1. What is the average distance in nucleotides between the restriction site in organism X for the following restriction enzyme AND what type of ends does the enzyme *Pst* I create after restriction endonuclease digestion? Assume an AT:CG ratio of 25:75.

/ is the cut site

***Pst* I**	***Providencia stuartii***	**5′ CTGCA/G 3′** **3′ G/ACGTC 5′**

A. $(4)^6$ nucleotides AND 3' sticky ends
B. $(3)^4$ / $(4)^6$ nucleotides AND 3' sticky ends
C. $(4)^6$ nucleotides AND 5' sticky ends
D. $(3)^2$ / $(4)^6$ nucleotides AND 3' sticky ends
E. $(4)^3$ nucleotides AND 5' sticky ends

Marking: Best Answer B 1 mark (frequency); other marks for 3' sticky ends D 0.5 mark; A 0.5 mark

2. A linear double stranded DNA molecule has two target sites for restriction enzyme *Eco*I. What is the maximum number of unique fragments that can be produced if the sample is completely digested with *Eco*I?

A. 1
B. 2
C. 3
D. 4
E. 6

3. A linear double stranded DNA molecule has two target sites for restriction enzyme *Eco*I and one target site for *Ava*I. What is the maximum number of unique fragments that can be produced if the sample is partially digested with both enzymes?

A. 3
B. 4
C. 6
D. 9
E. 10

4. You are given a sample of a linear double stranded DNA fragment. You are to determine the number and order of restriction cut sites in that DNA. You divide the DNA sample into three aliquots. In your first experiment you digest one aliquot of the DNA sample with *Eco*RV (RV) and after gel electrophoresis you observed three bands indicating fragments 30kb 15kb and 6kb in size. You then digest the second aliquot with *Eco*RI (RI) and after gel electrophoresis you observe four bands indicating fragments that are 18kb, 15kb, 10kb and 8kb in size. With the third aliquot you perform a double digest using *Eco*RV and *Eco*RI and you observe four bands indicating fragment sizes of 15kb, 8kb 7kb and 3kb in size. Which is the correct map of the enzyme cut sites?

A. 3kb RI 8kb RV 7kb RI 15kbRV 15kb RI 3kb

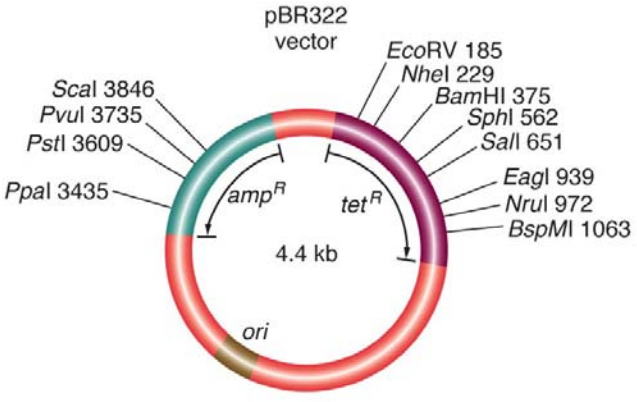
B. 15kb RI 7kb RV 7kb RI 15kbRV 3kb RI 8kb

C. 7kb RI 3kb RV 15kb RI 3kbRV 8kb RI 8kb

D. 15kb RI 15kb RV 3kb RI 3kbRV 7kb RI 8kb

E . 3kb RI 15kb RV 15kb RI 3kbRV 8kb RI 7kb

5. You are given the following vector.



You attempt to insert a sequence of interest after digesting the vector with *Sca*I *and* *Eco*RV in a double digest. What is the phenotype of the host after transformation with recombinant vector?

A. ampR tetS
B. ampS tetR
C. ampS tetS
D. ampR tetR
E. A and C above

6. A plasmid vector has a gene for ampicillin resistance (ampR) and a gene for tetracycline resistance (tetR). The *tet* gene is cut with a restriction enzyme and donor DNA cut with the same enzyme is inserted in the *tet* gene. What phenotype of the cells needs to be selected to show evidence of transformation with the recombinant vector?

A. ampR tetS
B. ampS tetR
C. ampS tetS
D. ampR tetR
E. tetR only

7. Using Southern Blot analysis, a clone of a region of the factor IX gene from rat is radiolabelled and used under high temperature and low salt conditions to probe an *Eco*RV digest of genomic DNA from a mouse. The autoradiogram shows no labelling. This means that

A. mice do not have a factor IX gene
B. mice do not have a factor IX-like gene
C. the mouse factor IX gene is present in low copy number in the genome
D. the protocol stringency was too high
E. the protocol stringency was too low

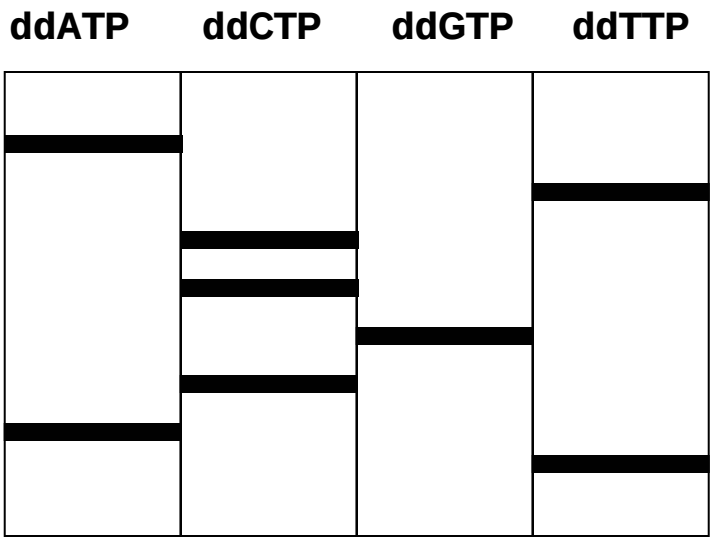
8. You have an extremely large insert that you wish to ligate into a cloning vector. Which vector would you be least likely to use?

A. YAC
B. BAC
C. PAC
D. plasmid
E. lambda phage

9. A researcher is looking for a method to digest a sample of genomic DNA to obtain a collection of small fragment sizes and is not concerned about where the genomic DNA is cut. A rapid and lowest cost method would be which of the following?

A. Subject the genomic DNA to minimal amounts of physical shearing
B. Subject the genomic DNA to excessive amounts of physical shearing
C. Digest the genomic DNA with multiple restriction endonucleases
D. Digest the genomic DNA with a single four-base cutter
E. Digest the genomic DNA with a single eight-base cutter

10. After using the Sanger method for sequencing DNA (dideoxy nucleotide methods), you observe the following autoradiogram. Samples were loaded at the top and electrophoresis is from top to bottom.



From the autoradiogram, which nucleotide on the nascent strand is furthest from the sequencing primer:

A. ddATP
B. ddCTP
C. ddGTP
D. ddTTP
E. it is not possible to determine this from the information provided

11. Which of the following does base 1 to 100 of a DNA sequence chromatogram represent?

A. the sequence of the template DNA strand 5' to 3'
B. the sequence of the nascent DNA strand 5' to 3'
C. the sequence of the nascent DNA strand 3' to 5'
D. the nascent sequence furthest from the sequencing primer
E . the DNA strand complementary to the strand represented in an autoradiogram of a Sanger dideoxynucleotide sequencing reaction

12. Assume that a genome mapping project used the following methods: DNA sequencing (D), RFLP mapping (R), Gene mapping (G), SSR mapping (S), and physical mapping (P). Which of the following is the most appropriate order of these techniques in terms of decreasing resolution?

A. DRGSP
B. PSGRD
C. DPSRG
D. GRSPD
E. RSPDG

13. Which of the following best describes the inheritance of a particular autosomal microsatellite marker present in a mother who is homozygous for that marker?

A. must be present in all children
B. may be in at least ½ of her children on average
C. may be in at least ¼ of her children on average
D. will be rare in her children
E. cannot be present in any of her children

14. Which of the following best describes the inheritance of a particular autosomal minisatellite marker present in a father who is hemizygous for that marker?

A. must be present in all children
B. may be in at least ½ of his children on average
C. may be in at least ¼ of his children on average
D. will be rare in his children
E. cannot be present in any of his children

15. Which of the following is the number of closed reading frames in the following sequence from a double stranded genome?

5'-TTTTGAATTAAATCCTCAG-3'

A. 1
B. 2
C. 3
D. 4
E. 5

16. Which marker provides the lowest resolution mapping?

A. RFLPs
B. SNPs
C. SSRs
D. minisatellites
E. Geimsa band

17. Which of the following is the order of the clones E,F,G and H in their contig?

BAC Clone	STSs
E	4 3 2
F	6 9
G	3 6 7 8
H	1 2 4

A. EFGH
B. GHFE
C. FHGE
D. HEGF
E. HGEF

18. Which of the following terms best describes mutations resulting in the conservative substitution of amino acids?

A. synonymous substitutions
B. silent mutations
C. spontaneous mutations
D. nonsense mutations
E. missense mutations

19. Which of the following is the mutation resulting in high frequency from a pyrimidine dimer?

A. GG to TT tandem-base mutation
B. CC to TT tandem-base mutation
C. deletion
D. insertion
E. nonsense mutation

20. What is the interaction between planar nucleotide mimics and DNA such that the presence of DNA and the length of DNA fragments can be deciphered following gel electrophoresis?

A. mutation
B. intercalation
C. ligation
D. adduct formation
E. alkylation

21. Acridine Orange and Ethidium Bromide cause which type of mutations?

A. G to T transversions
B. CC to TT tandem-base mutations
C. C to T transitions
D. chromosomal rearrangements
E. deletions and insertions

22. Which mutation type would you chose to induce if you wanted to assess the phenotypic effect of the complete absence of gene function?

A. base substitution in the 3'UTR
B. transposable element insertion interrupting the promoter sequence
C. nonsense mutation in a 3' exon
D. conservative substitution in a 5' exon
E. base substitution in a splice site for a 5'exon

23. Which of the following mutations defines the situation where a patient has the mutation in every cell of their body but neither parent has the mutation in any cell of their bodies?

A. somatic mutation
B. germline mutation
C. nonsense mutation
D. conservative mutation
E. nonconservative mutation

24. Which of the following does not produce a spontaneous mutation?

A. Aflatoxin
B. cytosine methylation
C. transposon mobility
D. depurination
E. deamination

25. In the *E. coli lacI* gene, the sequence CTAACTAACTAACTAA is most prone to which type of mutation?

A. transversion
B. deletion
C. reversion
D. transition
E. inversion

26. In the mouse alcohol dehydrogenase gene, the sequence ATCGTA is most prone to which type of spontaneous mutation?

A. transversion
B. deletion
C. reversion
D. transition
E. insertion

27. Which of the following are physical maps?

A. STS map
B. contig map
C. restriction map
D. an ordered sequence of overlapping clones
E. all of the above

28. Which of the following is the minimal tiling path for the following data?

BAC Clone	STSs
A	2 3 4 5
B	1 2 3 4
C	5 6 7 8
D	3 4 5 6
E	7 8 9
F	4 5 6 7
G	9 10 11
H	9 10

A. FEBG
B. ACH
C. BFEG
D. ACEH
E. DCHG

29. Which of the following is the correct order of steps in the synthesis of cDNA from RNA?

A. NaOH treatment, reverse transcription, polymerization, S1 nuclease digestion
B. reverse transcription, polymerization, NaOH treatment, S1 nuclease digestion
C. polymerization, NaOH treatment, reverse transcription, S1 nuclease digestion
D. reverse transcription, NaOH treatment, polymerization, S1 nuclease digestion
E. reverse transcription, NaOH treatment, S1 nuclease digestion, polymerization

30. You are creating a high resolution map and want a multiallelic marker. Which of the following would give you the highest resolution map?

A. SNPs
B. RFLPs
C. microsatellites
D. SSRs
E. trinucleotide repeats

31. Which of the following techniques would you use to demonstrate that functional protein has been produced from a gene construct that you inserted into an expression vector and used to transform a host?

A. Restriction Enzyme digest followed by gel electrophoresis
B. Southern Blot
C. Northern Blot
D. Western Blot
E. none of the above

32. The analysis of a nascent strand after DNA sequencing revealed a novel mutation. Which of the following is the most likely mechanism for the following mutation observed?

5' GATATCATATC 3' to 5' GATATAATATC 3'

A. nascent strand slippage
B. template strand slippage
C. adduct formation by a reactive oxygen species
D. intrastrand crosslink
E. deamination

33. You suspect that humans have a gene for curiosity like one recently isolated from cats. An exon of the curiosity gene in the cat was recently sequenced and you designed primers that flank that gene. The primers permit PCR amplification of the gene sequence from cats. You plan on trying to amplify the similar gene in humans using a PCR technique. Which of the following modifications of your first PCR would you make for the greatest likelihood in amplifying a curiosity-like gene in humans?

A. raise the melting temperature
B. increase the extension time
C. raise the extension temperature
D. lower the annealing temperature
E. extend the annealing time.

34. Depurination occurs at an adenine and the SOS response is invoked. Which of the following describe the resulting mutation?

A. transition
B. transversion
C. conservative
D. nonconservative
E. deletion

35. Which of the following mutations likely cause the observation of copy number variants observed using SNP CHIP assays?

A. inversions
B. deletions
C. transitions
D. deletions
E. reversions

This question was dropped from the test due to an inconsistency in the printing across the four versions of the test.

36. A hybrid allotetraploid species (4*n* = 36) was crossed to one of the suspected parents (2*n* = 18). When the F_1 underwent meiosis, the prophase chromosome configuration was examined. If the suspicion about the suspected parent was correct, what would the chromosome configuration look like at the time of chromosome pairing?

A)	27 univalents would be observed
B)	9 bivalents and 9 univalents would be observed
C)	18 bivalents and 9 univalents would be observed
D)	18 bivalents and 18 univalents would be observed
E)	9 trivalents would be observed

37. Two phenotypically normal parents with normal karyotypes have a son who has an XXY karyotype. Discounting new mutation as a reason, which of the following events provides a possible explanation how the son inherited this karyotype?

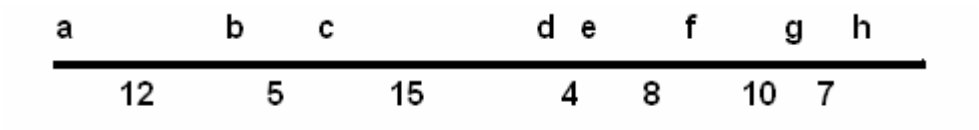
Possible events:-

i) non-disjunction in his father at meiosis I
ii) non-disjunction in his father at meiosis II
iii) non-disjunction in his mother at meiosis I
iv) non-disjunction in his mother at meiosis II

Choose between:-

A) only possibility i)
B) either possibility ii) or iii)
C) either possibility iii) or iv)
D) any of possibilities i), iii) or iv)
E) all of the above possibilities could explain this event

38. The map below shows a region of chromosome # 3 in normal plants of a certain species.



You are given a plant that has one homolog of chromosome #3 that is normal as above and one that has an inversion such that the gene order is now (a b f e d c g h).

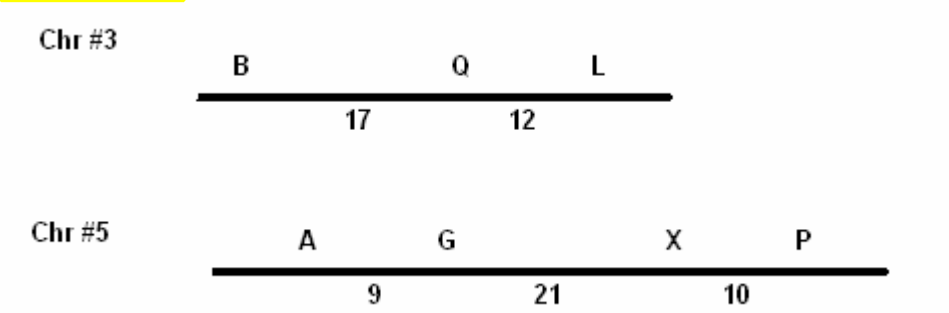
When this plant is used in mapping, what value would you expect to find for the distance between genes f and d ?

A) 12 map units
B) 24 map units
C) 6 map units
D) 0 map units
E) It would be impossible to predict

39. Which of the following might normally be expected to be a lethal event in humans?

A) monosomy
B) an inversion
C) a translocation
D) duplication of a chromosome region
E) two of the above

40. The map of the genes found on chromosomes 3 and 5 in a certain animal is shown below.



You find a new strain (labelled V16) of this same plant that is BbXx. When you testcross V16 to a bbxx plant you find the following results:-

F1 progeny	**B_ X _**	**17**
	B_xx	**35**
	bbxx	**18**
	bbX_	**30**

<u>What event most likely occurred in V16?</u>

A) A paracentric inversion
B) A pericentric inversion
C) A translocation
D) A deletion
E) Chromosome doubling to produce an autopolyploid

41. Males and females of all organisms must have an equal complement of gene products, a failure to properly dosage compensate is lethal. In *Drosophila* this process involves the __i__, normally expressed in __ii__.

A) i) SRY, ii) males
B) i) *mle*, ii) males
C) i) *mle*, ii) females
D) i) *tra*, ii) females
E) i) numerator/denominator, ii) both males and females

42. You are working as a councillor in a medical infertility clinic. You are counselling a young couple in their mid twenties who are having difficulty conceiving a child. You draw blood from both the male and female and inspect the chromosome complement of each. You discover that the genotype of the female is 46XY. What would you suspect as a possible genetic cause of this abnormality?

i) androgen receptor gain of function
ii) translocation of SRY to the X chromosome during meiosis in the female's father
iii) duplication of SRY region
iv) null mutation of the androgen receptor gene

A) i and iii
B) ii and iv
C) i, ii, iii
D) iv
E) all of the above

43. Considering the following cross, what would be the ratio of each sex you would expect in the progeny?

Sxl^{GF}/Sxl^{LF} Dsx^{wt}/Dsx^{LF} x Sxl^{GF}/Sxl^{LF} Dsx^{wt}/Dsx^{LF}

A) 9 females, 3 males, 4 intersex
B) 6 males, 6 females, 1 intersex
C) 12 females, 5 males
D) 15 males, 13 females, 4 intersex
E) 12 females, 3 males, 1 intersex

44. If you were to cross a female fly homozygous for *Den*^{LF} mutation, with a male fly homozygous for a *Tra*^{LF} mutation, and then cross the F1, how many phenotypically male flies would you expect if you had a total of 1000 offspring (assume independent assortment of genes).

A) 571
B) 1000
C) 666
D) 333
E) 0

45. Which of the following statements regarding sex chromosome dosage compensation is correct?
i) Humans balance sex chromosome dosage by inactivating an X chromosome
ii) Male mice are able to inactivate an X chromosome
iii) Male *Drosophila* dosage compensate by hypertranscribing their X chromosome
iv) In humans, non-disjunction of a sex chromosome yields a syndrome typically much less severe than does non-disjunction of an autosome.

A) i and iii
B) ii and iv
C) i, ii and iii
D) iv only
E) all of the above

46. You want to create a mouse strain with a targeted loss of function mutation for an important gene for heart development called *tinman*. Organisms lacking the expression of this gene fail to develop a heart – just like the tin man from the Wizard of Oz! To do this we create a targeted construct with a negative selectable marker. What is the function of the negative selectable marker?

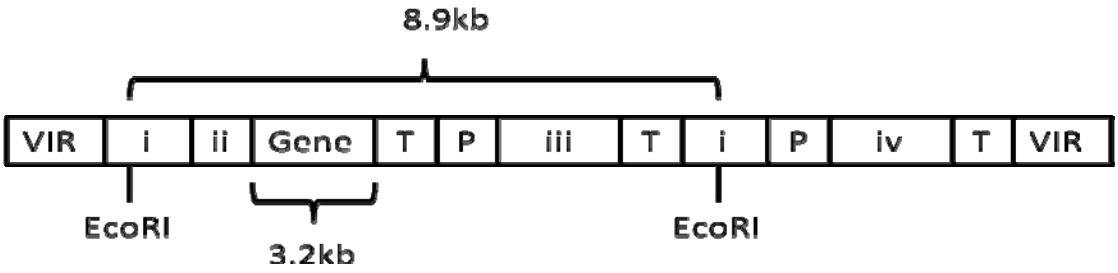
A) Allows the gene to be expressed only in certain tissues and/or at specific times.
B) Will turn the organism green under fluorescent light
C) Yields antibiotic resistance to the organism
D) Selects against organisms that have the construct incorporated improperly
E) None of the above

47. While working in a research laboratory you discover a novel transcription factor important for patterning the limbs, which you call *octopus*. Mice lacking this gene have a duplication of the third, fourth and fifth digits; resulting in eight fingers and toes. In order to study if the *octopus* protein interacts with other proteins *in vivo* you perform a screen in yeast, where you can express two or more genes at the same time and look for interactions. In order to successfully express this gene in yeast you need to create a construct with the following:

A) Multi cloning site, Ori, positive selectable marker
B) Multi cloning site, ARS, negative selectable marker
C) Homologous recombination sequence, negative selectable marker, positive selectable marker
D) Multi cloning site, ARS, positive selectable marker, centromere
E) Multi cloning site, Ori, negative selectable marker, centromere

Questions 48, 49 and 50 all relate to the following information:
One day while vacationing in the tropics one day you are out hiking when your friend points out a chameleon perched on a branch. You yourself had missed the chameleon as it is camouflaged perfectly to the precise colour of the branch on which it is sitting. As you watch, the chameleon begins to slowly walk along the branch and into the leaves, and to your amazement, its body colour changes from brown to green and its body begins to slowly sway back and forth as if it were just another leaf. At this moment a crazy idea comes over you and as soon as you make it back to UWO you set to work in your laboratory to clone the gene(s) responsible for the chameleon's ability to change its body pigment. To your surprise and relief you find that only one gene is responsible. You decide that you could make a great profit if you could market a breed of dog which could camouflage itself much like the chameleon.

48. You begin by creating a targeted construct to an intergenic region of euchromatin which you believe should not disrupt the normal function of genes in the surrounding region. You create a construct suitable for transfection in order to make your mutant canine. The construct you create is as shown below. Label the pieces of the construct correctly.



A) i) homologous recombination sequences, ii) chameleon promoter, iii) positive selectable marker, iv) negative selectable marker

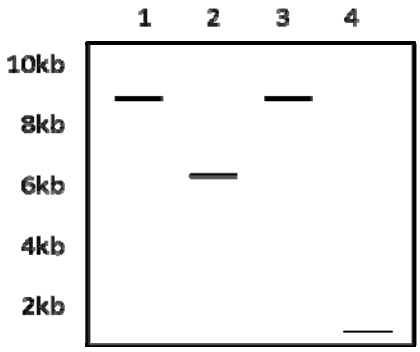
B) i) ARS sequences, ii) chameleon promoter, iii) positive selectable marker, iv) negative selectable marker

C) i) homologous recombination sequences, ii) canine promoter, iii) negative selectable marker, iv) positive selectable marker

D) i) homologous recombination sequences, ii) chameleon promoter, iii) negative selectable promoter, iv) positive selectable marker

E) i) homologous recombination sequences, ii) canine promoter, iii) positive selectable marker, iv) negative selectable marker

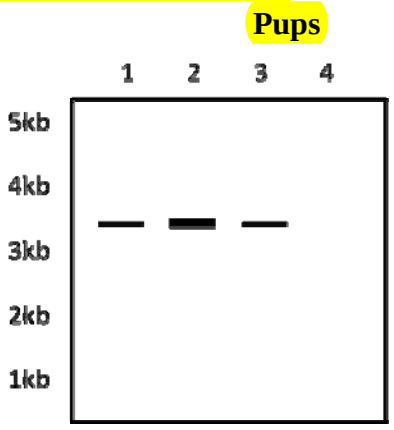
49. The positive marker you use is green fluorescent protein (GFP) inserted behind a promoter specific to the eyes, such that the eyes will glow green when exposed to fluorescent light. After mutating canine embryos and allowing them to develop, you screen the offspring (pups) and find four have eyes which fluoresce green. You draw blood from these individuals, isolate DNA, digest the DNA with *Eco*RI and perform a Southern blot using a probe specific for your gene of interest. If the resulting blot looks as follows:



In which individuals *could* the insert have been incorporated using the intended homologous recombination?

A) 1 and 3
B) 2 and 4
C) 1, 2 and 3
D) 4 only
E) 1, 2,3 and 4

50. While you do not observe any canine pups camouflaging themselves, you decided to confirm that your gene of interest is being transcribed. You take a small sample of skin from the pups and isolate RNA in order to perform a Northern Blot, and you get the following results:



Which of the following can you conclude from this data?

i) Individuals 1, 2 and 3 are transcribing the gene
ii) Individual 2 is transcribing the gene at a greater rate that individuals 1 and 3
iii) Individual 4 is not transcribing the gene
iv) Individuals 1, 2 and 3 are making a functional protein

A) i and iii
B) ii and iv
C) i, ii and iii
D) iv only
E) all of the above