Rewarding Learning

Centre Number

71	

Candidate Number

ADVANCED
General Certificate of Education
2014

Biology

Assessment Unit A2 2

assessing

Biochemistry, Genetics and Evolutionary Trends

AB221

[AB221]

MONDAY 2 JUNE, AFTERNOON

TIME

2 hours.

INSTRUCTIONS TO CANDIDATES

Write your Centre Number and Candidate Number in the spaces provided at the top of this page.
Write your answers in the spaces provided in this question paper.
There is an extra lined page at the end of the paper if required.
Answer **all eight** questions.

INFORMATION FOR CANDIDATES

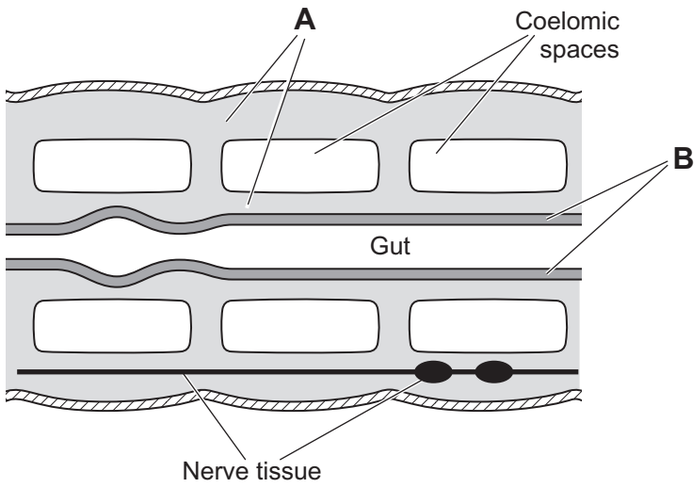
The total mark for this paper is 90.
Section A carries 72 marks. Section B carries 18 marks.
Figures in brackets printed down the right-hand side of pages indicate the marks awarded to each question or part question.
You are reminded of the need for good English and clear presentation in your answers.
Use accurate scientific terminology in all answers.
You should spend approximately **25 minutes** on Section B.
You are expected to answer Section B in continuous prose.
Quality of written communication will be assessed in Section B, and awarded a maximum of 2 marks.
Statistics sheets are provided for use with this paper.

For Examiner's use only	
Question Number	**Marks**
1	
2	
3	
4	
5	
6	
7	
8	
Total Marks	

Section A

Examiner Only	
Marks	Remark

1 **(a)** The diagram below represents a section through an annelid.



(i) Identify the body layers **A** and **B**.

A _____

B _____ [2]

(ii) Describe **one** piece of evidence from the diagram which shows that annelids are metamerically segmented.

_____

_____ [1]

(iii) Annelids are described as being bilaterally symmetrical. Explain what is meant by 'bilateral symmetry' and suggest why it is not evident in the diagram.

_____

_____

_____

_____

_____

_____ [2]

(b) Describe the type of skeletal support found in the phylum Annelida and the phylum Chordata.

Annelida _____

_____

Chordata _____

_____ [2]

Examiner Only	
Marks	Remark

Examiner Only	
Marks	Remark

2 Nucleic acids have important roles in the synthesis of polypeptides (proteins).

(a) Complete the table below concerning a range of features of three types of nucleic acid.

Feature \ Nucleic acid	DNA	mRNA	
Length	50–250 million base pairs	75–3000 nucleotides	70–80 nucleotides
Nitrogenous bases		adenine, guanine, cytosine, uracil	adenine, guanine, cytosine, uracil
Where made in cell	nucleus		nucleus
Location in cell	nucleus		throughout the cell

[4]

(b) Explain why the length of the DNA is measured in base pairs and the mRNA in nucleotides.

_____

_____

_____

_____

_____ [2]

(c) Explain the very large difference in length between DNA and mRNA.

_____

_____

_____

_____

_____ [2]

Examiner Only	
Marks	Remark

3 **(a)** The process of photosynthesis involves two stages which are distinct yet linked. These are known as the light-dependent and the light-independent stages.

(i) State precisely where the light-independent stage takes place.

_____ [1]

(ii) Explain the link between the two stages of photosynthesis.

_____

_____

_____

_____

_____

_____ [2]

(b) In the light-independent stage, glycerate phosphate is the first product formed following carbon fixation.

(i) Name the compound which fixes carbon dioxide to produce glycerate phosphate.

_____ [1]

Examiner Only	
Marks	Remark

Cacti are plants which are adapted to very hot, sunny, and dry conditions. Their stomata only open during the relatively humid and cooler desert nights.

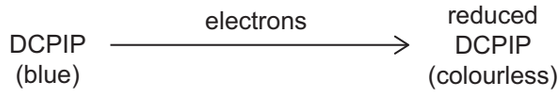
Carbon dioxide diffuses into the plants during the night and is fixed into a compound called malate, rather than glycerate phosphate.

The malate formed is then stored in the cell vacuole overnight. In the morning it is broken down, releasing high concentrations of carbon dioxide which then diffuses into the chloroplast. At this stage the light-independent reaction takes place.

(ii) Using the information provided, explain how this variation of photosynthesis is advantageous to cacti.

[3]

(c) The redox indicator DCPIP is blue when oxidised but colourless when reduced, as shown below.



In an experiment investigating the light-dependent stage of photosynthesis, a suspension of chloroplasts was prepared by grinding fresh leaves in a buffer solution and then separating the chloroplasts from the leaf debris by centrifugation (spinning at high speeds).

(i) Suggest the advantage of using isolated chloroplasts rather than ground-up leaf tissue.

Examiner Only

Marks	Remark

_____

_____ [1]

The isolated chloroplasts were treated as outlined in the table below. The results of the investigation are also included in the table.

Tube	Treatment	Colour	
		At start	After 30 minutes
A	water + DCPIP in bright light	blue	blue
B	chloroplast suspension + DCPIP in bright light	blue/green	green
C	chloroplast suspension + DCPIP in darkness	blue/green	blue/green

(ii) Using the results for all three tubes, explain fully the result for tube **B**.

_____

_____

_____

_____

_____

_____

_____

_____

_____ [3]

Examiner Only	
Marks	Remark

4 A consequence of sexual reproduction is variation in offspring.

(a) Apart from mutations, identify **three** processes that contribute to variation in a sexually-reproducing organism.

1. _____

2. _____

3. _____ [3]

(b) Babies produce the enzyme lactase to digest lactose, the disaccharide in milk. However, as they grow into adulthood some people lose the ability to produce lactase and so cannot digest lactose.

The ability to produce lactase into adulthood varies in different populations and is linked with milk consumption. In populations which do not keep cows to produce milk (e.g. in Asia) it is rare for adults to produce lactase. Conversely, in populations which keep dairy cattle (e.g. in Europe) there are high frequencies of adults capable of producing lactase.

Lactase production is determined by a single gene with two alleles, one allele coding for lactase production while the other allele fails to code for an effective enzyme. DNA analysis of human skeletal remains shows that the allele for lactase production was absent in adults until 3000 to 8000 years ago, when it was apparently introduced following a mutation. Other investigations indicate that human populations began using cows as a source of milk 8000 to 9000 years ago.

(i) In terms of its usage in the passage above, explain what is meant by the term 'population'.

_____

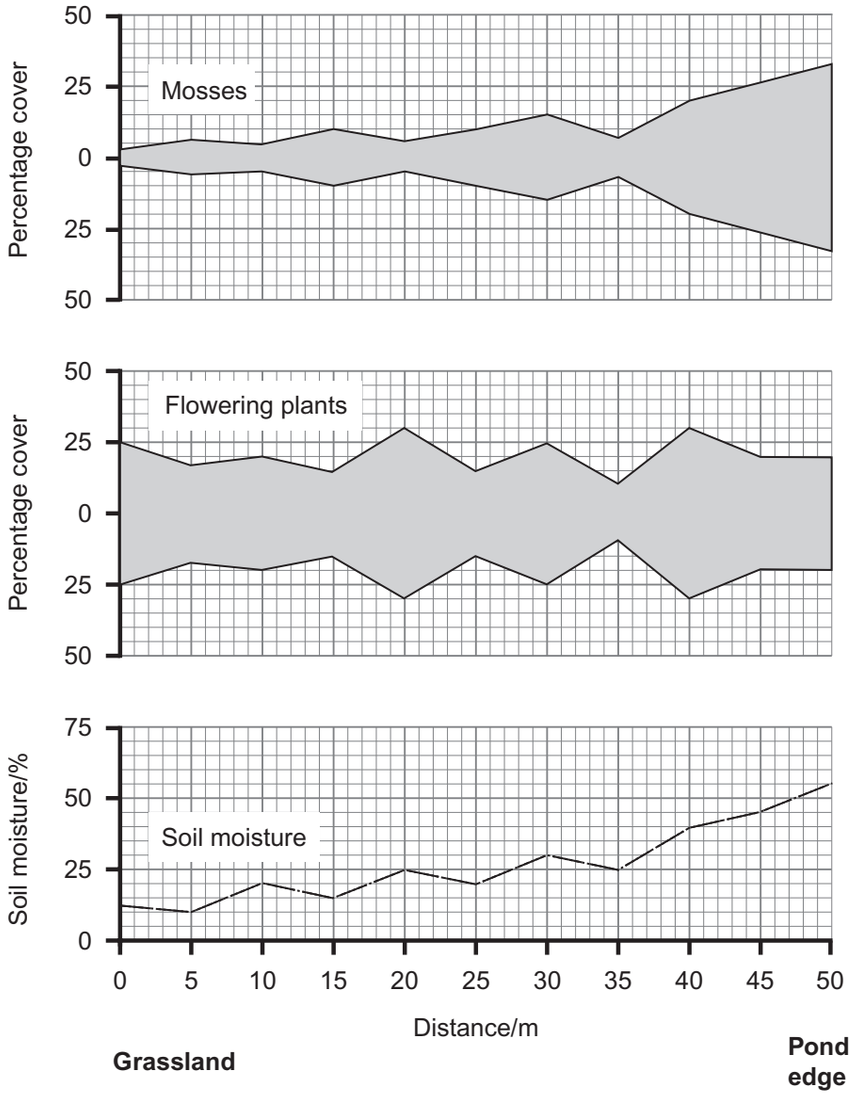
_____ [1]

(ii) In terms of selection and evolutionary change in populations, explain the initial absence of the enzyme lactase in human adults and the subsequent development of some populations in which lactase is present in many of the adults.

[5]

Examiner Only	
Marks	Remark

5 **(a)** The distribution of two plant groups, mosses and flowering plants, was investigated along a 50 metre transect from grassland to the edge of a pond. At 5 metre intervals, the percentage cover of mosses and flowering plants was determined. The soil moisture level was also measured at each sampling point. The results are shown graphically below.



Examiner Only	
Marks	Remark

(i) Describe the relationship between the distribution of each plant group and soil moisture levels.

_____

_____

_____

_____

_____

_____ [2]

(ii) With reference to the ability of mosses and flowering plants to regulate water loss, suggest explanations for the distribution shown.

_____

_____

_____

_____

_____

_____

_____

_____

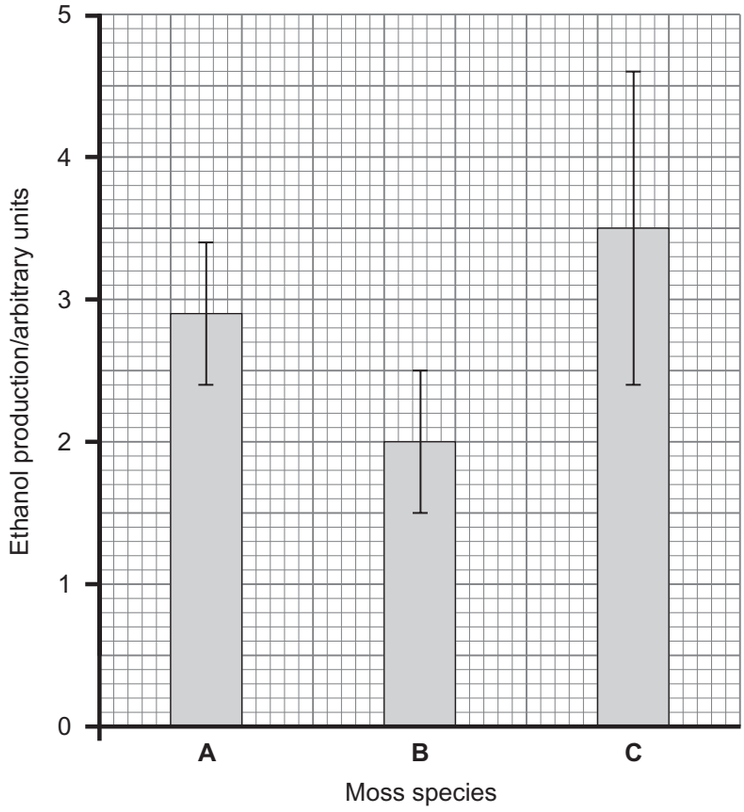
_____ [3]

Examiner Only	
Marks	Remark

Examiner Only	
Marks	Remark

(b) Ethanol production in three of the species of moss identified (**A**, **B** and **C**) at the pond edge was investigated. A number of ethanol readings was taken from the soil water in the immediate vicinity of each moss species and the mean was calculated for each species.

Mean ethanol production (with 95% confidence limits) by the three species of mosses is shown in the bar chart below.



(i) Explain why the mosses produced ethanol.

_____

_____

_____

_____

_____ [2]

(ii) The mean levels of ethanol produced by the three species may not be significantly different. Give evidence from the graph which supports this statement.

_____

_____ [1]

(iii) Based on the data provided, it is not possible to indicate if the difference in ethanol production between species has a genetic origin.

Suggest how you could experimentally confirm if the difference in ethanol production among the three species has a genetic basis, rather than a purely environmental basis.

_____

_____

_____

_____

_____

_____ [2]

Examiner Only	
Marks	Remark

6 **(a)** Distinguish between the terms ‘dominance’ and ‘epistasis’.

Examiner Only	
Marks	Remark

_____

_____

_____

_____

_____ [2]

(b) The colour of squash fruit is controlled by two genes that have the alleles **A/a** and **B/b**. The **B/b** gene is suppressed (not expressed) in the presence of the **A** allele. If the **B/b** gene is expressed, the presence of the **B** allele codes for a yellow squash and absence of the **B** allele codes for green. If the **B/b** gene is suppressed the squash are white.

A cross between two squash plants, each heterozygous for both genes, produced 126 white squash, 26 yellow squash and 8 green squash, approximating to a ratio of 12:3:1.

Complete a genetic diagram to show the genotypes and phenotypes of the offspring.

[5]

Examiner Only	
Marks	Remark

(c) The chi squared test can be used to check if the results of the cross statistically fit a ratio of 12:3:1.

Examiner Only

Marks	Remark

(i) Complete the table below and calculate the χ^2 for these results.

Category	**Observed (*O*)**	**Expected (*E*)**	**(*O*–*E*)**	**$(O-E)^2$**	**$\frac{(O-E)^2}{E}$**
white	126				
yellow	26				
green	8				

Calculated χ^2 value _____ [2]

(ii) On the basis of your calculated χ^2 value, state the following:

- the degrees of freedom for the test _____
- the probability value _____ [2]

(iii) Explain fully the outcome of your statistical test.

_____

_____

_____

_____

_____ [2]

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(Questions continue overleaf)

Examiner Only	
Marks	Remark

7 Cystic fibrosis is a condition caused by a fault in the CFTR protein, a trans-membrane protein responsible for pumping chloride ions out of cells.

If the CFTR protein is faulty, chloride ions may not be pumped out of cells. This results in the mucus immediately outside some cells (e.g. cells lining the airways in the lungs) becoming thick and viscous as a consequence of reduced water content.

The symptoms of cystic fibrosis include clogged airways in the lungs and blocked enzyme ducts in the pancreas.

(a) Using the information provided, suggest the role of chloride ions in maintaining a normal thin, watery mucus in the lung airways.

_____

_____

_____

_____

_____ [2]

Around 70% of people with cystic fibrosis in northern Europe have the same gene mutation: three base pairs are missing, with the loss of a phenylalanine amino acid in the protein. The other 30% can have any of up to a thousand different types of mutations, some with only a single base being affected.

The severity of the condition in individuals varies and depends on the degree of protein malformation, which in turn depends on the type and extent of mutation involved.

(b) In relation to protein structure, explain the link between the type and extent of mutation and the severity of the cystic fibrosis.

[3]

(c) About 1 in 2500 babies in northern Europe is born with cystic fibrosis. The condition is caused by an autosomal recessive disorder.

Using the Hardy-Weinberg equation, calculate the percentage of people in northern Europe who are heterozygous (carriers) for cystic fibrosis.

[3]

Examiner Only	
Marks	Remark

(d) Gene therapy is a potential procedure for reducing symptoms in individuals with cystic fibrosis. This involves inserting donor DNA, that codes for the functional CFTR protein, into the cells of affected individuals.

Genetically Modified (GM) crops are developed using the similar process of inserting donor DNA into the cells of crops such as maize and rice. GM crops have many advantages. For example, varieties have been developed that:

- provide nutritional enhancement, e.g. rice rich in beta-carotene (precursor of vitamin A necessary for visual photopigments)
- produce compounds that are toxic to insects
- have an increased ecological range, e.g. are able to grow in more arid conditions than the original variety

(i) Using the information provided, explain the economic and health advantages of using GM crops.

[4]

Examiner Only	
Marks	Remark

Nonetheless, the use of GM crops (unlike gene therapy) has significant public opposition and is banned in many European countries.

(ii) Give **two** reasons why there is significant public opposition to GM crops.

1. _____

_____

2. _____

_____

_____ [2]

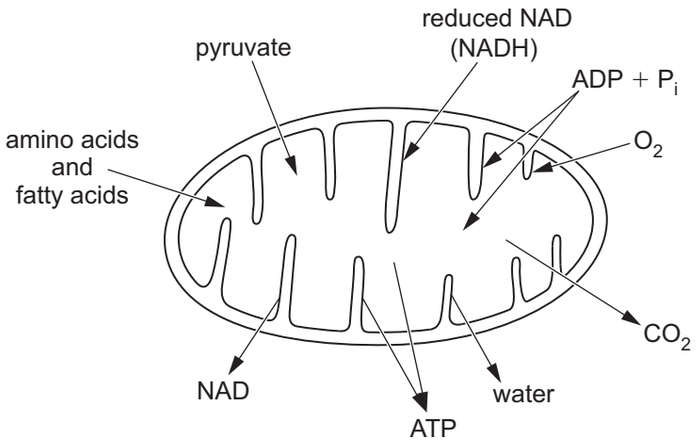
Examiner Only	
Marks	Remark

Section B

Examiner Only	
Marks	Remark

Quality of written communication is awarded a maximum of 2 marks in this section.

8 Mitochondria are the organelles most associated with ATP production in the cell. The diagram below represents a mitochondrion and identifies substances that typically enter and leave the organelle as it carries out its function.



(a) Using the information provided, give an account of how the substances labelled in the diagram are used or produced in a mitochondrion during the production of ATP. [12]

(b) Analysis of the mitochondria in a cell, using the electron microscope, provides an insight into the metabolic activity of that cell. Explain how appropriate microscopic analysis of mitochondria, in terms of their number and structure, can provide information about cellular metabolic activity. [4]

Quality of written communication [2]

(a) Using the information provided, give an account of how the substances labelled in the diagram are used or produced in a mitochondrion during the production of ATP.

Examiner Only	
Marks	Remark

Examiner Only	
Marks	Remark

Examiner Only	
Marks	Remark

(b) Analysis of the mitochondria in a cell, using the electron microscope, provides an insight into the metabolic activity of that cell. Explain how appropriate microscopic analysis of mitochondria, in terms of their number and structure, can provide information about cellular metabolic activity.

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Marks	Remark

Extra lined page

Examiner Only	
Marks	Remark

177662

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Biology

Statistical Formulae and Tables

Statistics Sheets

Statistical Formulae and Tables

1 Definition of Symbols

n = sample size

$\bar{x}$ = sample mean

$\hat{\sigma}$ = estimate of the standard deviation

These parameters are obtained using a calculator with statistical functions, remembering to use the function for $\hat{\sigma}$ – which may be designated a different symbol on the calculator – with (n – 1) denominator.

2 Practical Formulae

2.1 *Estimation of the standard deviation (error) of the mean* ($\hat{\sigma}_{\bar{x}}$)

$$\hat{\sigma}_{\bar{x}} = \sqrt{\frac{\hat{\sigma}^2}{n}}$$

2.2 *Confidence limits for population mean*

$$\bar{x} \pm t\sqrt{\frac{\hat{\sigma}^2}{n}}$$

which can be rewritten, in terms of $\hat{\sigma}_{\bar{x}}$, as

$$\bar{x} \pm t(\hat{\sigma}_{\bar{x}})$$

where t is taken from t tables for the appropriate probability and n – 1 degrees of freedom.

3 Tests of significance

3.1 *Student's t test*

Different samples are denoted by subscripts; thus, for example, $\bar{x}_1$ and $\bar{x}_2$ are the sample means of sample 1 and sample 2 respectively.

The following formula for t is that to be used:

$$t = \frac{\bar{x}_1 - \bar{x}_2}{\sqrt{\frac{\hat{\sigma}_1^{\,2}}{n_1} + \frac{\hat{\sigma}_2^{\,2}}{n_2}}}$$

which can be rewritten, in terms of $\hat{\sigma}_{\bar{x}}$, as

$$t = \frac{\bar{x}_1 - \bar{x}_2}{\sqrt{\hat{\sigma}_{\bar{x}_1}^{\,2} + \hat{\sigma}_{\bar{x}_2}^{\,2}}}$$

with $n_1 + n_2 - 2$ degrees of freedom.

3.2 *Chi squared test*

Using the symbols O = observed frequency, E = expected frequency and Σ = the sum of

$$\chi^2 = \sum \frac{(O-E)^2}{E}$$

with $n - 1$ degrees of freedom (where n is the number of categories).

Table 1 Student's t values

d.f.	$p = 0.1$	0.05	0.02	0.01	0.002	0.001
1	6.314	12.706	31.821	63.657	318.31	636.62
2	2.920	4.303	6.965	9.925	22.327	31.598
3	2.353	3.182	4.541	5.841	10.214	12.924
4	2.132	2.776	3.747	4.604	7.173	8.610
5	2.015	2.571	3.365	4.032	5.893	6.869
6	1.943	2.447	3.143	3.707	5.208	5.959
7	1.895	2.365	2.998	3.499	4.785	5.408
8	1.860	2.306	2.896	3.355	4.501	5.041
9	1.833	2.262	2.821	3.250	4.297	4.781
10	1.812	2.228	2.764	3.169	4.144	4.587
11	1.796	2.201	2.718	3.106	4.025	4.437
12	1.782	2.179	2.681	3.055	3.930	4.318
13	1.771	2.160	2.650	3.012	3.852	4.221
14	1.761	2.145	2.624	2.977	3.787	4.140
15	1.753	2.131	2.602	2.947	3.733	4.073
16	1.746	2.120	2.583	2.921	3.686	4.015
17	1.740	2.110	2.567	2.898	3.646	3.965
18	1.734	2.101	2.552	2.878	3.610	3.922
19	1.729	2.093	2.539	2.861	3.579	3.883
20	1.725	2.086	2.528	2.845	3.552	3.850
21	1.721	2.080	2.518	2.831	3.527	3.819
22	1.717	2.074	2.508	2.819	3.505	3.792
23	1.714	2.069	2.500	2.807	3.485	3.767
24	1.711	2.064	2.492	2.797	3.467	3.745
25	1.708	2.060	2.485	2.787	3.450	3.725
26	1.706	2.056	2.479	2.779	3.435	3.707
27	1.703	2.052	2.473	2.771	3.421	3.690
28	1.701	2.048	2.467	2.763	3.408	3.674
29	1.699	2.045	2.462	2.756	3.396	3.659
30	1.697	2.042	2.457	2.750	3.385	3.646
40	1.684	2.021	2.423	2.704	3.307	3.551
60	1.671	2.000	2.390	2.660	3.232	3.460
120	1.658	1.980	2.358	2.617	3.160	3.373
∞	1.645	1.960	2.326	2.576	3.090	3.291

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Table 2 χ^2 values

d.f.	$p = 0.900$	0.500	0.100	0.050	0.010	0.001
1	0.016	0.455	2.71	3.84	6.63	10.83
2	0.211	1.39	4.61	5.99	9.21	13.82
3	0.584	2.37	6.25	7.81	11.34	16.27
4	1.06	3.36	7.78	9.49	13.28	18.47
5	1.61	4.35	9.24	11.07	15.09	20.52
6	2.20	5.35	10.64	12.59	16.81	22.46
7	2.83	6.35	12.02	14.07	18.48	24.32
8	3.49	7.34	13.36	15.51	20.09	26.13
9	4.17	8.34	14.68	16.92	21.67	27.88
10	4.87	9.34	15.99	18.31	23.21	29.59
11	5.58	10.34	17.28	19.68	24.73	31.26
12	6.30	11.34	18.55	21.03	26.22	32.91
13	7.04	12.34	19.81	22.36	27.69	34.53
14	7.79	13.34	21.06	23.68	29.14	36.12
15	8.55	14.34	22.31	25.00	30.58	37.70
16	9.31	15.34	23.54	26.30	32.00	39.25
17	10.09	16.34	24.77	27.59	33.41	40.79
18	10.86	17.34	25.99	28.87	34.81	42.31
19	11.65	18.34	27.20	30.14	36.19	43.82
20	12.44	19.34	28.41	31.41	37.57	45.32
21	13.24	20.34	29.62	32.67	38.93	46.80
22	14.04	21.34	30.81	33.92	40.29	48.27
23	14.85	22.34	32.01	35.17	41.64	49.73
24	15.66	23.34	33.20	36.42	42.98	51.18
25	16.47	24.34	34.38	37.65	44.31	52.62
26	17.29	25.34	33.56	38.89	45.64	54.05
27	18.11	26.34	36.74	40.11	46.96	55.48
28	18.94	27.34	37.92	41.34	48.28	56.89
29	19.77	28.34	39.09	42.56	49.59	58.30
30	20.60	29.34	40.26	43.77	50.89	59.70
40	29.05	39.34	51.81	55.76	63.69	73.40
50	37.69	49.33	63.17	67.50	76.15	86.66
60	46.46	59.33	74.40	79.08	88.38	99.61
70	55.33	69.33	85.53	90.53	100.43	112.32
80	64.28	79.33	96.58	101.88	112.33	124.84
90	73.29	89.33	107.57	113.15	124.12	137.21
100	82.36	99.33	118.50	123.34	135.81	149.45

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