Visualization and Simulated Animations of Pathology and Symptoms of Parkinson's Disease

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ABSTRACT

Diseases caused by a neuron degenerative disorder are important topics in neuroscience. Several of these, including Parkinson's disease, have been selected as examples in the BISC395 syllabus. Students study the diseases' biochemical features, such as pathology, symptoms, genetic aspect, therapeutic treatment and the basic mechanism in the molecular level of drugs. There are many particles, molecules and pathways involved in each topic. In the past, such complicated content was presented in class only through text and pictures. Students found it difficult to learn and sometimes they even lost interest during class.

To overcome this, we have developed a Simulated Learning Aid (SLA) using Parkinson's disease as the first example. The SLA is composed of videos, 2D simulated animations of biochemical pathways and a self quiz. The videos, showing the daily movements of Parkinson's disease patients, such as tremor, rigidity, akinesia and postural instability, help students understand more about its symptoms. The animations and simulated neural pathways allow students to visualize the movements of particles or molecules, conformational changes of organisms and the connection of nerves between different targets in the brain. At the end of each topic, a self quiz in multiple choice format is provided for reinforcement and consolidation. Apart from using the SLA in class for demonstration purposes, we will upload it on to online servers such as WebCT or TeachingWeb. That way students can access the programme not only in class but also from anywhere.

Keywords

Parkinson's disease, simulated learning aids, biochemical pathways, pathology, symptoms

OVERVIEW OF PARKINSON'S DISEASE

Parkinson's disease is a progressive disorder of movement that occurs mainly in the elderly. It is characterized by muscle rigidity, tremors, a slowing of physical movement (bradykinesia) and, in extreme cases, a loss of physical movement (akinesia). It affects the basal ganglia, and its neurochemical origin was discovered in 1960 by Hornykiewicz, who showed the dopamine content of the substantia nigra and corpus striatum in postmortem brains, of patients with a loss of dopaminergic neurons in the substantia nigra and degeneration of nerve terminals in the striatum. The damage is believed to be caused by excitotoxicity, oxidative stress and apoptosis. The drugs used for treatment of Parkinson's disease fall into the following categories: supplement of dopamine, drugs that mimic the action of dopamine at D2- of D3- receptor, MAO-B inhibitors, muscarinic acetylcholine receptor antagonists.

CONTENTS DESIGN OF THE COURSE

In the BISC395 course, several diseases related to the nerve system have been selected to be taught in class. Parkinson's disease is one example for discussion. Students are taught its clinical symptoms, progression changes and pathological hypothesis. Of the clinical symptoms, tremor, rigidity, akinesia, bradykinesia and postural instability are the most characteristic. Parkinsonism symptoms are supposed to be caused by a shortage of dopamine resulting form the impairment of dopaminergic neurons in the Central Nerve System (CNS). Following the recognition of the symptoms, three biochemical hypotheses are introduced to students: (a) the neurotoxicity hypothesis, (b) the free radical hypothesis and (c) the death of dopaminergic neurons in substantial nigral hypothesis. The last part discusses the drugs used in clinical treatment. Several strategies are applied to treat Parkinson's disease: (a) inactivate the dopamine degradation enzyme, (b) increase the precursor of dopamine, and (c) use the agonists of dopamine.

STUDENT'S NEED

According to past experiments, students mainly have two difficulties during study. Firstly, the lecturer can only describe the symptoms by using text and pictures. Students cannot imagine or identify what is exactly meant by "akinesia" or "bradykinesia". It may be good enough for exam purposes to just remember the terms. But students with biochemistry major are supposed to know more and be more accurate. Providing an actual video recording of a Parkinson's disease patient would be helpful.

Secondly, students found it hard to understand the movement of molecules and consequents caused by interaction between organelle and molecules. It is believed that Parkinson's disease is a neurodegenerative disorder caused by multi factors. Several hypotheses have been proposed. In BISC395, three of these: apoptosis, neurotoxicity and oxidative stress, are selected. The complexity of the biochemical pathways in each hypothesis as well as the

intricate relationships between them can leave students bewildered.

VISUALIZATION AND SIMULATIONS OF HYPOTHESIS OF PARKINSON'S DISEASES

With the help of CELT, a series of Simulated Learning Aids (SLAs) have been developed which mainly contain visualization and simulations of biochemical hypothesis of Parkinson's disease. These are expected to show students the biochemical pathways of hypothesis of neurotoxicity and free radical. In addition, three drugs, developed by three different strategies, were selected for demonstration purposes. On the first page of the SLA, videos capturing Parkinsonism symptoms are provided by link. 2D animated simulation of biochemical pathways of hypothesis and drugs interactions have been built after the front page. The 2D animations mainly demonstrate the details of the pathways, such as the movement of molecules, interactions between particles and organisms, signal transduction of nerves and the conformational changes of cellular organisms. Brief instructions were also added to describe the pathways' key stages. Each part of the animation of the pathway contains a small quiz with 5~6 multiple choice questions on the basic knowledge and key points of that part. Its aim is self-assessment by the students. Labeled pictures also help them.

The SLAs' core component is constructed by Flash. The materials, including text, pictures and animations, are stored in the modular reusable blocks. These blocks are linked and presented in a hierarchical structure. Links are shown in the designated main page. The 2D animations are created in Flash. These are generally small in file and allow interaction by the user. Furthermore, we are considering the addition of background music or narration of the instructions to draw students' attention.

FURTHER WORKS

The SLAs' prototype is almost finished. All the animations of pathways have been built. Because of our experience and other problems, there should be many improvements to come. Firstly, we could capture the video of Parkinsonism symptoms ourselves. The resolution of the online video is not satisfactory. Videos with higher resolution can better draw students' attention in classroom. Capturing the movement of Parkinsonism patients in hospital or associated places could be implemented. Secondly, pathways could be demonstrated in 3D animation. 2D animation can show the movement of particles and molecules. However 3D animation can demonstrate the shape and conformational changes of cellular organism as well. Besides, 3D animation can show the particles, molecules and organism to students in a relative scale. Thirdly, deep brain stimulated surgery, another strategy in the clinical therapy of Parkinson's disease, could be introduced. This surgery is one of the newest technologies being used to cure Parkinson's disease. More information or background could be provided.

CONCLUSION

Parkinson's disease is one of the leading diseases impacting millions of the elderly worldwide. Its pathology is not clear. But it is clear that Parkinson's disease is caused by multi factors. As teaching staff, it is difficult to illustrate such complicated subjects only on

paper or by PowerPoint. Through SLAs, actual situations can be simulated in the class. Students will get a clear impression of the framework and have a better understanding of Parkinson's disease. Next year, the SLA programme will be implemented in class.

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