

Oct 31/2015

BIOL*1090
Introduction to Molecular and Cellular Biology
Midterm Examination Fall 2015

31 October 2015

Dr. Van Raay

VERSION # 2

Part A: Multiple choice (35 marks)

Part B: Problem solving, short answer and fill in the blanks (32 marks)

Total marks: 67

Total time: 120 minutes

1. **PRINT your name and student number** in the spaces provided at the top left corner of this page AND on the Test Scoring Answer Sheet.
2. This examination consists of **16 pages** and is in two parts, Sections A and B. Please attempt ALL questions for Section A. Follow the instructions for Section B.
3. Answer Section A **IN PENCIL** on the provided **Test Scoring Answer Sheet**. **ONLY** Test Scoring Answer Sheets will be marked for Section A.
4. Answer sections B in pen using the space provided on the question paper itself. **Part B written in pencil may not be submitted for a regrade.**
5. This examination terminates after **exactly 90 minutes**.

Part A: SCANTRON

Part B:

30.5
/32

Marker Initials:

Part A. Multiple Choice (35 marks)

Select the **BEST** answer to the question provided and mark it on your Test Score Answer Sheet. A correct answer is worth one mark.

1) The principle of segregation states that:

- a) In a homozygote, two different alleles separate from each other during the formation of gametes
- b) In a heterozygote, two different alleles separate from each other during the formation of gametes.
- c) In a heterozygote two identical alleles separate from each other during the formation of gametes
- d) In a heterozygote two of the same alleles do not separate from each other during the formation of gametes
- e) None of these are correct

2) Recombination happens during which stage of meiosis:

- a) Meiosis I, Prophase stage
- b) Meiosis I, Metaphase stage
- c) Meiosis II, Metaphase stage
- d) Meiosis II Prophase stage
- e) Meiosis I, Diplomena stage

3) The ABO blood system in humans is controlled by three distinguishable alleles. Two of the alleles are dominant over the third allele. This is an example of what genetic principle?

- a) Allelic Series
- b) Incomplete dominance
- c) Codominance
- d) Dominant Negative
- e) Plieomorphism

4) A mutant allele that interferes with the function of the wild-type allele is known as:

- a) Loss of function mutation →
- b) Partial loss of function mutation
- ~~c) Recessive mutation~~
- d) Gain of function mutation →
- e) Dominant negative mutation

answer → e)

5) A medical technician is analyzing a blood sample in a clinical lab. It is determined that the red blood cells have just the A antigens on their surface. In this case, the genotype of the red blood cells is:

- ~~a) Homozygous ii~~
- ~~b) Heterozygous $I^A I^B$~~
- c) Heterozygous $I^A i$
- ~~d) Heterozygous Ao~~
- ~~e) Codominant $I^A I^B$~~

6) Which of the following can control gene expression?

- a) Temperature
- b) Biological factors such as an individual's sex
- c) Diet
- d) None of these
- e) All of these

7) Why was Mendel successful at tracking patterns of inheritance?

- a) Mendel used the garden pea, which at the time, was a good model organism
- b) Mendel tracked only one contrasting phenotypic characteristic at a time \rightarrow yes
- c) Mendel used an organism that was true breeding \rightarrow yes
- d) a, b and c could be true
- ~~e) The other monks were too busy brewing beer~~

8) The morphologic output of an organism's allelic constitution is also known as its:

- a) Phenotype \rightarrow
- b) Mosaic nature
- c) Genotype
- d) Genetic code
- e) Appearance

$A^Y \quad A^Y \quad A^+$
 $A^Y \quad A^Y A^+ \quad A^Y A^+$
 $A^+ \quad A^Y A^+ \quad A^+ A^+$

9) In mice, a cross between $A^Y A^+$ heterozygotes produces two kinds of progeny, yellow ($A^Y A^+$) and gray-brown ($A^+ A^+$), in a ratio of 2:1. Why is there an altered ratio of individuals produced?

- a) $A^Y A^Y$ individuals die during embryonic development due to the presence of a lethal mutation
- ~~b) $A^Y A^+$ individuals are physiologically more able to adapt to the birth process~~
- ~~c) There is more than one gene that controls coat colour, leading to non-mendelian ratios~~
- ~~d) $A^Y A^+$ individuals are the mutant phenotype and occur more frequently in nature~~
- ~~e) The single A gene controls two traits: coat colour and early development~~

10) Which of the following is a principle that Mendel could have only discovered using dihybrid crosses?

$Aa Bb$

- 1. Principle of segregation \rightarrow
- 2. Principle of dominance \times
- 3. Principle of independent assortment

- a) 1
- b) 2
- c) 3
- d) 1 and 2
- e) 2 and 3

11) What is a genetic cross between one homozygous recessive individual and one of unknown genotype?

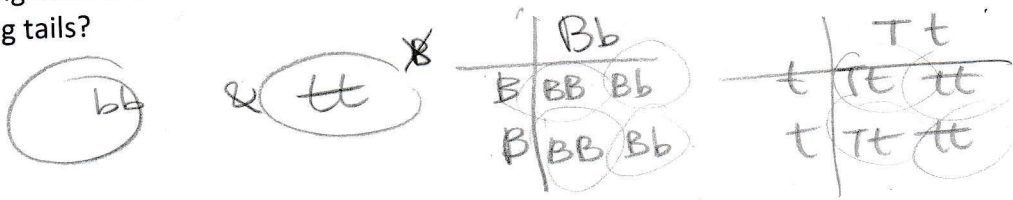
- a) Self cross
- b) Complementation Test
- c) Dihybrid cross
- d) Test cross \rightarrow
- e) F1 cross

12) In a monohybrid cross, if the P generation consists of plants that are true breeding then the F2 generation will consist of organisms that exhibit what ratio of dominant phenotypes to recessive phenotypes?



- a) 3:2
- b) 1:2
- c) 1:3
- d) 3:1
- e) None of these

13) Black fur (b) in mice is recessive to white fur (B). Short tails (T) are dominant to long tails (t). What proportion of the offspring from a cross between an individual with the genotype $BbTt$ and $Bbtt$ will have black fur and long tails?



- a) 1/16
- b) 3/16
- c) 6/16
- d) 1/2
- e) none of these

14) In human and other mammals, the number of cells that result from oogenesis is:

- a) One egg
- b) Two eggs
- c) One egg and one polar body
- d) One egg and two polar bodies
- e) One egg and three polar bodies

15) Which of the following best reflects mitosis?

→ NOT cell cycle!

- a) Prophase, Metaphase, Anaphase, Telophase ✓
- b) Interphase, Metaphase, Anaphase, Prophase, Telophase, Cytokinesis
- c) G1, Synthesis, G2, Prophase, Metaphase, Anaphase, Telophase, Cytokinesis ✓
- d) Interphase, Prophase, Metaphase, Anaphase, Telophase, Cytokinesis
- e) None of the above, these all reflect meiosis.

16) Which of the following is not part of the mature mRNA:

- a) UTRs
- b) Introns ✓
- c) Exons — is
- d) Shine-Dalgarno sequence
- e) Poly A tail — is

introns

17) Which of the following is a method for analyzing a cross involving 2 genes?

- a) Punnett Square Method
- b) Forked Line Method
- c) Probability Method
- d) All of these
- e) None of these

18) DNA in a double helix is antiparallel. What does antiparallel mean?

- a) The bases are hydrogen bonded to each other
- b) The backbone is made up of phosphodiester linkages
- c) One strand runs in a 5' to 3' direction, and the other strand runs in a 3' to 5' direction
- d) A bonds to T and C bonds to G
- e) Each strand serves as a template for the other

19) Which of the following is NOT true in the generation of Prokaryote proteins:

- a) There are -10 and -35bp regions upstream of the mRNA transcription start site *true*
- b) Polymerase binds directly to the DNA *true*
- c) Several genes can be transcribed on one mRNA transcript *true.*
- d) Transcription initiation is DNA sequence independent →
- e) Transcription and translation can occur simultaneously *true.*

20) Two possible mutations that could result in a prematurely truncated protein are:

- a) Nonsense mutation; Insertion of 1 nucleotide *early stop*
- b) Random mutation; Silent mutation *Nonsense.*
- c) Deletion of 3 nucleotides; Frameshift mutation
- d) Missense mutation; Insertion of 2 nucleotides
- e) Silent mutation; Deletion of 2 nucleotides

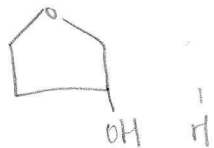
21) It is well known that as you get older there are two things that don't stop growing: your nose and your earlobes. Assume that you are homozygous "AA" at the ear lobe attachment locus and the cells in your ear lobe are undergoing cell division. Which of the following is/are true?

- a) One of these cells will undergo meiosis resulting in 4 haploid cells each carrying the "A" allele
- b) After cytokinesis, each cell will be genetically unique
- c) Several of the cells may exit the cell cycle, each ending up with 4 copies of the "A" allele
- d) After DNA synthesis there will be 4 copies of the "A" allele →
- e) None of these are true



22) Which of the following is not true?

- a) At position 2' on the pentose sugar, RNA has a hydroxyl group, but DNA does not → *true*
- b) The DNA template strand is in the 3' to 5' direction *true.*
- c) RNA is transcribed in the 5' to 3' direction *true*
- d) RNA is unstable, DNA is stable *true*
- e) Protein is translated and synthesized in the 5' to 3' direction *true.*



23) In mammals, dosage compensation for X-linked genes is achieved by:

- a) Hyperactivating one of the X chromosomes in males
- b) Inactivating the Y chromosome in males
- c) Inactivating the Y chromosome in females
- d) Inactivating one of the X chromosomes in females →
- e) Inactivating one of the X chromosomes in males

24) You cross your favourite red rose (YY) with your favourite yellow rose (yy) and end up with a beautiful orange rose. This can best be explained by the phenomenon of:

- a) Dominance hierarchy
- b) Incomplete dominance →
- c) Co-dominance
- d) Dominant negative allele
- e) All of the above

25) Which of the following is not representative of the genetic code?

- a) Codons are adjacent
- b) Genetic code is degenerate ✓
- c) Genetic code is non-overlapping ✓
- d) Genetic code is nearly universal ✓
- e) Genetic code is unordered → *fake*

3' CGTA 5'
mRNA) (GCA)

26) Which of the following statements is false?

- a) Gene action can be controlled by the environment → *me*
- b) Male patterned baldness is an example of a sex-linked trait. → *False*
- c) A single gene can control different phenotypes → *b*
- d) A phenotype can be influenced by 2 or more genes. → *b*
- e) Coat colour in rabbits is an example of an allelic series → *b*

5' ATGC 3'
CGTA
compliment) → TACG
r/c) → (GCA)

27) The sequence of the mRNA is most similar to:

- a) The DNA nontemplate strand
- b) The reverse complement strand
- c) snRNA
- d) a and c
- e) a and b

3' CGTA
compi → (GCA)
3' ATGC 5'
compliment : TACG
mRNA) : UACG

28) Which of the following is true in the generation of eukaryotic proteins:

- a) Termination of transcription requires a hairpin sequence followed by 6 'A' nucleotides^f
- b) Polymerase recognizes termination sequence AAUAAA, and the mRNA is cleaved at downstream GU site ✓
- c) Transcription occurs in the cytoplasm, translation occurs in the nucleus^f
- d) TATA box occurs approximately 20 upstream of the translation initiation site *true.*
- e) Ribosomal machinery binds DNA^f

transcription

29) You have a plant breeding program in your dorm room. All plants are of the same species, most are flowering but a few, in every couple of generations, do not flower. Which of the following statements best describes the genetics of your plants?

- a) Flowering is recessive
- b) Flowering is co-dominant
- c) Having no flowers is dominant
- d) Flowering is dominant
- e) None of these

Most flower

30) From the question above, you are curious about the non-flowering ones and so you incross or selfcross these for several generations and are confident you now have a true breeding, non-flowering plant (how you can breed a non-flowering plant is a mystery, but just assume that you can). You can now use this plant for:

- a) Performing a test cross with your flowering plants to determine their genotype → yes
- b) Perform a complementation test between several of your other non flowering plants of the same species to identify new alleles
- c) Perform a complementation test between several of your other non flowering plants of the same species to identify new genes
- d) (a) and (b) are correct
- e) (a), (b) and (c) are correct

answer.
e)

same alleles
gene

or diff genes

BB cc x bb CC
dihybrid cross

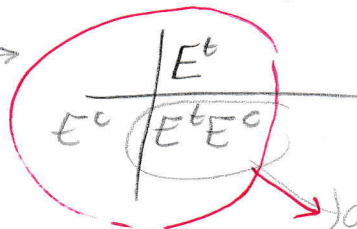
$E^t E^t$ vs. $E^c E^c$

Bc / $BbCc$

31) A complementation test is essentially:

- a) A monohybrid cross
- b) A dihybrid cross
- ~~c) A test cross~~
- ~~d) A test of epistasis~~
- e) Both a and b

answer e).



all are

true

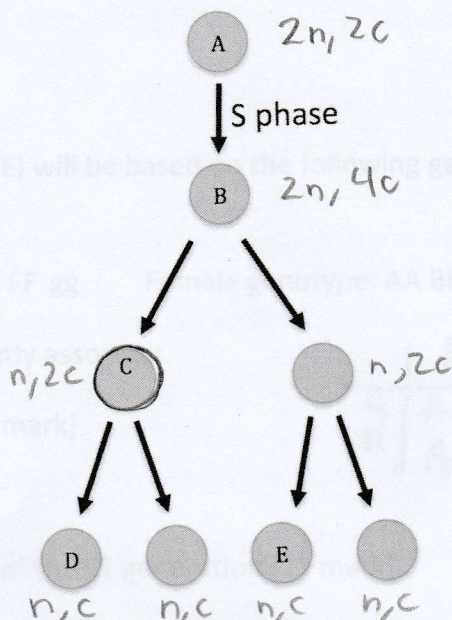
32) A dihybrid cross is one in which:

- a) One trait is being studied
- b) Two organisms are being studied at the same time
- c) Two traits are being studied at the same time
- d) One organism is being studied
- e) None of these

Scanlon - manissa

questions - Prof raay

For questions 33 to 35 refer to the diagram below. Circle A is a spermatogonium that will enter meiosis to eventually give rise to 4 mature sperm, two of which are labeled D and E:



33) The numeric values for ploidy level (n) and the DNA content (c) for the labelled circle C is:

- a) $n=2; c=4$
- b) $n=4; c=2$
- c) $n=2; c=2$
- d) $n=4; c=4$
- e) $n=1; c=2$

34) The numeric values for ploidy level (n) and the DNA content (c) for the labelled circle B is:

- a) $n=2; c=4$
- b) $n=4; c=2$
- c) $n=2; c=2$
- d) $n=4; c=4$
- e) $n=1; c=2$

2, 4

35) Which of the steps is most like mitosis?

- a) A to B
- b) B to C
- c) C to D
- d) B to D
- e) B to E

meiosis (2)
 $c \rightarrow D$

Part B (11 questions, 32 marks): Problem solving, short answer, fill in the blanks

1) The following 5 questions (A-E) will be based on the following genotype of the P generation: [6 marks total]

Male genotype: aa BB CC DD ee FF gg Female genotype: AA BB cc DD EE ff gg

All of the genes are independently assorting.

A) How many loci are there? [1 mark]

7

	A	A
a	Aa	Aa
a	Aa	Aa

B) What is/are the genotype(s) of the F1 generation? [1 mark]

Aa BB Cc DD Ee Ff gg

C) How many different kinds of gametes will be produced by the F1's? [1 mark]

$(2)(1)(2)(1)(2)(2)(1) = 2^4 = 16$ gametes

* D) What is the ploidy level (n) and DNA content (c) of the F1 generation? [1 mark]

n = 2 ; c = 2

E) The F1's are self-crossed. What is the probability of generating the following genotype:

CC DD Ee gg? Show your work (Ignore the A, B and F genes). [2 marks]

F1: ~~Aa~~ BB Cc DD Ee ~~Ff~~ gg × Cc DD Ee gg

c	c
C	Cc
c	cc

D	D
D	DD
D	DD

E	e
E	Ee
e	ee

g	g
g	gg
g	gg

$P(cc) = \left(\frac{1}{4}\right) \times P(DD) = (1) \times P(Ee) = \left(\frac{1}{2}\right) \times P(gg) = (1) = \left(\frac{1}{8}\right)$

is the probability

2) Taking linear, double stranded DNA and packaging it into the nucleus is quite a feat. There are several levels of condensation that have to occur to achieve this and a different level of condensation occurs during cell division. Fill in the missing information as required. [12 marks]

- A. Diameter (in nm) of linear, double stranded DNA before any proteins are added is: 2
- B. The nucleosome core is composed of DNA wrapped around this number of histones: 8
- C. The length of DNA (in nucleotide pairs) wrapped around this nucleosome core is: 146
- D. Diameter of the nucleosome core (in nm) is: 11
- E. The complete nucleosome has one more histone called: Histone H1
- F. The last histone added stabilizes the complete nucleosome which then undergoes supercoiling to form the 2nd round of DNA condensation that has a diameter (in nm) of: 30
- G. This chromatin fiber is the basic structural unit of the metaphase chromosome.
- H. After DNA synthesis each chromosome is duplicated to form sister chromatids. These sister chromatids are identical with respect to one another.
- I. After DNA synthesis, sister chromatids are held together by the protein: Cohesin.
- J. Once the cell enters mitosis the DNA is further compacted by the protein: condensin.
- * K. Around metaphase, the protein that holds the sister chromatids together begins to break down except at the: Centromere.
- L. Both proteins are completely broken down and the chromosomes de-condense at this stage of mitosis: telophase

3' TACG 5'

5' AUGC 3'

Refer to the single stranded DNA below to answer questions 3, 4 and 5.



3) What is the complementary sequence? Show just the first 8 nucleotides and make sure to include labels for orientation. [1 mark]



4) What is the reverse complementary sequence? Show just the first 8 nucleotides and make sure to include labels for orientation. [1 mark]

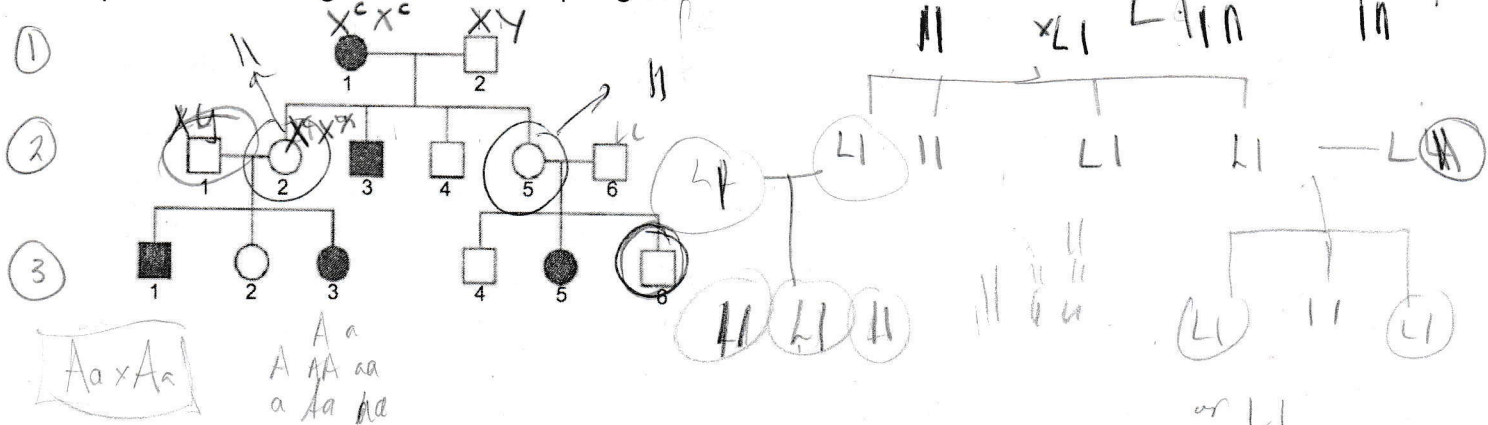


5) What is the sequence of the mRNA? Show just the first 8 nucleotides and make sure to include labels for orientation. [1mark]



More questions on the next page

For questions 6 through 10 refer to this pedigree:



6) If the pattern of inheritance is dominant, what genetic phenomenon can account for individuals II-2 and II-5? [1 mark]

~~(sex linked gene)~~

~~II-2 & II-5 are female non-carriers~~

Individuals II-2 and II-5 are homozygous recessive females.

7) What evidence is there that the pattern of inheritance is recessive? Be specific. [1 mark]

- Looking at II-1 and II-2, both are unaffected thus their genotype (if inheritance was dominant) would have to be homozygous recessive (e.g. aa) and if you cross aa x aa, all children should have been unaffected which is NOT TRUE!

8) If the pattern of inheritance is recessive what is one of the assumptions about recessive traits that does not really hold true? [1 mark]

recessive inheritance

~~that individuals marrying into the~~

→ They skip a generation!

→ And that individuals marrying into the family won't carry recessive genes (again looking at II-4 the mames in & most carry recessive gene)

9) Assuming a recessive mode of inheritance, what is the probability that III-6 is a carrier? [1 mark]

→ II-5 and II-6 must have genotype Aa x Aa

→ $\begin{matrix} & A & a \\ A & AA & Aa \\ a & Aa & aa \end{matrix}$ Probability is 1/4
Carrier is Aa thus it is $\frac{2}{3}$

10) Assuming a recessive mode of inheritance, what is the probability that the next child of couple II-1 and II-2 will be affected? [1 mark]

→ Both are heterozygotes... are Aa x Aa.

$\begin{matrix} A & a \\ A & AA & Aa \\ a & Aa & aa \end{matrix}$ } probability is $\frac{1}{4}$ that the child is affected! 4

DO EITHER QUESTION 11 OR QUESTION 12. NOT BOTH. We will only mark Question 11 if it is not clear which one you attempted.

11) Hemophilia is a sex-linked trait. A normal woman marries a normal man and they have 1 daughter and 2 sons. One son has hemophilia but the other two are normal. The normal daughter marries a hemophiliac man and they have 3 sons and 2 daughters. One son and one daughter have hemophilia but other 3 children are normal. [6 marks]

A) Draw a pedigree showing the sex-linked genotypes of all the individuals in the pedigree. [3 marks]

B) What is the probability that the unaffected granddaughter is a carrier? [1 mark]

C) What is the probability that the original couple will have another child that has hemophilia? [2 marks]

12) A couple, both heterozygous for a recessive mutation, want to have a family of 4 children, but need to know the risks of having only two of these children with the disease. Using the binomial probability formula below, calculate the probability that only 2 of the 4 children will be homozygous recessive. Show your work. [6 marks]

$$\left[\frac{n!}{x! y!} \right] p^x q^y$$

heterozygous couple: Aa x Aa

	A	a
A	AA	Aa
a	Aa	aa

p (h. recessive) = 1/4

p (not h. recessive) = 3/4

$$= \frac{4!}{2! 2!} \left(\frac{1}{4} \right)^2 \left(\frac{3}{4} \right)^2$$

= 0.2109375

= $\frac{27}{128}$ is the probability only

2 of 4 children are

homozygous recessive

therefore affected.