PART 2

Read the text below and answer questions 14–26.

DECODING ARTEFACTS: MICROSCOPES, DNA, AND VIRTUAL REALITY

Archaeologists once relied largely on what could be seen with the naked eye: an object's shape, decoration, and the most obvious signs of wear. Today, artefacts are increasingly "read" through invisible traces—microscopic scratches, molecular residues, genetic fragments, and digital reconstructions. This shift has increased scientific precision, but it has not abolished interpretive uncertainty. On the contrary, the more technically impressive a method becomes, the easier it is for a result to be treated as a definitive story rather than as one line of evidence. The central challenge is therefore methodological as well as philosophical: how to combine powerful tools without confusing measurement with meaning.

Lithic use-wear (microwear) analysis exemplifies this tension. Under high magnification, analysts examine microscopic polish, edge rounding, and fine striations on stone tools to infer how they contacted materials such as hide, wood, bone, or plant fibres. A tool used to scrape hide may develop a distinctive sheen and directional scratch pattern, while one used on reeds can produce different micro-chipping and polish distribution. Yet microwear signatures can overlap, and post-depositional processes may mimic genuine traces of use. Abrasion during burial, pressure from sediments, or modern handling can create damage that resembles purposeful contact. For this reason, many laboratories rely on experimental replication: researchers reproduce tool use under controlled conditions and compare the resulting wear with archaeological traces, treating the experiment as a reference library rather than as proof of a single activity.

Residue analysis approaches artefacts through chemical survival rather than surface damage. Pottery and tools can retain lipids absorbed into pores, starch granules lodged in crevices, or proteins that bind to surfaces. Increasingly, archaeologists use gas chromatography–mass spectrometry (GC-MS) to identify lipid biomarkers, including fatty acids and other molecular signatures that can suggest animal fats, dairy processing, or particular plant oils. However, the promise of residue work is matched by vulnerability to contamination. Soil can introduce compounds; later handling can transfer modern substances; and conservation chemicals used in museums can overwhelm ancient traces. Credible claims therefore require controls, clean sampling, and cautious language about what can and cannot be ruled out. Even when a compound is identified accurately, linking it to a precise behaviour—ritual, trade, routine cooking—remains an inferential step that must be defended rather than assumed.

Ancient DNA (aDNA) has extended this logic of invisible evidence still further. Once associated mainly with human remains, aDNA research now includes animals, plants, and even sediments, where genetic fragments can indicate that a species was present even when bones or seeds are absent. High-throughput sequencing can recover short, damaged fragments and match them against reference databases to infer domestication histories, population mixing, or changing ecosystems around a site. Yet aDNA work is exceptionally sensitive to contamination, requiring strict protocols and dedicated clean facilities. Survival conditions also vary sharply: heat and humidity accelerate decay, meaning that preservation is often uneven across regions and contexts. Interpretation depends on the completeness of reference databases, which can be limited for understudied areas. As a result, genetic absence is not always evidence of historical absence, and confident conclusions must be framed with explicit acknowledgment of sampling limits.

Digital technologies offer a different kind of access—less biochemical, more spatial. Virtual reality (VR), photogrammetry, and 3D modelling allow researchers to document artefacts and sites in high detail, creating manipulable models that can be rotated, measured, and shared without moving fragile originals. In some projects, fragments are assembled digitally to test reconstruction hypotheses before physical restoration begins, reducing the risk of irreversible mistakes. VR can also support public engagement, allowing users to “enter” reconstructed spaces or examine objects from angles that museum cases do not permit. Yet immersive presentation carries its own interpretive danger: it can create a false sense of certainty. A plausible reconstruction may be mistaken for a measured record unless uncertainty is clearly marked, and visual realism can disguise the fact that multiple alternatives were possible.

These methods are most powerful when they converge, but convergence is not the same as certainty. A pottery vessel might show microwear consistent with scraping, residues of starchy plants detected by laboratory analysis, and aDNA traces in surrounding sediment that suggest particular crops in the local environment. Taken together, these lines can strengthen inference by ruling out some explanations and making others more plausible. However, triangulation does not eliminate ambiguity. The same evidence can support multiple scenarios—routine cooking, specialised processing, or episodic ritual use—depending on context, comparison samples, and assumptions about behaviour. The most responsible interpretations therefore treat science as constraint rather than as storytelling: evidence narrows what is likely, but rarely dictates a single narrative.

Access and expertise determine who benefits from these advances. Microscopes and reference collections require training; GC-MS and clean laboratories demand investment; high-throughput sequencing depends on expensive infrastructure; and VR requires

scanning equipment, software, and skilled modelling. As a result, wealthier institutions may dominate interpretation, while local teams become data providers rather than equal partners. Collaborative models increasingly emphasise shared authorship, training, and control over digital files, particularly where artefacts and human remains carry cultural or political sensitivities. Looking ahead, automated pattern recognition may speed classification of wear marks or residue spectra, and portable devices may bring some lab techniques into the field. Yet automation can conceal assumptions in training data, and portability can encourage premature conclusions if used without proper controls. The enduring task will be to combine precision with humility about what the evidence can support.

Questions 14–18

Complete the sentences below. Choose **NO MORE THAN TWO WORDS** from the text for each answer.

14 In microwear work, analysts study fine ..... and polish to infer tool use.

15 The passage notes that post-depositional processes may ..... genuine use-wear traces.

16 Reliable residue claims require controls and ..... to reduce contamination.

17 The text states that DNA preservation can be damaged rapidly by heat and .....

18 In digital reconstructions, interpretations should be clearly marked with ..... to avoid misleading realism.

Questions 19–22

Match each statement with the correct analytical method, **A–D**, below.

List of Analytical Methods

A Microwear analysis
B Residue analysis
C Ancient DNA (aDNA)
D Virtual Reality (VR) and 3D modelling

19 This approach can infer species presence from genetic material even when no bones or seeds are recovered.

20 This method can be compromised when modern substances from soil, handling, or museum treatments overwhelm ancient traces.

21 This technique allows fragile artefacts to be examined virtually and fragments to be tested in reconstruction before restoration.

22 This analysis links microscopic surface damage to contact with materials by comparing traces with controlled experiments.

Questions 23–26

Select the correct answer.

23 What main caution does the writer give about technically impressive findings?

A They usually provide too little detail to support any interpretation
B They can encourage an overconfident narrative that exceeds what evidence warrants
C They make comparisons between different sites impossible
D They prevent archaeologists from combining different forms of data

24 Why does the passage refer to experimental replication in microwear studies?

A To remove the need for controls in chemical residue analysis
B To ensure that burial damage cannot affect any interpretation
C To recreate tool use and compare resulting traces with archaeological wear
D To replace microscopy with genetic methods whenever possible

25 What does the passage suggest about using several techniques together ("triangulation")?

A It can strengthen inference, even though multiple explanations may still remain
B It guarantees that one interpretation will be confirmed as correct
C It is useful only when results can be presented in virtual reality
D It works only if all methods yield identical outcomes

26 What risk is associated with future automation and portable analytical tools?

A They will eliminate the need for training and expert judgement
B They will make contamination in DNA analysis impossible
C They will reduce the need for collaboration and shared authorship
D They may conceal assumptions and encourage conclusions before proper controls are applied

Answer Key

14. striations

15. mimic

16. clean sampling
17. humidity
18. uncertainty
19. C
20. B
21. D
22. A
23. B
24. C
25. A
26. D