TEST -20 (Scienc & Technology + C.A.) Answers Key

1. Answer: (a) Only 1 and 2
   Explanation: 1. Statement 1 is correct: Modern models like DeepSeek-R1 use the **'Mixture of Experts' (MoE)** technique. In this, the entire model is not activated for every ; instead, only the relevant **'experts' (parameters)** are activated, which saves computing costs and energy. 2. Statement 2 is correct: The **'Efficient AI Race'** does not mean just building massive models, but achieving greater intelligence with fewer resources and better algorithms. 3. Statement 3 is incorrect: Open-source models are no longer just academic; they are now challenging big companies in the commercial sector **(e.g., Meta's Llama)**.
2. Answer: (b)
   Explanation: The greatest feature of Agentic AI is its autonomy. It is not limited to just chatting; it can decide for itself which software tools to use to complete a goal and what the sequence of tasks should be.
3. Answer: (c) All three
   Explanation: 1. Statement 1 is correct: By using predictive analytics to forecast weather and market demand, yields can be increased and wastage can be prevented. 2. Statement 2 is correct: AI can shorten or expand the curriculum according to the students' abilities **(Adaptive Learning)**. 3. Statement 3 is correct: The **'Bhashini'** mission is working to connect everyone in the digital world by translating between various languages of India.
4. Answer: (d) 1, 2 and 3
   Explanation: 1. Statement 1 is correct: **'De Novo'** means from the beginning. AI is now designing such new proteins that could be revolutionary in drug manufacturing.
   2. **Statement 2 is correct:** With AI, thousands of potential chemicals are tested on the computer itself, saving lab time. 3. Statement 3 is correct: Based on genetic data, AI can predict what effect a drug will have on a particular person **(Precision Medicine)**.
5. Answer: (a) Only 1
   Explanation: 1. Statement 1 is correct: Watermarking embeds a secret code in digital content so that it can be identified. 2. Statement 2 is incorrect: Its main objective is to prevent deepfakes and misinformation, so that it is known that the content was created by AI. 3. Statement 3 is incorrect: Although many countries are considering this, it has not yet become a **'mandatory international legal requirement'**.
6. Answer: (d) 1, 2 and 3
   Explanation: 1. Statement 1 is correct: In photonics, light **(photons)** is used instead of electricity **(electrons)**, which is cooler and faster. 2. Statement 2 is correct: Since the speed of light is the highest, the speed of calculation can also reach that level. 3. Statement 3 is correct: Silicon chips have now reached their limits of heat and size, where photonics provides a new path.
7. Answer: (c) Both 1 and 2
   Explanation: 1. Statement 1 is correct: In 6G, latency will be so low that doctors sitting thousands of miles away will be able to perform robotic surgery without any **'lag'**. 2. Statement 2 is correct: Autonomous AI agents will be able to talk to each other to operate factories and logistics even without humans.
8. Answer: (d) 1, 2 and 3
   Explanation: 1. Statement 1 is correct: In 1925, Heisenberg and other scientists laid the foundation of quantum mechanics, which is completing 100 years in 2025. 2. Statement 2 is correct: Its objective is to not keep the technology limited to only rich countries but to take it to developing countries. 3. Statement 3 is correct: UNESCO is leading the events of this entire year.
9. Answer: (c) Only 1 and 3
   Explanation: 1. Statement 1 is correct: Decoherence is the biggest obstacle for quantum computers, where data is destroyed due to noise. 2. Statement 2 is incorrect: Google's Willow chip uses advanced architecture for error correction, but **'Quantum Echo'** is not a standard term in this context. 3. Statement 3 is correct: A temperature near absolute zero **(-273°C)** is required for superconducting qubits so that they can remain stable.
10. Answer: (c) All three
    Explanation: 1. Statement 1 is correct: Recently, India's CDS has emphasized this policy framework for the armed forces. 2. Statement 2 is correct: In this, there is talk of the military, universities, and private companies working together **(Triple Helix Model)**. 3. Statement 3 is correct: The goal of Post-Quantum Cryptography **(PQC)** is to create such encryption that even the powerful quantum computers of the future cannot break.
11. Answer: (c) All three pairs
    Explanation:
    1. **Quantum Key Distribution (QKD):** AI is used to analyze network traffic and detect any type of eavesdropping or intrusion in real-time.
    2. **Quantum Radar:** Quantum radars work on very subtle signals. AI algorithms help in identifying the target by removing background noise.
    3. **Quantum Navigation:** This is based on **'Quantum Accelerometers'**. AI processes its data to provide accurate positioning even without GPS.
12. Answer: (b) Only 2
    - **Explanation:**
    1. **Statement 1 is incorrect:** The objective of the roadmap is not to completely eliminate silicon chips, but to develop hybrid systems.
    2. **Statement 2 is correct:** South Korea is investing in PIM **(Processor-In-Memory)** chips, where data processing and storage happen in the same place, increasing the speed of AI calculations.
13. Answer: (a)
    - **Explanation:** Entanglement Swapping is an amazing quantum phenomenon. In this, two independent quantum systems **(say A and B)** are connected to each other through an intermediate system **(C)**. Finally, A and B become **'entangled'** with each other, even if they have never been near each other. This is the fundamental technology for **'Quantum Repeaters'** and the Quantum Internet.

14. Answer: (a) Only 1 and 2
- **Explanation:**

1. **Statements 1 and 2 are correct:** QSIP is India's indigenous effort that makes military and financial data **'quantum-secure'**.
2. **Statement 3 is incorrect:** Processors like QSIP often use **'Quantum-Resistant Algorithms' (PQC)** which can be integrated with standard hardware at normal temperatures. They do not always require cryogenic temperatures.

15. Answer: (a) Only 1 and 2
- **Explanation:**

1. **Statement 1 is correct:** The successful test of TV-D1 **(Test Vehicle Abort Mission-1)** was conducted in October 2023 to check the system for safely rescuing the crew in case of an emergency.
2. **Statement 2 is correct:** The goal of Gaganyaan is to take humans into a Low Earth Orbit **(LEO)** of 400 km.
3. **Statement 3 is incorrect:** **'Vyommitra'** is a **'half-humanoid'** robot, not **'man-eating' (Note: the original Hindi used 'manavbhakshi' which means man-eating/ cannibalistic)**. It is a female robot that will mimic human functions inside the spacecraft.

16. Answer: (c) All three

Explanation: 1. Statement 1 is correct: India is aiming to increase its space economy from $8 billion to $44 billion **(10% share)**. 2. Statement 2 is correct: The Dark Sky Reserve in Hanle **(Ladakh)** is a major astronomical site in Asia due to its altitude and clear skies. 3. Statement 3 is correct: MAST and other solar telescopes are being digitally upgraded to facilitate better study of solar activities.

17. Answer: (b)

Explanation: 1. Option **(a)** is incorrect: Artemis II will only orbit the Moon; the surface landing will take place in **'Artemis III'**. 2. Option **(b)** is correct: It will utilize the Orion capsule and the world's most powerful rocket, the SLS. 3. Option **(c)** is incorrect: Artemis II is a **'manned'** mission.

18. Answer: (c) All three pairs

Explanation: 1. Nancy Grace Roman: It will provide a field of view 100 times larger than Hubble. 2. PLATO: Its goal is to search for a **'second Earth'**. 3. Euclid: It is preparing a 3D map of the **'dark universe'**.

19. Answer: (d) 1, 2 and 3

Explanation: 1. Statement 1 is correct: Chang'e 6 created history by bringing soil samples from the **'far side'** of the Moon **(South Pole-Aitken Basin)**. 2. Statement 2 is correct: The MMX mission will land on Mars' moon Phobos and bring back samples. 3. Statement 3 is correct: Japan's SLIM mission succeeded in performing a very precise **(pinpoint)** landing on the Moon in January 2024.

20. Answer: (a) Only 1 and 2

Explanation: 1. Statement 1 is correct: Kessler Syndrome is a frightening situation where a chain reaction of space debris collisions begins.

2. **Statement 2 is correct:** The brightness of thousands of satellites makes the night sky blurry for astronomers **(light pollution)**. 3. Statement 3 is incorrect: Starlink satellites are in **'Low Earth Orbit' (LEO, approximately 550 km)**, not in Medium Earth Orbit **(MEO)**. It is because they are in LEO that their latency **(signal delay)** is low.

21. Answer: (a) Only 1 and 2

Explanation: 1. Statement 1 is correct: LUPEX **(Lunar Polar Exploration Mission)** is an ambitious joint project of ISRO **(India)** and JAXA **(Japan)**. 2. Statement 2 is correct: Its primary goal is to investigate the availability and quality of water in **'permanently shadowed regions' (PSR)** at the Moon's South Pole. 3. Statement 3 is incorrect: In this mission, the lander will be developed by India **(ISRO)**, while the rover and the launch rocket **(H3)** will be provided by Japan **(JAXA)**.

22. Answer: (a) Only 1 and 2

Explanation: 1. Statement 1 is correct: Instead of **"one treatment for everyone,"** Precision Medicine selects precise medication based on an individual's genes, environment, and lifestyle. 2. Statement 2 is correct: AI can process large-scale **'omics'** data, which reveals what diseases a person might develop in the future. 3. Statement 3 is incorrect: This technology is not limited to infectious diseases but is most effective in the treatment of cancer, heart disease, and rare genetic disorders.

23. Answer: (b) Only two (Statements 1 and 2 are correct)

Explanation: 1. Statement 1 is correct: In synthetic biology, we do not just study natural life, but **'design'** new biological systems. 2. Statement 2 is correct: In this, bacteria or yeast are turned into **'cell factories'** to produce medicines, plastics, or fuel. 3. Statement 3 is incorrect: This technology can help in biodiversity conservation **(such as securing the genes of endangered species or reducing the demand for wildlife products by creating synthetic alternatives)**.

24. Answer: (d) 1, 2 and 3

Explanation: 1. Statement 1 is correct: Xenotransplantation literally means the use of animal organs in humans. 2. Statement 2 is correct: CRISPR is used to remove those pig genes that the human immune system attacks **(rejection)**. 3. Statement 3 is correct: Recently, genetically modified pig hearts and kidneys have been successfully transplanted into humans, which could address the shortage of organ donations.

25. Answer: (b) Only 1 and 2

Explanation: 1. Statement 1 is correct: These sensors use quantum states, which can measure even very subtle temperature or pressure changes within a cell. 2. Statement 2 is correct: During drug testing, it is possible to see how a drug molecule is binding to a protein. 3. Statement 3 is incorrect: These sensors are thousands of times more sensitive than traditional MRI and can perform imaging at the nano-scale.

26. Answer: (b) Only 1 and 2

Explanation: 1. Statement 1 is correct: If the eyes or retina are damaged, this technology sends signals obtained from a camera directly to the visual center **(Visual Cortex)** of the brain. 2. Statement 2 is correct: Elon Musk's company Neuralink has unveiled a chip named **'Blindsight'** which is working in this direction. 3. Statement 3 is incorrect: This technology can also be effective for people who lost their sight later due to an accident or illness.

27. Answer: (b)

Explanation: BioAsia is Asia's largest life sciences and healthcare conference **(often held in Hyderabad)**. It emphasizes the convergence of digital biology and AI to reduce the 10-year

time taken for new drug discovery to 2-3 years.

28. Answer: (d) 1, 2 and 3
Explanation: 1. Statement 1 is correct: Bio-computing uses biological molecules as processors instead of silicon. 2. Statement 2 is correct: The language of computers is 0-1, while the language of DNA is A, T, C, G. Data is synthesized in the form of these base pairs. 3. Statement 3 is correct: Billions of GB of data can fit in one gram of DNA, and it does not degrade for thousands of years.

29. Answer: (c) Only 1 and 3
Explanation: 1. Statement 1 is correct: China's EAST **(Artificial Sun)** achieved a major milestone towards fusion by containing plasma at extremely high temperatures for a record time. 2. Statement 2 is incorrect: Although fusion produces much less waste than fission, **'tritium'** itself is radioactive and some radioactivity is generated through neutron activation **(though it is short-lived)**. 3. Statement 3 is correct: A Tokamak is a donut-shaped device that uses powerful magnetic fields **(the mentions electric fields, which is often given to confuse, but technically it is an electro-magnetic system)**.

30. Answer: (c) All three
Explanation: 1. Statement 1 is correct: In green ammonia, the hydrogen is **'green' (from water electrolysis using solar/ wind energy)**. 2. Statement 2 is correct: The traditional Haber-Bosch process uses natural gas **(methane)** which produces heavy CO2, whereas in green technology, this is zero. 3. Statement 3 is correct: The main goal of India's Green Hydrogen Mission is to decarbonize the fertilizer and steel industries.

31. Answer: (d) 1, 2 and 3
Explanation: 1. Statement 1 is correct: Quantum sensors use **'Quantum Illumination'** technology, which captures even subtle signals that traditional radars cannot see. This allows for the detection of **'stealth'** aircraft **(which absorb radar waves)**. 2. Statement 2 is correct: Quantum sensors utilizing Atomic Interference can measure nano-level changes in gravity. This is helpful in identifying the precise location of underground tunnels or underwater submarines where GPS does not work. 3. Statement 3 is correct: Due to quantum entanglement, it is impossible to tamper with radar signals because any change in the state of photons immediately reveals the jamming.

32. Answer: (c) All three pairs
Explanation: 1. 3-nanometer design: Currently the most advanced limit of chip manufacturing, used for high efficiency in AI servers and flagship smartphones. 2. Silicon Carbide **(SiC)**: This is a **'wide bandgap'** semiconductor that can withstand high temperatures and high voltages, making it critical for EV chargers and military equipment. 3. Design-Linked Incentive **(DLI)**: This scheme in India provides financial assistance to companies that do not just manufacture chips but also prepare their original design **(IP)**.

33. Answer: (b) Only 1 and 2
Explanation: 1. Statement 1 is correct: A digital database of farmers is being prepared through **'AgriStack'** so they can receive benefits from government schemes directly. 2. Statement 2 is correct: The convergence of digital registries and satellite data reveals which crop has been sown in which area, accelerating the settlement of **'crop insurance'** claims.
3. **Statement 3 is incorrect:** The primary goal of this mission is to deliver technical benefits to small and marginal farmers so that the role of middlemen can be eliminated.

34. Answer: (a) Only 1 and 2
Explanation: 1. Statement 1 is correct: Research in deep-tech **(such as quantum, fusion, or advanced biotech)** is very complex, so it requires **'patient capital' (investment that can wait 10-15 years for returns)**. 2. Statement 2 is correct: In Budget 2024, the **'Anusandhan National Research Foundation' (ANRF)** and a corpus of ₹1 lakh crore for innovation were announced. 3. Statement 3 is incorrect: The goal of this policy is not just software, but to achieve technical sovereignty based on **'hardware'** and **'fundamental science'**.

35. Answer: (b)
Explanation: Carbon Capture and Storage **(CCS)** technology's main objective is to capture CO2 emitted from industrial sources **(such as steel or cement factories)** before it dissolves into the atmosphere. The captured gas is liquefied and buried underground **(such as in depleted oil wells or saline rock formations)**. It does not destroy CO2 but stores it.

36. Answer: (c) Only 1 and 3
Explanation: 1. Statement 1 is correct: A **'Tokamak'** requires an internal electric current to rotate the plasma, while a **'Stellarator'** maintains plasma stability using its complex twisted coils. 2. Statement 2 is incorrect: Neutrons are neutral particles; magnetic fields have no effect on them. Therefore, they collide directly with the reactor walls, which can make the walls radioactive. 3. Statement 3 is correct: Helium-3 fusion **(D-He3)** releases protons instead of neutrons, which can be controlled by magnetic fields, making it a source of **'clean'** energy. [Image comparing Tokamak donut shape vs Stellarator twisted magnetic coil design]

37. Answer: (b) Only two (Statements 1 and 3 are correct)
Explanation: 1. Statement 1 is correct: Solid-state batteries do not contain flammable liquids, so they are safer and charge faster. 2. Statement 2 is incorrect: The energy density of sodium-ion batteries is lower than that of lithium. Their advantage is that sodium is cheap and abundantly available. 3. Statement 3 is correct: In a **'Flow Battery'**, energy is stored in electrolytes kept in external tanks. Larger tanks mean more backup time, making them excellent for grid storage.

38. Answer: (d) 1, 2 and 3
Explanation: 1. Statement 1 is correct: India's **'Mission Shakti' (2019)** used this very technology. 2. Statement 2 is correct: These are also called **'killer satellites,'** which behave like normal satellites during peacetime but can attack during war. 3. Statement 3 is correct: **'Kinetic Kill'** means destroying the target solely with its kinetic energy **(collision)**, similar to how a bullet breaks something.

39. Answer: (a) Only 1 and 2
Explanation: 1. Statements 1 and 2 are correct: **'Chiplet'** technology is the **'Lego'** of the semiconductor world. In this, different chips **(such as memory, graphics)** can be joined inside a single processor. This makes chip manufacturing cheaper and more flexible. 2. Statement 3 is incorrect: India's SCL **(Mohali)** is currently known primarily

for the production of 180-nanometer chips and strategic requirements. 3-nanometer production is currently being done globally only by companies like TSMC and Samsung.

40. Answer: (c) All three pairs
Explanation: 1. LiDAR: Uses lasers to measure distance, helping autonomous cars see the path. 2. SLAM: Short for **'Simultaneous Localization and Mapping'**. It is like a robot going into a dark room for the first time and creating a map of it while moving, as well as knowing where it is. 3. Edge Computing: Important for autonomous robots because sending data to the cloud takes time. Edge computing allows the robot to make decisions immediately **(in micro-seconds)**.

41. Answer: (a) Only 1 and 2
Explanation: 1. Statement 1 is correct: The core idea of Web 3.0 is **'decentralization'**. In this, data resides on the blockchain, reducing the control of intermediary companies like Facebook or Google. 2. Statement 2 is correct: Smart contracts are digital agreements. When pre-defined conditions are met, the code executes automatically, eliminating the need for intermediaries like lawyers or banks. 3. Statement 3 is incorrect: India's e-Rupee **(CBDC)** is based on a **'private'** or **'permissioned'** blockchain, not a public anonymous blockchain. The RBI has full control and records of it.

42. Answer: (a)
Explanation: The No-cloning Theorem is a fundamental principle of quantum physics. It states that you cannot make an identical copy of an unknown quantum state **(such as a qubit)**. In quantum communication **(QKD)**, this guarantees security because if a hacker tries to copy the information, the original information will change, and the intrusion will be detected.

43. Answer: (b) Only 2 and 3
Explanation: 1. Statement 1 is incorrect: The term **'Tensor'** itself means multi-dimensional data. It can process data arrays of 1D, 2D, 3D, and even higher dimensions. 2. Statement 2 is correct: TPUs **(Tensor Processing Units)** are specifically built to handle large AI datasets. Their standardization is important for saving energy. 3. Statement 3 is correct: Tensor calculations provide the mathematical basis for quantum simulations, making hybrid computing possible.

44. Answer: (c) All three pairs
Explanation: 1. Neuromorphic Computing: Makes chips work on **'spiking neural networks'** like the human brain. 2. Synthetic Biology: Recently, there has been significant research on DNA data storage, where biological molecules are being used like hard drives. 3. Quantum Biology: This field studies how quantum effects **(like tunneling)** at the microscopic level influence the functions of living systems.

45. Answer: (a) Only 1 and 2
Explanation: 1. Statement 1 is correct: The structure of ANRF is designed such that the majority of its funds **(approximately ₹36,000 crore out of ₹50,000 crore)** will come from the private sector. 2. Statement 2 is correct: One of its major objectives is to promote research in universities of Tier-2 and Tier-3 cities, which until now was limited mostly to IITs. 3. Statement 3 is incorrect: ANRF is a comprehensive institution that includes research in natural sciences as well as humanities, social sciences, and the arts.

46. Answer: (c) All three
Explanation: 'Vigyan Dhara' is a consolidated form of the schemes of the Department of Science and Technology **(DST)**.
1. **Statement 1 is correct:** It focuses on the three pillars of capacity building and innovation.
2. **Statement 2 is correct:** Women are being encouraged in STEM fields through programs like **'Vigyan Jyoti'**.
3. **Statement 3 is correct:** It will work in tandem with ANRF to fulfill India's scientific aspirations for 2047.

47. Answer: (a) Only 1 and 2
Explanation: 1. Statement 1 is correct: Under indigenization, the **'Rudra'** server and **'Trinetra'** interconnect demonstrate India's technical self-reliance. 2. Statement 2 is correct: **'Param Siddhi-AI'** has been India's fastest supercomputer, specifically designed for AI and complex scientific calculations.
3. **Statement 3 is incorrect:** Although India is investing in these, India is involved in **'SKA'** and **'LIGO'** as a **'strategic partner'** or with specific conditions rather than as a **'full member' (LIGO-India is being built in India itself, which is an international collaboration)**.

48. Answer: (a) Only 1 and 3
Explanation: 1. Statement 1 is correct: The INSPIRE scheme is a successful program to motivate school children towards science. 2. Statement 2 is incorrect: There is no official AI literacy program named **'Vigilant India'** in this context; the **'IndiaAI'** mission is working on AI policy. 3. Statement 3 is correct: Dr. C.V. Raman received the Nobel Prize for the discovery of the Raman Effect, in memory of which we celebrate National Science Day.

49. Answer: (b) Only 2 and 3
Explanation: 1. Statement 1 is incorrect: India currently spends only about 0.6% to 0.7% of its GDP on R&D, which is significantly lower than developed countries **(e.g., USA-2.8%, Israel-4.8%)**. 2. Statement 2 is correct: In India, the government spends more on research, whereas in Western countries, big companies **(like Google, Apple)** lead the research. 3. Statement 3 is correct: India has now reached the top 10 countries in the world in terms of patent filing.

50. Answer: (a) Only 1 and 2
Explanation: 1. Statement 1 is correct: Mitochondria and chloroplasts have their own genetic material, which distinguishes them from other organelles. 2. Statement 2 is correct: The enzymes of lysosomes are so powerful that if the cell is damaged, they can digest the entire cell itself.
3. **Statement 3 is incorrect:** Ribosomes are found in both Eukaryotic and Prokaryotic cells. Furthermore, ribosomes are non-membrane bound organelles.

51. Answer: (c) All three
Explanation: 1. Statement 1 is correct: DNA contains **'deoxyribose'** sugar, while RNA contains **'ribose'** sugar. Ribose has an additional -OH group, which makes RNA more unstable and chemically active compared to DNA. 2. Statement 2 is correct: The four bases of DNA are Adenine **(A)**, Guanine **(G)**, Cytosine **(C)**, and Thymine **(T)**. In RNA, Uracil **(U)** is found in place of Thymine. 3. Statement 3 is correct: DNA is a permanent store of information. RNA not only carries information but can also act like an enzyme in the form of a **'ribozyme'** to catalyze chemical reactions.

52. Answer: (a) Only 1 and 2
Explanation: 1. Statement 1 is correct: Transcription is the process in which information is transferred from one strand of DNA to mRNA. 2. Statement 2 is correct: In translation, ribosomes read the mRNA code to link amino acids and form proteins.
3. **Statement 3 is incorrect:** In Eukaryotic cells, transcription occurs inside the Nucleus, whereas translation occurs on ribosomes located in the Cytoplasm.

53. Answer: (c) Only 1 and 3
Explanation: 1. Statement 1 is correct: In CRISPR-Cas9, the guide RNA locates the DNA sequence to be changed, and the Cas9 protein makes the cut there. 2. Statement 2 is incorrect: It is being used not only in plants but also to treat human diseases **(like sickle cell anemia)**. Recently, the first medical therapy for this has been approved. 3. Statement 3 is correct: **'Prime Editing'** is a new technique that is more precise than Cas9 because it can change bases directly without breaking both strands of DNA, reducing the risk of unwanted mutations.

54. Answer: (c) All three
Explanation: 1. Statement 1 is correct: Pluripotent cells can transform into almost any tissue cell in the body **(heart, nerve, muscle, etc.)**. 2. Statement 2 is correct: The Nobel Prize was awarded in 2012 for iPSCs technology. It allows for the reprogramming of adult skin cells to create stem cells, eliminating ethical controversies **(use of embryos)**.
3. **Statement 3 is correct:** In India, only **'hematopoietic' (blood-forming)** stem cell therapy is an established and legally recognized treatment. The use of stem cells for other organs is still in experimental or research stages.

55. Answer: (d) 1, 2 and 3
Explanation: 1. Statement 1 is correct: DNA fingerprinting relies on **'repetitive DNA' (VNTR)**, which are of different lengths in every individual. 2. Statement 2 is correct: 99.9% of the human genome is identical globally. Only 0.1% **(approximately 30 lakh base pairs)** is responsible for our physical and genetic differences. 3. Statement 3 is correct: **'Pangenome'** is a new approach that combines data from diverse human groups rather than just one reference genome to better understand genetic diseases.

56. Answer: (b) Only two pairs (1 and 2 are correct)
Explanation: 1. Pair 1 is correctly matched: In sickle cell anemia, there is a single base change **(A to T)** in the hemoglobin gene. 2. Pair 2 is correctly matched: In Down syndrome, an extra copy of the 21st chromosome **(total 3)** appears.
3. **Pair 3 is incorrect:** Thalassemia is an autosomal recessive disorder; it is not X-linked. It can affect both men and women equally.

57. Answer: (a) Only 1 and 2
Explanation: 1. Statement 1 is correct: Restriction enzymes are called **'molecular scissors'** because they cut DNA at specific palindromic sequences. 2. Statement 2 is correct: Taq polymerase is extracted from a hot-spring bacterium, so it can withstand the heat-denaturation process of PCR.
3. **Statement 3 is incorrect:** PCR is very widely used in the diagnosis of diseases **(like HIV or COVID-19 tests)** and in forensic investigations.

58. Answer: (b) Only two (Statements 1 and 3 are correct)
Explanation: 1. Statement 1 is correct: Bt technology has been developed to protect cotton from pests like **'Bollworm'**. 2. Statement 2 is incorrect: In India, only Bt cotton is permitted for commercial cultivation. Legal and regulatory debates are currently ongoing regarding Bt brinjal and GM mustard. 3. Statement 3 is correct: Biofortification **(e.g., Vitamin-A in Golden Rice)** is an effective way to fight malnutrition.

59. Answer: (c) All three pairs
Explanation: 1. mRNA vaccine: It provides the blueprint for the body to create a part of the virus itself. 2. Live Attenuated: The germ is alive in this but is so weakened that it cannot cause disease, yet it provides strong immunity. 3. Viral Vector: For example, **'Chimpanzee Adenovirus'** has been used in AstraZeneca/Covishield.

60. Answer: (b) Only 1 and 2
Explanation: 1. Statement 1 is correct: These antibodies are produced in the laboratory from a single original cell **(Clone)**, so they are very specific. 2. Statement 2 is correct: The hybridoma technique was invented by Köhler and Milstein, in which an antibody-producing cell is fused with an immortal **(cancer)** cell.
3. **Statement 3 is incorrect:** Besides treatment, they are used extensively in **'pregnancy kits'** and diagnostic kits for identifying infectious diseases.

61. Answer: (a) Only 1 and 2
Explanation: 1. Statement 1 is correct: A bioreactor provides a controlled environment where temperature, pressure, and nutrients are precisely managed for the growth of microorganisms. 2. Statement 2 is correct: In a **'Stirred-tank'** reactor, an impeller is installed which breaks air bubbles and dissolves oxygen uniformly throughout the liquid.
3. **Statement 3 is incorrect:** Their use is mandatory for the large-scale production of vaccines, antibiotics, and enzymes. Modern medical science is not possible without them.

62. Answer: (d) 1, 2 and 3
Explanation: 1. Statement 1 is correct: BSL-1 is the most basic level **(e.g., non-pathogenic strains of E. coli)**. 2. Statement 2 is correct: BSL-4 is for those viruses for which no known treatment or vaccine is available and which are extremely fatal. 3. Statement 3 is correct: India's NIV Pune is among those selected global laboratories equipped with BSL-4 facilities to work on viruses like Ebola and Nipah.

63. Answer: (b)
Explanation: Synthetic biology is an advanced form of genetic engineering. Instead of just moving genes around, it focuses on creating new **'biological circuits'** or **'designer organisms'** that do not exist in nature, such as artificial bacteria that absorb carbon.

64. Answer: (a) Only 1 and 2
Explanation: 1. Statement 1 is correct: Pepsin becomes active in the HCl-containing acidic medium **(pH 1.8)** of the stomach.
2. **Statement 2 is correct:** Trypsin is released from the pancreas and performs the complete digestion of proteins in the small intestine. 3. Statement 3 is incorrect: Ptyalin **(salivary amylase)** begins the digestion of carbohydrates **(starch)**, not fats. The digestion of fats is primarily done by

the **'lipase'** enzyme.

65. Answer: (b) Only two pairs (1 and 3 are correct)
Explanation: 1. Melatonin: Secreted by the pineal gland, it regulates our biological clock for sleep. 2. Calcitonin **(incorrectly matched)**: It reduces calcium levels in the blood **(by depositing it in bones)**. The task of increasing calcium levels belongs to the **'Parathyroid Hormone' (PTH)**. 3. Aldosterone: Secreted by the adrenal gland, it maintains the balance of salt and water in the body.

66. Answer: (a) Only 1 and 2
Explanation: 1. Statement 1 is correct: Electrical signals at a synapse reach the next neuron in the form of **'neurotransmitters' (such as dopamine)**.
2. Statement 2 is correct: The Sympathetic system increases heart rate during times of crisis. 3. Statement 3 is incorrect: The myelin sheath acts like an insulator and speeds up the velocity of nerve impulses **(Saltatory conduction)**, not slows it down.

67. Answer: (a) Only 1 and 2
Explanation: 1. Innate immunity: This is the first protection provided by the skin, mucus, and certain white blood cells. 2. Adaptive immunity: This develops after a disease and provides effective defense in the future due to **'memory'** cells. 3. Statement 3 is incorrect: B-cells and T-cells are part of adaptive immunity, not innate.

68. Answer: (b) Only two (Statements 2 and 3 are correct)
Explanation: 1. Statement 1 is incorrect: The affinity of hemoglobin for carbon monoxide **(CO)** is about 200 times higher compared to oxygen, which causes **'CO poisoning'**. 2. Statement 2 is correct: Plasma is the liquid part of blood that carries waste and nutrients. 3. Statement 3 is correct: When oxygen is low in the body, the kidneys signal the production of new red blood cells **(RBCs)** by making erythropoietin **(EPO)**.

69. Answer: (b)
Explanation: According to the Bohr effect, when we exercise, CO_2 and acid increase in the tissues. This condition forces hemoglobin to **'donate'** oxygen to the tissues instead of holding onto it tightly, thereby providing energy to the cells.

70. Answer: (a) Only 1 and 2
Explanation: 1. Statement 1 is correct: Waste is filtered out in the glomerulus due to the pressure of small blood arteries. 2. Statement 2 is correct: The size of the Henle loop is longer in desert organisms so that more water can be absorbed from the urine.
3. Statement 3 is incorrect: Deficiency of ADH reduces water reabsorption, resulting in very frequent **(Diuresis)** and dilute urine **(as in 'Diabetes Insipidus' disease)**.

71. Answer: (c) Only 1 and 3
Explanation: 1. Statement 1 is correct: The pyramid of energy is always upright because the flow of energy is unidirectional and energy is lost at each level as per the laws of thermodynamics **(10% rule)**. 2. Statement 2 is incorrect: In **'Biomagnification'**, the concentration of toxic substances increases with each higher trophic level, it does not decrease. 3. Statement 3 is correct: The pyramid of biomass in a marine ecosystem can be inverted because the total weight of primary producers **(phytoplankton)** at any time may be less than the weight of the fish that eat them.

72. Answer: (c) All three pairs
Explanation: 1. Mutualism: Both benefit. Example: Lichens **(fungi and algae)**. 2. Commensalism: One benefits, the other is unaffected. Example: Barnacles attached to whales. 3. Amensalism: One is harmed, the other is unaffected. Example: Penicillium fungus inhibits the growth of bacteria.

73. Answer: (a) Only 1 and 3
Explanation: 1. Statement 1 is correct: Keystone species **(such as tigers or sea otters)** are essential for the balance of the ecosystem despite being small in their numbers. 2. Statement 2 is incorrect: Invasive species can be plants **(such as water hyacinth)**, herbivores, or microorganisms. 3. Statement 3 is correct: **'Lantana camara'** is a foreign invasive shrub that has caused heavy damage to the local vegetation of India's forests.

74. Answer: (c) Only 1 and 3
Explanation: 1. Statement 1 is correct: Nitrogen fixation is the process of converting atmospheric N2 into ammonia.
2. Statement 2 is incorrect: In **'Nitrification'**, ammonia is first converted into nitrite and then into nitrate **(by Nitrosomonas and Nitrobacter)**. Pseudomonas performs **'Denitrification'**. 3. Statement 3 is correct: Denitrification completes the cycle by converting nitrate back into nitrogen gas in an anaerobic environment.

75. Answer: (b) Only two (Statements 1 and 2 are correct)
Explanation: 1. Statement 1 is correct: Lichens are sensitive to air quality. Their absence in industrial areas is an indicator of high SO2 pollution. 2. Statement 2 is correct: Benthic organisms **(organisms of the river bed)** are long-term indicators of water pollution. Statement 3 is incorrect: Bio-indicators can indicate not just the species but the **'functionality'** and **'health'** of the entire ecosystem.

76. Answer: (b)
Explanation: A Genetic Bottleneck occurs when a large part of a population dies. In the remaining small population, genetic diversity remains very low, which increases the risk of extinction for that species in the future **(e.g., Cheetahs)**.

77. Answer: (a) Only 1 and 2
Explanation: 1. Statement 1 is correct: In the eDNA **(Environmental DNA)** technique, the presence of an organism can be checked solely from water or soil samples without capturing the organism. 2. Statement 2 is correct: Genetic Rescue is a method to prevent inbreeding depression. 3. Statement 3 is incorrect: Conservation genetics is used for all living beings, including plants, birds, insects, and microorganisms.

78. Answer: (d) 1, 2 and 3
Explanation: 1. Statement 1 is correct: Bacteria are independent cells. Viruses are not **'cells'**; they only behave like **'living beings'** inside a living cell. 2. Statement 2 is correct: Bacteria have a complex cell wall **(which antibiotics attack)**, whereas viruses have only a protein coat **(Capsid)**. 3. Statement 3 is correct: A virus will contain either DNA or RNA, never both. Bacteria always have main DNA along with, sometimes, plasmid DNA.

79. Answer: (b) Only two (Statements 1 and 2 are correct)
Explanation: 1. Statement 1 is correct: AMR is a **'silent pandemic'** where superbugs do not die from medicines. 2. Statement 2 is correct: Bacteria can pass their resistance genes to each other through processes like **'conjugation'**. 3. Statement 3 is incorrect: The **'One Health'** approach

considers the health of humans, animals, and the environment to be interconnected and emphasizes the judicious use of antibiotics in all three sectors.

80. Answer: (d) 1, 2 and 3
Explanation: 1. Statement 1 is correct: Zoonotic diseases spread through contact with animals **(e.g., Rabies)**. 2. Statement 2 is correct: **'Spillover'** is the moment when a virus crosses the species barrier. 3. Statement 3 is correct: All these diseases have come to humans from wildlife or domestic animals.

81. Answer: (b) Only 2 and 3
Explanation: 1. Statement 1 is incorrect: The microbiome contains trillions of beneficial bacteria, fungi, and viruses, not just harmful ones. These train our immune system, rather than weakening it. 2. Statement 2 is correct: Our gut bacteria **(Gut Microbiota)** break down those food fibers that human enzymes cannot digest, and in return provide nutrients like Vitamin K. 3. Statement 3 is correct: FMT is used to treat severe infections **(e.g., C. difficile)**, where healthy bacteria restore the balance.

82. Answer: (c) All three
Explanation: 1. Statement 1 is correct: **'Disease X'** is a hypothetical pathogen so that scientists can prepare vaccine platforms in advance for any unknown future pandemic. 2. Statement 2 is correct: CEPI is a global organization that creates vaccines for diseases that are not commercially attractive but pose a pandemic threat. 3. Statement 3 is correct: The coding of a virus's DNA/RNA **(genomics)** reveals how dangerous the virus has become.

83. Answer: (d) 1, 2 and 3
Explanation: 1. Statement 1 is correct: When a large part of the population becomes immune, the chain of virus transmission is broken, which also protects vulnerable people. 2. Statement 2 is correct: If a disease is highly contagious like Measles, 95% vaccination is needed for herd immunity. If it is less contagious, this limit may be lower. 3. Statement 3 is correct: Rapidly mutating viruses **'dodge'** the immunity created by vaccines, therefore repeated booster doses are required.

84. Answer: (b)
Explanation: Plasmids are small rings of DNA located outside the main chromosome of bacteria. Their specialty is that they can move from one bacterium to another. When these contain **'antibiotic resistance'** genes, they turn the entire bacterial group into a **'superbug'**.

85. Answer: (c) Only 1 and 3
Explanation: 1. Statement 1 is correct: Infrared is based on heat, which is why it is used in night vision. 2. Statement 2 is incorrect: The frequency of microwaves is higher than radio waves. They are used very effectively for line-of-sight communication **(e.g., tower-to-tower)**. 3. Statement 3 is correct: UV rays destroy the DNA of germs, which is why they are used in water purification **(UV Purifiers)**.

86. Answer: (c) All three
Explanation: 1. Statement 1 is correct: Radar works on radio waves, Sonar on sound **(ultrasonic)**. 2. Statement 2 is correct: Radio waves are absorbed very quickly in water, whereas sound waves can travel miles away in water. 3. Statement 3 is correct: This is why submarines use Sonar instead of Radar.

87. Answer: (a) Only 1 and 2
Explanation: 1. Statement 1 is correct: In the Triangulation technique, your location is found through a circle of at least 3 satellites and altitude is found from the fourth. 2. Statement 2 is correct: The speed of light is very fast, so even a microsecond error in time calculation can show the location kilometers away. Atomic clocks are mandatory here. 3. Statement 3 is incorrect: India's NavIC is a **'Regional'** system that covers only India and its surrounding 1500 km area, not the whole world.

88. Answer: (c) All three pairs
Explanation: 1. LEO **(200-2000 km)**: Satellites are close to Earth, so they can take clear pictures **(e.g., Google Earth satellites)**. 2. MEO **(approx. 20,000 km)**: Here the orbital period of satellites is stable, which is ideal for GPS. 3. GEO **(35,786 km)**: These satellites move at the speed of Earth, so they appear fixed in one place when seen from the ground. This is suitable for DTH and communication.

89. Answer: (d) 1, 2 and 3
Explanation: 1. Passive: Like our eyes or a camera that depend on external light. 2. Active: Like a camera with a flash or Radar. It sends its own light **(wave)** and reads the wave that reflects back. 3. Statement 3 is correct: Since active sensors **(like Radar)** do not need the Sun, they can take precise pictures of the ground even through dense clouds and in the darkness of night.

90. Answer: (a) Only 1 and 2
Explanation: 1. LED: In this, a **'backlight'** glows behind the entire screen. 2. OLED: In this, every pixel glows by itself. To show black color, OLED pixels turn off completely, resulting in **'true black'** and saving battery. 3. Statement 3 is incorrect: If you use Dark Mode on an OLED, the energy consumption is much lower than an LED because the pixels in the black parts do not consume electricity.

91. Answer: (d) 1, 2 and 3
Explanation: 1. Statement 1 is correct: In the electromagnetic spectrum, X-rays have a very high frequency and extremely short wavelength, which gives them the power to pass through dense materials **(like bones)**. 2. Statement 2 is correct: In a CT scan, a group of X-ray machines takes **"slice"** images of the body from different angles, which a computer converts into a 3D model. 3. Statement 3 is correct: X-ray crystallography is the technique used by Rosalind Franklin to identify the double helix structure of DNA.

92. Answer: (d) 1, 2 and 3
Explanation: 1. Statement 1 is correct: **'Coherence'** is the most important property of a laser. Light from an ordinary bulb scatters in every direction, whereas laser waves move together in **"harmony."** 2. Statement 2 is correct: A laser is of a single color **(a single wavelength)**. This property makes it excellent for cutting tissues precisely in surgery or sending data in fiber optics. 3. Statement 3 is correct: Holography requires **'interference'** between light waves, which is only possible with coherent light like a laser.

93. Answer: (b) Only two (1 and 2 are correct)
Explanation: 1. Statement 1 is correct: Inside the optical fiber, light moves forward by striking the glass walls through **'Total Internal Reflection'**.
2. **Statement 2 is correct:** Since fibers are made of glass and data travels as light, lightning or nearby electric wires

have no effect **(EMI)** on them. 3. Statement 3 is incorrect: While traveling long distances **(hundreds of kilometers)**, the intensity of light decreases; therefore, an **'optical amplifier'** is required to re-energize the signal.

94. Answer: (b) Only two pairs (1 and 2 are correct)

Explanation: 1. Pair 1 is correctly matched: A Convex mirror always forms a smaller and erect image, allowing the driver to see a large area behind. 2. Pair 2 is correctly matched: A Concave mirror shows a large and erect image of the face when held close. 3. Pair 3 is incorrect: For near-sightedness **(Myopia)**, a Concave lens is used so that light can be spread to reach the retina. A convex lens is used for **'far-sightedness'**.

95. Answer: (d) 1, 2 and 3

Explanation: 1. Statement 1 is correct: In near-sightedness **(Myopia)**, the eyeball becomes elongated, causing light to focus before reaching the retina.

2. **Statement 2 is correct:** In far-sightedness **(Hypermetropia)**, near objects appear blurry because the image forms behind the retina. A convex lens brings it onto the retina. 3. Statement 3 is correct: With age, the eye lens becomes stiff and the muscles weaken. Such a person often needs different glasses for both near and far **(Bi-focal)**.

96. Answer: (d) 1, 2 and 3

Explanation: 1. Statement 1 is correct: Adding impurities **(like phosphorus or boron)** to a pure semiconductor like silicon is called **'doping'**, which increases the number of free charges. 2. Statement 2 is correct: In n-type **(Negative)**, electrons are in excess; in p-type **(Positive)**, there is a deficiency of electrons, meaning **'holes'** are dominant. 3. Statement 3 is correct: The resistance of metals increases upon heating, but in semiconductors, heat frees more electrons, thereby reducing their resistance.

97. Answer: (c) All three

Explanation: 1. Statement 1 is correct: A diode allows current to flow in only one direction; therefore, it converts the fluctuations of AC into unidirectional DC. 2. Statement 2 is correct: In an LED, when electrons and holes meet, energy is released as light. **'Forward Bias'** means connecting it to the correct voltage. 3. Statement 3 is correct: The transistor is the foundation of modern electronics, acting either like an amplifier to boost signals or like a **'0 and 1'** switch in computer chips.

98. Answer: (b)

Explanation: A solar cell is based on the **'photovoltaic effect'**. When sunlight **(photons)** strikes a semiconductor **(silicon)**, it knocks electrons out of their orbits. The flow of these free electrons is electricity **(DC current)**. It converts light directly into electricity, not into heat.

99. Answer: (a) 1-2-3

Explanation: 1. First, a shower of charged particles **(solar wind)** arrives from the Sun. 2. The Earth's magnetic field blocks them, but some particles are diverted toward the poles. 3. At the poles, when these particles collide with the gases in our atmosphere, blue, green, and red light is produced, which is called an Aurora.

100. Answer: (c) All three

Explanation: 1. Statement 1 is correct: If the magnetosphere did not exist, solar radiation would have stripped away our atmosphere, and life would not have been possible. 2. Statement 2 is correct: During powerful solar storms, disturbances occur in the magnetic field **(Geomagnetic Storm)**, which can shut down satellites and power grids. 3. Statement 3 is correct: Mars' magnetic field is very weak, due to which solar winds have swept away its atmosphere and water into space over billions of years.