In this lab, we’ll explore modeling enzyme activity by Hill Function.

- study the form of Hill function
- understand what each parameter represent
- practice symbolically compute derivatives

**Hill Functions**

Hill functions are used to model a variety of chemical and biological processes. A common application of the Hill equation is modeling cooperative enzymes, where the binding of a molecule at one site alters the affinity of the enzyme for its substrate and hence regulates the enzyme activity. Positive cooperativity occurs when an enzyme has several sites to which a substrate can bind, and the binding of one substrates molecules increases the rate of binding of other substrates.

Cooperativity can be recognized by plotting binding rate against substrate concentration. The form of the Hill function is as follows:

\[
H(s) = \frac{As^n}{K^n + s^n}, \tag{1}
\]

where \( A > 0, k > 0, \) and \( n \geq 1. \) In the Hill function we write down, \( H(s) \) is the rate of binding and \( s \) is the substrate concentration. This week, we will explore some features of these exciting functions.

**Question 1:**
Plot the Hill function and its derivative for \( A = k = n = 2. \) For this question, you can use the provided code `lab7_Hill.R`. This code plots the function \( H(s) \) and its derivative in the same graph. You need to complete this code by finding the first derivative for \( H(s) \).

**Question 2:**
How does changing \( A \) change the Hill function? To answer this question, generate at least two different plots with different values of \( A \), while keeping \( k = n = 2 \) fixed. You can copy/paste and change the code from problem 1. Reference your plots to explain how changing the value of \( A \) changes the Hill function and its derivative.
Question 3:
How does changing $k$ change the Hill function? To answer this question, generate at least two different plots with different values of $k$, while keeping $A = n = 2$ fixed. You can copy/paste and change the code from problem 2. Reference your plots to explain how changing the value of $k$ changes the Hill function and its derivative.

Question 4:
How does changing $n$ change the Hill function? To answer this question, generate at least two different plots with different values of $n$, while keeping $A = k = 2$ fixed. You can copy/paste and change the code from problem 2. Reference your plots to explain how changing the value of $n$ changes the Hill function and its derivative.

Question 5:
In the application listed above, $A, k,$ and $n$ all have a meaning that relates to enzyme binding. The interpretations corresponding to each of these constants are listed below. Which of these three constants do you think represents:

- How cooperative the enzymes are?
- The maximum binding affinity?
- The concentration of substrate when binding affinity has reached half its maximum value?

Explain your reasoning behind each answer.