**Year 12 Human Biology**

**Unit 3 Response to infection**

**ER VACCINES MARKING KEY**

1. Define Covid-19 (2 marks)

A type of Coronavirus. Causative agent SARS COV2

1. Name the genus and family of COVID-19 (1 mark)

SARS-CoV-2 belongs to the *Betacoronavirus* genus of the *Coronaviridae* family (need both for full mark)

1. In what year was SARS COV 2 first identified? Where (what city) was it discovered? (2 marks)

Dec 2019. Wuhan, China

1. Name the animal that SARS COV 2 is believed to have come from and how it is transmitted from this animal host to humans?  (2 marks)

Bat and the intermediate host between bats and humans is yet to be identified.

1. Which organs of the human body does COVID-19 most affect?  (2 marks)

COVID-19 is seen as a disease that primarily affects the lungs, it can also damage many other organs, including the heart, kidneys and the brain. (Must include the lungs to get full marks)

1. COVID-19 affects different people in different ways. Most infected people will develop mild to moderate illness and recover without hospitalization. List 3 symptoms of Covid-19. (3 marks)

Most common symptoms:

fever

cough

tiredness

loss of taste or smell

Less common symptoms:

sore throat

headache

aches and pains

diarrhoea

a rash on skin, or discolouration of fingers or toes

red or irritated eyes

Serious symptoms:

difficulty breathing or shortness of breath

chest pain

1. For those infected with covid, the highest mortality is recorded amongst what groups of people/individuals?

Elderly (1) and individuals with chronic health issues (1), including diabetes and hypertension.

1. At the time of the article how many cases and mortality had resulted from Covid-19? (1 mark)

To date, the COVID-19 pandemic has resulted in over 25 million confirmed infections and almost one million deaths worldwide

1. Why is COVID-19 so much more contagious than previous COVID like diseases? (2 marks)

The rate of recombination has been found to be higher in the S genes that code for the S protein. 10 Studies have suggested that the association of the S protein of SARS-CoV-2 with angiotensin-converting enzyme 2 (ACE-2) is stronger than that of the S protein of SARS-CoV;(1) this may have resulted in its rapid transmission and more infectious nature**. (1)**

1. Define what is a vaccine and explain how they bring about increased immunity. (7 marks)

Must define a vaccine:

A vaccine is a biological preparation that provides active acquired immunity to a particular infectious disease (1)

Then explain

|  |  |
| --- | --- |
| **Description** | **Mark** |
|  |  |
| Vaccines contain dead/attenuated/sub units/toxoids derived from the pathogen. | 1 |
| This vaccine will be recognised by your B-lymphocytes | 1 |
| B-Lymphocytes will become sensitised, enlarged and divide into many clones | 1 |
| Most B-lymphocytes become plasma cells and secrete antibodies | 1 |
| Some B-lymphocytes become memory cells | 1 |
| Memory cells stay in the body and will flood the body with antibodies/react much faster if the person becomes infected with the pathogen which prevents illness. | 1 |
| **Total** | **6** |

1. The development of a vaccine typically takes between 10-15 years to be ready for clinical testing. However, the first vaccine for Covid-19 was ready for testing in many months. How was this made possible and why do you think there was an urgency for the vaccine to be developed? (3 marks)

How: Owing to the rapid identification and publication of the SARS- CoV-2 gene sequence, it was only a matter of months before the first vaccine candidate was ready for clinical testing. (1)

Urgency: Rapidly spreading virus world-wide. Pandemic with high high morbidity and high mortality. (1) Threat of future epidemics for coronaviruses. (1)

1. a. In the development of COVID-19 vaccines, what unique identifier of the coronavirus is being used as a target for vaccine development?  (1 mark)

Spike protein (1)

b. Explain why this is the target. OR How does the SI subunit allow the virus to enter the cell

(2 marks)

The S1 subunit of the receptor-binding domain (RBD) of the S protein initially interacts with the ACE2 receptor for attachment, thereafter entering the host cell by fusing the viral and host membranes with the help of the S2 subunit (1).10,17–20

In this manner, the S protein plays a keyrole in the internalization of the virus, receptor binding, membrane fusion, tissue tropism, and host range and has thus emerged as an important target for vaccine development.(1)

1. Describe the 3 methods of vaccine development from the article and how they differ from one another. (6 marks)
2. Inactivated vaccine (1) - The development of inactivated vaccines requires a target virus to be initially inactivated, either chemically or by irradiation. This allows the nucleic acids of the virus to be destroyed, while keeping the viral antigens intact.(1)
3. Live-attenuated vaccine (1) - Live-attenuated vaccines are being developed from live coronaviruses whose virulence has been reduced under laboratory conditions. This technique allows for the virus to replicate in the host while producing only mild pathogenesis, if any. (1)
4. Recombinant vaccines (1)- recombinant vaccines are made using bacterial or yeast cells to manufacture the vaccine. A small piece of DNA is taken from the virus or bacterium against which we want to protect and inserted into the manufacturing cells. (1)
5. What is the potential public health risk of an inactivated coronavirus vaccine?  (1 mark)

There is a potential public health risk associated with incomplete inactivation, which leads to undesired immune or inflammatory responses. (1)

1. What are the safety concerns of using the live-attenuated vaccine?   (2 marks)

Any two of the following:

Live- attenuated vaccines are one of the basic technologies used for the development of licensed human vaccines. However, the spread of CoV via the faeces of individuals who have received a live-attenuated vaccine (1) and the risk of its recombination with wild-type CoV (1) are among its major safety concerns. Another issue is its suitability for the older population, who are at a higher risk of severe disease (1)

1. Why was recombinant DNA more advantageous over the other 2 vaccines? (1 mark)

Greater response predictability and improved efficiency.(1)

1. There are 5 types of Recombinant COVID-19 vaccines outlined in this paper. Briefly outline why they all fall under this category of vaccine. (2 marks)

All use the DNA to make the S protein and build immunity to it (1) Via the person’s cells making the protein or by acknowledging recombinant proteins that will trigger the immune system to create T cells or antibodies… B cells? (1)

1. The 3 main vaccines approved for use today are Pfizer, AstraZeneca and Novavax. All have been developed using different methods of technology. Complete the following table: (3 marks)

|  |  |
| --- | --- |
| Approved Vaccine | Method of technology used |
| Pfizer | Recombinant DNA - mRNA (1) |
| AstraZeneca | Recombinant DNA - Non replicating viral vector (1) |
| Novavax | Recombinant DNA - Protein Subunit (1) |

1. Which is more advantageous and why: mRNA or DNA based recombinant vaccines? (3 marks)

Messenger RNA (mRNA)-based CoV vaccines are considered to be more advantageous than DNA-based vaccines (1)

since they do not require entry into the host cell nucleus to be transcribed (1).

Therefore, a lower dose can be used, without the need for any special delivery mechanisms. Moreover, mRNA based vaccines avoid the risk of integration with the host cell genome (1)

and are able to produce pure viral protein.

The technology associated with this vaccine is also capable of bypassing time-consuming standardization processes, thus speeding up its commercial production. (1)

For marks must have first 2 points, then any 1 of the other 2.

1. What is needed to confirm safety of a vaccine (2 marks)

The development of a vaccine requires extensive planning and research with regard to its design, production, and purification (1) as well as preclinical trials in model animals to confirm its safety (1)

1. Quick disappearance of antibody response is a major issue with COVID-19 vaccines. Why is this a problem and how are they combatting it? (2 marks)

One major issue in the development of a SARS-CoV-2 vaccine is the probability of quick disappearance of the antibody response generated against the vaccine.

CoV infection has been previously found to be incapable of inducing a long-lived antibody response, resulting in the re-infection of individuals with a similar virus after a long period. (1)

Combatting with double vaccinations/booster shots (1)

1. Which vaccine do you think will be the most successful vaccine and what evidence supports this? (4 marks)

Recombinant DNA vaccines will be most successful (1)

The greatest advantage of DNA- and RNA-based vaccines is their potential for rapid development and reduced side effects (1).

DNA vaccines have shown strong potential to trigger immune responses against CoVs in animal models.

In a previous study on mice, a DNA vaccine encoding the S protein of SARS-CoV was found to induce T cells, a neutralizing antibody response, and protective immunity.29

A group of prototype DNA vaccines expressing various SARS-CoV-2 S proteins has been developed and tested in 35 rhesus macaques. The vaccinated macaques demonstrated specific humoral and cellular immune responses. Further upon being challenged with SARSCoV-2, the animals showed a remarkable reduction of viral replication in the upper and lower respiratory tract. The data displayed the significant role of DNA vaccine against SARS-CoV -2 infection.30

Smith et al (2020) reported the immunogenicity of a synthetic DNA-based vaccine against SARS-CoV-2, INO-4800 in multiple animal models. The immunized animal showed specific T cell responses, and antibodies that not only neutralized SARS-CoV-2 and blocked S protein-ACE2 interaction, but also circulated through the lungs. The study emphasized on its further evaluation as a potential contender for COVID-19 vaccine.31

Presently, Inovio Pharmaceuticals are evaluating a DNA plasmid-based prophylactic vaccine (INO-4800) against SARS-CoV-2 in a phase 1 trial.

Looking for 3 good pieces of evidence to support their decision

1. Describe one socio-cultural and one economic factor that influence whether or not parents choose to have their children immunised. [2]

* Economic – cost of visiting a doctor/ cost of the vaccine /priorities of government [1]
* Socio-cultural – perceived health concerns and side effects of vaccine / lack of availability or access to vaccine / ethical or religious objection to medical intervention. [1]