1. What are the various stages of vaccine development? Illustrate. How is efficacy of a vaccine calculated? Explain.

Approach:
In the introduction you can start with explanation of what is vaccine and how it works. It expects candidates to describe about various stages of vaccine development in the first half. In the next half it is expected to mention the method to   calculate efficacy. To fetch more marks giving a current relevance is necessary.

Introduction:
Vaccine is a a mild form of a disease that is put (injected) into a person or an animal's blood using a needle (an injection) in order to protect the body against that disease. The outbreak of the novel coronavirus has triggered an international effort to develop a safe and effective vaccine against COVID-19, perhaps at breakneck speed.

Body:
Stages in the development of a vaccine:

According to the Centres for Disease Control and Prevention (CDC), there are six stages of vaccine development: exploratory, pre-clinical, clinical development, regulatory review and approval, manufacturing and quality control.

- Exploratory: This is research-intensive phase of the vaccine development process which is designed to identify "natural or synthetic antigens that might help prevent or treat a disease".
- Pre-clinical: During this phase, researchers use tissue-culture or cell-culture systems and animal testing to determine whether the candidate vaccine will produce immunity or not.
- Clinical development: It is a three-phase process. During Phase I, small groups of people receive the trial vaccine. In Phase II, the clinical study is expanded and vaccine is given to people who have characteristics similar to those for whom the new vaccine is intended. In Phase III, the vaccine is given to thousands of people and tested for efficacy and safety.
- For instance, Oxford vaccine shows 90% efficacy in Phase-3 trial. Moderna has completed enrolment of its late-stage phase 3 COVID-19 vaccine study, with 30,000 participants now enrolled in the study in October 2020.
- Regulatory review and approval: If a vaccine passes through all three phases of clinical development, the vaccine developer submits a Biologics License Application (BLA) to the licensing authority.
- Manufacturing: Major drug manufacturers provide the infrastructure, personnel and equipment necessary to create mass quantities of vaccines.
- Quality control: Stakeholders must adhere to procedures that allow them to track whether a vaccine is performing as anticipated. Recently, Russia became the first country to officially register a Covid-19 vaccine and declare it ready for use.

Vaccine Efficacy calculation method:
- Vaccine efficacy is the percentage reduction of disease in a vaccinated group of people compared to an unvaccinated group, using the most favourable conditions.
- It is best measured using double-blind, randomized, clinical controlled trials, such that it is studied under 'best case scenario".
- Vaccine efficacy studies are used to measure several possible outcomes such as disease attack rates, hospitalizations, medical visits, and costs.
- The outcome data (vaccine efficacy) generally are expressed as a proportionate reduction in disease attack rate (AR) between the unvaccinated (ARU) and vaccinated (ARV), or can be calculated from the relative risk (RR) of disease among the vaccinated group. Following is the formula through which Vaccine efficacy is Calculated.

$$VE = \frac{ARU - ARV}{ARU} \times 100\%,$$

- Here, VE = Vaccine efficacy, ARU = Attack rate of unvaccinated people, ARV = Attack rate of vaccinated people.
- The advantages of a vaccine efficacy have control for all biases that would be found with randomization, as well as prospective, active monitoring for disease attack rates, and careful tracking of vaccination status for a study population there is normally a subset as well, laboratory confirmation of the infectious outcome of interest and a sampling of vaccine immunogenicity.
- The major disadvantages of vaccine efficacy trials are the complexity and expense of performing them, especially for relatively uncommon infectious outcomes of diseases for which the sample size required is driven up to achieve clinically useful statistical power.

Conclusion:
Coronavirus pandemic has impacted almost every sector and left a disastrous impact on the affected sector or groups. Due to this sheer scale of impact it becomes imperative to expedite the vaccine development to unprecedented level so that its impact will be minimised and a pre-covid-19 normalcy can be brought in to lives of people.

2. Discuss the working principle of DNA and RNA vaccines.

Approach - It expects students to write about DNA and RNA and working principles of DNA and RNA vaccines.

Introduction

The two main types of nucleic acids are DNA and RNA. Both DNA and RNA are made from nucleotides, each containing a five-carbon sugar backbone, a phosphate group, and a nitrogen base. Nucleic acid vaccination is a technique for protecting against disease by injection with genetically engineered DNA (as a plasmid) or RNA (as mRNA). Nucleic acid vaccines consist only of DNA or RNA, which is uptake by cells and transformed into protein.

Body

Vaccination is the process in which substances called antigens are introduced artificially into the body to stimulate the immune system, the set of cells that protects the body against infections. Development of nucleotide vaccines based on DNA, and the related molecule RNA, promising area of progress in the field.
Working principle of the DNA and RNA vaccine:

- Vaccine mechanism: An RNA is injected in the body. This RNA encodes the information to produce the antigen, which is a protein from a pathogen, which will stimulate the immune system. Inside the cells, the RNA is used to synthesise the antigen, which is exposed to the cell surface. Then, a subset of immune system cells recognises the antigen and trigger an immune response (direct response and long-term memory)
- Mode of injunction: They can be injected in various ways (under the skin, in the vein or in lymph nodes) and then they can enter our body's cells. Those cells will use the RNA sequence of the antigen to synthesise the protein. After this step, the mechanism is similar to classical vaccines: the antigen is presented at the surface of a subset of cells and triggers the activation of specific cells of the immune system.
- Disease prevention: Vaccination with RNA induces a primary response by instructing the body's cells to produce an antigen that is presented to the immune system. This activates specific cells, which create a memory for this antigen. Later, when the real pathogen is present, those cells recognise the same antigen and react rapidly and strongly against the infectious agent secondary response.
- Different from conventional: For a classical vaccine, the antigen is introduced in the body to produce an immune response. However, in the case of DNA or RNA-based vaccines, no antigen is introduced, only the RNA or DNA containing the genetic information to produce the antigen. That is, for this specific class of vaccines, introduction of DNA and RNA provides the instructions to the body to produce the antigen itself.

Advantages -
- Inexpensive: There are several reasons why naked nucleic acids are attractive candidate vectors for the development of vaccines for infectious diseases and cancer. Genetics vaccines are relatively inexpensive and easy to manufacture and use.
- High Efficacy: Nucleic acid vaccines consist only of DNA or RNA, which is taken up and translated into protein by host cells. Their immunogenicity and efficacy have been analysed in a large number of systems, and the results of preclinical studies have supported human clinical trials. They may even be effective against non-infectious conditions such as cancer and autoimmune diseases, where conventional vaccines do not work.
- Stable in harsh conditions: DNA vaccines are also said to be more stable than conventional vaccines in warm climates if kept dry and/or sterile at pH8. They can be stored at room temperature without losing their activity, whereas traditional vaccines require refrigeration.
- Large scale production: A DNA or RNA vaccine, on the other hand, takes a small part of the virus' own genetic information. Experts say the virus' genetic information can be replicated and produced relatively easily. And that's what scientists want in a live situation, such as the SARS-CoV-2 / COVID-19 pandemic, where billions of people need protection very quickly.

Disadvantages -
- Problem which exists with all gene therapy, that is, the DNA of the vaccine may be integrated into the host chromosome, resulting in oncogenes or turn off tumour suppressor genes. Extended immune stimulation of exogenous antigens may cause chronic inflammation or autoantibody production.
- Limited to protein immunogens (not useful for non-protein based antigens such as bacterial polysaccharides).
- Inducing antibody production against DNA.
- DNA vaccines may have a relatively poor immunogenicity.

When will we see gene-based vaccines for COVID-19?
- Some DNA vaccines have been approved for veterinary use. And there are many others in clinical trials for human use, including those for SARS-CoV-2.
- Many will use what's called an "adaptive clinical trial design" to speed up the process from discovery to development to trial and approval to production. Moderna is studying its messenger RNA (mRNA) vaccine in the US.

Conclusion

Biotech companies have been touting mRNA and DNA vaccines as the ideal technologies for rapidly fighting new pathogens, and the coronavirus pandemic may be their best chance yet to prove their worth. There are no approved mRNA or DNA vaccines, and neither has ever been tested in a large-scale clinical trial for an infectious disease. The COVID crisis is a great opportunity for those technologies to be pushed.

3. Discuss the recent progress achieved in drone technology. What are its potential commercial applications? Examine.

Approach:

Students are expected to write about the recent progress achieved in drone technology in first part and examine its potential commercial applications in second part.

Introduction:

Unmanned Aerial Vehicle (UAV) i.e. Drones are rapidly growing in popularity even though they are still in the infancy stage in terms of mass adoption and usage. Drones have already broken through rigid traditional barriers in industries which otherwise seemed impenetrable by similar technological innovations. Drones have given one side a clear age in the conflict between Armenia and Azerbaijan ushering new age of warfare.

Body:

The new Unmanned aerial vehicle technology covers everything from the aerodynamics of the drone, materials in the manufacture of the physical UAV, to the circuit boards, chipset and software, which are the brains of the drone. For A typical unmanned aircraft is made of light composite materials to reduce weight and increase manoeuvrability. This composite material strength allows military drones to cruise at extremely high altitudes.

Recent developments in drone technology:
- UAV drones are equipped with different state of the art technology such as infrared cameras, GPS and laser (consumer, commercial and military UAV).
- An unmanned aerial vehicle system has two parts, the drone itself and the control system. Drones are controlled by remote ground control systems (GSC) and also referred to as a ground cockpit.
- Huge space for technological upgradation: Expect The nose of the unmanned aerial vehicle is where all the sensors and navigational systems are present. The rest of the body is full of drone technology systems since there is no space required to accommodate humans.
- Recently the engineering materials used to build the drone are highly complex composites designed to absorb vibration, which decrease the sound produced. These materials are very light weight.
- Growth of drone technologies achieved transformative design, 360* gimbals, higher value instrumentation, intelligent piloting modes etc
- Cutting age drone technology made possible commercial suitability, platform and payload adaptability, intelligent piloting models etc.

The emerging global market is more business services oriented, many corporations look to capitalize on these commercial opportunities. There are multiple ways through

which wide range of companies are harnessing drone technology for commercial purposes across industries.

- Emergency response: Innovations in camera technology have had a significant impact on the growing use of drones. UAVs outfitted with thermal imaging cameras have provided emergency response teams with an ideal solution for identifying victims who are difficult to spot with the naked eye.
- Disaster relief: drones have proved useful during times of natural disaster. In the aftermath of hurricanes and earthquakes, Disaster management companies used UAVs to assess damage, locate victims, and deliver aid. And in certain circumstances, they are helping to prevent disasters altogether.
- Healthcare: Many rural regions around the world lack access to high quality healthcare. While medical supplies can be delivered by traditional means, certain circumstances call for quick access to drugs, blood, and medical technology, commercial organisations can fulfil these needs with the help of drones.
- Agriculture: Farmers across the world are continuously striving to reduce costs and expand yields. With the use of drones, agricultural workers are able to gather data, automate redundant processes, and improve efficiency.
- Weather forecasting: Today, most data is collected through stationary structures or captured with geospatial imaging solutions. Drones, however, offer a versatile option that can physically follow weather patterns as they develop. Moreover to that water-based unmanned surface vehicles (USVs) are changing the way data is gathered.
- Maritime: Inspecting ships is also an important part of the industry hence, few companies has designed an underwater drone used to inspect hulls from below.
- Waste Management: Innovations in waste collection are still emerging, including drones that have help to clean oceans. Few companies focus on robots used to help maintain systems for wastewater management.
- Infrastructure Development: While drones serve a useful purpose in construction planning and management, they also have the potential to be used to develop physical infrastructure.

Conclusion:

Over the past few years, drones have become central to the functions of various businesses and governmental organizations and have managed to pierce through areas where certain industries were either stagnant or lagging behind. As these technologies continue to evolve and grow, drones will become safer and more dependable. This would allow for their subsequent mass adoption, provided the strict DGCA regulations drone technology and usage are loosened to some degree.

4. What do you understand by the 'dark web'? Why is it a serious threat? Explain.

Approach:

It expects students to write about – in first part write about what do you know about Dark Web – in second part write about threats possess by Dark Web – in end write few advantages of it.

Introduction:

The dark web is the World Wide Web content that exists on darknets: overlay networks that use the Internet but require specific software, configurations, or authorization to access.

Body:

Dark Web:
- The dark web refers to encrypted online content that is not indexed by conventional search engines. Sometimes, the dark web is also called the dark net.
- The dark web is a part of the deep web, which just refers to websites that do not appear on search engines.
- Most deep web content consists of private files hosted on Dropbox and its competitors or subscriber-only databases rather than anything illegal.
- Specific browsers, such as Tor Browser, are required to reach the dark web. Using the dark web often provides considerably more privacy than just using Tor to access the web.
- Many dark web sites simply provide standard web services with more secrecy, which benefits political dissidents and people trying to keep medical conditions private.
- Unfortunately, online marketplaces for drugs, exchanges for stolen data, and other illegal activities get most of the attention.

Dark Web possess serious threats because:
- The dark web empowers ordinary people, but some people will inevitably abuse that power. The dark web can make it easier to commit some of the worst crimes.
- For example, the combination of the dark web and cryptocurrencies theoretically makes it much easier to hire someone to commit a murder.
- While the dark web promises privacy to its users, it can also be used to violate the privacy of others. Private photos, medical records, and financial information have all been stolen and shared on the dark web.
- Since there's more content to analyze, Deep Web search engines tend to be slower than standard search engines. Searching the Deep Web also requires a more precise search string.
- Deep Web searches should be reserved for serious, painstaking research, not for simple questions and basic Web surfing.

- Deep Web searches may also return sensitive personal information from normally restricted databases, creating ethical dilemmas and leaving individuals susceptible to fraud and identity theft.
- Everything on the deep web is completely untraceable and it's only a matter of time before criminals take advantage of it. To put it simply, the deep web has become a corrupted hub of criminal activity.
- The transfer of drugs, illegal weapons and the hiring of contract killers is an almost daily occurrence on this medium. Illegal bidding market places similar to E-bay have been set up on the deep web to sell these illegal goods and, no matter how hard they try; there is nothing the law can do to stop it.
- These illegal market places are extremely efficient and even boast a user-friendly interface and search bar to help criminals save time in locating their illegal goods.
- The currency used in these marketplaces is the cyber currency Bitcoin, which only adds to the impossibility of the transfers and guilty parties being traced.

However, Dark web had some advantages like:

- The dark web helps people to maintain privacy and freely express their views. Privacy is essential for many innocent people terrorized by stalkers and other criminals.
- The increasing tendency of potential employers to track posts on social media can also make it difficult to engage in honest discussions publicly.
- Finally, the popularity of the dark web with criminals makes it a perfect way for undercover police officers to communicate.
- One of the biggest advantages of the dark web is the difficulty of blocking it. Common forms of censorship, which block traffic to websites at specific choke points along the Internet hierarchy, do not work with encrypted overlay networks. For similar reasons, the dark web is more resistant to surveillance by governments and corporations.
- Whistle blowers, journalists, and other professionals at risk of targeted surveillance use the dark web to communicate sensitive information. And organizations including Human Rights Watch and the Electronic Frontier Foundation support the use of and access to the dark web.

Conclusion:

The internet, like most things in life, is both a boon and a curse. In the right hands and with the right guidance, it can be a pathway to unparalleled opportunities for learning and growth. Without proper regulation, however, it can be extremely destructive and may negatively impact someone's future.

5. Examine the current and potential applications of wearable devices.

Approach:

It is straightforward question where, it expects students to write about – in first part current applications of wearable devices – while in second part you need to write about potential applications of wearable devices.

Introduction:

Wearable technologies are smart electronic devices (electronic device with micro-controllers) that are worn close to and/or on the surface of the skin, where they detect, analyse, and transmit information concerning e.g. body signals such as vital signs, and/or ambient data and which allow in some cases immediate biofeedback to the wearer

Body:
Current applications:
- For Kids and Families: Wearable devices provide parental assistance. Whether kids are going to a school event or a friend's house, they will be accessible thanks to wearable tech all the time. You can get your kid a GPS tracker, a screen less smartphone or some other device among many more options.
- Health and Wellness: If you feel overstressed at work, then it's time to give yourself a break. Find the mind-body balance and meditate yourself after a long workday. Sometimes your mind can be tired along with your body, so it shouldn't be all about body health, but also mental health. From sleep tracking to heart rate monitoring, you can ask help from a smart assistant to check on what's going on in your body.
- Music: They offer the ability to take your podcasts and music to hangouts. Without the need of headphones, you and your friends can listen to music at the same time. Also, you can use these wearable speakers underwater, so the music will be with you even in the pool.
- Adventure: Dealing with bigger cameras is a difficult task when you're trying to record your adventures. It causes many accidents, especially for those who like outdoor and underwater sports like hiking, skiing, or diving. Thanks to these lightweight wearable cameras, no need to carry additional gears in your backpack.

Potential applications:
- The Public and Personal Safety: In contrast with the position that wearable technology will give harm to security, the wearable devices will provide the safety of the society. For example, in the near future Bio-censors will be integrated into the wearable devices, and these censors will monitor the brain activities.
- Business: The wearable technologies are expected to innovate the companies' strategies and the way of doing business. In the near future, there will be no need to go to meetings physically. Instead of W/C meetings, the managers

may meet in a virtual meeting room formed by augmented reality and all the decisions will be recorded.

- Research: Wearable technologies provides several opportunities for companies in the context of market research. Researchers use some eye-tracking techniques in the laboratory experiments. In the future, they can gather real-life data via eye-tracking software built in a smart glasses.
- Production: In production and in the logistics workers should work very efficiently and find and bring the necessary parts. However, sometimes they can be confused about the location of the necessary parts or products. With Smart glasses, when the factory needs some parts, the list may be automatically uploaded to the glasses. It can put them in the order and may navigate the optimum route for the workers, and this lead to time and cost efficiency.
- Sales: Retailers can use a system that customers upload shopping list to the Smart Glasses, and the glasses will make the customers finish their shopping as fast as possible via indoor navigation. In addition, there may be no need to try on clothes in the near future. When we choose a dress the smart glasses may show the dress on the wearer virtually and it will be like looking at a mirror.
- Tourism: Augmented reality integrated wearable technologies enable people to visit cities, tourist attractions virtually without going there. They also use virtual city sightseeing tours. New virtual tourism companies may emerge in the near future.
- Entertainment: With the emergence of wearable technologies, there will also be a paradigm shift in the gaming industry. Oculus Rift, which is a virtual reality head-mounted display, can be considered as the preliminary version of this shift. When a user wears this head-mounted display he/she can view the virtual environment almost as real.

Conclusion:

Today, the diffusion of the wearable technologies is just at the early adopter stage both for the society and companies. In the near future the evolution of wearable technologies, especially smart glasses and smart watches, will almost be completed their evolutions and these technological devices will be adopted by the societies and companies. Wearable technologies will be a milestone both for daily life of people and the way of doing businesses of the companies in the future.