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Mini Review

Recent Development of Organ-on-a-Chips for Biomedical Applications

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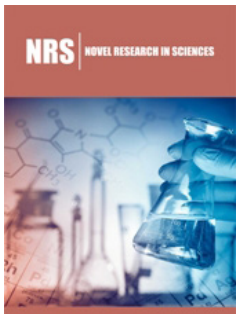

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Introduction

Coronavirus disease (COVID-19) pandemic was occurred and continuously getting worse on 2020. A first patient of COVID-19 was reported on Wuhan City, China on Dec 2019. There is no vaccines and target drugs for COVID-19 because it is a new evolved infectious disease. The corona virus of COVID-19 was rapid spread to many peoples and nations within several months. World Health Organization (WHO) announced that 216 countries or areas in the world was infected by COVID-19 with 16,523,815 confirmed cases and 655,112 confirmed deaths on 29 July 2020 [1].

Although vaccines and drugs for COVID-19 are highly needed, developing vaccines and new drugs require high cost and long time. Recently organ-on-a-chip or human-on-a-chip was suggested a new test method to reduce cost and time for developing a new drug [2,3]. Especially these organ-on-a-chip can replace an animal in a non-clinical test [2,3]. In this review, recent developed organ-on-a-chips and their various applications are explained.

Organ-on-a-chip & Human-on-a-chip

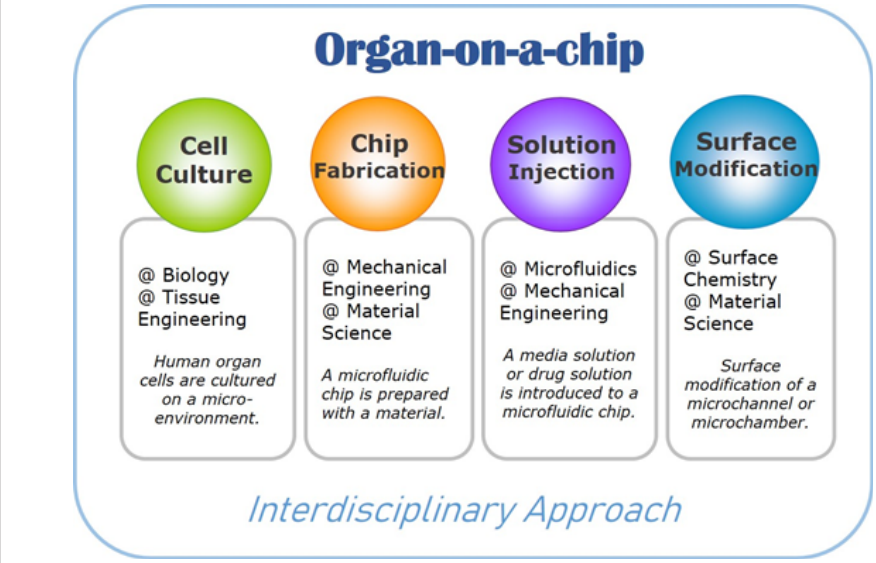

Figure 1: Interdisciplinary approach with different science and engineering majors for the Organ-on-a-chip.

An organ-on-a-chip have a kind of human organ cells like liver cells, heart cells, kidney cells etc. Researchers generally culture various organ cells on a petri-dish. However, the general culture condition on a petri-dish is different from live condition of a human body. Especially cultured cells on a petri-dish are under 2D-cultured condition. But live organ cells

in a human body are placed in 3D environmental condition. The organ-on-a-chip can provide 3D culture environment with various microfluidic channels that can supply a nutrient or a solution [2,3]. Thus, an organ-on-a-chip is a good mimic model of a human organ. Recently there are various kinds of organ-on-a-chips were prepared including lung-on-a-chip, heart-on-a-chip, liver-on-a-chip, kidney-on-a-chip [4-8]. Furthermore, multi-organs can be placed on a chip called human-on-a-chip that can have liver cells, kidney cells, and lung cells in one chip [9-11]. Therefore human-on-a-chip can applicable to drug screening or various biomedical applications [9-11].

Interdisciplinary approach for the organ-on-a-chip

The organ-on-a-chip is technically based on a lab-on-a-chip or a microfluidic chip [3-8]. Actually, an organ-on-a-chip is a kind of small microchips. Human organ cells are placed and cultured on a chip [9-11]. A culture media or a solution can introduce to the cells by microchannels of the chip. By designing the structural geometry of a microfluidic chip, each optimized microfluidic condition can be prepared in a micro-culture condition.

Actually, the organ-on-a-chip is related to several different science and engineering fields as shown in Figure 1. Thus, interdisciplinary approach is required to prepare and optimize the micro-culture conditions. Biology and tissue engineering are important for organ cell culture. Mechanical engineering, microfabrication and material science are important to prepare a microfluidic chip or lab-on-a-chip. Microfluidics is important to manipulate a tiny solution of a culture media or drug solution. Surface chemistry is important to adjust surface condition or modification. On optimization of the above important technologies, an organ-on-a-chip can be prepared in good condition.

Major Applications

Clinical trials of a new drug are necessary to take FDA approval. However high cost of clinical trials is problematic. A median cost for clinical trials of a new drug is about $19 million according to Johns Hopkins Bloomberg School of Public Health [12]. Furthermore, developing a new drug takes about 15 years according to Nature Reviews [13]. Recently organ-on-a-chips or human-on-a-chips as a novel test method of a new drug have gained interest to reduce cost and time [9,10].

A non-clinical test with an animal is generally done in the developing procedures of a new drug. After success of the non-clinical test with an animal, clinical trials can be progress in the next step. However, many new drugs are fail in clinical trials although the new drugs were success in an animal test. Actually, human body is different from an animal body. Thus, the toxic test and efficient test results of a new drug with an animal could be resulted in different results with a clinical trial. In this point, a new drug test with organ-on-a-chip or human-on-chip is useful because these chips have real live cells of a human body. Especially a human-on-a-chip consisted of several human organ cells such as liver, lung, heart etc. should be a replaceable method instead of an animal test.

Organ-on-a-chip have various applications including basic cell biology, biomedical engineering, cancer study, drug screening, microfabrication and manipulation, environment study, toxicology, medical device test etc. [9-11,14].

Conclusion

A non-clinical test of a new drug with an organ-on-a-chip instead of an animal can reduce cost and time. However, organ-on-a-chip and human-on-a-chip is now initial stage. Thus, several technical limitations of these chips need to be overcome to apply various biomedical applications including drug screening. Since 2011 various organ-on-a-chips such as lung-on-a-chip, heart-on-a-chip, liver-on-a-chip and multi-organ-on-a-chip were prepared and tested [3-11]. Based on the rapid developing organ-on-a-chip, the application fields of the chip continuously expand to various biotechnological and medical applications.

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