# Grading of Problem Set #5: Diffusion and Target Search

Lecture "Interactions of Proteins and Nucleic Acids: Biophysical Concepts and Theoretical Descriptions (BPC2024)"

Winter Term 2024/2025 | Prof. Dr. Karsten Rippe

Web page: [https://malone.bioquant.uni-heidelberg.de/teaching/BPC\_lectures/BPC\_1+2.html](https://malone.bioquant.uni-heidelberg.de/teaching/BPC_lectures/BPC_1%2B2.html)

##

## Grading Rubric (per question)

**Note**: The distribution of the maximum point value per question part is given below. Full points can be awarded despite solutions not being perfect.

**11.0-12.0: Excellent**

* Complete, correct methodology
* Clear reasoning
* Independent analysis demonstrated
* Proper units
* **Note 1 to the grader**: Be lenient on minor calculation errors
* **Note 2 to the grader**: Give full points for correct calculations even if explanations are brief

**8.0-10.75: Very Good**

* Minor gaps or errors
* Good reasoning shown
* Some improvements possible
* Mostly independent work

**5.5-7.75: Good**

* Significant gaps present
* Basic understanding shown
* Major improvements needed
* Partial independence

**3.0-5.25: Fair**

* Major conceptual errors
* Some correct elements
* Substantial revision needed
* Limited independent thought

**0-2.75: Insufficient**

* Missing or minimal correct content
* Major misunderstandings
* No demonstrated understanding
* No independent analysis

**Common Point Deductions**

* Missing units: -0.5 per instance
* Unexplained assumptions: -0.5 per instance
* Calculation errors: -0.25 to -1 depending on impact
* Missing references: -0.5 per required citation
* Unclear reasoning: -1 to -2 per section

##

## Distribution of points between question parts for Problem Set #5

**General principles used for Problem Set #5**

* Correct application of diffusion equations
* Clear understanding of diffusion principles in biological contexts
* Proper calculation and unit handling
* Understanding of target search mechanisms
* Integration and reference of lecture material and literature
* Please indicate in a comment if unreferenced use of AI tools is suspected

###

### Question 1: GFP Diffusion (12 points total)

**1a) 4 points - Diffusion time calculations**

* 1 point: Correct methodology and formula for mean squared displacement
* 3 points: Accurate calculations for all four cellular contexts with proper units (0.75 points each)

**1b) 4 points - Efficiency of diffusion and alternative transport mechanisms**

* 1 point: Correct identification of cells where diffusion is inefficient
* 1.5 points: Proper explanation of why diffusion is inefficient
* 1.5 points: Accurate description of alternative transport mechanisms

**1c) 4 points - MSD analysis**

* 1 point: Correct description of free diffusion MSD
* 1.5 points: Proper explanation of anomalous diffusion in the nucleus
* 1 point: Accurate comparison between the two scenarios
* 0.5 points: Discussion of confinement effects at longer time scales

###

### Question 2: Target Search by p53 (12 points total)

**2a) 4 points - Search time estimation**

* 1.5 points: Correct identification and application of Berg & von Hippel formula
* 1.5 points: Accurate calculation with proper units
* 1 point: Proper handling of parameters (radius of DNA target, radius of sphere)

**2b) 4 points - Search time vs. translocation time comparison**

* 1.5 points: Correct calculation of translocation time
* 1.5 points: Accurate comparison between search and translocation times
* 1 point: Discussion of the significance of the difference

**2c) 4 points - Mechanisms to reduce search time**

* 1.5 points: Correct explanation of facilitated diffusion (sliding)
* 1.5 points: Accurate description of at least one additional mechanism (intersegmental transfer)
* 1 point: Description of a third mechanism (e.g., reduced search volume through compartmentalization)

###

### Question 3: One-Dimensional Diffusion Along DNA (12 points total)

**3a) 4 points - Derivation of sliding length**

* 2 points: Correct step-by-step derivation of the formula
* 1 point: Proper explanation of the physical meaning of each step
* 1 point: Clear connection to diffusion principles

**3b) 4 points - Calculation of l\_slide and 3D diffusion time**

* 1.5 points: Accurate calculation of l\_slide with proper units and conversion to base pairs
* 1.5 points: Correct calculation of 3D diffusion time
* 1 point: Comparison between 1D and 3D diffusion times

**3c) 4 points - Efficiency of one-dimensional diffusion**

* 1.5 points: Discussion of dimensionality reduction and its effects
* 1 point: Explanation of the antenna effect
* 1 point: Analysis of optimal search strategies
* 0.5 points: Conclusion on whether 1D diffusion speeds up search with given parameters

##

## Point Deductions

* -0.25 points: Minor omissions or unclear explanations
* -0.5 points: Missing references where needed
* -0.75 points: Significant gaps in explanation
* -1 point: Major conceptual errors