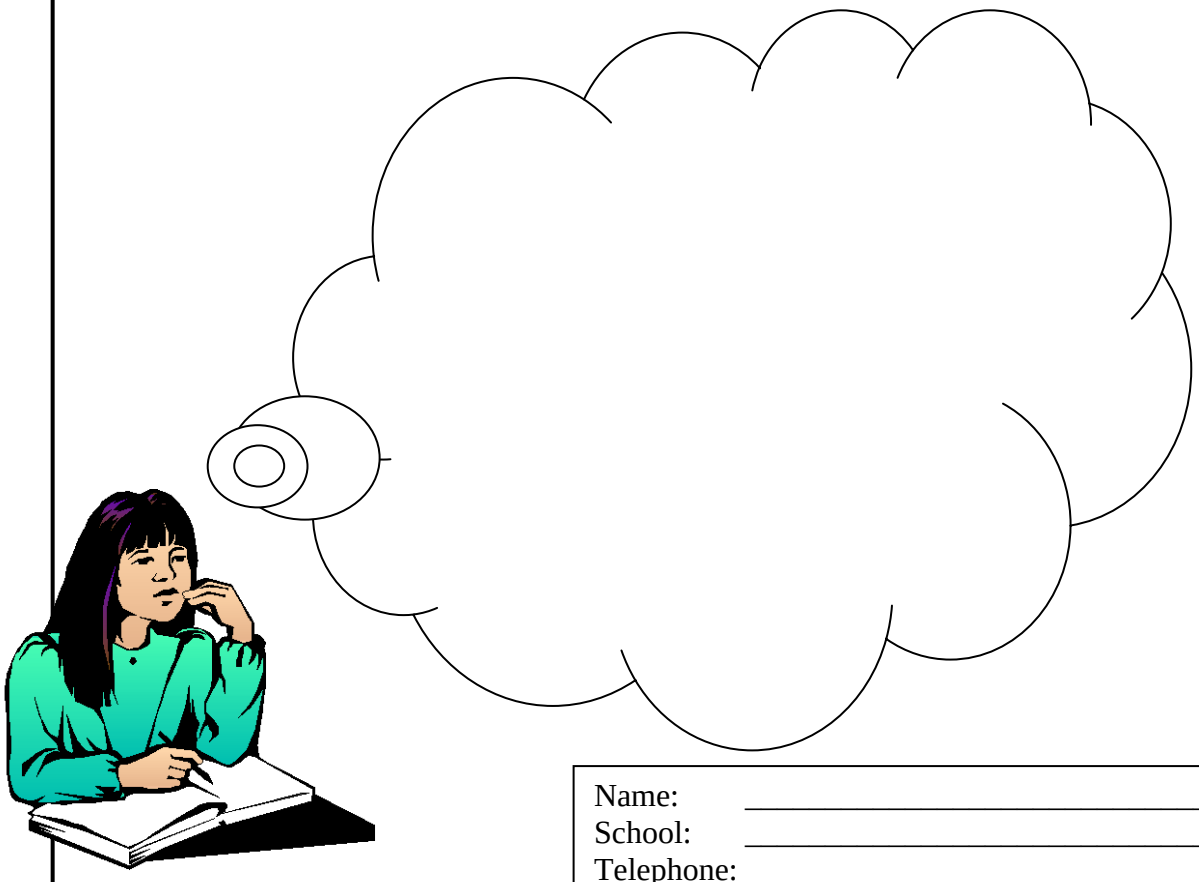
Having to teach evolution as a school subject in 2008

Table: _____ Initials :_____

How do you feel about having to teach evolution in 2008? Explain your answer



If you have any WORRIES OR CONCERNS about teaching evolution next year, and have not explained them above, please add them here.



Name: _____
School: _____
Telephone: _____

Appendix C2

Do you think you know enough about evolution to teach it?

Do you think you know enough about evolution to teach it?

Please indicate your answer by placing a tick (T) in the relevant box or column.

How good is your detailed understanding of the fundamental concepts of evolution you are required to teach in 2008?

	Excellent	Good	Satisfactory	Poor
• **Biological evidence of evolution of populations and fundamental aspects of fossil studies**				
o Fossilization.				
o Fossils as evidence of ancient life.				
o Interpretation of the fossil record by means of morphological Divergence - homologous, analogous structures.				
• **Origin of species**				
o Definition of biological evolution				
o Evolution theories (Darwin's theory and Lamarck's theory.				
o Mutation and the part they play in evolution.				
o Variation (genotypic and phenotypic) in populations with examples e.g. White lions, cheetahs, Galapagos finches.				
o Natural selection.				
o Macroevolution – what it is and various lines of evolution (branches of the evolutionary tree) over geological time.				
o Formation of species at an (ecological, reproductive, and genetic level).				
o Inbreeding and outbreeding (with examples)				
• **Popular theories of mass extinction**				
o Continental drift, Ice age, volcano activity, heating and cooling of the atmosphere, and disease.				
o Extraterrestrial theories (explosion of star, meteor collision, comets).				
• **Cradle of humankind – South Africa**				
o Where are humans thought to have originated?				
o Differentiate between anthropology, palaeontology, and archaeology.				
o Possible origin of humankind on Earth.				

Appendix C3

Explain what do you think is meant by "evolution" in biology

Explain what you think is meant by "evolution" in biology.



Do you believe that the theory of evolution could explain diversity of life on Earth? Tick the relevant box and give a reason for your answer.

	Reason
Yes	
No	

Do you believe that humans could have evolved from an ape-like-ancestor? Tick the relevant box and give a reason for your answer.

	Reason
Yes	
No	

Appendix C4

Evolution quiz

Table: _____ Initials :_____

Evolution Quiz

Indicate whether you consider the following statements to be true or false ***by circling T or F***

(1) Evolution explains how the Earth was created. T / F

(2) Evolution explains how life began. T / F

(3) Evolution negates the existence of a God. T / F

(4) Evolution is just a theory, and therefore has little scientific credibility. T / F

(5) Evolution is a theory in crisis as it is continually debated by scientists. T / F

(6) Evolution is not believable because it cannot be tested. T / F

(7) Evolution of new species has never been observed. T / F

(8) Individual organisms evolve in response to environmental changes. T / F

(9) Evolution "betters" organisms and increases their complexity, resulting in steady progress upward from lower animals to humans. T / F

(10) Missing links in the fossil record disprove evolution. T / F

(11) Evolution occurs when organisms develop features they need to survive. T / F

(12) Ancient humans (cavemen) once hunted dinosaurs. T / F

(13) Evolution explains that people evolved from apes, chimpanzees or monkeys. T / F

(14) Life began when the Earth was formed. T / F

(15) Evolution has taken place in order for humans to develop. T / F

(16) All individuals of a species evolve simultaneously. T / F

(17) Evolution results in an increase in variation within organisms in a population. T / F

(18) Evolution is when physical features in a population change to suit the available food source. T / F

Appendix C5

Case scenario for acquired characteristics

Case 1

Maggie is obsessed with her cell phone, and sends SMS messages to all her friends everyday, especially her boyfriend Henry (who is also an SMS fanatic). Both Maggie and Henry develop large and muscular thumbs from all the action. After matric they get married and have two children.

Will their children have bigger thumbs than normal children? Tick (✓) Yes ☐ No ☐

Explain your answer

Case 2

Thabo had an accident while working in the South African mines and his right leg was cut off. He later married a woman with two normal legs.

Will their children be born with one leg? Tick (✓) the relevant box. Yes ☐ No ☐

Explain your answer

Case 3

Nyiko lost his eyesight in an accident at the age of five. He later married a girl who also lost her eyesight in an accident at a very early age.

Will their children also be blind? Tick (✓) the relevant box. Yes ☐ No ☐

What are your reasons for saying this?

Table: ____ Initials _____ School: _____

Appendix C6

The creation / evolution continuum of beliefs. Where do you stand?

Table: _____ Initials _____

The creation / evolution continuum of beliefs. Where do you stand?

Look carefully at the definition associated with each category of beliefs.

In which category do you think you belong? Indicate by ticking in the appropriate box in the last column.

creation ↓ **evolution**	Flat Earthers	Believe that the earth is flat because a literal reading of the Bible demands it.		☐
	Geocentrists	Accept that the earth is spherical, but not that the sun is in the centre of the solar system. They reject much modern physics, chemistry and biology.		☐
	Young Earth Creationists	They interpret Genesis literally (God created the Earth and all living things in 6 consecutive days). They reject modern physics, chemistry, and geology concerning the age of the earth (which they believe is from 6 to 10 thousand years old), and they deny biological descent with modification.		☐
	Old Earth Creationists	Their beliefs allow for a harmonization of the ideas of special creation with scientific ideas of evolution, as by the 1800's scientific evidence for evolution was well established. They accommodate creation and evolution in a number of possible ways.		☐
		Gap Creationism	Assumes a pre-Adamic creation that was destroyed before Genesis 1:2, when God recreated the world in six days, and created Adam and Eve. A time gap between two separate creations (Genesis1:1 and 1:2) allows for accommodation of the proof of the ancient age of the earth with Special creationism.	☐
		Day-Age Creationism	Accommodates science and religion by recognising each of the six days of creation as long periods of time (thousands or millions of years instead of merely 24 hours long).	☐
		Progressive Creationism	These views are held by the majority of "Old-Earthers". It combines Special Creationism with a fair amount of modern science. They accept the fossil record as an accurate representation of history by explaining that God created "kinds" of plants and animals sequentially over a long period of time.	☐
		Intelligent Design Creationism	They believe that the incredible complexity of organisms could not have evolved by chance, and so must have been controlled by an "intelligent designer" - God. This allows for a fair amount of microevolution, but supporters feel that mutation and natural selection are not adequate to explain the evolution some organisms to others (such as humans from apes) and that this required the hand of God.	☐
	Evolutionary Creationists	Believe that God the Creator uses evolution to bring about universe according to His plan. This is very similar to the next belief system listed in terms of their scientific beliefs, but are more conservatively Christian.		☐
	Theist Evolutionists	Believe that God creates through evolution. Some see God as intervening at critical intervals during the history of life (especially in the origin of humans). Others believe that humans may be descended from more primitive forms, but the hand of God was needed for the creation of the human soul.		☐
	Materialist Evolutionists	This is a non-religious belief system which accepts only scientific explanations for life and its diversity. Some proponents are neutral to religious ideas, while others say that the supernatural does not exist and thus reject the ideas of creationists.		☐

Based on an article on the National Centre for Science Education website
http://www.natcenscied.org/resources/articles/1593_the_creationevolution_continu_12_7_2000.asp

Appendix C7

What support do you feel you still need in order to feel confident about teaching evolution in 2008?

Table: ____ Initials _____

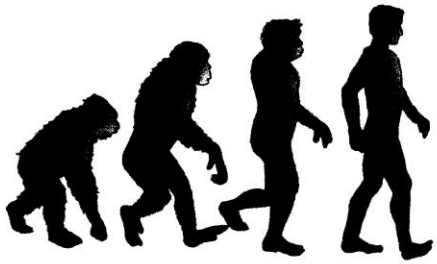
What support do you feel you need in order to prepare you to teach evolution next year?



Appendix D

2008 workshop invitation letter

Invitation to FET *Life Sciences* teachers
to attend one or more of a workshop series on
the teaching of evolution in Grade 12 Life Sciences



Dealing with concerns, and preparing to teach evolution in 2008

Are you

- expected to teach evolution to Grade 12s in 2008?
- in the dark about what is expected of you?
- unsure about the potential problems that may arise and how to deal with them?
- interested in meeting others in the same boat and sharing ideas?
- wanting explanations, ideas, materials and support?

If so, this Saturday morning workshop series is for you

Saturday 16th, 23rd February, and 1 March 2008
Excursion to *Cradle of Humankind* 8th March 2008 ALL DAY

BOOKING IS ESSENTIAL

Reasons for attending

The new curriculum for Grade 12 *Life Sciences* requires that the topic of evolution be taught, in detail, in 2008. Many *Life Sciences* teachers have a number of concerns about teaching the topic, and are unsure about what to teach and how to teach it.

In the limited time available, this workshop series has been designed to deal with these concerns and to suggest activities and resources.

We have dynamic guest speakers:

- **The Rev. Dr. Susan van Niekerk** (a committed Christian and scientist)
- **Dr Amanda Esterhuysen** (an archaeologist with a passion for teaching her subject)
- **Dr Francois Durand** (a zoology lecturer with a passion for evolution)

We have organized a fascinating **optional** excursion to two exciting venues at one of South Africa's world heritage sites, the *Cradle of Humankind*, so that teachers can assess their possible use for field trips

- the *Maropeng Centre*
- the *Sterkfontein Cave*

Free Maropeng CD with worksheets for each school on the excursion

Surprise teaching aid for teachers attending all three workshops

What will be covered in each session

Workshop 1: Saturday 16th February 08h45 – 13h00 R70

- identifying concerns, to ensure that these can be addressed
- an overview of beliefs about how life began and how the different species came into being, including scientists' theories
- ways of dealing with possible conflicts
- what Grade 12 Life Sciences teachers will be required to teach
- the nine requirements of the new curriculum, and implications for teachers' classroom practices
- geological time scales

Workshop 2: Saturday 23rd February 08h45 – 13h00 R70

- teachers' knowledge and skills repertoire, and implications for teaching evolution
- a more detailed review of the content teachers need to cover
- overview of common misconceptions that may affect learners' conceptual understanding of evolutionary theory.
- "walking in the learners' shoes" – trying out activity-based ideas for teaching evolution
- suggestions for field trips and excursions
- review of Grade 12 textbooks on evolution.

Workshop 3: Saturday 1 March 08h45 – 13h00 R70

- linking genetics and evolution
- more advanced content on hominid evolution
- answering frequently-asked questions about evolution
- access to web-based resources
- talk on Sterkfontein and archaeology, by the dynamic Dr Amanda Esterhuysen

ONLY R180 if you attend ALL three workshops

Excursions: Saturday 8th March 09h00 – 17h00 Approx. cost R100

This visit will be organised only if there is sufficient interest. The cost has yet to be determined. There will not be a bus. We need to organise the transport.

- visit to the *Maropeng Centre*, armed with worksheets for you to try out, so you can evaluate how you would use the visit for your learners
- free CD of worksheets for all grade levels, for each school represented
- optional additional visit to the *Sterkfontein Caves* museum, which tells the story of the hominid finds and how they helped scientists to develop a theory about how humans evolved
- for the intrepid explorers, a tour through the caves, to hear the story and see the sights (and sites of important finds)

Attend one or more of these exciting sessions
(note big discount if you attend all three workshops)

When:	Sat. 16th, 23rd February and Sturday 1 Match 2008 (optional excursion 8th March) Registration from 08h15 (please register well before the scheduled starting time, 08h45 for workshops, 08h30 for excursion)
Where:	University of the Witwatersrand (Main Campus)
For whom:	*Life Sciences* teachers
Facilitators:	Martie Sanders, Rebecca Govender, Nonyameko Ngxola
Guest speakers:	The Reverent Dr Susan van Niekerk, Dr Amanda Esterhuysen, Dr Francois Durand
Contact:	To book, contact Martie: Tel: (011) 717-6481(w) (011) 787-9288 (after hours) Fax: (011) 403-1429 E-mail: Martie.Sanders@wits.ac.za

DO YOU WISH TO ATTEND?

We need to find out what the demand is for this workshop.

Please complete the reply form, and return it to Martie as a matter of urgency (by Friday 1 February 2008)

Appendix E

Letter of approval from the Human Research Ethics Committee

UNIVERSITY OF THE WITWATERSRAND, JOHANNESBURG
Division of the Deputy Registrar (Academic & Research)

M E M O R A N D U M

TO: **Ms N Ngxola, APES**

FROM: Ms Santha Maistry
Secretary: Human Research Ethics Committee (Non-Medical)
Room 10004, 10th Floor, Senate House, University.
Tel: (011) 717-1252 Fax: (011) 339-5708
Email: Saintha.maistry@wits.ac.za

DATE: **29 May 2008**

REF: **R14/49/1**

The following protocol was considered at a meeting of the Human Research Ethics Committee (Non-Medical) on Friday 16 May 2008. The Committee requires the following amendments/corrections/information from you before your application can be approved:

Protocol H0502 Ms N Ngxola, APES, Teaching evolution in the new curriculum: Life Sciences teacher's concerns and needs.
The following problems were identified

- There is no need to shred the data
- Need to obtain permission from the Education Department for carrying out the research in public school.

The following amendments needs to be discussed with your supervisor before approval can be given

Please let me have the amendments **within two weeks.** Protocols on which no action has been taken will be removed from the agenda without approval after three months.

Cc:

NB: Please highlight the changes you submit

Appendix F

Evolution definitions from six biology dictionaries and the comments of an "evolution expert"

Source	Definition of "evolution"	✓ or ×	Comments
Collins reference dictionary of biology (1988).	*An explanation of the way in which present-day organisms have been produced, involving changes taking place in the genetic make-up of populations that have been passed to successive generations.*	✓	but misleading - too close to reproduction.
	According to Darwinism, evolutionary mutations have given rise to changes that have, through natural selection, either survived in better adapted organisms, or died out.		what is an "evolutionary" mutation? doesn't allow for neutral mutations + can a "change" survive or die out?
	Evolution is now generally accepted as means which give rise to new species (as opposed to Special Creation), but there is still debate about exactly how it has taken place and how rapidly changes can take place.	✓	"has taken" implies that it has happened in the past only.
	Is this definition complete: Yes / No (Please explain what aspects are missing, if any) • Has the key element, but also some misleading words & phrases. • Does not distinguish between microevolution and macroevolution.		
Chambers biology dictionary (1989).	*Changes in the genetic composition of a population during successive generations.*		— needs to include natural selection here.
	The gradual development of more complex organisms from simpler ones.		- No, because can also progress from complex to simple.
	Is this definition complete: Yes / No (Please explain what aspects are missing, if any) Does not mention natural selection, formation of species, microevolution + macroevolution. Not only plants and animals! All of life has evolved - fungi, prokaryotes, etc.		
A concise dictionary of biology (1990).	*The gradual process by which present diversity of plant and animal life arose from the earliest and most primitive organisms, which is believed to have been continuing for at least 3000 million years.*		
	Until the middle of the 18th century it was generally believed that each species was divinely created and fixed in its form throughout its existence.	✓	
	Lamarck was the first biologist to publish a theory to explain how one species could have evolved into another, but it was not until the publication of Darwin's on the Origin of Species in 1859 that special creation was seriously challenged.	✓	
	Unlike Lamarck, Darwin proposed a feasible mechanism for evolution and backed it up with evidence from the fossil record and studies of comparative anatomy and embryology. + artificial selection		which is? - evolution by natural selection
	The modern version of Darwinism, which incorporates discoveries in genetics made since Darwin's time, probably remains the most acceptable theory of species evolution.	✓	

	More controversial, however, and still to be firmly clarified, are the relationships and evolution of groups above species level.	✓	
	Is this definition complete: Yes / No (Please explain what aspects are missing, if any) Does not define evolution by natural selection. Does not distinguish microevolution and macroevolution.		
The new Penguin dictionary of biology (1990).	*(1) Microevolution: changes in appearance of populations and species over generations.* (the gene pool)		Not all genes are expressed in appearance.
	(2) Macroevolution or phyletic evolution: origins and EXTINCTIONS of species and grades.		not sure what a "grade" is.
	Microevolution includes changes in mean and modal phenotype, morph ratios, etc.	✓	
	such as occur within populations from one generation to the next.		
	When statistically significant changes in such variables (or the genes responsible for them) occur with time, (due to changes in) (which variables?)		this "or" could be misleading.
	a population may be said to evolve.		
	Macroevolution includes large-scale phyletic change over geological time (e.g. successive origins of crosspterygian fish, amphibians, reptiles, birds and mammals),		I feel that this definition should include something about speciation as well as "large-scale phyletic change"
	as well as extinctions of taxa within such groups.		
	It is usually accepted that causes of evolutionary change include NATURAL SELECTION and GENETIC DRIFT,	✓	
	and that macroevolutionary change can be explained by the same factors that bring about microevolution.	✓	
	Debate has recently centred upon the rate of evolutionary change.	✓	
	Some biologists accept that evolution largely occurs by gradual ANAGENESIS, others stress the role of CLADOGENESIS and take the view that species persist unchanged for considerable periods of time, and that relatively rapid speciation events punctuate the fossil record (punctuated equilibrium). (E)	✓	
	Darwin considered both to be possibilities. At the molecular level, controversy centres on the respective influences in evolution of random alterations in genetic material (the materialist view) and selective changes (the selectionist view).	✓	
	Opposed to evolutionary explanations of the composition of the Earth's fauna and flora is the group of views termed 'special creationism', which holds that there are no bonds of genetic relationship between species, past or present.	✓	
	Athough Anaximander (6th cen. BC), Empedocles (5th cen. BC) and Aristocle (4th cen. BC) all held evolutionary views of some kind, they depended more on a priorism than on observation and testable theory	✓	
	Lamarck is often considered the most influential evolutionary thinker prior to Charles Darwin		

One good thing about this definition is that it distinguishes between these two scales of evolution.

use the dictionary's layout

	and Alfred Wallace but his theory was very different from theirs. They themselves drew apart on the question of human origins and the role of sexual selection. *Evidence for common descent and the fact of evolution comes principally from molecular biology, comparative biochemistry, comparative morphology (e.g. anatomy and embryology),* *geographical distributions of organisms and fossil records. The modern theory of evolution (NEO-DARWINISM) derives largely from the kind of genetical knowledge which Darwin lacked, principally by occurrence of Mendelian segregation, which helps explain how variations can be maintained in populations. Evidence for microevolution and Darwinian natural selection* *(amounting to his 'special theory of evolution') stems largely from population genetics, although Darwin himself drew heavily on the analogy of ARTIFICIAL SELECTION.*	✓ ✓	
	Is this definition complete: Yes / No (Please explain what aspects are missing, if any) Mostly correct information.		
The Pan dictionary of biology (1990) – not necessarily	*The gradual process of change that occurs in populations of organisms over a long period of time.* — microevolution can happen over short time periods		Needs to distinguish between micro and macroevolution. Natural selection should be included here.
	It manifests itself as new characteristics in a species, or change in predominance of existing characteristics which could lead to ~~and~~ the formation of new species. — New species formed only under certain conditions		
	Is this definition complete: Yes / No (Please explain what aspects are missing, if any) No mention of Natural selection. Does not distinguish macro and micro evolution.		
Collins English dictionary (1991).	*Biology. A gradual change in the characteristics of a population of animals or plants over successive generations:* *accounts for the origin of existing species ~~form~~ from ancestors unlike them* — ancestral species are not necessarily unlike existing ones. Issues of scale here e.g. if thinking about reptiles → mammals then this is true, but if thinking about different species of the same type of organism e.g. dolphins, then this is not true.		What about other life forms? *
	Is this definition complete: Yes / No (Please explain what aspects are missing, if any)		

Same sorts of issues here:
- no mention of natural selection
- definition does not distinguish between microevolution and macroevolution.

Source	Definition of 'natural selection'	✓or ×	Comments
Collins reference dictionary of biology (1988).	*The mechanism, proposed by Charles Darwin, by which gradual evolutionary changes take place.*		microevolutionary changes can be relatively rapid.
	Organisms which are better adapted to the environment in which they live produce more viable young, so increasing their proportion in the population and thus being 'selected'.		same mention of genes / the * gene pool needed here.
	Such a mechanism depends on the variability of individuals within the population. *Such variability arises through mutation, the beneficial mutants being preserved by natural selection.*		
	Is this definition complete: Yes / No (Please explain what aspects are missing, if any) More emphasis on the gene level needed.		
Chambers biology dictionary (1989).	*An evolutionary theory which postulates the survival of the best adapted forms, in a population from generation to generation with the inheritance of those characteristics wherein their fitness lies,*		
	and which arise as random variations due to mutations;	✓	
	it was first propounded by Charles Darwin, and is often referred to as Darwinism or the Darwin theory	✓	
	Is this definition complete: Yes / No (Please explain what aspects are missing, if any) Needs to make it clear that populations evolve, not individuals		
A concise dictionary of biology (1990). Oxford Reference	*The process that, according to Darwinism, brings about the evolution of new species of animals and plants.* + other life forms.		
	Darwin noted that the size of any population tends to remain constant despite the fact that more offspring are produced than are needed to maintain it.	✓	
	He also saw that variations existed between individuals of the population and concluded that disease, competition, and other forces acting on the population eliminated those individuals less well adapted to their environment.	✓	
	The survivors would pass on any inheritable advantageous characteristics (i.e. characteristics with survival value) to their offspring	✓	
	and in time the ~~composition~~ gene pool + characteristics of a population would change in adaptation to a changing environment.		

"composition" is a bit vague.

	Over a ~~long~~ sufficient ~~time~~ period ~~of time~~ this process could give rise to ~~the~~ organisms so different from the original population that new species are formed.		Not necessarily a "long" time. Misleading since there are species of the same genera of organisms e.g birds that are very similar, yet do not interbreed and so are discrete species.
	Is this definition complete: Yes / No (Please explain what aspects are missing, if any) Some aspects of this definition are okay		
The new Penguin dictionary of biology (1990).	*Most widely accepted theory concerning the principal casual mechanism of evolutionary change ('descent with modification'); propounded by Charles Darwin and Alfred Russel Wallace.*	✓	
	The theory asserts that, given ~~diversity~~ variation (both genetic and phenotypic) among individuals making up a species population, not all individuals in the population at a time t_0 will contribute equally to the make-up of the population at a subsequent time t_1.	✓	"diversity" usually associated with species. "variation" - with genotypic and phenotypic differences.
	To the extent that this is due to the effects of heritable differences upon individuals, natural selection has occurred.		This sentence would be difficult to understand without prior knowledge.
	Confusion arises over the use of Herbert Spencer's phrase 'the survival of the fittest'.	✓	The key concept is those who survive and reproduce.
	Individual organisms do not survive through geological time (unlike some evolutionary lineages)' but what they inherit and pass on does: that is, genes.	✓	
	The theory of natural selection asserts that the genetic composition of an evolutionary lineage will change through time by non-random transmission of genes from one parental generation to the next, a non-randomness ('selection')	✓	
	due solely to the fact that not all gene combinations are equally suited to a given environment,	✓	
	and that consequently individuals differ in their biological (Darwinian) fitness.	✓	
	Constraints upon genotype from the environment, which produce this differential gene transmission, are termed 'selection pressure'	✓	
	It is commonly assumed that all regular components of a species' phenotype have been favoured by natural selection,	✓	
	but evolution may sometimes result from causes other than natural selection.	✓	
	Is this definition complete: Yes / No (Please explain what aspects are missing, if any) Mostly okay.		
The pan dictionary of	*The process, which Darwin called the 'struggle for survival', by which organisms less adapted to their environment tend to perish'*		A bit simplistic.

- less adapted individuals may survive but reproduce

not necessarily. The key issue is which individuals get to pass on their genes since it is possible

biology (1990)	*and better-adapted organisms tend to survive.* — see comment to an previous page. *According to Darwinism, natural selection acting on a varied population results in evolution.*	✓	
	Is this definition complete: Yes / (No) (Please explain what aspects are missing, if any) Does not make it clear that it is populations that evolve.		
Collins English dictionary (1991).	*A process resulting in the survival of the individuals from a population of animals or plants that are adapted to the prevailing environmental conditions.*	— not only	
	The survived (ing) individuals tend to produce more offspring than those less well adapted, so the genetic composition of the population is changed. from one generation to the next.		
	Is this definition complete: Yes (No) (Please explain what aspects are missing, if any) Needs to emphasise the genetic aspect.		

a change in the characteristics of a population / ~~group~~ taxon over a period of time.

To be totally correct it needs to explain. how & why

- the changes must be genetically-based so they can pass from to successive generations
- organisms better adapted to survive :- their environment are reproductively more successful, so their "favourable" genes are passed to more offspring — and thus "spread" through a population (known as natural selection)
- changes can be small (within populations) or larger (totally change species so they can no longer interbreed + produce viable offspring) — microevolution or if changes are big (eg. produce a new class/phylum) — macroevol.
- changes must be genetic. in populations.