Agricultural Sciences

TEST & EXAM PREPARATION

Liesl Sterrenberg, Grace Elliott & Helena Fouché

GRADE

12

CAPS

2-in-1

THE ANSWER SERIES *Your Key to Exam Success*

Grade 12 Agricultural Sciences 2-in-1 CAPS

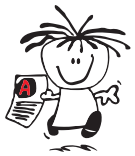
TEST & EXAM PREPARATION

This 2-in-1 study guide presents the challenging content material of Grade 12 Agricultural Sciences in an easy-to-use format that stimulates consistent revision as well as pre-exam consolidation.

Key Features:

- Illustrated skills summary
- Curriculum-based check lists per topic
- Comprehensive terminology lists per topic
- Questions and answers per topic
- Exam papers and memos
- Answers and memos in a separate booklet

As you work methodically through this study guide, you will become increasingly prepared to achieve excellent results in your exams.



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THIS STUDY GUIDE INCLUDES

1 Questions per Topic on:

- Animal Nutrition
- Animal Production, Protection and Control
- Animal Reproduction
- Agricultural Management and Marketing
- Factors of Production
- Basic Agricultural Genetics

2 Exam Papers

(all answers in separate booklet)

E-book available

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CONTENTS

All Answers to Topic-based Questions as well as the Memos to the Exam Papers are compiled in a separate booklet.

BASIC AGRICULTURAL GENETICS

Use this handy **checklist** below to ensure you have covered the content required in the curriculum. Note the **key verbs** used (e.g. distinguish, describe, define, compare, classify, name, tabulate, etc.) as they are the **active words** that will determine the **focus** of each topic according to the latest examination guidelines.

CHECKLIST ☑

MONOHYBRID AND DIHYBRID INHERITANCE

Genetic concepts

- ❑ Define basic genetic terminology:
  - ❑ Genetics
  - ❑ Heredity
  - ❑ Genes
  - ❑ Chromosomes
  - ❑ Alleles (homozygous and heterozygous)
- ❑ Distinguish between genotype and phenotype, dominant and recessive genes
- ❑ Indicate a monohybrid inheritance/crosses (Mendel's First Law: Law of Segregation)
- ❑ Indicate a dihybrid inheritance/dihybrid cross (Mendel's Second Law: Law of Independent Assortment)
- ❑ Use various methods, such as a Punnett square, genetic diagrams and schematic representations to illustrate the crosses
- ❑ Describe Mendel's Laws:
  - ❑ Law of Segregation

Mendel's Law of Segregation states that alleles at the same locus on homologous chromosomes separate from each other during meiosis so that each gamete has only one copy of the gene for a characteristic.

  - ❑ Law of Independent Assortment

Mendel's Law of Independent Assortment states that genes for different characteristics are arranged separately from each other during the formation of gametes in meiosis.

- ❑ Distinguish between qualitative and quantitative characteristics

THE PATTERN OF INHERITANCE

- ❑ Identify and describe the pattern of inheritance that leads to different phenotypes:
  - ❑ Incomplete dominance
  - ❑ Co-dominance
  - ❑ Multiple alleles
  - ❑ Polygenic inheritance
  - ❑ Epistasis
- ❑ Define the concept of prepotency and atavism with relevant examples
- ❑ Describe the sex chromosomes and sex-linked characteristics (examples)

VARIATION AND MUTATION

- ❑ Define genetic terminology:
  - ❑ Variation
  - ❑ Mutation
  - ❑ Selection
- ❑ Identify and describe the importance of variation and selection
- ❑ Distinguish between the types of variation:
  - ❑ Continuous variation
  - ❑ Discontinuous variation
- ❑ Discuss the causes of variation:
  - ❑ External causes (environmental)
  - ❑ Internal causes (genetic)
- ❑ Distinguish between types of mutations:
  - ❑ Gene/point mutations
  - ❑ Chromosome mutations
- ❑ Identify the types of mutagenic agents and their effects (changes in chromosome structures)

SELECTION

- ❑ Indicate the general principles of selection:
  - ❑ Biometrics
  - ❑ Heritability
  - ❑ Estimated Breeding Values (EBVs)
- ❑ Compare natural and artificial selection
- ❑ Indicate the selection methods used by plant and animal breeders:
  - ❑ Mass selection
  - ❑ Pedigree selection
  - ❑ Family selection
  - ❑ Progeny selection and breeding values
- ❑ Identify and describe animal breeding systems:
  - ❑ Inbreeding with relevant examples
  - ❑ Linebreeding with relevant examples

Inbreeding and linebreeding are **related breeding systems**, while crossbreeding, upgrading, species crossing and outcrossing are **unrelated breeding systems**.

  - ❑ Crossbreeding
  - ❑ Upgrading
  - ❑ Species crossing
  - ❑ Outcrossing
- ❑ Name the advantages and disadvantages of these different breeding systems

GENETIC MODIFICATION/GENETIC ENGINEERING

- ❑ Define the concept of genetic modification/genetic engineering in plants and animals (with relevant examples)

Stages of genetic engineering process:

- Desired gene is isolated
- Desired gene is copied
- Transfer of desired genes into plant's own genes
- Modified tissue is developed into new plant
- Checking that inserted genes function normally
- Checking that inserted genes appear in progeny

- ❑ List the aims of genetic modification of plants and animals
- ❑ Indicate the advantages of genetic engineering over traditional methods

- ❑ Identify and describe the current uses/application of genetically modified plants
- ❑ Indicate the techniques used to genetically modify plants/animals

Techniques of GM in animals:

- micro-injection
- retroviral vectors

Techniques of GM in plants:

- recombinant DNA
- electroporation uses electric currents to penetrate plant cells with desired gene
- micro-injection transfers desired gene directly into recipient nucleus
- gene gun (biolistic delivery) fires tiny gold-coated gene particles into the plant embryo
- bacteria e.g. *Agrobacterium tumefaciens*

- ❑ Name the characteristics of GMOs

Characteristics of GMOs include: heat or cold-resistant crops, pesticide-resistant crops, high nutritive crops, stronger, disease-resistant animals, iron-rich milk for human consumption.

- ❑ Indicate the potential risks of GMOs
- ❑ Describe the potential benefits of genetically modified crops

TERMINOLOGY AND CONCEPTS

Use this **reference list** to extend your understanding of **terms** in Agricultural Sciences. It is vital to know your terms and definitions. This list is **more than definitions**, it provides an **extensive explanation** for each term and places it in context. Refer to this list as you study the content and work through the questions and answers.

MONOHYBRID AND DIHYBRID INHERITANCE

heredity	the transfer of genetic characteristics from generation to generation
genetics	the study of heredity; how characteristics are passed from parents to offspring
gene	unit of inheritance composed of a segment of DNA on a chromosome that codes for a particular characteristic
DNA (deoxyribonucleic acid)	large molecule (polymer) in the nucleus that forms the hereditary material of chromosomes and carries all the genetic instructions for cell functioning
genetic trait	characteristic that is coded in the genes and passed from parents to offspring
chromosome	thread-like structure visible in the nucleus of a dividing cell; consists of two chromatids joined by a centromere and composed of DNA that carries genetic information
locus	specific position of a gene on a chromosome

DNA → gene → chromatid → chromosome

alleles	alternative forms of the same gene found at a particular locus on a pair of homologous chromosomes
meiosis	type of cell division that produces four haploid daughter cells e.g. gametes (animals) or spores (plants)
progeny	offspring/descendants/young of parent individuals
haploid cell	cell with a single set of chromosomes; half the number of chromosomes found in other body/somatic cells e.g. 23 chromosomes in a human sperm cell/egg cell
diploid number	cell with a double set (full complement) of chromosomes e.g. 46 chromosomes in a human body/somatic cell
homologous chromosomes	two chromosomes (one from each parent) found in diploid cells that are similar in size, shape and genetic composition and have corresponding alleles for the same characteristic
homozygous/ homozygote	a pure-bred individual with two identical alleles (corresponding genes e.g. AA/aa/BB/bb on a pair of homologous chromosomes) for a particular characteristic; both alleles are expressed in the phenotype
homozygosis/ homozygosity	the condition of being/forming a homozygote by combining two identical alleles in fertilisation
heterozygous/ heterozygote	a hybrid individual with two different alleles (corresponding genes e.g. Aa/Bb on a pair of homologous chromosomes) for a particular characteristic; only the dominant allele is expressed in the phenotype
heterozygosis/ heterozygosity	the condition of being/forming a heterozygote by combining two different alleles in fertilisation
hybrid	a heterozygous individual; offspring of two genetically different parents
genotype	genetic composition of an individual contained in a pair of alleles for a particular characteristic e.g. Bb or BB

phenotype	observable, physical characteristics of an individual as determined by the genotype (genetic composition) e.g. hornless, red flowers, long wings
dominant allele	gene that masks the recessive gene, always expressed in the phenotype and represented by a capital letter e.g. A or B
recessive allele	gene that is masked by a dominant gene, only expressed in the phenotype if the corresponding allele is identical; represented by a small letter e.g. a or b
dominance	a pattern of inheritance where one allele (dominant) masks the effect of the corresponding allele (recessive) in the phenotype
cross-pollination	transfer of pollen from the male anther of one flower to the female stigma of another flower on a different plant
self-pollination	transfer of pollen from the male anther of one flower to the female stigma of the same flower or another flower on the same plant
monohybrid inheritance/cross	genetic cross between parents involving one characteristic e.g. seed shape
filial generation	offspring generation (progeny) from a genetic cross between two parents
F_1 generation	first filial generation that consists of offspring resulting from a genetic cross in the first parental generation (P_1)
F_2 generation	second filial generation that consists of offspring resulting from a genetic cross of the second set of parents (P_2) from the F_1 generation
genetic diagram	diagram that shows how genetic characteristics are inherited from each parent, the gametes and potential combinations of genotypes in the offspring

Punnett square	diagram in a table format that shows how genetic characteristics are inherited from each parent, the gametes and potential combinations of genotypes in the offspring
genotypic ratio	proportional relationship between the number of times each genotype appears in the offspring generation, expressed as a ratio e.g. 1AA : 2Aa : 1aa
gamete	reproductive cell (sex cell) formed during meiosis e.g. sperm cell/ovum
phenotypic ratio	proportional relationship between the number of times each phenotype appears in the offspring generation, expressed as a ratio e.g. 3 wrinkled seeds : 1 smooth seed
segregation	separation of alleles when homologous chromosomes separate in meiosis
Law of Segregation/ Mendel's First Law	alleles at the same locus on homologous chromosomes separate from each other during the formation of gametes (meiosis) so that each gamete has only one copy of the gene for a characteristic; alleles recombine in fertilisation to restore paired alleles in the offspring
dihybrid inheritance/ cross/ dihybridism	genetic cross between parents involving two characteristics e.g. seed shape and seed colour
Law of Independent Assortment/ Mendel's Second Law	genes for different characteristics are arranged separately from each other during the formation of gametes in meiosis

THE PATTERN OF INHERITANCE

incomplete/ partial dominance	pattern of inheritance where neither allele is dominant over the other and both characteristics (represented by capital letters) are expressed as a blend (intermediate form) in the heterozygous phenotype e.g. BB = black, WW = white, BW = grey
co-dominance	pattern of inheritance where both alleles are equally dominant and both are expressed in the heterozygous phenotype e.g. BB = black feathers, WW = white feathers, BW = black feathers and white feathers
multiple alleles	pattern of inheritance where more than two alleles control a characteristic e.g. 4 alleles for coat colour ($C/c^{ch}/c^{h}/c$): CC = brown fur, $c^{ch}c^{ch}$ = black-tipped white fur, $c^{h}c^{h}$ = white fur with black fur patches, cc = white fur
epistasis	pattern of inheritance where the action of one gene is modified or controlled by one/several other genes e.g. different comb shapes in chickens, coat colour in horses
polygenic inheritance	pattern of inheritance where a phenotypic characteristic is determined by more than one pair of genes; multiple genes resulting in continuous (gradual/quantitative) variation e.g. milk production, height, weight, wool production
clone	genetically identical individual to the parent
prepotency	ability of a parent to transfer genetic characteristics to offspring due to the presence of more homozygous dominant alleles; offspring more likely to resemble that parent
atavism	reappearance of a homozygous recessive characteristic after absence for several generations known as a 'throwback' e.g. red-and-white calf born to generations of black-and-white parents
sex chromosomes/ gonosomes	one pair of chromosomes called X and Y chromosomes in each body/somatic cell that determines the gender of the individual e.g. females have XX, males have XY
sex-linked inheritance/ sex-linkage	genes carried on sex chromosome (X chromosome); being male or female determines whether the individual will have the condition and forms part of the phenotype e.g. hairlessness in Holstein bull

VARIATION AND MUTATION

variation	differences in genotypes/phenotypes of individuals of the same breed due to external and/or internal causes e.g. shape, colour, height etc.
histogram	type of graph that represents continuous/numerical data in columns with no gaps in between
normal distribution	a common, continuous distribution of values that forms a symmetrical, bell-shaped curve with most values centred around the mean
mean	a type of average calculated by dividing the sum of the numbers by the number of data values
continuous variation	a complete range of phenotypes of a quantitative characteristic due to polygenic inheritance (controlled by many genes), showing a normal distribution (bell-shaped) curve e.g. weight gain, milk production
discontinuous variation	quantitative characteristics controlled by one or two genes with distinct (clear-cut) phenotypes with no intermediate forms; represented in a bar graph / pie chart e.g. four comb types in chickens
quantitative characteristics	characteristics controlled by a number of genes (polygenic inheritance) that produce continuous variation (intermediate forms) in a particular phenotype e.g. wool production, crop yields, disease resistance, size of fruit
qualitative characteristics	characteristics controlled by one or a few genes that produces discontinuous variation with distinct phenotypes e.g. gender, horned/polled cattle, seed colour
crossing over	exchange of genetic material (DNA) between adjacent homologous chromosomes during meiosis that introduces variation in the genotypes of the gametes/offspring
mutation	random change in the genetic composition (DNA/gene/ chromosome) of a cell
mutant	an organism, cell or gene produced as a result of a mutation
gene (point) mutation	a change in the base pair sequence of the DNA in a gene, triggered by mutagenic agents e.g. X-rays, radiation or chemicals
chromosome mutation	change in the structure/number of chromosomes
polyploidy	a mutation with more than two sets of homologous chromosomes in a cell due to abnormal cell division e.g. triploid (3 sets) or tetraploid (4 sets); results in beneficial characteristics in plants like increased vigour or disease-resistance
aneuploidy	a mutation due to a change in the normal number of chromosomes e.g. an extra chromosome leads to trisomy (3 chromosomes instead of a homologous pair) which causes growth defects in plants
mutagen/ mutagenic agent	a physical/chemical factor that causes a change in the DNA (mutation) e.g. X-rays, chemicals, ultraviolet radiation

External (environmental) causes are non-hereditary factors from the surroundings e.g. nutrition, climate. Internal (genetic) causes are hereditary factors in the genotype affected by: crossing over in meiosis, fertilisation, DNA mutations.

SELECTION

selection	process by which genetically superior organisms are chosen for breeding to produce quality offspring with desirable characteristics
heritability	the degree to which a characteristic/phenotype is determined by genes as opposed to environmental effects; expressed as a percentage and determines farming strategy focused on breeding or improving environment
estimated breeding value (EBV)	indicator of the genetic merit of an animal, the value of the genes passed onto offspring as measured by the performance of the offspring (progeny); expressed as a positive/negative value to indicate whether offspring is above/below average for a particular characteristic
natural selection	individuals with variations best adapted to a particular environment will be selected to survive and reproduce
artificial selection	identifying individuals for breeding based on human intervention to produce new varieties with desirable characteristics
mass selection	inaccurate method of selection for breeding based on phenotype (physical appearance) only
pedigree selection	traditional, slower method of selection based on quality of ancestors (maternal and paternal) rather than the individual
family selection	faster method of selection for breeding based on relatives of the individual from the same generation
progeny selection (animals)	slower method of selection of individuals for breeding based on the records of their offspring in more than one generation
progeny testing/progeny performance	reliable method of selection of individuals for breeding based on the performance/phenotype of their offspring/progeny produced by different matings

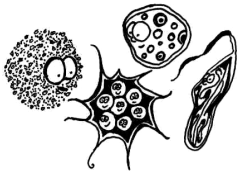
siblings	brothers/sisters that have both parents in common, same father and mother
half-siblings	brothers/sisters that have one parent in common, either mother or father
breeding	mating/crossing animals/plants to produce offspring by sexual reproduction
selective breeding	a process whereby superior organisms are mated/crossed to produce offspring with desirable characteristics
breed/strain	a group of animals with a distinctive set of characteristics as a result of breeding
cultivar	plants with distinctive, desirable characteristics produced through artificial selection
inbreeding	mating/crossing of plants/animals that are closely related to retain desirable characteristics; it introduces weaker characteristics due to expression of homozygous recessive alleles e.g. brother × sister or father × daughter
pure-bred/ inbred	individual produced from inbreeding; a cross of true-breeding/homozygous parents to ensure offspring show desirable characteristics of unmixed breed
inbreeding depression	decrease in performance with each generation in the crossing of two closely related individuals due to expression of homozygous recessive alleles, the opposite of hybrid vigour/heterosis e.g. loss of vigour and lethal genes
linebreeding	form of inbreeding where a superior individual is mated with less closely related individuals so that progeny maintain desirable characteristics from individuals not directly related and show increased homozygocity e.g. grandfather × granddaughter or aunt × nephew
cross-breeding	mating of unrelated individuals of different breeds/strains within the same species to produce offspring with desirable characteristics and greater genetic variation; offspring shows hybrid vigour/heterosis; normally associated with animals

hybrids/ crossbreeds	offspring from hybridisation/crossbreeding of unrelated parents from different breeds/strains of the same species; individuals show hybrid vigour/heterosis
hybridisation	crossing individuals of different species to produce a hybrid which often expresses hybrid vigour/heterosis; normally associated with plants
hybrid vigour/ heterosis	superior characteristics and increase in performance in a hybrid individual compared to both parents e.g. improved yield/fertility/size
outcrossing/ outbreeding	crossing of an unrelated individual with an inbred individual within the same breed or species
upgrading	rapid system of crossbreeding where a superior pure-bred male (good sire) is mated with females of inferior breed from a poor herd generation after generation to produce better quality offspring and eventually a superior herd/pure-breeding/pedigree stock
species crossing	a breeding system where individuals from similar, but different species are mated to produce offspring with desirable characteristics, offspring are often sterile e.g. horse × donkey = mule (hardy, stronger to carry heavy loads)

The term 'hybrid' is normally associated with plants and 'crossbreed' is commonly associated with animals.

GENETIC MODIFICATION/ENGINEERING

genetic modification (GM) or genetic engineering	direct manipulation of the genes/DNA by inserting genetic material from one organism to another to introduce desirable characteristics e.g. genetically engineered bacteria produce vaccines/insulin
genetically modified organism (GMO)/ transgenic organism	organism that has genes from another organism inserted into its DNA to express desirable characteristics e.g. drought-resistance, improved taste, increased size
recombinant DNA technology	manipulation of genetic material to form a modified DNA fragment with a desirable characteristic called recombinant DNA
gene libraries	host cells/organisms that produce/store genes used in DNA technology e.g. yeast cells, bacteria



Question 22

In an animal production unit the following data of heifers has been collected for breeding purposes:

Live mass (kg)	134	135	136	137	138	139	140	141	142	143	144	145	146
Number of animals	10	15	20	30	40	60	75	65	45	35	15	10	5

22.1 Give the appropriate term for the phenomenon represented by the data above. (1)

22.2 Determine the number of heifers if 12% of the total number of heifers are selected. (3)

22.3 Use the data to find the mass of an average heifer. (1)

22.4 In a normal commercial production unit, what would a farmer do with:

22.4.1 heifers with the highest live mass (1)

22.4.2 heifers with the lowest live mass (1)

Question 23

A commercial farmer has seven different breeds of sheep on four different experimental farms. There is a huge variation in the weights of the sheep on different farms. The record of samples of the lambs picked from the four farms are as follows:

Kilogram	Number of lambs
20 - 29	2
30 - 39	5
40 - 49	8
50 - 59	10
60 - 69	6
70 - 79	3
80 - 89	2

23.1 Translate the information in the table to a line graph. (5)

23.2 State **two** environmental causes of variation in the weight of the lambs. (2)

23.3 Indicate whether the characteristic that caused the type of variation in the table is qualitative or quantitative. (1)

23.4 Justify your answer in Question 23.3. (2)

Question 24

Mutagens change the genetic material of an organism causing errors in the genes of organisms. How will the following mutagenic agents affect the DNA structure of the gene?

24.1 gamma and X-rays (1)

24.2 metals such as nickel and chromium (1)

24.3 viruses (1)

Question 25

The table below shows the estimated breeding value (EBV) for specified characteristics in Bonsmara cattle and Boer goats.

Species	Characteristic	Heritability
Bonsmara	Birth weight	38
	Post-weaning weight	30
	Meat tenderness	65
	Lean meat	38
Boer goat	Birth weight	35
	Post-weaning weight	60
	Lean meat	35
	Fleece weight	12

21.3 **Continuous variation**

- complete range of characteristics from one extreme to another

Discontinuous variation

- has a few clear-cut forms/no intermediate forms in between (2)

21.4
- process of choosing/identifying specific individuals
- for their desired characteristics/traits
- to be used in the production of quality offspring. (3)

Question 22

22.1 continuous variation (1)

22.2 Total:
10 + 15 + 20 + 30 + 40 + 60 + 75 + 65 + 45 + 35 + 15 + 10 + 5
= 425 ✓

∴ 12% (0,12) × 425 ✓ = 51 heifers ✓ are selected (3)

22.3 Average mass = 140 kg (1)

look for the biggest 'Number of animals' in the table

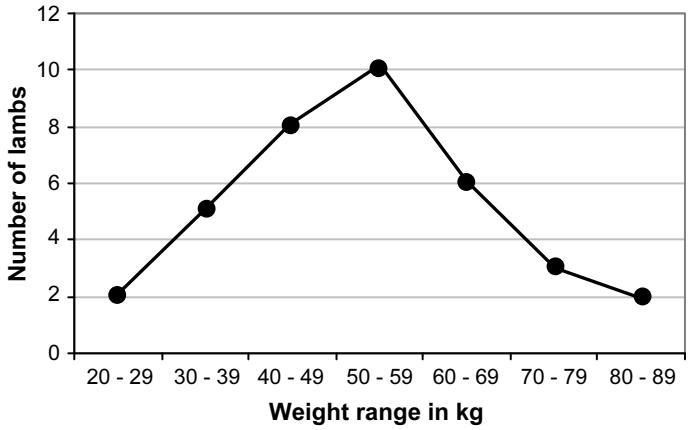
22.4.1 selection for breeding purposes (1)

22.4.2 cull/slaughter/sell (1)

Question 23

23.1

Variation in the weight of different breeds of sheep



Marking guidelines:

- line graph ✓
- correct heading ✓
- correct labelling of x and y axes ✓
- correct scaling ✓
- correct plotting of points ✓

(5)

23.2
- diet
- shelter
- pest and diseases
- water
- climate

(any 2) (2)

23.3 quantitative (1)

23.4
- the characteristic is measurable/or can be quantified
- can take on a whole series of values like body size/weight/ wool production, etc. (2)

Question 24

24.1 damages DNA molecule and causes it to break (1)

24.2 change the chemical structure of a DNA molecule (1)

24.3 insert their own DNA (1)

Question 25

25.1 Bonsmara - meat tenderness

Boer goat - post-weaning weight (2)

25.2 The heritability of both characteristics is greater than 50% **OR** more controlled by genes (2)

25.3
- heritability is less than 50%
- characteristics will be more influenced by the environment **OR** less controlled by genes (2)