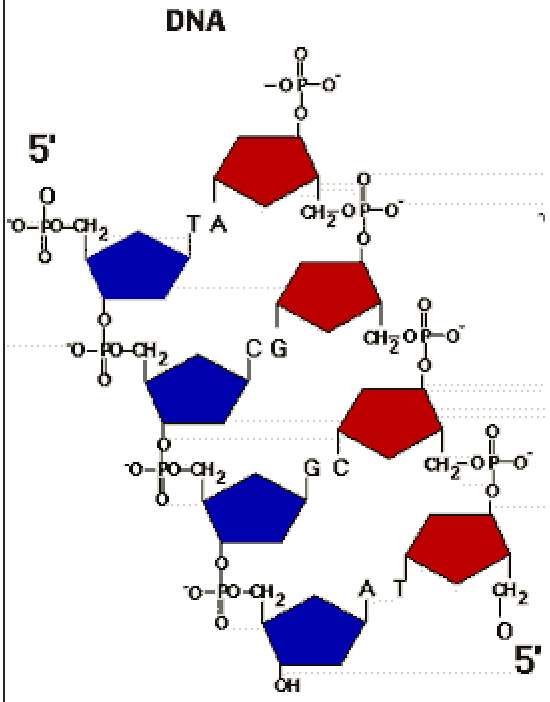
THE BIOLOGY PROJECT • BIOMATH

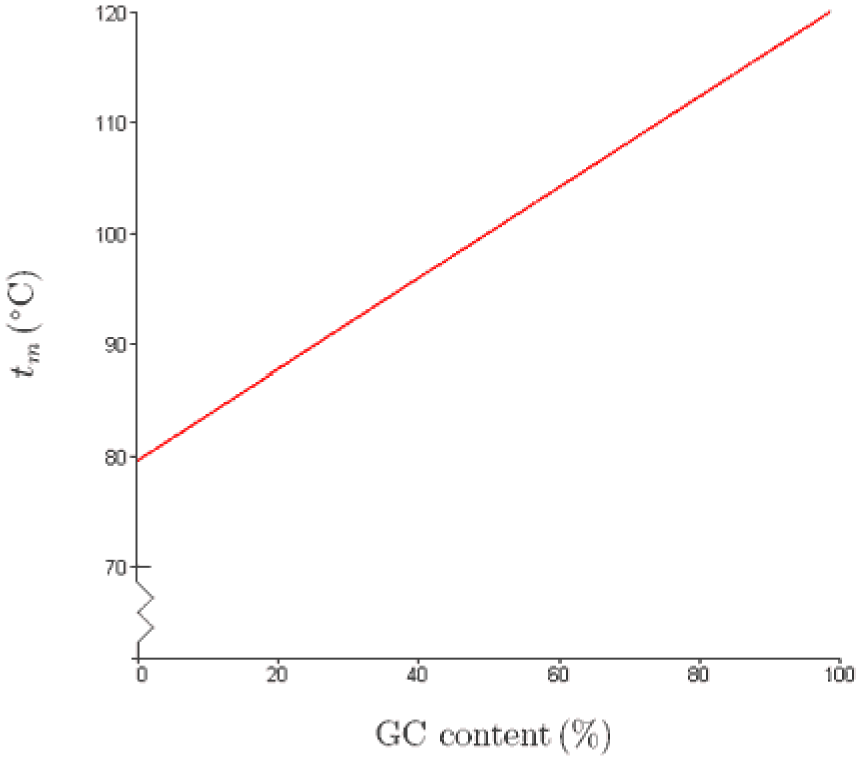
Linear Functions Applications

DNA melting temperature



DNA secondary structure, the double helix, is held together by hydrogen bonds between base pairs. Specifically, adenine bases pair with thymine bases and guanine bases pair with cytosine bases. Heating a DNA sample disrupts these hydrogen bonds, thus “unwinding” the double helix and denaturing the DNA. Because three hydrogen bonds form between guanine/cytosine base pairs and two hydrogen bonds form between adenine/thymine base pairs, more energy is required to denature the former. DNA with a greater number of guanine/cytosine base pairs denatures at a higher temperature than adenine/thymine base pairs. In fact, there is a linear relationship between the amount of guanine and cytosine in a given DNA molecule, known as the GC content, and the temperature at which the double helix will denature, called the melting point (denoted as t_m).

Imagine you have a number of different DNA samples each measuring 250 base pairs in length. Suppose that the samples are dissolved in a buffer containing 1 M NaCl and that they differ only in their GC content. If you were to calculate the melting point for the different DNA molecules, and plot it against the molecule’s GC content, you would get a line, as shown below:



In general, the linear equation used to calculate the melting point of a DNA molecule (in °C) is,

$$t_m = 81.5 + 16.6\left(\log\left[\mathrm{Na}^+\right]\right) + 0.41\,(\%\,\mathrm{GC}) - \left(\frac{500}{\text{length of DNA}}\right),$$

where Na^+ is the molar concentration (moles/L) of sodium ions and the length of DNA is measured in base pairs (bp). In the following exercises, assume that $[Na^+]$ = 100 mM which implies the melting temperature of a DNA molecule is given by,

$$t_m = 64.9 + 0.41\,(\%\,\mathrm{GC}) - \left(\frac{500}{\text{length of DNA}}\right).$$

Use this equation to answer the following questions:

[Calculate the melting temperature of a DNA molecule.]

[Determine the % GC content of a DNA molecule given its melting temperature.]

[Compare the melting temperature of two DNA molecules.]

[Determine the maximum melting temperature for a DNA molecule of known length.]

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