Room CE 6 08:15 – 11:15

BIO-105

EXAMEN 2020

First Name : _____

Last Name : _____

Highest possible score : 61 pt

Grade = (your points / 12) + 1

Tips for rough numerical estimation:

$2^{10} \approx 10^3$
$4^{10} = (2 \cdot 2)^{10} \approx 10^6$

Multiple choice questions: only one answer is correct.

No negative points for the wrong answers.

Question 1 1 pt

A cell is separated from its environment by a plasma membrane.
Inside the plasma membrane, a typical human cell consists of

a. only 1 compartment
b. 2 compartments
c. 3 compartments
d. 4 compartments
e. more than 4 compartments

Question 2 1 pt

In a typical DNA molecule, bonds keeping together the two DNA strands are

a. covalent bounds
b. ionic bounds
c. hydrogen bounds
d. van der Waals bounds
e. hydrophobic interactions

Question 3 1 pt

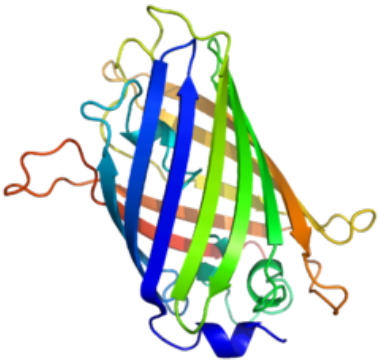
Peptide bonds joining amino acids in a polypeptide are

a. covalent bounds
b. ionic bounds
c. hydrogen bounds
d. van der Waals bounds
e. hydrophobic interactions

Question 4 1 pt

Which type of secondary structure is most abundant and form a barrel in the GFP protein?

_____



Green Fluorescent Protein

Question 5

Eukaryotic cells have three RNApolymerases.
RNApolymerase I is in charge of producing 1 pt

a. mRNA (messengers)
b. tRNA (transfer RNA)
c. rRNA (ribosomal RNA)
d. snRNA (short nuclear RNA)

Question 6 1 pt

When 1 glucose is transformed into 2 pyruvates by glycolysis, the *net* production of ATP is

a. 0 ATP
b. 1 ATP
c. 2 ATP
d. 4 ATP

Question 7 1 pt

E. coli, a Bacterium, has

a. one RNA polymerase

b. two RNA polymerases

c. three RNA polymerases

d. four RNA polymerases

Question 8 **Not covered in 2021** 3 pt

The protein Lac repressor is encoded by the Lac I gene.
The Lac I gene

a. is part of the Lac operon.
RIGHT WRONG

b. encodes a protein that can bind to the Lac promoter and attract an RNA polymerase to the promoter only when lactose is present in the culture medium.
RIGHT WRONG

c. encodes a protein whose DNA binding activity is regulated by phosphorylation.
RIGHT WRONG

d. encodes a protein whose DNA binding activity is regulated by the cAMP concentration.
RIGHT WRONG

e. encodes a protein that recognizes a DNA sequence and binds tightly to it only when lactose is present in the culture medium
RIGHT WRONG

Question 9 **Not covered in 2021** 3 pt

Mitochondria are most likely bacteria that became part of eukaryotic cells by endosymbiosis.
Give at least 3 evidence supporting this view:

_____

_____

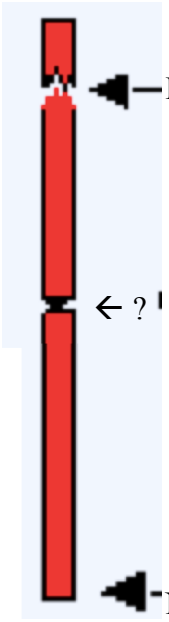
_____

_____

Question 10 **Not covered in 2021**

When a chromosome is broken (double strand DNA break) a repair system is able to rejoin the 2 chromosome fragments.
Explain how this repair system distinguish a DNA break to be repaired from a normal chromosome end.

2 pt



_____

_____

_____

_____

Question 11 1 pt

Exposition to UV light (especially UV B) causes DNA damages.
The typical damage cause by UV light is

a. single strand DNA break.
b. double strand DNA break.
c. Adenine (A) to Guanine (G) mutation.
d. covalent bounds between two Thymine (T) on the same strand.
e. covalent bounds between a Thymine T on one strand and its complementary Adenine (A) on the other strand.

Question 12 1 pt

When the gene encoding the MC4R receptor is deleted in a mice strain, the resulting phenotype is

a. red fur (= yellow fur)
b. obesity because of an excessive food intake
c. red fur and obesity because of excessive food intake.
d. withe fur

Question 13 1 pt

When the gene encoding the MC1R receptor is deleted in a mice strain, the resulting phenotype is

a. red fur (= yellow fur)
b. obesity because of an excessive food intake
c. red fur and obesity because of excessive food intake.
d. withe fur

Question 14 1 pt

Give one biological function of the melanin pigment :

_____

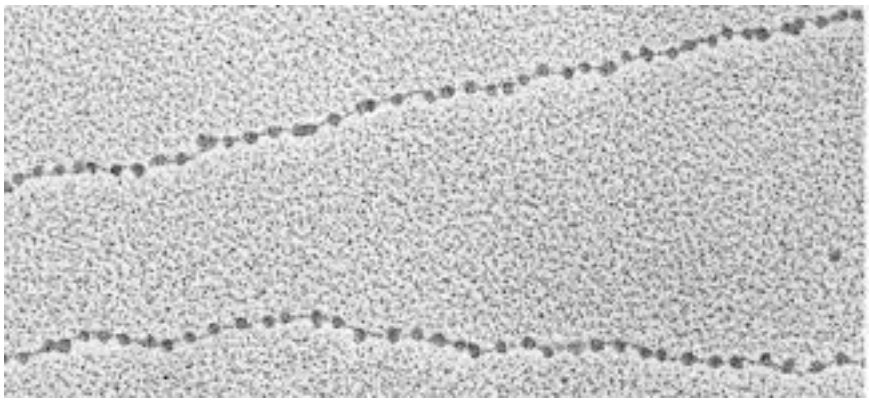
_____

Question 15 1 pt

When a signal molecule released from an emitter cell diffuses around the emitter cell but does not enter the blood stream, the intercellular communication is said to be

_____ (1 word)

Question 16 **Not covered in 2021** 1 pt



The DNA shown on this picture is from

A a Bacterium

B an eukaryotic cell

Question 17

The genome of a bacterium has been sequenced. The entire genome is $2 \cdot 10^6$ bp long. A little portion (100 bp) of the genome sequence is given here :

5' CTAGTCGAT<u>C</u> TGGCTTAT<u>A</u>C GACT<u>A</u>TGCAC GCAAATGCGG CATATAGCGA

TAGCACCTAG TCGCAGTCGC GCGCGCGCTA GTTAGCGTCC GTCTGGCTTG 3'

(10) (19) (25)

17.1 Taking the given sequence as the coding strand 3 pt
what is the length of the polypeptide encoded

a) by the given sequence _____ amino acids

after mutations : only 1 mutation in each scenario, the rest of the sequence is unchanged

b) when, at position 10, C is deleted _____ amino acids

c) when, at position 19, A is replaced by G _____ amino acids

d) when, at position 25, A is replaced by G _____ amino acids

17.2 The DNApolymerase III of this Bacterium works at a speed of 1000 bases/second. Calculate the time required for the replication of the genome :

17.3 You want to amplify the sequence given above using PCR: 3 pt

How many primers do you need to amplify this sequence? _____

How long the primer(s) should be? _____

Justify this length: _____

_____

Give the sequence of the primer(s) you would use:

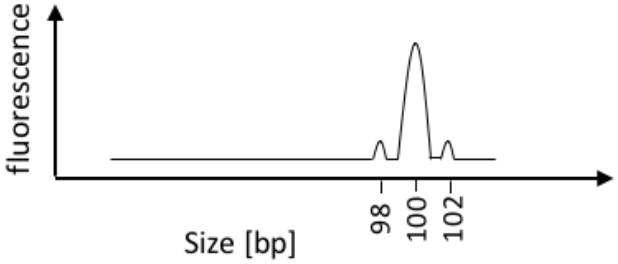
_____

_____

_____

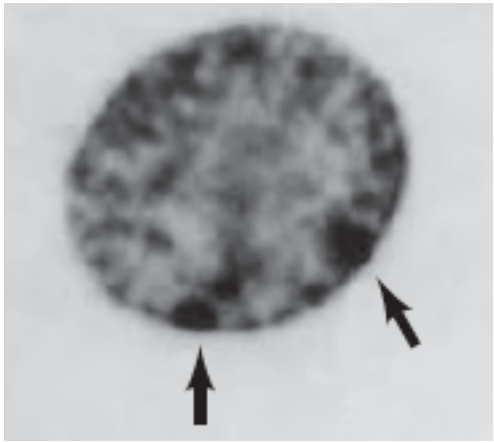
_____

17.4 You have used fluorescent primer(s) to do the PCR reaction.
You analyze the size of the amplification product using capillary electrophoresis: the results show a large peak at 100 bp, as expected, and 2 minor peaks at 98 and 102 pb.



Explain the result: 2 pt
why more than one peaks, what are the minor peaks, what about their size, …

Question 18
Cheek cells are taken from a young woman.

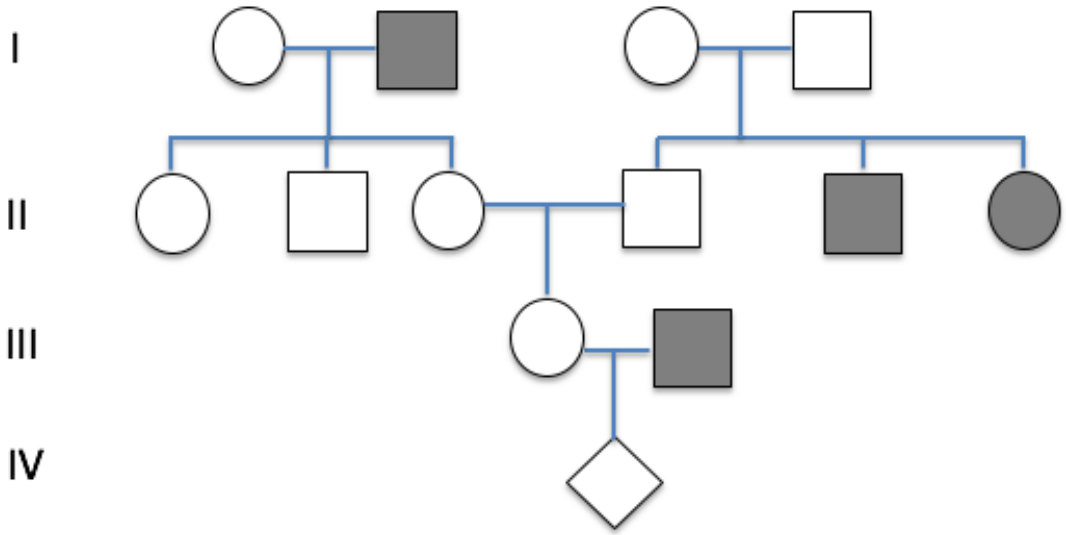


Under the microscope one observes two dark spots in the cell nucleus.

What do you conclude? 2 pt

Question 19

The woman in generation III has a maternal grandfather with red hairs; she also has a paternal uncle and a paternal aunt with red hairs.
She is married to a red hair man.



We assume that the red hairs phenotype is due to mutations in gene encoding the Mc1R receptor (the usual cause for red hairs). Transmission is autosomal recessive.

19.1 What is the probability for her first child to have red hairs? 3 pt
(show your calculations)

19.2 Her first child is a dark hair girl. Now what is the probability that her second child will have red hairs?
(show your calculations) 4 pt

Question 20

Consider the following cross:

	female Drosophila	X	male Drosophila
	eye color: white wings: long		eye color: red wings: miniature
F1	52 female Drosophila eye color: red wings: long		48 male Drosophila eye color: white wings: long

You cross a F1 female and a F1male from the preceding cross:

F1 female Drosophila	X	F1 male Drosophila
eye color: red wings: long		eye color: white wings: long

Knowing that the Miniature locus and the White eye locus are both on the X chromosome at a distance of 36 cM (centiMorgan), give the different phenotypes and their relative proportions expected among 100 offspring of the F2 generation.

F2: 5 pt

50 males		50 females	
phenotypes	number	phenotypes	number
_____		_____	
_____		_____	
_____		_____	
_____		_____	
_____		_____	
_____		_____	
_____		_____	

Question 21 2 pt

Male : dwarf, agouti
Dwarfism is due to absence of growth hormone (GH)

X

Female : normal size, albino

X

Female F1

male : dwarf, albino

A dwarf, agouti male is crossed with a normal size, albino female.
The F1 are 100% agouti, normal size.
F1 females are crossed with dwarf, albino males.
Describe the phenotypes of the F2 and the relative proportions (%) of these phenotypes assuming that the Tyrosinase locus (causing albinism) and the Growth hormone locus (causing dwarfism) are on the same chromosome 66 cM apart.

Question 22 2 pt

Male : dwarf, agouti
Dwarfism is due to absence of growth hormone (GH)

Female : normal size, albino

X

X

Female F1 Male F1

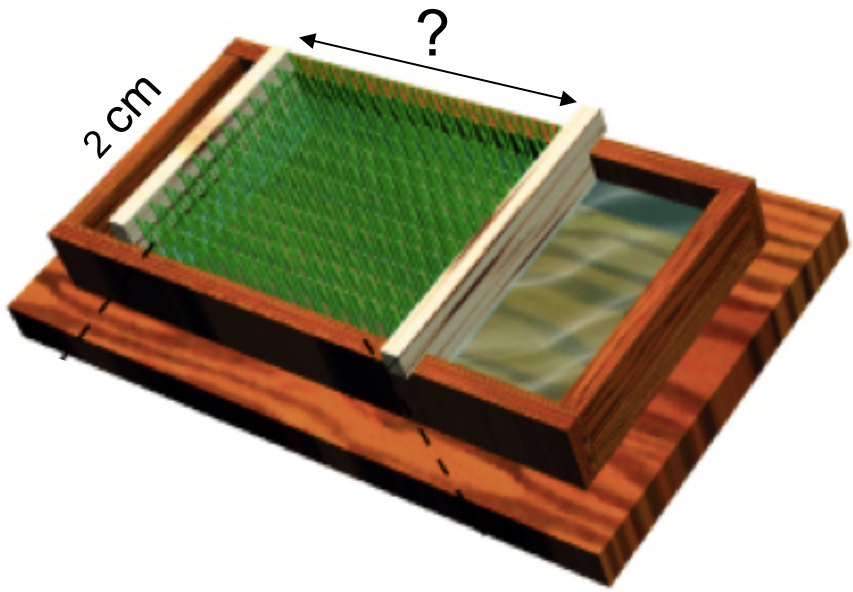
A dwarf, agouti male is crossed with a normal size, albinos female.
The F1 are 100% agouti, normal size.
F1 females are crossed with F1 males.
Describe the phenotypes of the F2 and the relative proportions (%) of these phenotypes assuming that the Tyrosinase locus (causing albinism) and the Growth hormone locus (causing dwarfism) are on two different chromosomes.

Question 23 2 pt

In an experiment, a blood sample is drawn from a healthy human being.
1 µL of this blood is found to contain $4 \cdot 10^6$ red blood cells (RBC).
Membrane lipids are extracted for the RBC obtained from 1 µl of blood and then spread on water in a 2-cm-wide Langmuir through.
What is the distance ℓ between the barriers when the cohesive forces between the lipid molecules signal that a monolayer has been formed ?

The surface area of a human red blood cell = 100 μ^2.
Lipid extraction yield (efficiency) = 100 %

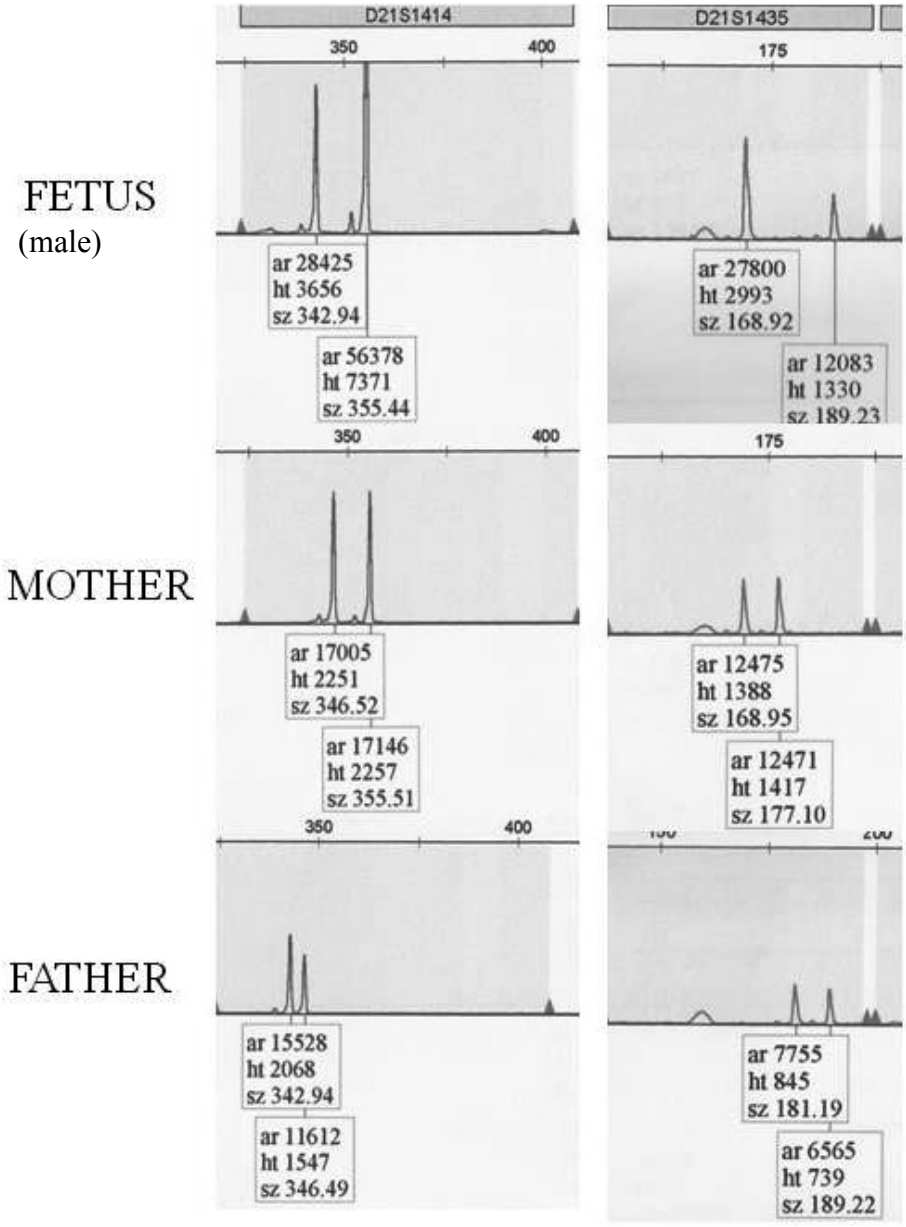
ℓ = _____



Calculations :

Question 24 4 pt

The figure shows the results of a prenatal analysis of 2 microsatellites.
ar = area under the curve; ht = height; sz = size of the amplification product [bp]
Assume that both microsatellites are located close to the centromere of chromosome 21.

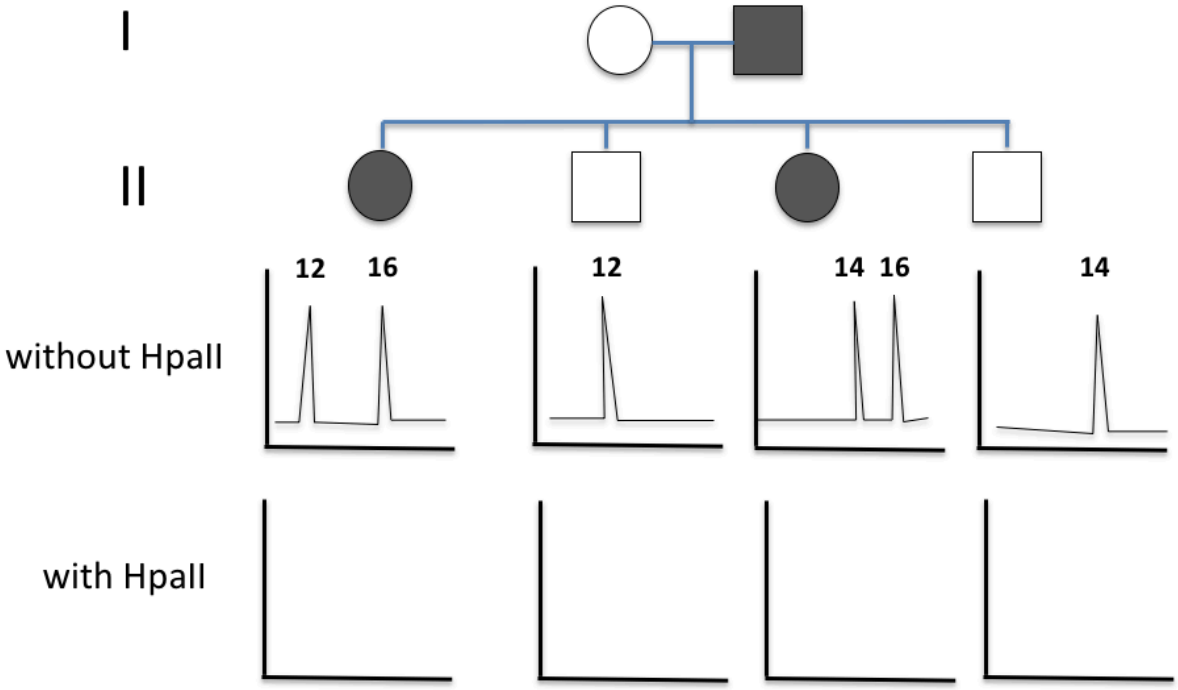


Based on these results, what is the most likely karyotype of the fetus ? _____

In case of any abnormality, indicate its parental origin and the stage of meiosis when the problem occurred.

Question 25 4 pt

A couple has 2 daughters and 2 sons. The father is colorblind (does not distinguish green from red), the mother distinguishes green from red.
Their 2 sons distinguish red from green but their 2 daughters are colorblind!
According to textbooks, colorblindness is transmitted by the X chromosome:
- males are colorblind when their X chromosome is mutated
- carrier females (1 X chromosome mutated) are not colorblind;
- homozygote females (2 X chromosomes mutated) are colorblind.
The family presented here is exceptional.



The HUMARA assay has been done for all 4 children.
Results without digestion by HpaII are given.

Genotype of the mother: _____

Genotype of the father: _____

Is the mother carrier for colorblindness? YES NO

Draw the most likely results of the HUMARA assay with digestion by HpaII before the PCR.
Explain your reasoning.

Question 26 **Not covered in 2021** 4 pt

26.1 The Rb gene (retinoblastoma) is

a. a cancer-causing gene (oncogene)
b. an anti-cancer gene (tumor suppressor)

26.2 In hereditary retinoblastoma, a child develop retinoblastoma only if both the father and the mother are carriers of a Rb mutation.

Right Wrong

Peter Falk was diagnosed with and cured from a unilateral retinoblastoma when he was 3 year old.

26.3 Considering his age when diagnosed and the fact that his cancer was unilateral, Peter Falk presented probably with

a. hereditary retinoblastoma
b. sporadic retinoblastoma

Still considering Peter Falk and in coherence with your answer above:

• he had an increased risk to develop a cancer (different from retinoblastoma) later in life (compare to the general population)

Right Wrong

• his daughter had a much higher risk to be diagnosed with retinoblastoma than the general population

Right Wrong

26.4 In retinoblastoma cells, both copies of the Rb gene are inactivated by mutations. The 2 mutations may be different or identical.

• retinoblastoma cases with 2 identical mutations are extremely rare

Right Wrong

• since mutagenesis is a random process, by chance the same mutation can occur twice in the same cell. This explains cases with 2 identical mutations.

Right Wrong