Science & Biomed

IMPACT
TONBRIDGE SCHOOL

Science & Biomed enables students to think, investigate and problem solve through the lens of a scientist and biomedical researcher. Learning is driven by engagement with the environmental challenge of soil pollution, considering how contaminants such as heavy metals affect ecosystems, agriculture and human health.

Through hands-on investigation using advanced analytical techniques, including Scanning Electron Microscopy (SEM) and Energy Dispersive X-ray Spectroscopy (EDX), students examine how pollutants interact with soil systems. This process develops evidence-based reasoning as students interpret data and refine their understanding through practical enquiry. The course develops an understanding of science as an interconnected discipline, applied to real-world environmental and societal challenges.

Course structure

Learning is structured around a six-phase Challenge that mirrors authentic scientific investigation. This includes the exploration of soil composition, the collection and interpretation of data, and the evaluation of environmental risk using SEM and EDX analysis. Students investigate how contaminants accumulate in soil, how environmental factors influence distribution, and how these processes relate to biological impact. Working through a structured cycle of enquiry, analysis and reflection, they develop towards an evidence-based judgement on land suitability for agricultural use. Tutors guide students in forming hypotheses, testing ideas and refining conclusions through collaborative scientific practice.

Skills gained

Science & Biomed enables students to develop scientific understanding, analytical precision and an investigative mindset. They interpret microscopic and elemental data, explain interactions between chemical and biological systems, and construct evidence-based conclusions.

- Students **communicate scientific ideas** using precise terminology, structured reasoning and supported argument.
- **Presentation skills** and **confidence** grow with final competitions providing a platform to showcase understanding of scientific terminology using evidence based reasoning.
- The programme develops **critical thinking, collaboration**, **resilience** and **analytical reasoning**, supporting progression into science, medicine and related disciplines.
- Students gain practical experience of **advanced analytical techniques** and understand how scientific evidence informs **real-world decision making**.

Key learning objectives

- Develop an integrated understanding of science through investigation that combines chemistry, biology and physics.
- Examine the properties, sources and behaviour of heavy metals in soil and their impact on ecosystems and human health.
- Interpret SEM imagery and EDX data to identify patterns, trends and anomalies.
- Investigate how environmental factors, including proximity to pollution sources, influence soil contamination.
- Form and test hypotheses, analyse data and draw evidence-based conclusions.
- Communicate scientific understanding through structured discussion, written analysis and presentation.
- Evaluate uncertainty and limitations, recognising the iterative nature of scientific enquiry.

Example challenge

Roadside pollution - the big question: "How does one determine whether the topsoil is suitable and safe for long-term farming?

Final Outcome: Participants will make an informed judgement based on their own guided scientific observation, on whether a piece of land for sale would make suitable farmland for a tight-knit, multigenerational agricultural family.

PHASE	ACTIVITY	SKILLS DEVELOPMENT
PHASE 1 **Foundation and Orientation**	Introduction to SEM and EDX (what they are, how they work), and why topsoil health matters. Students explore the scenario: a family assessing land near a busy road for food growing.	**Scientific & Biomedical Skills** • Understand the basic principles of Scanning Electron Microscopy (SEM) and Energy Dispersive X-ray Spectroscopy (EDX) , recognise key soil components (minerals, organic matter, contaminants) and understand why topsoil health is critical for food safety and human health (bioaccumulation, toxicity) **Practical Investigation & Problem Solving** • Interpret simplified SEM images (scale, contrast, morphology), identify what makes a "good" vs "contaminated" soil sample , frame investigational questions (e.g. Where might contamination be highest? Why?), make predictions based on environmental context (e.g. proximity to road) **Science & Biomed Communication** • Use key terminology accurately (e.g. resolution, electron beam, elemental analysis, contamination), ask scientific questions and articulate hypotheses, translate a real-world problem into a scientific investigation **Collaboration & Reflective Working** • Share prior knowledge and assumptions about pollution, listen and build on others' ideas, reflect on initial biases (e.g. "near a road must be unsafe")
PHASE 2 **Exploration and Practice**	Students examine SEM images and conduct EDX spot analysis and elemental mapping (simulated or real datasets). Work in small teams of 2-3 to extract measurements.	**Scientific & Biomedical Skills** • Read and interpret SEM micrographs (surface features, particle types) and EDX outputs (spectra peaks, elemental maps), recognise key elements linked to contamination (e.g. Pb, Cd, Zn) **Practical Investigation & Problem Solving** • Extract quantitative and qualitative data from images and spectra, use measurement tools (scale bars, relative abundance), decide where to take EDX spot analyses (justifying sampling choices), manage variability between samples balanced with sample size **Science & Biomed Communication** • Record observations clearly and systematically, use clear labelling, tables or structured sheets for data entry, justify choices (e.g. "We sampled this region because…"), begin using evidence to support claims **Collaboration & Reflective Working** • Work effectively in small teams (role allocation: observer, recorder, analyst), negotiate decisions and resolve disagreements, reflect on data quality and limitations during collection
PHASE 3 **Application and Collaboration**	Teams combine their datasets into a shared class dataset (e.g. central spreadsheet or board). Identify patterns in elemental presence (e.g. heavy metals near road).	**Scientific & Biomedical Skills** • Understand how larger datasets improve reliability, recognise patterns across multiple samples (spatial trends, consistency), appreciate concepts of reproducibility and sample size **Practical Investigation & Problem Solving** • Combine datasets into a shared format (spreadsheet or board), standardise units and categories, identify anomalies or outliers, begin grouping data (e.g. "near road" vs "further away") **Science & Biomed Communication** • Present data visually (tables, simple graphs, maps), summarise group findings concisely, compare results between teams, use appropriate scientific language when reporting trends **Collaboration & Reflective Working** • Contribute responsibly to a shared dataset, cross-check others' data for accuracy, reflect on consistency between groups, develop accountability for shared scientific outcomes

PHASE	ACTIVITY	SKILLS DEVELOPMENT
PHASE 4 **Independence and Mastery**	Students interpret pooled data: compare elemental concentrations, identify contaminants, relate findings to soil health and possible pollution sources.	**Scientific & Biomedical Skills** • Interpret elemental concentrations and distributions, link specific elements to pollution sources (e.g. traffic --> Pb, Zn), understand thresholds and risk (intro to toxicology concepts) and sources of pollution., relate soil contamination to potential biological impact (plants --> humans) **Practical Investigation & Problem Solving** • Compare datasets (e.g. gradients with distance from road), identify correlations and possible causation, evaluate reliability of conclusions based on evidence, consider alternative explanations **Science & Biomed Communication** • Construct evidence-based explanations, use comparative language (higher/lower, significant pattern), support claims with specific data points, begin structuring scientific **arguments** **Collaboration & Reflective Working** • Debate interpretations within groups, challenge ideas constructively, reflect on uncertainty and limitations, revise conclusions based on new insights
PHASE 5 **Consolidation and Presentation**	Students read short scientific literature extracts (adapted) on soil contamination and health impacts. Class discussion to evaluate findings and consider uncertainties.	**Scientific & Biomedical Skills** • Engage with adapted scientific literature (soil contamination, health impacts), connect experimental findings to established science, understand uncertainty, bias, and limitations in research **Practical Investigation & Problem Solving** • Evaluate the strength of evidence (their data vs literature), identify gaps in investigation (e.g. missing samples, limited resolution), consider next steps or improvements, explore real-world constraints (cost, time, ethics) **Science & Biomed Communication** • Participate in structured scientific discussion, compare findings with published knowledge, use evidence to support or challenge claims, communicate uncertainty clearly (e.g. "This suggests…, but we cannot be certain because…") **Collaboration & Reflective Working** • Listen critically to others' viewpoints, respect differing interpretations, reflect on how their thinking has changed, recognise the iterative nature of science
PHASE 6 **Evaluation and Reflection**	Groups present their conclusions: Is the land suitable? What are the risks? What would they recommend to the family?	**Scientific & Biomedical Skills** • Synthesize knowledge of SEM, EDX, and soil science, apply findings to a real-world biomedical/environmental decision, understand risk assessment in a practical context **Practical Investigation & Problem Solving** • Draw justified conclusions from complex data, make recommendations (e.g. safe/not safe, mitigation strategies), balance evidence with uncertainty, consider feasibility of solutions **Science & Biomed Communication** • Present a clear, structured scientific argument, use visuals effectively (graphs, SEM images, maps), tailor communication to a non-expert audience (the family), answer questions and defend conclusions **Collaboration & Reflective Working** • Work as a team to produce a coherent presentation, reflect on individual and group contributions, evaluate strengths and areas for improvement , build confidence in presenting scientific work