

How to calculate the molecular weight of nucleic acids

Oligonucleotides are used for a wide range of applications, for example, as a primer during polymerase chain reactions (PCR) for DNA amplification or as a therapeutic drug in gene therapy.

For some applications, it is helpful to know the molecular weight of an oligonucleotide in order to calculate the amount of substance in a solution or to estimate the suit-

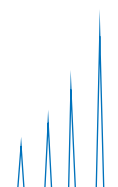
able particle pore size for analysis by size exclusion chromatography (SEC).

This expert tip provides assistance in calculation of the molecular weight of single-stranded as well as double-stranded DNA and RNA molecules. It also contains typical molecular weights of poly(dT) oligonucleotides and naturally occurring RNAs.

Molecular weight of single nucleotides

Nucleotide	Molecular Weight (g/mol)	Average Molecular Weight (g/mol)
Ribonucleotide Triphosphates		
ATP	507.2	499.4
CTP	483.2	
GTP	523.2	
UTP	484.1	
Ribonucleotide Monophosphates		
AMP	347.2	339.5
CMP	323.2	
GMP	363.2	
UMP	324.2	

Nucleotide	Molecular Weight (g/mol)	Average Molecular Weight (g/mol)
Deoxyribonucleotide Triphosphates		
dATP	491.2	487.0
dCTP	467.2	
dGTP	507.2	
dTTP	482.2	
Deoxyribonucleotide Monophosphates		
dAMP	331.2	327.0
dCMP	307.2	
dGMP	347.2	
dTMP	322.2	



Approximate calculation of the molecular weight of nucleic acids

Approximate molecular weight of nucleic acids
ssDNA
MW = (N_n x average molecular weight of a nucleotide) – 62g/mol
dsDNA
MW = [(N_n x average molecular weight of a nucleotide) – 62g/mol] x 2
ssRNA
MW = (N_n x average molecular weight of a nucleotide) + 178g/mol
dsRNA
MW = [(N_n x average molecular weight of a nucleotide) + 178g/mol] x 2

N_n: number of the nucleotides within the nucleotide chain.

The subtraction of 62g/mol considers that synthesised DNA does not contain a 5' monophosphate but are instead 5' and 3' hydroxylated. The addition of 178g/mol considers that transcribed RNA contains a 5' triphosphate.

Exact calculation of the molecular weight of nucleic acids

For calculation, the MW of a monophosphate minus the MW of a water molecule are used due to the loss of water and two phosphate groups during nucleotide chain elongation.

Molecular weight of ssDNA
MW = (A_n x 313.2g/mol) + (C_n x 289.2g/mol) + (T_n x 304.2g/mol) + (G_n x 329.2g/mol) – 62g/mol
Molecular weight of dsDNA
MW (sense strand) + MW (antisense strand) = [(A_n x 313.2g/mol) + (C_n x 289.2g/mol) + (T_n x 304.2g/mol) + (G_n x 329.2g/mol) – 62g/mol] + [(A_n x 313.2g/mol) + (C_n x 289.2g/mol) + (T_n x 304.2g/mol) + (G_n x 329.2g/mol) – 62g/mol]

A_n, C_n, T_n, G_n: number of the respective nucleotide units within the nucleotide chain.

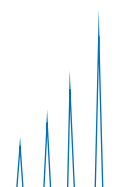
The subtraction of 62g/mol considers that synthesised DNA does not contain a 5' monophosphate but are instead 5' and 3' hydroxylated. To calculate the MW of a nucleic acid chain cut by restriction enzymes the mass of a 5' monophosphate (+79g/mol) needs to be added, which is left by most restriction enzymes.

Molecular weight of ssRNA
MW = (A_n x 329.2g/mol) + (C_n x 305.2g/mol) + (U_n x 306.2g/mol) + (G_n x 345.2g/mol) + 178g/mol
Molecular weight of dsRNA
MW (sense strand) + MW (antisense strand) = [(A_n x 329.2g/mol) + (C_n x 305.2g/mol) + (U_n x 306.2g/mol) + (G_n x 345.2g/mol) + 178 g/mol] + [(A_n x 329.2g/mol) + (C_n x 305.2g/mol) + (U_n x 306.2g/mol) + (G_n x 345.2g/mol) + 178 g/mol]

Molecular weight is valid at physiological pH.

A_n, C_n, U_n, G_n: number of the respective nucleotide units within the nucleotide chain.

The addition of 178 g/mol considers that transcribed RNA contains a 5' triphosphate.



Typical molecular weights of nucleic acids

Molecular weight of poly(dT) oligonucleotides

Name	Length (mer)	Molecular weight (Da)
dT 10mer	10	2,980
dT 15mer	15	4,501
dT 20mer	20	6,022
dT 25mer	25	7,543
dT 30mer	30	9,064
dT 40mer	40	12,106
dT 60mer	60	18,190
dT 80mer	80	24,274
dT 100mer	100	30,358
dT 120mer	120	36,442

Molecular weight of ribosomal RNAs (rRNAs)

rRNA	Approx. length (mer)	Molecular weight (Da)
Human		
5S	121	39,097
5.8S	156	50,674
18S	1868	603,030
28S	5069	1,640,423
Mouse		
5S	121	39,222
5.8S	158	51,018
18S	1870	603,378
28S	4712	1,525,058
Drosophila		
5S	134	43,548
5.8S	123	39,840
18S	1995	642,010
28S	3945	1,277,908
Yeast		
5S	121	39,175
5.8S	158	50,907
18S	1800	580,000
25S	3396	1,097,722
Escherichia coli		
5S	120	39,038
16S	1542	499,926
23S	2904	926,984

