INTRODUCING MOLECULAR BIOLOGY TO MEDICAL PHYSICISTS

Kwan Hoong Ng[1], Deming Chau[2], Thamil Selvee Ramasamy[3]

1 Department of Biomedical Imaging, Faculty of Medicine, University of Malaya, Kuala Lumpur, Malaysia
2 Department of Biomedical Science, Faculty of Medicine and Health Sciences, Univesiti Putra Malaysia, Serdang, Malaysia
3 Department of Molecular Medicine, Faculty of Medicine, University of Malaya, Kuala Lumpur, Malaysia

Abstract –

Molecular biology helps us understand how genetic information is converted to functional proteins, how proteins interact through complex networks to determine the fate and function of a cell and how mutations lead to diseases. In the era of molecular medicine and ommissionin medicine, medical physicists need to acquire basic knowledge of molecular biology in order to communicate and collaborate with clinical and life science colleagues. This article documents our experience in introducing molecular biology as an academic module in a regional training course for educators held in Kuala Lumpur, Nov 2019. The module consists of didactic lectures, simulation, group exercises, etc. From the positive feedbacks that we received, the participants benefited from the exposure and we plan to produce some learning materials for future courses.

Keywords- **Cancer biology**, **Molecular biology, Molecular medicine, Personalised medicine**

I. INTRODUCTION

The completion of the human genome project in the early 21st century and the subsequent initiation of the global effort to map human cancer genes were built on tools and techniques developed through the 20th century. The engine behind this drive towards our better understanding of the foundation of life and improvement of living experience on the earth is built on decades of knowledge on cellular and molecular biology – the study of how molecules in the cell give rise to functions in the body. Today, technologies such as gene cloning, gene sequencing, PCR, gene editing, targeted-cancer therapy are converging at a rapid rate to change the way human diseases are diagnosed and treated. Molecular biology helps us understand how genetic information is converted to functional proteins, how proteins, like factory workers, interact through complex networks to determine the fate and function of a cell and how mutations lead to diseases [1].

II. WHY MEDICAL PHYSICISTS SHOULD LEARN MOLECULAR BIOLOGY

Traditionally medical physicists have been working with radiology, radiotherapy and nuclear medicine – all requiring knowledge of human anatomy and physiology. However, as we are in the era of molecular and ommissionin medicine, molecular biology has become fundamental in understanding how nuclear medicine works. Molecular biology is also driving new innovations and discoveries in medical physics. Thus, it behooves medical physicists to acquire basic knowledge and understanding in order for them to communicate and collaborate with their clinical and life science colleagues [2].

4. THE EXPERIENCE OF INTRODUCTION MOLECULAR BIOLOGY IN IAEA REGIONAL TRAINING COURSE RAS6088

This Training Course on ‘Basic Radiation Dosimetry, Molecular Biology and Radiobiology for Radiotherapy Medical Physics’, was held in Kuala Lumpur, Malaysia, from 18 to 22 November 2019.

A seven-hour module on molecular biology consisting of didactic lectures, simulation, group exercises, etc. were delivered by D Chau and TS Ramasamy.

Topics covered:

1. Introduction to molecular biology

2. Central dogma of molecular biology

3. Cell Signaling
   3.1 Cell cycle
   3.2 DNA mutation and repair

4. Cancer biology

5. Application of molecular biology in medicine

the students were asked to compare activities inside a car factory with activities inside a cell. This analogy allowed the students to find similarities between a car factory and a cell, such as the assembly line in a car factor is analogous to the production of proteins from DNA information.

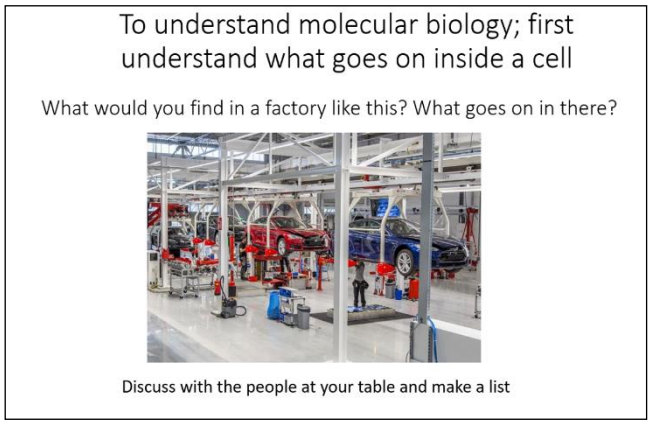

Figure 1: **An example of lecture slide** in which an active learning mode was employed to foster understanding of students of cell and molecular biology using a day-today related metaphor.

In the next session, the students were asked to differentiate between gene, genome, DNA, nucleotide and chromosomes. A cookbook analogy was used to link these concepts. A cookbook contains instructions, gene contains information; a recipe is made up of words, gene is made up of DNA/nucleotide; recipes are translated into making a dish, genetic information is translated to make proteins, which captures the central dogma of molecular biology [3].

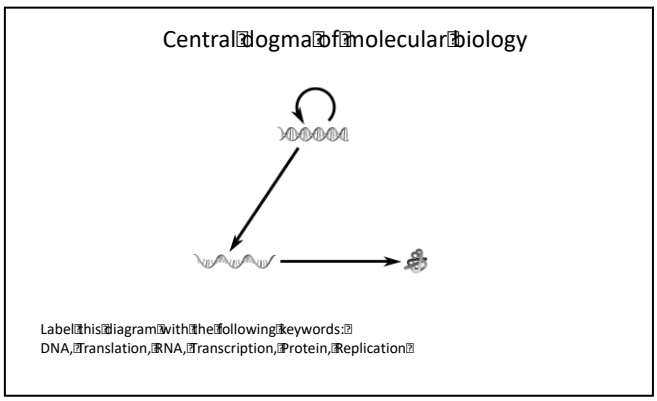

Figure 2: Learning about the central dogma of molecular biology through active learning.
The students were given an unlabelled diagram depicting the central dogma of molecular biology and tasked to labeled this diagram with the given keywords. They were allowed to use online resources as they worked through this task.

Cancers share many common features and these features are commonly called the cancer hallmarks [4]. Rather than telling the students what these hallmarks are, these students were asked to work in groups and prepare a short 5-minute presentation on 4 of the 10 hallmarks of cancer. The students used online resources for this assignment.

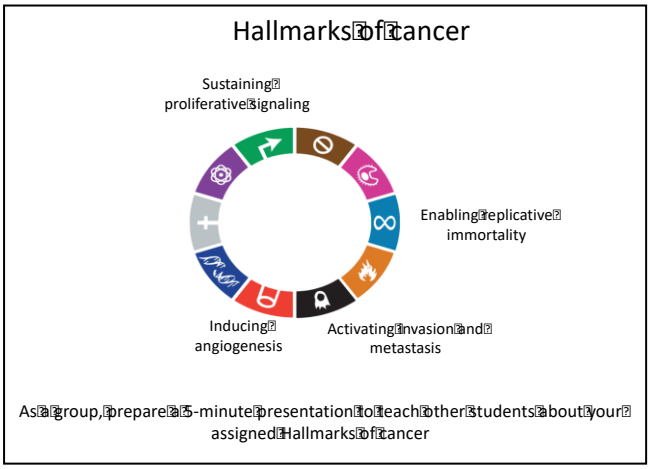

Figure 3: Peer-learning the Hallmarks of Cancer. The students were tasked to work in a group and prepare a short presentation to teach other students about the Hallmarks of Cancer.

Since the early 2000s, targeted therapy has become one of the common regiments in cancer therapy. The basis of targeted therapy is rooted in our understanding of genes and mutations. As a closing on the discussion of molecular biology, the students were given a case study on the use of genetic information to classified common breast cancer subtypes and how these information is used to guide whether the patients will be given tamoxifen or Herceptin as drug.

Figure 4: **Group activity and presentation.** Students actively participated in teaching and learning process, in which they used online resources and group discussion to presents some of the hallmarks of cancer.

III. OUTOCOMES OF STUDENT ACTIVIE LEARNING AND LECTURE ON MOLECULAR BIOLOGY

The course which is conducted based on lecture, quiz, discussion and group activities was instrumental in provoking the thought of the students to absorb the concept in molecular biology. Students were asked to provide metaphors for these concepts, in turn, this facilitate their understanding of the concept and pave a path to amalgamate this understanding in their job related knowledge. The student group presentation on the selected topics, in turns, has demonstrated their great interest and knowledge acquisition. This indeed stimulate their readiness to apply knowledge of molecular biology in radiobiology and facilitate new discover and develop which are much needed.

VI. CONCLUSION

The introduction of molecular biology in the RTC has proven to be a great success. The participants could relate to what they have been exposed to in the clinical settings. This session serves as a model for universities that conduct post-graduate programmes on medical physics. We hope to produce suitable teaching materials to share with others.

This article is based on the local experience of organizers and participants of an IAEA Regional Training Course held under the Technical Cooperation project RAS6/088; it does not represent in any way IAEA official opinions nor views.

REFERENCES:

[1] Crick F. Central Dogma Of Molecular Biology. *Nature*. 1970; 227: 561–563.

[2] Ng KH. Medical physics in 2020: will we still be relevant? Australas Phys Eng Sci Med. 2008 Jun;31(2):85-9.

[3] Erasmus RT, Murthy DP, Ogunbanjo BO. Basics Of Molecular Biology And Its Applications: I. Molecular Biology In Medicine: Basic Concepts. *P N G Med J*. 1996 Mar;39(1):56-66.

[4] Hanahan D, Weinberg R. The Hallmarks Of Cancer. *Cell* 2000;100:57–70.

[5] Hanahan D, Weinberg RA. Hallmarks Of Cancer: The Next Generation. *Cell*. 2011 Mar 4;144(5):646-74.

** images were retrieved from www.google.com under Google's "labeled for noncommercial reuse".

Contacts of the corresponding author:

Author: Kwan Hoong Ng, PhD
Institute: Department of Biomedical Imaging, University of Malaya.
City: Kuala Lumpur
Country: Malaysia
Email: ngkh@ummc.edu.my