Learn Chemistry

Chemistry's Interfaces: The Reality of Nutrition

Tutor Guide

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National HE STEM Programme

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Table of Contents

Introduction

This resource is designed as an introduction to the some of the most important aspects of chemical biology. The resource achieves this by introducing students to a number of important chemical structures which play major biological roles within human metabolism. Students are placed in the roles of graduate interns to the National Academy of Science. The Academy's internship programme requires students to do a number of closely related jobs including acting as editors for a scientific magazine published by the academy, to act as representatives of the Academy of Science in a radio interview and to produce press releases for use in both scientific and mainstream press.

This activity is written for university level chemistry students with a limited experience of biology. This resource is best suited for early stage university students (years one or two) but given the flexible nature of problem based learning the resource could also be used students at later stages of their education who would be expected to provide more sophisticated solutions.

Criterion	Value
Intended level	Year 1-2
Subject area	Chemical Biology
Contact Hours	3-4 hours
Group size	4-6
Credit value	2 credits (20 hours) without the extension task

Tutor text has been included in this version of the problem. The tutor text is shown in red; this text should not be shown to students.

Outline tutor answers have been provided for the facilitation questions. Please note that these are neither model answers nor guidelines to the amount of content that students should produce. These answers only provide a minimal outline of the concepts being asked and students should go into more detail and provide examples of each of these concepts.

We recommend that this problem is used with small groups of students (typically group sizes of 4-6 work best). We also recommend that each facilitator guides no more than 2 or 3 groups – if a facilitator has to work with any more groups than this, it is likely to mean that very little time is spent with each group.

We have found that postgraduate students can make good PBL/CBL facilitators if they are given guidance in this style of teaching and the nature of the problem before the start of the module. It is advisable to have at least one staff facilitator on duty during all sessions.

Background

This primary inspiration for the context of this resource is the authors' dissatisfaction of the portrayal of chemical biology by the media. It is hoped that in addition to learning some key aspects of biological and chemical science, this resource will help encourage students to critically evaluate science they encounter in the media.

This resource makes use of a number of types of assessment which share a common theme of communication. The authors have found that the use of C/PBL resources can be an ideal way of teaching communication skills in a scientific context and it is hoped that this resource will raise awareness of the relevant issues when communicating science to a range of audience types.

Transferable Skills Development

This resource makes use of a number of types of assessment which share a common theme of communication. The authors have found that the use of C/PBL resources can be an ideal way of teaching communication skills in a scientific context and it is hoped that this resource will raise awareness of the relevant issues when communicating science to a range of audience types. The following transferable skills are encountered in this problem:

- Working in a small group on a mini-project **- Relevant throughout the problem**

- Critical thinking, decision making and independent learning **– Relevant throughout the problem**
- Time management and planning – **Relevant throughout the problem**
- Preparing concise written critiques of active areas of scientific research - **Session 1.**
- Critiquing a piece of scientific writing – **Session 1.**
- Writing short scientific articles for a range of audience types – **Sessions 1 and 4**
- Orally communicate an understanding of an area of scientific research in an interview scenario (such as a radio interview) – **Groups prepare for this between sessions 2 and 3 and are interviewed in session 3.**

The Scenario

Editing Nutrition and Health

Students are first asked to proof read a guest editorial in the Academy's 'Nutrition and Health' journal written by a nutritionist who has starred in a number of TV shows and written several best-selling books. The article contains a number of factual inaccuracies which the students need to identify. Students are given three choices:

1. Approve the editorial for printing
2. Correct the mistakes and print the editorial
3. Decide that the editorial is not fit to be printed and suggest another editorial is used

If the students choose option 1 they will receive complaints from readers and the chief editor and will be required to prepare a two page article about the structure and function of proteins to undo some of the damage done by the inaccurate editorial. If students chose option 2 they will receive a letter from Dr Sally's legal team asking for scientific clarification of why they changed her article. If students choose option 3 they will need to write a full scientific explanation of what is wrong with the article and submit this to the chief editor. Although the precise form of the deliverable depends on which option the students take, the learning outcomes covered and the general format of the deliverable (i.e. a written assignment) remains the same in each case.

Question Time

In the second part of the problem students are asked to listen to a recording of a recent radio interview that Dr Sally has given. Some of the statements that Dr Sally makes in the interview are a little odd so the radio station has invited the Academy to make a response. The students are asked to go along to the broadcast to be interviewed.

This part of the problem has been written to allow the user to run it in a variety of ways. The original intention was that the interview with the students would be recorded as a podcast (and perhaps peer reviewed by other students) but if that is technically difficult to achieve the task would work just as well by conducting the interview live – perhaps in front of an audience of peers who could assess the process.

A number of suggested questions for the interviewer to ask are given on the following pages.

Sensors (An Extension Task)

The final (optional) part of the problem requires students to write two articles on the use of fluorescence in chemical biology based on a press release that is provided in this resource. Students need to write separate articles for use in scientific literature and in the popular media.

Tutor text

The red text in this version of the guide is meant to be seen by the tutor only. This text includes guidance on how the problem can be run, marking criteria, feedback from the trials and some (where appropriate) example answers.

Wk	Session	Topics	Transferable Skills	Assessment	Feedback
1	1 (60-90 minutes)	• Proteins • Enzymes • Enzyme Kinetics	• Team working • Group discussion • Independent learning • Critical thinking • Decision making • Written communication	• A letter of response to the editor giving details of the decision made regarding the publication of the editorial. • A two-page magazine article for publication in a magazine read by biochemists at a range of levels: from interested A-level students to practicing chemistry, biology and biochemistry researchers. This response should include an analysis of the kinetic data provided.	<u>In session:</u> • For students who publish the editorial including some or all of the errors – a copy of the email from the chief editor which includes the complaint from the reader complaint • For students who correct Dr Sally's editorial – a copy of the email from Dr Sally's legal team <u>Before next session:</u> Receive brief written formative feedback on article prior to the next session
2	2 (60-90 minutes)	• Nucleic Acids and DNA • Fatty Acids and Lipids • Polysaccharides and Carbohydrates	• Team working • Group discussion • Independent learning • Planning • Oral communication • Time management	Students should use part of this session to prepare material for the radio interview (either in the form of a podcast or a live interview given in front of an audience of peers).	<u>In session:</u> Provide verbal feedback on the students' group debate/practise interview. Encourage the students to answer questions which allow the students to correct statements made by the interviewer.
2	3 (20-30 minutes)	• Nucleic Acids and DNA • Fatty Acids and Lipids • Polysaccharides and Carbohydrates	• Team working • Oral communication • Time management	A mock radio interview to respond to the information provided by Dr Sally in the previous programme, (either in the form of a podcast or a live interview given in front of an audience of peers).	Students should receive formal feedback on the podcast/interview.
Ext. Task	Optional	Use of fluorescence in biological applications	• Team working • Planning • Independent Learning • Written communication	To write two articles (one for mainstream newspapers and another for scientific magazines and journals) to convince the public of the merits of biochemical applications of fluorescence (including a simple description of the physical basis of the technique).	Students should receive formal feedback on the two articles.

Student Outputs

'Chemistry's Frontiers – The Reality of Nutrition' is a group-based exercise. By the end of the module student groups should have produced the following outputs.

Part 1

Students will produce two outputs for this part of the problem:

- A letter of response to the editor giving details of the decision made regarding the publication of the editorial.
- A two-page magazine article for publication in a magazine read by biochemists at a range of levels: from interested A-level students to practicing chemistry, biology and biochemistry researchers. This response should include an analysis of the kinetic data provided.

Part 2

Students will give a short (5-10 minute) interview on nutrition and chemical biology based on the points raised in Dr Sally's radio interview. This interview may take the form of a podcast or a live interview.

Part 3 Optional extension task)

The students will produce two articles on **(600 words or less)** on the use of fluorescence in biochemical research. These articles should explain the underlying scientific principles and include details on recent research based applications of this technique. The two articles should be pitched at different audiences (a newspaper article for non-experts and a New Scientist/Chemistry World article for an audience with some level of interest and/or expertise in the area).

Facilitation Session Guide

Suggested Texts:

Berg, J.M., Tymoczko, J.L. & Stryer, L., ***Biochemistry***. Palgrave.
Atkins, P. & de Paula, J., ***Atkins' Physical Chemistry***. Oxford University Press.

Session 1 (60-90 minutes)

Pre-Session Preparation

You should advise students to research and be prepared to discuss the following topics in the facilitation session:

- Proteins
- Enzymes
- Enzyme Kinetics

We recommend reading the following topics in *Biochemistry* (Berg *et al*):

- Sections 1.1-1.3 (possibly 1.4)
- Sections 2.1-2.6
- Sections 8.1-8.5
- Sections 23.1 and 23.2 (possibly 23.5)

Introducing the Scenario

Give students a brief (5-10 minutes) overview of the scenario which includes a description of their roles within the context of the problem. You should find the opening slides of the PowerPoint presentation useful for this.

Intended Learning Outcomes

By the end of this problem students should be able to:

- explain how amino acids form proteins
- explain how amino acid side chains affect the properties of a protein
- describe the meaning of Primary, Secondary, Tertiary and Quaternary protein structure,
- explain the roles of proteins in cells and how their structure affects their function
- describe the mechanism of protein catabolism and its importance
- understand the role of enzymes in terms of chemical thermodynamics and kinetics
- explain the general mechanism by which enzymes catalyse biochemical processes
- calculate kinetic parameters related to enzyme catalysed processes in terms of the Michaelis-Menten model
- work in a small group to analyse and critique a scientific article based on both the style of writing and the scientific content
- decide on the best course of action based on a group discussion
- communicate with scientific colleagues at a professional level

Resources

Make the following resources available to students **before** this facilitation session:

- The introduction to the problem
- The facilitation questions, the email from the chief editor requesting the students help, Dr Sally's Editorial and the kinetic data.

During the session it would be useful for students to have access to computer facilities with an internet connection.

Students should be provided with the following resources as needed:

- **For students who correct Dr Sally's editorial** – a copy of the email from **Dr Sally's legal team**
- **For students who publish the editorial including some or all of the errors** – a copy of the email from the chief editor which includes the complaint from the reader complaint.

Assessment

The students should decide which course of action to take regarding the publication of the editorial during the facilitation session. Students should work on the justification of this decision outside of timetabled hours but they may get on to planning how they will do this during the facilitation session. The students the need to write a two page two-page spread article on the structure and function of proteins (with a specific emphasis on diet). Students are asked to include an analysis of the provided kinetic data in this article.

The group should be asked to submit their attempt at this article in time to receive brief written feedback ahead of the next facilitation session – the exact timescale depends on how this is scheduled at your institution but we suggest having the second facilitation session one week after the first session. This is designed to be a group task.

Student Introduction

You are working for the National Academy of Science as part of a team of graduate interns. The Academy publishes a monthly magazine called 'Nutrition and Health' which is aimed at professionals working in this area as well as at interested members of the public.

Please issue the following email in advance of facilitation session 1:

From: Chief Editor [chiefeditor@nutritionandhealth.com]

To: Graduate Interns

Cc:

Subject: Nature and Health – the Diet Issue

Dear Intern team,

I have a small project for you to work on for the next week or so. I would like you to work as sub-editors for the next issue of Nutrition and Health. I am afraid I will be away at a conference so won't be able to put the issue together myself. This should be an easy task as you only really need to do one thing – Dr Sally will be acting as guest editor and I would like you to make sure that the content that she submits meets our usual rigorous standards (please see the bullet point summary below). I'm sure it will be fine and this will turn out to be an easy assignment.

Dr Sally has also provided some kinetic data from a study that her research group conducted into a digestive enzyme. Dr Sally thought we might want to include a summary of this (her research group isn't sure how to interpret the data) – please take a look at this and use it as you see most appropriate.

Best wishes,

Dr Livid,

Chief Editor of Nutrition and Health

- All articles must be written in proper English. The use of correct spelling and grammar is essential.
- All articles must be based on our current understanding of scientific concepts. Where possible this must be supported by examples from research literature.
- All 'Nutrition and Health' articles must be written in a format which makes them interesting and accessible to as wide an audience as possible. Our subscribers range from A-level students to lifelong practitioners of nutritional science so it is essential that the articles are written at an appropriate level.
- All references to the work of others must be fully cited.
- Only copyright free images can be used.

Nutrition and Health

Volume 16, edition 4 – The Diet Issue

Editorial: Dr Sally

"I am honoured to be acting as the guest editor of this month's edition of Nutrition and Health. Thanks to the internet we find ourselves living in a generation of information overload so it is very important that we become skilled in evaluating the quality of the information that we encounter. Our understanding of nutrition is becoming increasingly sophisticated and it is the scientific community's responsibility to ensure this information is disseminated in a way that will ensure everyone can benefit from the latest findings.

A number of challenges remain for the nutritional sciences. My research team is working on uncovering the scientific basis of the metabolism of food in order to help improve our understanding of what constitutes a healthy diet. We know that proteins play an important role in this process but the details of what they do remain unclear. We consume a lot of protein in the form of meat, poultry, fish, nuts and eggs so it's vital that we know what they do, how they do it and how we can maximise their effect by managing our protein intake. Proteins form a range of diverse structures but we don't know very much about what causes them to adopt these structures and how the three dimensional structures relates to their chemical properties but we do know that certain types of proteins, known as enzymes, can speed up reactions. Our understanding of how these proteins are synthesised from the food we consume is limited. We are hoping that our current research will allow us to develop an understanding of the underlying physical basis of enzyme catalysed process that will potentially allow us to measure (and even predict) the rates of enzyme catalysed processes.

This is a very exciting time to be researching the nutritional sciences, as society has never depended on us more."

Dr Sally

The Northland Foundation for Nutritional Health

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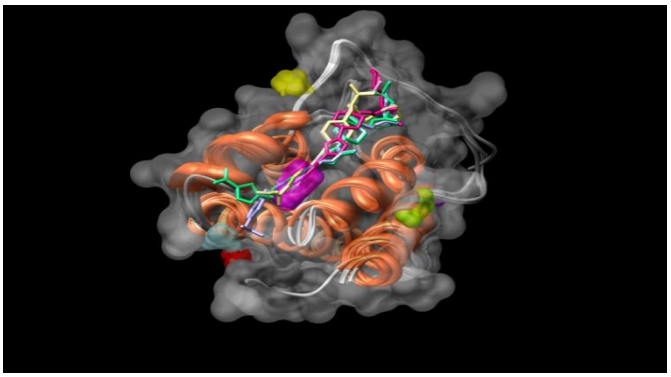
This month's issue:



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Jon Fuller, Image courtesy Centre for Bioscience, the Higher Education Academy, ImageBank

Notes for the tutor: There are number of questionable statements in the above editorial which are summarised as follows:

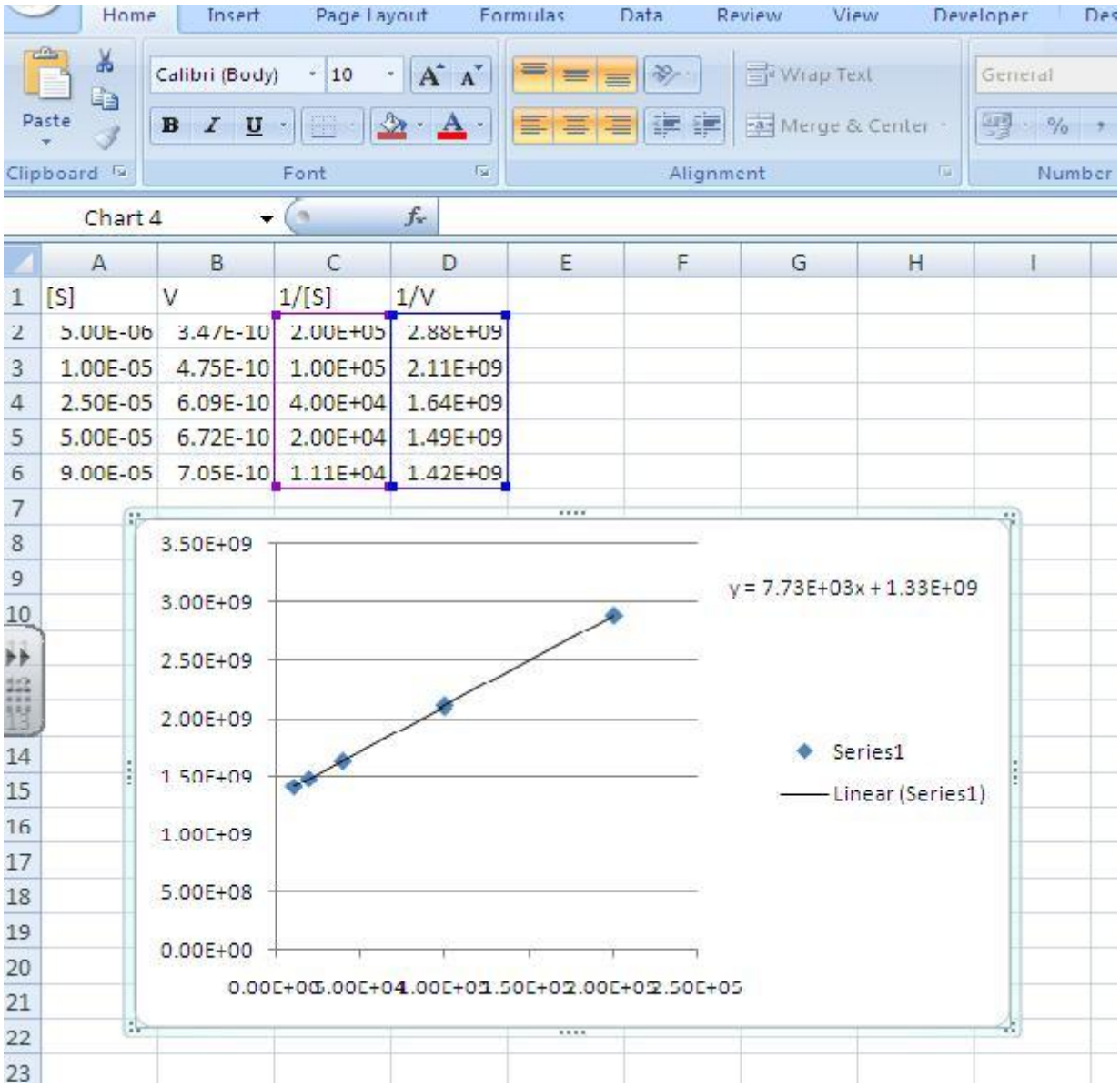
- **"My research team is working on uncovering the scientific basis of human metabolism of food in order to help improve our understanding of what constitutes a healthy diet." We already have a good picture of the relevant processes, students should be able to research the underlying science with ease.**
- **"We know that proteins play an important role in this process but the details of what they do remain unclear." Again we know quite a lot about this so students should be able to explain the various roles that proteins play in living systems.**
- **"Proteins form a range of diverse structures but we don't know very much about what causes them to adopt these structures and how the three dimensional structures relates to their chemical properties…" Students should be able to discuss the four levels of protein structure and indicate the significance of the chemical and physical interactions between different parts of the protein to each of these levels of structure. More advanced students can research techniques for visualising (X-ray crystallography, NMR) and predicting (RaptorX) the 3D structure of proteins.**
- **"Our understanding of how these proteins are synthesised from the food we consume is limited "Again, we know quite a lot about how proteins are synthesised.**
- **"We are hoping that our current research will allow us to develop an understanding of the underlying physical basis of enzyme catalysed process that will potentially allow us to measure (and even predict) the rates of enzyme catalysed processes." The kinetic effect of enzymes on biological processes can be effectively modelled by using the Michaelis-Menten model. Students should analyse the data provided by Dr Sally's group by creating a Lineweaver-Burke plot and determining values of K_M and V_{max} to illustrate how the data can be analysed.**

Please provide all students with the following kinetic data:

Concentration of substrate (mol dm^{-3})	Amount of product produced (mol min^{-1})
5.00×10^{-6}	3.47×10^{-10}
1.00×10^{-5}	4.75×10^{-10}
2.50×10^{-5}	6.09×10^{-10}
5.00×10^{-5}	6.72×10^{-10}
9.00×10^{-5}	7.05×10^{-10}
5.00×10^{-5}	3.47×10^{-10}

The concentration of enzyme was 12.5 pM.

Tutor Guide: Screen grab of data analysis of kinetic data:



Students can analyse the data by creating a Lineweaver-Burke plot as shown above. The y-axis intercept gives a value of $1/V_{max}$ and the x axis intercept gives $-1/K_M$.

This plot demonstrates that this data obeys Michaelis Menten kinetics

$K_M = 5.8 \times 10^{-6}$ M

$V_{max} = 7.5 \times 10^{-10}$ mol/min = 1.25×10^{-11} mol/s

Turnover rate: $k_3 = \frac{V_{max}}{[E]} = \frac{1.25 \times 10^{-11} \frac{mols^{-1}}{10 \times 10^{-3}\, dm^3}}{12.5 \times 10^{-12}\, moldm^{-3}} = 100\ s^{-1}$

Facilitation questions

You may want to ask some of the following questions to stimulate discussion amongst groups during this session:

Highlight to students that these are guidelines questions which should help them work on achieving the intended learning outcomes. You may need to remind students of this in subsequent sessions.

- What happens to protein when we eat it?
  Students should discuss the digestion of proteins (in the stomach and duodenum) into free amino acids (by HCl which separates proteins into amino acids followed by enzyme catalysed digestion of the amino acids) which are then metabolised.
- Why do we need protein in the diet?
  Proteins act as sources of amino acids (including essential amino acids – those which cannot be biosynthesised by the human body) which are used to biosynthesise the proteins essential to life.
- What are typical functions of proteins in the body?
  Proteins have a wide range of functions in the body. These include: Structural support, storage of amino acids, transport of other proteins and molecules, movement, communication between and within cells etc. There are a large number of functions – students should aim to list these and explain how a single type of molecule can perform such a diverse range of roles.
- What chemical bonds are present in proteins?
  Peptide (C-N) bonds between successive amino acids in the protein chain are of key importance. Students should know the general condensation reaction scheme too. Weaker forces and bonds between different parts of the protein are discussed in questions below.
- What are the four levels of protein structure and their significance?
  Primary – the amino acid sequence. These amino acid residues are held together by covalent peptide bonds. Secondary – the highly regular local sub-structure (ie. α-helix and β-sheets structure) – hydrogen bonding plays an important part at this level, Tertiary – the 3D structure of the protein: this level of structure is dominated by weaker intermolecular interactions between groups in different part of the protein chain which fold the protein into a compact globule, Quarternary – the assembly of several proteins or polypeptides.
- What is an essential amino acid?
  This is an amino acid which cannot be biosynthesised by the body (see second question).
- What is the relationship between amino acids and proteins?
  Proteins are effectively long chains of amino acids held together by peptide (C-N) bonds. The actual structure is more complicated due to a range of other weak physical and strong chemical interactions between different parts of the chain (see structure question above).
- What factors influence the final structure of a protein?
  A number of strong chemical and weak physical interactions including hydrogen bonds between amine and carbonyl groups of amino acids within the protein backbone, ionic bonds between oppositely charged groups within the structure, hydrophobic effects from – the tendency of non-polar groups to cluster together to form micelles, van der Waals interactions between non-polar groups (students can discuss the range of interaction types possible within proteins) and disulphide bridges which are covalent links between two cysteine groups.

- Discuss the use of catalysts in chemical processes. How can you modify your simple energy level profile diagrams to show the alternative route taken if the process was catalysed?
  Catalysts change the rate (kinetics) of a chemical process by providing an alternative pathway. Catalysts do not affect the thermodynamics of a chemical process.
- What is meant by the active site of an enzyme?
  A location in a protein structure where substrates are able to bind and undergo chemical reactions. The size and 3D structure of the active site makes it highly specific for particular substrate structures.
- Discuss the various mechanisms by which enzymes may catalyse processes in biological systems.
  Students should discuss the lock and key and induced fit models of enzyme catalysis. Students can also discuss the impact of each of these mechanisms on the specificity of the enzyme.
- Discuss the effects of the physical environment (specifically temperature and pH) on the activity of enzymes.
  The complex 3D structures of enzymes can be broken down at high temperature conditions or at certain pH conditions. Under these conditions the enzyme becomes inactive.
- How may an enzyme be inhibited? Describe the common pathways by which this may be achieved.
  Students should discuss the mechanistic pathways: reversible (including competitive, non-competitive, uncompetitive and mixed inhibition mechanisms) and irreversible inhibition. Students should place a particular emphasis on the importance in the chemical interactions of 3D structure of the enzyme and substrate.
- Describe the kinetic model of enzyme catalysed processes in terms of the Michaelis-Menten model. How can the maximal rate of such a process be determined?

  V = rate, [S] = substrate concentration, k_3 = rate constant of conversion of enzyme substrate complex into product, $[E_T]$ = total enzyme concentration, V_{max} = maximal rate and K_M = the Michaelis constant.

  The maximal rate is: $V_{max} = k_3[E_T]$

  The Michaelis-Menten equation is: $V = V_{max}\frac{[S]}{\{S\}+K_M}$

  So, when [S] is low, the rate is directly proportional to the substrate concentration:

  $$V = \frac{[S]V_{max}}{K_M}$$

  At high substrate concentration the rate is independent of [S]:

  $$V = V_{max}$$

- Can we distinguish the different types of inhibition through kinetic studies?
  The Michaelis-Menten kinetic model can be used to predict the effect of each mechanism on various kinetic parameters.

- How can a Lineweaver-Burke plot be used to establish useful kinetic parameters from experimental data?
  A lineweaver-Burke plot can be obtained by plotting 1/V against 1/[S]. By looking at the reciprocal form of the Michaelis-Menten equation:

$$\frac{1}{V} = \frac{1}{V_{max}} + \frac{K_M}{V_{max}} \times \frac{1}{[S]}$$

  The vertical axis intercept will give $1/V_{max}$ and the horizontal axis intercept will give $-1/K_M$

Please issue the following email to students who publish a corrected version of Dr Sally's editorial:

From: **Chief Editor [chiefeditor@nutritionandhealth.com]**

To: **Graduate Interns**

Cc:

Subject: **FW: Request from Dr Sally**

Dear team,

Please take a look at this e-mail we have received from Dr Sally's legal team. Please draft a Summary of the errors that you spotted in her article and please prepare a two-page spread on the structure and function of proteins (obviously with a specific emphasis on diet). Please make sure this article makes it clear to our guest editor that our changes were based on scientific concerns. Please make sure the article will help our younger subscribers understand these concepts! Perhaps you could include an analysis of that kinetic data - remember to explain what it shows!

Best wishes,

Dr Livid,

Chief Editor of Nutrition and Health

From: **D Rowlands [drowlands@scientificlegal.com]**

To: **Nature and Health [Natureandhealth.com]**

Cc:

Subject: **Request from Dr Sally**

Dear Nature and Health magazine,

I am writing on behalf of my client Dr Sally regarding an article that she wrote for your magazine last month. Dr Sally was invited to write an editorial based on the cutting edge research that is being conducted in her laboratory. Dr Sally was surprised to see that your editorial team have made significant changes to the editorial without notifying her.

Dr Sally is currently considering her options before deciding what the most appropriate course of action is but in the meantime she would like us to inform you that she will be expecting to see a full explanation of these 'errors' in the next edition of your magazine.

Best wishes,

D Rowlands,

Scientific Legal

Please issue the following email to students who publish Dr Sally's editorial with some or all errors still present:

From: **Chief Editor [chiefeditor@nutritionandhealth.com]**

To: **Graduate Interns**

Cc:

Subject: **FW: Last month's editorial!**

Dear team,

Please take a look at this email we received from one of our readers (see attachment). I am not happy that we agreed to publish an editorial containing a significant number of factual errors. This is embarrassing for all of us and we will need to act fast in order to minimise the damage already done by Dr Sally's editorial. We will need to print an apology in the next issue. I also think it would be useful to run a two-page spread on the structure and function of proteins (obviously with a specific emphasis on diet). Please make sure this article clears up any confusion amongst our readers, our younger subscribers in particular! Perhaps you could include an analysis of that kinetic data - remember to explain what it shows!

Best wishes,

Dr Livid,

Chief Editor of Nutrition and Health

Dear Dr Livid,

Being a graduate of the London College of Nutrition I was very concerned by Dr Sally's editorial in the February issue of Nutrition and Health.

Dr Sally claims that not a lot is known about the structure and function of proteins. May I suggest that Dr Sally consults any introductory textbook – she may find that it makes her current research somewhat redundant!

I was frankly stunned to see that your editor chose not to discuss what we do know about protein structure and function: the four levels of protein structure, the kinetic theories of enzymes (eg. Michaelis Menten) and the catabolism of proteins to name just three areas that were overlooked!

I hope the quality of editorials improves or I may be forced to reconsider my subscription!

Prof Peeved

University of Northland

Group reflection

At the end of this session give students around 10 minutes to reflect upon their discussions in this session. Students should ask themselves whether they are confident that they understand the material covered or do they need to carry out further research on some topics.

Review your progress in this session and think about what remains to be done. Construct a brief plan of action – the plan should include a list of the tasks that each group member is expected to do and a timescale

for each of these tasks to be done. Remember to include enough time to proof read each other's work before submission. You should briefly present this plan to your tutor before the end of the session.

Ask the students to briefly summarise their progress during the session and to present a plan of what they intend to do before the next session.

Session 2: Question Time (60-90 minutes)

Pre-Session Preparation

You should advise students that they should be prepared to discuss the following topics in the facilitation session:

- Nucleic Acids and DNA
- Fatty Acids and Lipids
- Polysaccharides and Carbohydrates

We recommend reading the following topics in *Biochemistry* (Berg *et al*):

- Sections 4.1 and 4.2
- Sections 11.1 and 11.2 (possibly 11.3 and 11.4)
- Sections 12.1 -12.3

Intended Learning Outcomes

By the end of this problem students should be able to:

- draw the typical chemical structure of fats, carbohydrates and nucleic acids
- describe the biochemical role of fats, carbohydrates and nucleic acids
- give an oral presentation to communicate scientific concepts to a diverse audience

Resources

Make the following resources available to students **before** this facilitation session:

- The email asking the students to appear on next week's episode of this programme.
- Either the audio recording of Dr Sally's radio interview or the script of this interview (see appendix of this problem for text). If possible you could give students both of these resources.

During the session it would be useful for students to have access to computer facilities with an internet connection.

Facilitation questions

You may want to ask some of the following questions to stimulate discussion amongst groups during this session. **You may also wish to use some of these questions as the basis of the questioning in the interview with the student groups.**

- The major components of dietary fats are triglycerides (triacylglycerols). What are these?
  Triglycerides are uncharged esters of fatty acids of glycerol. Fatty acids are stored as triglycerols.
- How are the components of fat used in cells?
  Cell membranes are phospholipid bilayers, fats are also involved in energy storage and cell signalling
- What is an essential fatty acid? Why is it important?
  Essential fatty acids are fatty acids that humans cannot biosynthesise but require (i.e. ω-3 and ω-6). These fatty acids must form part of a healthy diet.
- What are phospholipids?
  Phospholipids consist of three components: fatty acids, a phosphate group, and an alcohol attached to the phosphate. The fatty acid components provide a hydrophobic

barrier; the rest of the molecule is hydrophilic which allows interaction with the surroundings.

- What is a monosaccharide? What is a disaccharide? What is a polysaccharide?
  Monosaccharaides are the simplest forms of sugar –they are the monomers which are connected by glycosidic linkages to form macromolecular polysaccharides. A disaccharide is a sugar molecule consisting of two monosaccharaides. A polysaccharide is a macromolecule built up from a large number (several hundreds or thousands) of monosaccharaides – each connected by glycosidic linkages.
- What happens to carbohydrate after it is eaten?
- **Carbohydrates are hydrolysed to monosaccharides in the small intestine**
- Why are sugars needed by cells?
  Monosaccharaides are an essential part of the cellular respiration process – they provide energy. Polysaccharides can be used to store energy in some types of cells. Saccharides can also have structural roles.
- What is a helix? What is a double helix?
  A helix is a repeating spiral pattern in the structure of a macromolecule. A double helix consists of two matching helices which are intertwined around a common axis.
- What makes up the backbone of DNA?
  DNA is composed of pentose sugar (deoxyribose) and phosphate backbone
- How are the two strands of DNA connected together?
  The two strands are connected by hydrogen bonds between the nitrogen bases in each strand.
- What are base pairs and how are they connected to the rest of the DNA molecule?
  The bases consist of a group of purine and pyrimidine derivatives. In DNA the purines are adenine and guanine; the pyrimidines are cytosine and thymine. The bases are connected to deoxyribose to form nucleosides, the phosphate monoesters of which are nucleotides. Base pairs are formed by the hydrogen bonds formed between two bases on the two strands of the double helix. Only certain combinations of bases can form base pairs: adenine (A) forms a base pair with thymine (T) and guanine (G) forms a base pair with cytosine (C).
- What are the differences between DNA and RNA?
- How long are typical strands of DNA?
  There are 247 million nucleotide base pairs in chromosome 1 – the largest human chromosome.
- What are the functions of nucleic acids in cells?
  Functions include DNA include the storage of genetic information, the synthesis of RNA and protein synthesis (via the base sequence). Functions of RNA include the direction of protein synthesis and transmission of genetic information. ATP acts as a short term energy store.
- What happens to nucleic acids after they are eaten?
  Nucleic acids are broken down in the small intestine by nucleases.
- Why aren't nucleic acids or nucleotides essential in the diet?
  The body can biosynthesise nucleotides and purine and pyrimidine bases.

The Interview

A media interview is another way of communicating scientific ideas; the content discussed in the first two sessions will form the basis of this interview. This interview will be based on a series of questions asked by the presenter of a radio programme on nutrition and health. You will spend most of the interview answering

these questions so you will need to think carefully about how to communicate your points at an appropriate level for the audience.

It is important to remember these points:

- This is not a standard oral presentation, the majority of the time you will be answering questions. You should not prepare a PowerPoint presentation!
- Communicate your responses at an appropriate level – the audience won't be experts so it won't be much use to simply quote findings direct from a research paper!
- Critically evaluate Dr Sally's interview and think carefully about the points you would like to get across. Compile a list of possible questions based on this discussion. Put yourselves in the shoes of the press.

Practice for the Interview

You should explain the format of the interview. The interview will last around five minutes and will be based on a series of questions from a radio interviewer (i.e. not a subject expert). The role of the radio interviewer is taken by the tutor. The key thing to emphasise is that this is an interview and not a presentation – students can't rehearse from a script as they don't know what questions will be asked or how the interviewer will respond to their answers. Students should be reminded that they should give descriptive answers which explain scientific principles in a way that will be accessible to the general public. The interviewer will know that the group would like to respond to Dr Sally's appearance but doesn't necessarily know what aspects of Dr Sally's interview the group disagrees with.

You should try to encourage students to prepare for the interview by staging a short debate within their groups during the facilitation session. You can seed the debate with some of the scientific questions above as well as some of the more general questions below but you should encourage the group to discuss this amongst themselves (they should nominate one member as the interviewer for this practice). Alternatives questions can be used but it would be to include questions which allow the students to correct statements made by the interviewer (the question below is an example).

- **Do you agree with Dr Sally's vision for the nation's diet? Is there an urgent need for the government to provide clearer guidelines on what we eat?**
- **Why do you disagree (or agree if appropriate!) with Dr Sally on this?**
- **Should we be eating carbohydrates? Could you explain why dietary supplements are so important to a healthy diet?**
- **So what is the role of dietary supplements?**
- **What, in your opinions, are some of the key dietary issues facing our nation?**
- **What can we do about these issues?**
- **I'm sure you must agree with Dr Sally's advice on trans fats? Isn't that accepted knowledge?**
- **You may include other questions and you want to encourage students to think of more questions based on the content of Dr Sally's interview and the relevant scientific concepts. Please note that some of these questions are similar to some of the recommended interview questions (page 22) so please be flexible with regards to**

Assessment

This will take place in session 3. The assessment for this part of the problem can either take the form of an audio recording (i.e. a podcast) of the group giving an interview on the same programme, alternatively it could take the form of a live interview given in front of an audience of peers (who can also assess the activity). Students should use the facilitation sessions to decide what the key message of their appearance on the programme will be, how they plan on getting the message across and some consideration of what kind of questions they should expect.

When conducting the interview give students a chance to open by summarising their key message, perhaps by opening with a line such as: “Welcome to the show. I understand you are here today to talk about some of the issues raised by Dr Sally’s interview last week, please tell us more…”. After they have given an opening statement students should be questioned on specific points by the interviewer – questions may be based on the facilitation questions listed above and should test specific points of scientific understanding within the context of the scenario.

Construct a brief plan of action – the plan should include a list of the tasks that each group member is expected to do and a timescale for each of these tasks to be done. Remember to include enough time to proof read each other's work before submission. You should briefly present this plan to your tutor before the end of the session.

From: **Chief Editor [chiefeditor@nutritionandhealth.com]**

To: **Graduate Interns**

Cc:

Subject: **Radio Interview**

Dear team,

Please listen to this recording of a recent radio interview given by Dr. Sally. Given the confusion that I'm sure this interview has caused, I have arranged for you to appear in next week's show – please try to undo some of the damage she has done to our profession! Remember, your responses to the interviewer's questions needed to be grounded in science but you must make sure the audience can understand what you are mean!

Best wishes,

Dr Livid,

Chief Editor of Nutrition and Health

Script of Dr Sally's radio interview:

Clip 1 – Carbohydrates Interview

Interviewer: Good morning and welcome to Health Matters. Today we will be discussing the role of carbohydrates in a healthy diet with our special guest and later in the show we'll be taking some of your health questions so if you have any health issues please get in touch. So first of all I'd like to welcome today's special guest, author of the bestselling book "Dr Sally's Eating for Health", Dr Sally.

Dr Sally: Good morning.

Interviewer: Good morning Dr Sally, a pleasure to have you with us today. So your new book has been another runaway success, congratulations.

Dr Sally: Thank you and thanks to everyone out there who has helped make it a best seller.

Interviewer: Could you please give us a brief summary of "Eating for Health" for the benefit of the one or two people who still haven't bought it?

Dr Sally: Of course Dave. This book is a gift from me to the good people of Northland. I want us to be a fit, healthy nation and it is my responsibility to share my nutritional insight with the public at a reasonable price.

Interviewer: So what insights have you got for the Northland public?

Dr Sally: I don't want to spoil the book but let's think about what's wrong with the nation's diet. I know the answer; the supermarkets know the answer, even the general public know the answer – Carbohydrates.

Interviewer: Carbohydrates?

Dr Sally: Absolutely! **Our diets are overloaded with carbohydrates. We need to dramatically reduce our dependence on carbohydrates as a nation. Carbohydrates are essentially incompatible with the human body so we need to cut them out of our diets.** It really is no wonder that we lead Europe in terms of obesity – we should be ashamed of ourselves! **We need to be teaching our children to cut carbohydrates out of their diets rather than ruining their lives at an early age by force feeding them carbs!**

Interviewer: This is clearly something you feel very strongly about.

Dr Sally: It's something that we should all feel very strongly about! As well as causing an alarming rise in national obesity levels, if we persist in allowing people to follow diets which include carbohydrates we will see a massive increase in diabetes levels. The NHS won't be able to cope!

Interviewer: If all of our listeners cut out carbohydrates now what should they eat instead?

Dr Sally: **Dietary supplements are an essential part of any healthy diet. My website sells a comprehensive selection of dietary supplements which should be enough to get the country back on track. All of this is in the book – that's why everyone needs to read it!**

Interviewer: So from a scientific perspective, what do we know about carbohydrates? Aren't carbohydrates efficient sources of energy? What kind of molecules are they? For instance, do they vary in composition and does this affect how unhealthy there are?

Dr Sally: **I really don't want to spoil the book. Remember "Eating for Health" is just £19.95 in all good book shops and supermarkets.**

Interviewer: Okay, thanks for now Dr Sally. Dr Sally will be back in ten minutes to answer your questions so get calling now. First we're going to take a look at how to stay healthy in the summer sun…

Clip 2 – Listener Q&A

Interviewer: We're back with Dr Sally now for your questions. We should have Becky from Scunthorpe on the line. Hello Becky?

Becky: Hello Dave.

Interviewer: Becky what's your question for us this morning?

Becky: I'm six months pregnant and I'm rather worried that my child will inherit cystic fiborsis as there is a history of it in my husband's family.

Dr Sally: Good morning Becky this is Dr Sally.

Becky: Good morning Sally.

Dr Sally: Sorry, it's Dr Sally.

Becky: Sorry Dr Sally.

Dr Sally: Becky you don't have anything to worry about here. **Inheritance actually has no bearing on health. Health depends entirely on what you eat, not who your parents are.**

Presenter: But what about conditions like Huntingdon's disease and haemophilia, are you saying that these conditions are not caused by inherited genes?

Dr Sally: **Possibly not. If you want to know more about this I suggest you read my book!**

Becky: I'm very confused now – I was sure cystic fibrosis was an inherited condition; I just wanted to know what the chances of my child acquiring the condition were!

Dr Sally: Okay Becky, thanks! Who's up next?

Presenter: Oh, sorry Becky, Dr Sally has accidentally (?!) cut you off. Next we have Jeff in Leyland.

Jeff: Good morning Dave and Dr Sally.

Both: Good morning.

Presenter: Jeff, what would you like to know?

Jeff: I've heard a lot about essential fatty acids but I'm still not sure what makes them so essential – why should I be ensuring I eat them and how I can tell what contains them?

Dr Sally: These fatty acids are called essential because that's exactly what they are, we can't make them in our own bodies so we must consume them as part of our diet.

Presenter: So what do we need to look for on labels?

Dr Sally: **Well you should be wary of saturated trans fats – these fats can contribute to heart disease so should be avoided but you should get as much ω-3 and ω-6 oil as possible. ω-3 can be found in fish, soybean and flax oils and ω-6 can be found in sunflower and corn oils.**

Presenter: Would you say that it's important that we recognise the importance of some fats in our diets? Fats usually get a very bad press!

Dr Sally: Absolutely. Fats belong to a class of chemical molecules known as lipids. **Phospholipids are non-polar lipid molecules which help to form membranes. These phospholipids come together to form little bubbles called micelles in the body, which are important in a number of cellular pathways.**

Presenter: Thanks for your call Jeff. I'm afraid that all the time we have for this week. Once again I'd like to thank Dr Sally for joining us today.

Dr Sally: Thank you, it's been a pleasure.

Presenter: Don't forget to join us next week when we'll be learning how the new fitness craze yomba is taking the nation by storm.

Key mistakes or omissions in the interview (for the tutor):

- **Dr Sally doesn't answer any of the questions about carbohydrates – carbohydrates act as energy stores, some carbohydrates have functional roles (e.g. ribose in RNA and deoxyribose in DNA) and as components of coenzymes.**
- **Carbohydrates certainly aren't incompatible with the human body as demonstrated by the range of functions they perform! We certainly shouldn't completely eliminate them from our diets and in fact the calories provided by cooked carbohydrates have been shown to be important in the development of the evolution of a larger brain in *Homo sapiens*.**
- **Dr Sally discusses saturated trans fats. The 'trans' labels indicates that these fats are the trans geometric isomers of unsaturated fats. Saturated fats cannot be assigned cis and trans labels.**
- **Dr Sally doesn't really explain what ω-3 and ω-6 fats are.**
- **It is not correct to describe phospholipids as being non-polar as they contain both hydrophobic (non-polar) tail groups and hydrophilic (polar) head groups.**
- **Phospholipids can form liposomes, micelles and lipid bilayers in solution. Lipid bilayers form continuous barriers around cells. Micelles are not known to have any significant role in cellular pathways.**
- **Dr Sally's claims on genetic inheritance are out of line with the currently accepted central dogma of molecular biology as proposed by Watson and Crick. Students need to consider**

genetics in the context of sexual reproduction – when a pair of offspring reproduce, the offspring inherits the one of the two alleles for each gene from each parent.

Group reflection

- **At the end of this session give students around 10 minutes to reflect upon their discussions in this session. Students should ask themselves whether they are confident that they understand the material covered or do they need to carry out further research on some topics.**
- Review your progress in this session and think about what remains to be done. Construct a brief plan of action – the plan should include a list of the tasks that each group member is expected to do and a timescale for each of these tasks to be done. Remember to include enough time to proof read each other's work before submission. You should briefly present this plan to your tutor before the end of the session.
- **Ask the students to briefly summarise their progress during the session and to present a plan of what they intend to do before the next session.**

Session 3: Question Time – Part 2 (20-30 minutes per group)

During the session you will need to provide students with audio recording facilities. Freely available software such as Audacity (http://audacity.sourceforge.net/) can be used to record and edit these clips. You will also need appropriate hardware (such as a microphone that can pick up a number of voices simultaneously).

If you are unable to do this there are two options:

1. **Ask the students to record the podcasts themselves if they have suitable audio recording equipment (Phones, tablets and laptops can be used effectively).**
2. **Run this session as a live interview rather than a podcast and invite an audience to award the marks.**

This session should be used to record the response interview. Students should come into the interview with a prepared list of points to discuss and should really control the direction of the interview but if students are finding it difficult to structure their argument you may prompt them by regularly questioning them.

- **Dr Sally didn't answer our questions about what we already know about carbohydrates. Perhaps you could give us some more details? Are carbohydrates efficient sources of energy?**
- **What kind of molecules are carbohydrates? For instance, do they vary in composition and does this affect how unhealthy there are?**
- **Is it correct to say that we should eliminate carbohydrates from our diets?**
- **Are vitamin supplements as important to our diet as Dr Sally suggested last week?**
- **You also had some concerns about Dr Sally's claims about genetic inheritance – could you provide more details on this?**
- **So could you have told our caller Becky what the chances of her child acquiring cystic fibrosis are?**
- **We've had a number of complaints about Dr Sally's claim about saturated trans fats last week. Can you provide more details on this?**
- **And finally, we believe you have something to add to Dr Sally's information on lipids and phospholipids?**

Extension Task: Sensors

Please note this is an optional extra task that should only be attempted if there is enough time and the level is suitable for the students doing the module.

Intended Learning Outcomes

By the end of this problem students should be able to:

- Describe the theory behind fluorescent technology and how it can be applied in biological research
- Communicate scientific concepts to a range of audience types by preparing short written reports (news articles in the form of this problem)

Resources

Make the following resources available to students to complete this extension task:

- Slides 11-2
- Explanation of task (see assessment for this section)
- Press release (see appendix for this section)
- Details of the paper: Borgia, M.B., et al. (2011) Single-molecule fluorescence reveals sequence-specific misfolding in multidomain proteins *Nature* 474, 662–665 doi:10.1038/nature10099

We recommend reading the following topics in *Atkins' Physical Chemistry* (Atkins and Paula):

- Section 13.4

Assessment

We need to raise public awareness of this important analytical technique. If the general public refuse to support the research we are doing we may find it difficult to generate funding in the future.

Read the following press release about an innovative biochemical application of fluorescence and think about how we can convince the public of the merits of this technique. This should including a simple description of the physical basis of the technique.

You should write two articles: one suitable for mainstream (non red-top tabloid) newspapers and another for use in scientific magazines and journals (e.g. Chemistry World and New Scientist)

From: **D. Carter (Dr) [carterd@nas.nld]**

To: **Graduate Interns**

Cc:

Subject: **Fluorescence**

Attachment: Story from the Northland Gazette

Dear Intern team,

Please read the attached letter recently published in the Northland Gazette. This is another example of the generally poor understanding of important biochemical analytical techniques amongst the general public. We need to raise public awareness of this important analytical technique. If the general public refuse to support the research we are doing we may find it difficult to generate funding in the future.

I have also attached a press release about an innovative biochemical application of fluorescence, please read through this and think about how we can convince the public of the merits of this technique. This should including a simple description of the physical basis of the technique and a description of some interesting applications of the technique in biochemical research.

You should write two articles: one suitable for mainstream (non red-top tabloid) newspapers and another for use in scientific magazines and journals (e.g. Chemistry World and New Scientist)

Best wishes,

Dr Carter,

Biochemical Studies Baffle the Public

Letter from the Northland Gazette

The Northland public is potentially being misled by scientists on a daily basis. Many biochemical studies make use of fluorescence to monitor biochemical processes on the molecular level. Potentially important conclusions about the mechanisms and kinetics of enzyme catalysed processes are being followed by fluorescent techniques but it remains unclear how accurate these techniques are and how they operate. I challenge the scientific community to come up with a suitable explanation of how the technique works and why it is so useful, in language that us non-boffins can understand!

Northland National Academy of Science

Press Release

In order for a protein to have the correct biological function, it is essential that chain of amino acids the protein is composed of folds into the right three-dimensional structure. The misfolding of proteins is responsible for a number of diseases including Alzheimer's and Parkinson's disease. Recent research has shown misfolding is more frequent if the sequence of the amino acids in the neighbouring protein domains is very similar.

Proteins are biological molecules essential for life. In humans, for example, they have a variety of roles including providing the basis for structures such as hair and skin and the function of cells that make up

organs with the body. Each protein has unique functions and these functions will be based on its three-dimensional structure, which usually consists of a number of sections, or “domains” It is therefore important that proteins avoid “misfolding processes”. However, this is no easy task since the same molecular interactions that stabilize the correct structure of individual proteins can also bring about interactions between protein molecules, causing them to misfold.

Colleagues from the Universities of Zurich and Cambridge used a technique called single-molecule fluorescence to identify situations in which protein misfolding are more likely to occur. In order to do this the team, headed by Prof. Benjamin Schuler from the University of Zurich, studied the largest protein found in humans, titin. This protein, which is composed of a number of domains, helps the stability and elasticity of the muscle fibres. Individual titin domains unfold when the muscle is heavily exerted to avoid damaging the muscle tissue. When the muscle relaxes again the domains refold; however, there is a danger that these unfolded domains may fold incorrectly.

To investigate how this occurs, the researchers attached small fluorescent molecules to the protein which acted as probes. “Using our laser-spectroscopic method we were able to determine distances on a molecular scale, i.e. down to a few millionths of a millimeter, through the energy transfer between the probes,” explains Prof. Schuler. This enabled the structures of correctly and misfolded proteins to be distinguished and thus the proportion of misfolding determined.

“The study of different titin domains in our experiments revealed that the probability of misfolding increases if neighboring domains are very similar in the sequence of their amino acids,” says Prof. Schuler. This is apparently the reason why neighboring domains in proteins have a limited degree of similarity. “This seems to be a key evolutionary strategy to avoid protein misfolding and thus guarantee their maximum functionality,” says Schuler.

Marking Criteria

Radio Interview:

- Did the group summarise the key errors made by Dr Sally in her interview and explain the science at an appropriate level for the general public?
- Did the group demonstrate a clear understanding of the scientific basis of the discussed topics (i.e. proteins, enzymes, enzyme kinetics nucleic acids and DNA, fatty acids and lipids, polysaccharides and carbohydrates)? Was it clear that the students had considered the points in the discussion questions from the first two sessions?
- Did the students respond well to questioning? Did the answers demonstrate that they had researched the concepts listed above?

Mark out of 10:

8 (or more) - The level of presentation in the interview was very well structured and clear. The group responded very well to all questions asked – responses were scientifically correct and delivered in a clear, confident manner. All of the points listed above were covered very well.

7 - The level of presentation was sufficiently clear to allow the listener to understand the key points made by the group. The group responded well to most questions – responses were scientifically correct and were delivered generally well. Most of the points listed above were covered well by the group's responses.

5 - The standard of presentation was adequate. The group managed to cover some of the points listed above – The group struggled to respond to some of the questions and appeared to be 'against the ropes' at times .There may have been some scientific errors.

3 - The standard of presentation was very poor. The group struggled with most of the questions and failed to address many (or all) of the points listed above. The group struggled with most (or all) of the questions asked.

Presentation of written solutions

- **A (1st) – Excellent** The solution is very well structured and produced. It is easy to find the different sections and there is similar presentation on different pages. Each section is virtually free from errors in grammar, spelling and punctuation and makes good use of **referenced & labelled** diagrams.
- **B (2.1) – Very good** The solution is well structured and produced. It is clearly written apart from relatively minor aspects which would not seriously affect the understanding of the reader. The solution makes good use of referenced and labelled diagrams to clarify key points in the answer.
- **C (2.2) – Good** Though reasonably well structured and produced, the solution contains significant errors in grammar and spelling. Diagrams were provide, these were not always referenced and/or there was little attempt made to relate these to the answer.
- **D (3rd) – Modest** The solution was disorganised and disjointed and so badly produced that it would inevitably misguide the reader. There were lots of errors – spelling, grammar, lots of different fonts and little or no evidence of teamwork. There was little or no effort to provide diagrams or examples to illustrate points in the answer.

Examples of points that you may expect to find in the problem solutions

Part 1 – Editorial

- Did the students decide to reject the editorial or publish it with significant changes? Students who published the editorial in its original form or with only one or two of the errors corrected clearly did not perform an in-depth review so this should be taken into account.
- Does the response evaluate the editorial and identify all of the errors highlighted in the tutor guide? Did the students provide a full explanation of why the statements were wrong?
- Did the two page spread show evidence of research from a range of sources (including both textbooks and original research)? Was this article written in a style which is suitable for chemistry and biology students at A2 level or in the first year of their degree studies?
- Did the students provide an analysis of the kinetic data provided by constructing a Lineweaver-Burke plot and determining the relevant kinetic parameters?
- You may also choose to ask students to hand in their answers to the discussion questions and mark these based on the solutions in the tutor guide.

Part 2 – Question Time

- Did the students indentify all of the questionable statements made by Dr Sally (as highlighted in the tutor guide)?
- Did the interview that the students recorded as a response cover the scientific basis of all of the areas highlighted in Dr Sally's interview?
- Did the students communicate this information that was accessible to a non-expert audience.

Part 3 – Peer Review – Extension Task

- Are the student responses to this part of the task suitable for the two different audience types that were detailed in the problem statement?
- Do the press releases provide explanations of the physical basis of fluorescence in a format that is suitable for the intended audience?
- Do the answers succeed in explaining how fluorescence has been applied to this specific research application?
- Do the press rereleases give other examples of how fluorescence is used in a biological context?
- Are other bio-sensing techniques discussed? Is fluorescence compared to these other techniques?