## The purpose of this document

This document has been created for training and supporting inspectors to conduct subject deep dives in schools. The training guidance provides a structure to explain variation in subject-level quality of education. It should be used in conjunction with handbooks for section 5, section 8 inspections of good and outstanding schools, and section 8 no formal designation (subject-specific) inspections.

## Points to consider when examining the evidence:

School leaders may not be able and should not be expected to articulate their intent **as it is outlined** in this document or to provide documents which neatly provide the evidence for these focus areas. Inspectors should always investigate claims that issues affecting quality of subject education are outside of the school's control. It should be evident that the issue has been identified prior to the inspection and that the school has taken steps to mitigate the ill effects. For example, in the case of text books, it should be clear that leaders have previously identified the issue and raised it with senior leadership, investigated funding, identified texts they would prefer, identified the specific weaknesses of the current text and taken specific action to mitigate against those weaknesses.

## The structure of this training guidance:

| **The six focus areas** |
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| These provide a structure to explain reasons for the quality of subject education as identified by inspection activities. Inspection activities are likely to be an iterative process as inspectors consider the evidence. Under each focus area there is one row and two columns. |

| **Column 1:** This is an outline of potentially stronger practice in the area each question explores.<br><br>It also provides likely responses and other evidence inspectors may encounter and gives explicit guidance on how to interpret these responses. | **Column 2:** This is an outline of weaker practice in the area each question explores.<br><br>It also provides likely responses and other evidence inspectors may encounter and gives explicit guidance on how to interpret these responses. |
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| **Inspector Questions:** These are organising questions which, together, cover the relevant points inspectors need to investigate under each focus area. These questions serve as headings and are not designed to be asked of school leaders. There are examples of useful **school-friendly** questions inspectors might ask of people or the evidence to explain reasons for the quality of subject education. This is **not** a comprehensive list of questions which may be asked. Inspectors should use their own judgement but will find the school-friendly question suggestions useful. | |

## Six focus areas

**1.** The school's understanding of progress in science and how that informs its approach to the curriculum
**2.** The extent to which teaching supports the goals of the science curriculum
**3.** The effectiveness of assessment in science
**4.** The extent to which there is a climate of high subject expectations where a love of the subject can flourish
**5.** The quality of systems and support for staff development
**6.** The extent to which whole-school policies affect the capacity for effective science education

## Inspectors are likely to use the following sources of evidence in making their judgements.

They will generally use:

- interviews with subject lead (if there is one) and/or the appropriate senior leader
- curriculum plans
- pupils' work
- discussions with pupils
- interviews with teachers
- lesson visits, including conversation with teachers, if possible.

Where appropriate, inspectors may use:

- the school's own records of lesson visits in the subject
- the resources available for teaching the subject (incl. school library, ICT facilities)
- the school's assessment policy
- assessment instruments, including mark schemes if there are any (not internal data)
- how the school provides pupils with feedback on their work
- how the school promotes the value of the subject, including via enrichment activities
- forms of support for inexperienced, non-specialist or struggling staff
- any support provided for the subject lead
- performance management's role in improving subject provision
- details of the timetable and staffing (including details of experience and qualifications of staff)
- school policies on teaching, assessment, homework, behaviour
- documents analysing strengths and weaknesses of the subject and any associated improvement plans.

| Focus area 1: The school's understanding of progress in science and how that informs its approach to the curriculum |
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| **Outline of potentially stronger practice in terms of intent, implementation and impact**<br>NB: answers will take many forms. Below are common findings to look out for | **Outline of weaker practice in terms of intent, implementation and impact**<br>NB: answers will take many forms. Below are common findings to look out for |
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| **Inspector question 1:**<br>**Scope**: How does the school understand what it means 'to get better' (progression) in the subject, and does the school give meaningful attention to all categories of knowledge in science? Is the scope commensurate with that outlined in the National Curriculum?<br><br>**School-friendly questions:**<br><br>▪ What does it mean to make progress in science?<br>▪ How is your curriculum organised? And why have you organised the curriculum in this way?<br>▪ How does your curriculum allow pupils to develop knowledge of working scientifically?<br>▪ Show me where the curriculum teaches pupils knowledge about: evolution, electricity and states of matter.<br>▪ Show me where the curriculum teaches pupils knowledge about: presenting and analysing data, variables . | |
| **Science, at its most fundamental, seeks to explain the material world:** why apples fall, why viruses spread and how painkillers work. These explanations are based on concepts, laws, theories and models that became established through scientific enquiry.<br><br>By learning about the products of science (substantive knowledge), pupils are able to explain the material world. But by also learning about how scientific knowledge gets established, through scientific enquiry, pupils learn about the nature and status of scientific knowledge. For example, recognising that scientific knowledge is open to revision in the light of new evidence and that an observation is different to an established scientific fact. | **The school primarily considers progress in terms of generic science 'skills'.**<br>Inspectors should check that the school does not see skills as separate from knowledge. Skills such as 'observation' or 'analysis' are dependent on scientific knowledge. A curriculum focusing on skills may focus on pupils taking part in activities such as 'observing' or 'classifying' without considering the substantive or disciplinary knowledge that pupils could be learning. For example, to classify flowering plants needs knowledge of floral parts.<br><br>**The curriculum does not plan for the progression of all categories of knowledge.**<br>The curriculum should outline what substantive and disciplinary knowledge pupils are learning and how this builds over time to develop expertise. In early |

**Substantive knowledge – the products of science**
This is referred to as scientific knowledge and conceptual understanding in the National Curriculum.

Examples of substantive knowledge include knowledge of: the **concept** of magnetism, the **theory** of evolution by natural selection, Newton's **laws** of motion and the geocentric **model** of the solar system (see question 2).

**Disciplinary knowledge – the practices of science.**
Disciplinary knowledge is knowledge of how scientific enquiry generates and grows substantive knowledge. The National Curriculum (NC) outlines what pupils need to know about disciplinary knowledge through the 'working scientifically' aspects of the NC.

Examples of disciplinary knowledge include knowledge of methods, measurement, variables and practical procedures (see question 3). It should not just be associated with 'doing' practical work.

**Disciplinary and substantive knowledge involve knowledge of procedures (know how to… and be able to…) and concepts (know that… because…).**
This is important as disciplinary knowledge is often considered only in relation to 'skills' or procedural knowledge.

**Disciplinary knowledge is embedded within the substantive content of science.**
It is not taught as a separate strand, rather it is always related to substantive knowledge e.g. disciplinary knowledge about scientific models is related to models of the solar system. This allows pupils to learn how scientific knowledge gets established and grows.

years, it is reasonable for the curriculum to focus on substantive knowledge only.

**Disciplinary knowledge is considered only in relation to carrying out practical work.**
Check that the curriculum defines what disciplinary knowledge pupils need to know as laid out in the 'working scientifically' area of the NC – this includes knowledge of concepts such as variable and prediction, as well as knowing how to carry out specific procedures e.g. using a thermometer to make accurate measurements. Schools should **not** achieve 'working scientifically' by placing practicals into their curriculum without identifying what component knowledge pupils are learning.

**The science curriculum is narrowed due to an excessive focus on English and maths (or other subjects) or because of pupil choice.**
Check that sufficient time is being given to teach the school science curriculum across all years, including Year 1. In early years, learning about the natural world should not be primarily through choice or chance.

**'We want pupils to 'be scientists'**
Check that 'being a scientist' is not expecting pupils to discover scientific concepts and/or procedures for themselves, or that science is only about doing experiments. To work scientifically, pupils will need to know a body of disciplinary and substantive knowledge. They should be able to use this knowledge to read, write, talk and represent science – not just take part in practical activities.

**'We follow a published/MAT SoW or buy in science kits which have progression of skills and knowledge built in.'**
Ofsted have no view on bought versus in-house schemes or resourced kits. Inspectors should apply the same questions to published schemes as any other to assess its quality and ensure that teachers and subject leaders understand how progression of knowledge is planned for over time.

**When taught as part of a thematic or cross-curricular approach, there is insufficient attention to teaching scientific content.**

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| | Check that adequate teaching time and logical sequencing of science content are embedded within thematic approaches. Check that pupils know the word 'science' and that they know science is a discipline in its own right. |

**Inspector question 2:**
**Scope and components**: Does the school ensure wide-ranging and expanding substantive knowledge of science? Are major concepts identified and developed?

**School-friendly questions:**

- What are the most important biology concepts pupils learn in Year 2? How does this build from what they learnt in the early years?
- When do pupils first learn about materials and matter? What concepts are they learning about?
- Can you show me where your curriculum, as a result of teaching specific knowledge, anticipates or addresses a misconception?
- Can you show me where pupils use their knowledge of what a material is, beyond when it is first taught?

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| **Substantive knowledge in science is organised around key scientific concepts such as evolution, forces or materials.**<br><br>Pupils will build increasingly secure and complex schemata for these concepts, throughout their school career, by knowing and remembering:<br>▪ more facts e.g. herbivores feed on plants<br>▪ more examples of the same concept e.g. deciduous trees, evergreen trees<br>▪ more procedures e.g. *how to* draw a food chain or *how to* draw a bar chart showing plant height<br>▪ more vocabulary, units and scientific nomenclature e.g. naming conventions for organisms or materials e.g. *Quercus robur* (common oak)<br>▪ more representations in the form of models (e.g. solar system model), diagrams (e.g. biological drawing of a flower), graphs (e.g. melting points).<br><br>**The curriculum explicitly outlines how substantive concepts are connected and related to each other.** This ensures pupils know how knowledge is organised in each discipline. For example, | **Curriculum plans do not include careful consideration of the need to develop key concepts over time.**<br><br>Leaders may be unable to describe what the key concepts in their curriculum are, or how these progress from early years through to Year 6. A consequence is that the curriculum appears to pupils and teachers as a series of isolated facts with no organising structure.<br><br>**Pupils are struggling to grasp new substantive concepts and/or use scientific vocabulary.**<br><br>This will be due to gaps or less confidence with prior knowledge. This is because, often, scientific knowledge is hierarchically arranged meaning that pupils must have learnt what came before to make sense of new learning. Necessary prior component knowledge needs to be identified by teachers and built into curriculum sequences.<br><br>**Pupils are unclear how knowledge from different topics is connected.**<br><br>Concepts in science are highly connected. If pupils have a superficial understanding of substantive knowledge, they are unable to make connections between concepts from different areas. For example, pupils may not connect their knowledge of flower reproduction to animal nutrition e.g. fruits and seeds are an important food source. |

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| pupils know that owls are birds and birds are animals, therefore owls are birds and animals.<br><br>**The curriculum anticipates and addresses likely pupil misconceptions e.g. plants get their food from the ground or a force is needed for an object to move.**<br>This could include using examples from the history of science and/or explicitly teaching pupils why the misconception is scientifically wrong. Schools should recognise that misconceptions are rarely addressed through a 'one off' activity but require pupils to encounter the scientific idea multiple times, over many different years.<br><br>**Over time, substantive knowledge remembered in long-term memory should become increasingly organised and connected. This will allow pupils to:**<br>▪ recognise the distinguishing features of science in relation to core concepts, objects of study (i.e. the material world) and methods<br>▪ provide increasingly detailed descriptions and explanations of phenomena, being able to link together knowledge from different topics and concepts<br>▪ recognise more scenarios as being instances of the same scientific principle (deep structure) e.g. lungs, leaves and elephants' ears look very different but are united by the fact they all have a large surface area to volume ratio<br>▪ solve more multi-stage/multi-part problems e.g. calculate how much salt will dissolve in a fixed amount of water<br>▪ ask questions about the world that extend from their scientific knowledge e.g. what is the evolutionary advantage of male animals having nipples? | **Pupils are acquiring and embedding misconceptions.**<br>Where scientific concepts are not taught and rehearsed, pupils are at risk of acquiring misconceptions in their place. For example, pupils might believe that gases do not have mass, or that a force is always needed to keep an object moving. Even with instruction, some pupils will develop misconceptions. The curriculum should explicitly address these e.g. by showing why the misconception is scientifically wrong. |
| **Inspector question 3:** | |

**Scope, Components:** Does the school ensure wide-ranging and expanding knowledge of disciplinary knowledge? This includes knowledge of concepts and procedures.

**School-friendly questions:**

- Show me how the curriculum is organised to ensure pupils' knowledge of working scientifically advances overtime.
- What does your curriculum say a Year 6 pupil should know and be able to do in terms of recording and presenting scientific data? What are the key concepts and procedures they are learning?
- Show me how pupils' knowledge of fair testing advances over time in the curriculum. What other scientific methods do pupils learn about?

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| **Scientific enquiry refers to the systematic approaches used by scientists to generate new knowledge.** It encompasses a range of methods and should not just be taken to mean 'data' collection but includes the full process that involves planning, implementing, analysing and drawing conclusions. Note that this should not be confused with enquiry-approaches to teaching science which are a pedagogy (see question 13).<br><br>**By learning about different types of scientific enquiry, pupils develop expanding disciplinary knowledge of the nature, processes and methods of science**. The National Curriculum specifies what disciplinary knowledge pupils need to know through the 'working scientifically' sections.<br><br>Pupils' disciplinary knowledge advances in broadly four areas through the science curriculum. Note that schools may use different subcategories and/or names.<br><br>1. **Methods to answer scientific questions** - this should reflect the diversity of scientific methods, not just 'fair testing' e.g. identifying, experimentation (fair testing), classification and grouping, pattern seeking, observing over time.<br>2. **Apparatus and techniques, including measurement –** knowledge of how to carry out specific procedures safely and | **The curriculum does not outline how disciplinary knowledge advances over time.**<br>For example, the curriculum does not identify how knowledge of fair tests is built upon. It may consider progression only in terms of being able to do more practicals and assumes pupils 'pick up' disciplinary knowledge simply by doing.<br><br>**Learning about scientific enquiry is reduced to just learning about fair tests.**<br><br>The National Curriculum outlines that pupils need to know about **different types** of science enquiries. The curriculum should ensure that pupils learn about all the different ways that scientists generate knowledge. This should include how hypotheses are developed, data is analysed, and conclusions are drawn. Scientific enquiry should always take place in a substantive context. E.g. classifying buttons is not science, whereas classifying butterflies is.<br><br>**Pupils are expected to learn disciplinary knowledge only as a by-product of doing experiments.**<br><br>Pupils should have an emerging awareness that scientific enquiry is not about trial and error or carrying out experiments, but involves a systematic approach that draws on a body of disciplinary and substantive knowledge. At times, learning how scientific enquiry establishes knowledge in science will require pupils to take part in the full process of a scientific enquiry. However, it is important that pupils have the necessary substantive and disciplinary knowledge to guide what is done and why and that pupils are not expected to learn about scientific enquiry simply as a by-product of doing. |

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| with proficiency. This includes the accurate measurement and recording of data.<br>3. **Analysis, presentation and evaluation of scientific data to draw valid conclusions** – knowledge of how to present and process scientific data in a variety of ways e.g. using specific graphs and tables, which are used, alongside substantive theory, to draw tentative conclusions. Pupils should recognise that explanation is distinct from data and does simply emerge from it.<br>4. **Development of scientific knowledge over time** - this involves knowledge of how scientific laws and theories develop over time.<br><br>**Disciplinary terms such as variable or precision are defined carefully, with due regard to their scientific meaning.** This will involve the curriculum specifying how key terms are defined for different ages so teachers are clear on what to teach.<br><br>**Pupils are aware scientific models are not copies of reality.**<br>When scientific models are introduced in the curriculum pupils learn when the model can be used and are aware of its strengths and limitations in relation to the scientific concept it is explaining. | **Key disciplinary terms such as 'accuracy' are not taught with sufficient attention to their scientific meaning.**<br>Check that disciplinary terms are being carefully defined e.g. an accurate measurement is a measurement assumed to be close to the true value and that teachers are clear on how terms are defined at each age.<br><br>**Pupils think a scientific model is a literal representation.**<br>They cannot explain how it is similar and different to the target concept it is explaining e.g. they think that electrical circuits are like 'central heating systems'. |

**Inspector question 4:**
**Components/sequencing:** does planning consider component content and its sequencing to build **substantive knowledge** over time and create 'readiness for future learning'?

- within the lesson sequence
- within the topic
- within the year or phase

**School-friendly questions:**
- Show me how you have broken down a Year 3 curriculum statement (i.e. from the NC) into component knowledge.
- Show me how the curriculum has broken down a complex idea or concept to make it easier for pupils to understand.
- Show me how you have sequenced knowledge within a unit/topic. What was your rationale?
- Show me how your curriculum prepares pupils for a particular topic as a result of teaching specific content in the previous year.

- What components taught in the early years about seasons get built upon in key stage 1? Can you show me where these components are used?

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| **Curricular planning breaks down the end goal (the composite) into the component knowledge required to achieve the end goal.**<br><br>Knowledge is sequenced so pupils develop increasingly extensive schemata that builds from what they already know.<br><br>**Substantive knowledge is sequenced to develop expanding knowledge of key concepts.**<br><br>The curriculum is structured to develop knowledge of core scientific concepts that transcend years and phases, for example state changes, forces, habitats. These core concepts will be revisited and built upon in different topics.<br><br>**Substantive knowledge is sequenced to take account of progression within and between concepts.**<br><br>For example, to understand the structure and function of plant roots, it is helpful if pupils know what plants need to grow and live.<br><br>**Substantive knowledge is sequenced to develop interconnected knowledge between concepts from different areas.**<br><br>The curriculum is structured to explicitly develop knowledge of how scientific concepts are organised and related to one another both within and between scientific disciplines. For example, in biology pupils can think about biological systems by integrating what they know about food chains and evolution.<br><br>**Substantive knowledge is sequenced to take account of relevant prior knowledge pupils bring to school.** | **The curriculum lists National Curriculum statements and/or early learning goals without breaking these down into component knowledge.**<br><br>It is important to check that the curriculum does not simply focus on practising the end goal. For example, the statement 'describe the simple physical properties of a variety of everyday materials' is not sufficient. **What** properties and **what** materials are pupils learning? Subject leaders should have a rationale for this selection.<br><br>**The curriculum requires pupils to learn too much new knowledge in one go because it is not broken down over time.**<br><br>For example, a lesson on evolution expects to teach pupils about variation, competition, predation, habitats. Instead, this component knowledge should have been taught and remembered beforehand.<br><br>**There is an assumption that content should be 'pushed' down into younger years to create a more 'rigorous' curriculum.**<br><br>It should not be assumed that teaching content earlier than is outlined in the National Curriculum is necessarily a good thing. The focus should be on creating an ambitious curriculum where there is sufficient time for pupils to learn and remember what has been taught, as opposed to covering more content at an earlier age. |

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| It will typically progress from describing objects and phenomena to explaining them using increasingly abstract concepts and quantitative procedures. Leaders should have a plan to help those pupils who do not bring relevant prior knowledge to school.<br><br>**Substantive knowledge is sequenced to avoid introducing misconceptions and allocates appropriate curriculum time that reflects what is being learnt.**<br><br>Component knowledge is sequenced to minimise the likelihood that pupils will develop misconceptions. This may involve allocating more curriculum time to teaching concepts that pupils commonly hold misconceptions in e.g. forces, electricity or evolution. | |

**Inspector question 5:**
**Rigour**: How does planning ensure the interplay of different categories of knowledge (**disciplinary and substantive**), thus ensuring pupils are given the capacity to consider subject specific questions for themselves?

**School-friendly questions:**

- Show me a practical activity that pupils complete in Year 6. Now show me where pupils learnt the necessary component knowledge to be successful in that practical.
- Show me how scientific knowledge and knowledge from working scientifically combine together in a topic?
  - How does this help pupils to better understand the scientific knowledge?
  - How does this help pupils develop their understanding of science as a discipline?
- How is a pupil's knowledge of science as a discipline in Year 6 different to Year 3?
- What mathematical aspects of the science curriculum do you teach before they are taught in maths? How do you ensure that you use a coherent approach?

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| **Complex disciplinary procedures and concepts such as precision, drawing graphs and separating mixtures are broken down into component knowledge so this can be sequenced and taught in the curriculum.** | **Lesson time is spent doing things such as 'drawing graphs' or 'doing an experiment' without clarity around how the activity achieves specific curriculum intent.**<br><br>This is probably because there is not clarity around exactly what component knowledge pupils need to know. This can be a particular problem with practicals |

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| **Disciplinary knowledge in science is taught within the best substantive context.**<br>For example, pupils will learn about the role of classification in developing knowledge in science (disciplinary knowledge) when learning about classification of organisms and classification of materials. Evolution is not the best context to teach pupils about variables as there are few experimental opportunities.<br><br>**The same disciplinary knowledge, e.g. drawing bar graphs, is used in a range of substantive contexts.**<br>Once disciplinary knowledge has been introduced in one substantive context, it should then be used and developed upon in subsequent years and in different contexts. This ensures that what is taught is not forgotten and can be developed upon.<br>**Mathematical knowledge should be sequenced in the curriculum to take account of when that content is taught in maths.**<br>When a mathematical concept or procedure is needed in science before it is taught in maths, subject leaders should agree what and how content is taught so that progression of knowledge in maths is not undermined.<br><br>**By learning how scientific knowledge is generated and grows, through the process of scientific enquiry, pupils develop their knowledge of the status and nature of substantive knowledge. For example, they know that:**<br>▪ science seeks to explain the material world and starts with knowledge<br>▪ science is NOT complete – it is subject to revision and change based on new evidence; this is affected by available technology<br>▪ science creates models that are not faithful copies of reality | which can be 'dropped' into the curriculum without sufficient consideration of necessary prior knowledge.<br><br>**Teaching disciplinary knowledge separately from any scientific context e.g. as a discrete topic.**<br>Disciplinary knowledge needs to be related to a specific substantive context. For example, disciplinary knowledge about models could be taught alongside substantive knowledge of the solar system.<br><br>**Procedures such as using hand lenses or drawing graphs are used so infrequently that pupils do not develop the proficiency to use them in their next stage of learning.**<br>Pupils need opportunities to use apparatus and techniques in a range of substantive contexts over a number of years to develop fluency. For example, if pupils only use hand lenses for one lesson in Year 1 and one lesson in Year 4 they will not develop expertise in using this piece of equipment. This will limit the range of practical activities pupils can successfully participate in and learn from.<br><br>**Students are taught inappropriate disciplinary methods.**<br>Inspectors should be wary of curricula that teach students how to solve problems/carry out procedures in ways that expert scientists don't. For example, always setting up practical equipment for students in advance. These inappropriate scaffolds are often a consequence of poor curriculum planning because necessary component knowledge needed to perform the composite has not been identified and taught in advance.<br><br>**Pupils are using different methods in science and maths.**<br>This might be because subject leaders have failed to ensure there is coherence in what is taught. Note: at times differences in what is taught are necessary. |

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| ▪ uses and implications of scientific knowledge are both positive and negative for society.<br><br>**This enables pupils to recognise that:**<br>▪ observations are dependent on scientific knowledge<br>▪ science is revised over time and depends on evidence<br>▪ models are simply representations e.g. materials are not made from little balls<br>▪ Darwin's theory is not a guess – there is substantial empirical evidence in support of it<br>▪ knowledge of diet can inform what we eat.<br><br>**It should not be assumed that pupils will develop their knowledge of the status and nature of scientific knowledge simply by 'doing science'.** Rather, the curriculum should explicitly teach pupils how specific aspects of scientific enquiry work and what their implications are for the substantive knowledge that gets produced.<br><br>This might, alongside explicit instruction, involve pupils using disciplinary knowledge, *together with substantive knowledge*, to**:**<br>▪ devise and answer their own scientific questions by carrying out different types of scientific enquiry. This includes all aspects of a scientific enquiry **not just data collection**<br>▪ evaluate claims base on science through analysis of the methodology, evidence and conclusions<br>▪ appreciate the explanatory power and limitations of science<br>▪ explain everyday and technological applications of science and consider their personal, social, economic and environmental implications. | **Pupils do not know how science produces knowledge as a discipline.**<br>For example, they make think scientific knowledge is just certain facts, or that science is just about doing fun experiments. They will not be able to give any evidence in support of the substantive knowledge they know e.g. how do we know that when salt dissolves in water it doesn't disappear? What evidence is there that humans are related to fish?<br><br>**Schools interpret 'scientific enquiries' as just data collection/doing a practical.**<br>As part of learning about scientific enquiry pupils make take part in one. This requires pupils to participate in raising questions based on substantive knowledge, collect data and then analyse the data and make conclusions. Scientific enquiry should **not** just be associated with data collection and inspectors should check that knowledge about all aspects is taught in the curriculum. There is no reason data collection should always take the longest amount of time.<br><br>**Pupils are expected to learn how science produces knowledge through implicit means, simply by carrying out a practical activity.**<br>Whilst a practical activity might be a suitable way to learn about specific aspects of scientific enquiry, it is important that there is clarity around what pupils are learning about scientific enquiry, and what this means for the knowledge that gets produced.<br><br>**Real world examples are used without pupils having the necessary knowledge to understand them.**<br>A school might prioritise real-world examples, such as the pros and cons of deforestation in Year 4 without pupils having knowledge of food chains and webs and habitats. Debates become just opinions and are not rooted in the science. |

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| | **Pupils do not have the opportunity to develop expertise in disciplinary practices because of limited resources.**<br><br>Because of a lack of practical resources, pupils may not have the opportunity to work individually, or at least in pairs. This means they won't have the opportunity to develop confidence in using apparatus through first-hand experience. Where this is the case, subject and school leaders should have plans in place to remedy this. Large group sizes for practical work should not become the norm. |
| **Inspector question 6:**<br>**Challenge:** Is planning for 'challenge' understood as building more knowledge over time towards ambitious curriculum end points?<br><br>**School-friendly questions:**<br>▪ How does your curriculum challenge pupils when learning about plants in key stage 1?<br>▪ What is the most challenging practical procedure that pupils carry out in Year 6? How does your curriculum plan for success?<br>▪ What is the most challenging scientific concept that pupils learn in Year 4? How does your curriculum plan for success? | |
| Challenge in science is considered in relation to pupils making sense of, and learning, ambitious curriculum content. For example, when learning about evolution in Year 6, pupils could learn about the evidence to support Darwin's theory of evolution, and can give a range of examples of evolution e.g. antibiotic resistance and peacock tails. They may know about the work of Alfred Wallace and Mary Anning.<br><br>**It is *not* appropriate to think about challenge in terms of whether:**<br><br>▪ **a pupil finds a lesson activity hard**<br>Many 'difficult' activities do little to further learning of an intended curriculum goal.<br>▪ **a question stem is higher up Bloom's or another taxonomy** | **Learning objectives are differentiated into all, most, some.**<br><br>Such approaches often fail to represent a genuine increase in challenge in terms of curricular goals. Neither does it recognise that all pupils need to learn all knowledge.<br><br>**'We always plan our science lessons to ensure pupils engage in 'higher order thinking' or stretch questions.'**<br><br>Approaching challenge in this way (e.g. having a stretch question that starts with analyse… or evaluate…) does not necessarily consider the specific substantive and disciplinary knowledge that pupils are learning and remembering.<br><br>**Inappropriate scaffolds become the end goal.** |

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| Science is not more difficult because a question requires pupils to 'evaluate' or 'analyse' something. For example, it is more challenging to ask pupils to 'state' the number of water molecules in a bottle of water than it is to 'explain' why giraffes have long necks.<br><br>▪ **pupils learn difficult content through discovery or 'research'**<br><br>Pupils should not be expected to learn complex substantive and disciplinary knowledge by simply taking part in practical activities or unscaffolded 'research' tasks. Knowledge should be carefully taught using the most effective methods.<br><br>▪ **A lesson has speed or pace**<br><br>A lesson should go at the pace which ensures the intended curriculum is learned. | Widespread use of inappropriate scaffolds, such as pupils always being given graph axes, can be a marker of a school not sufficiently challenging pupils to learn core knowledge.<br><br>**'Crack the code' or other similar activities.**<br><br>Challenging pupils to 'crack' a code to find the name of something is not challenging them in terms of 'what' they are learning. It is making the 'how' of learning inappropriately difficult through an activity.<br><br>**Asking pupils to discover a scientific law or theory without sufficient prior knowledge.**<br><br>Check carefully that pupils have the necessary prior substantive and disciplinary knowledge to learn from any practical activity they are doing.<br><br>**Pupils are expected to find information out for themselves. Frequently, this involves searching the internet or summarising lots of text.**<br><br>Pupils with little prior knowledge cannot usually find information out for themselves as they lack the expertise to identify the most important knowledge. Where pupils are using technology, such as iPads, to find information, leaders and teachers should have plans in place to ensure that a) pupils are safe when looking at websites, for example through being given specific website URLs to look at, b) pupils have the requisite knowledge of key search terms (including accurate spelling). |

**Inspector question 7:**
**Memory:** do teachers identify, emphasise and repeat crucial content so that pupils know more and remember more (make progress)?

**School-friendly questions:**

- How do you as a school go about agreeing which specific knowledge (ideas, concepts, vocabulary, etc.) pupils absolutely need to know within each topic you teach? For example, when teaching pupils about electricity.
- Show me which bits of your curriculum (like concepts, ideas, vocabulary, etc.) are really crucial to re-visit so that they are remembered.
- How do you structure the curriculum, so pupils remember the most crucial content covered?
- How do pupils know that the most important content is?

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| **The curriculum includes planned opportunities for practise and revisiting important concepts and procedures so that knowledge is remembered and built upon over time.**<br>There is evidence that teachers have planned enough systematic repetition over time of the most crucial content (including practical procedures) to ensure it is secure in memory and can be easily recalled and used by pupils.<br><br>This might be through formal retrieval, but also might be through skilful teacher exposition or questioning which revisits and secures prior knowledge. For younger children, stories, picture books and songs can be particularly powerful in introducing and rehearsing core content and associated vocabulary.<br><br>**Pupils are clear on what they need to know and have sufficient materials, e.g. class notes, to revise from.**<br><br>**Time for revision is planned intelligently throughout the curriculum**. This provides the opportunity for pupils to be taught how to revise independently. | **Leaders assume interesting activities in the curriculum are sufficient for pupils to remember what has been taught.**<br>The fact that some pupils can remember and articulate what was taught a year ago is not proof that all pupils have remembered. Leaders should assure themselves that pupils remember content, rather than the surface features of activities and exciting experiences. This require considerable practising of component parts.<br><br>**Classes regularly require prompts or scaffolds to remember prior learning to complete activities.**<br>While individuals may forget things, groups of pupils should not regularly require prompts. A lack of independence can indicate that pupils have failed to remember what was previously taught. This might also be seen in practical work where pupils are unable to manipulate or name common apparatus.<br><br>**The school uses 'knowledge organisers' ineffectively.**<br>How knowledge organisers are used is much more significant than if they exist. E.g. if pupils spend time memorising material that is excessively detailed or too general to be meaningful, that is problematic. When remembering knowledge in science pupils need to remember knowledge of concepts AND how these concepts are related to other concepts. It is not simply a laundry list to be learnt.<br><br>**Content is interleaved ineffectively.**<br>Check what the school means by interleaving. For example, if interleaving involves pupils being presented with lots of unrelated knowledge e.g. lesson on materials, lesson on space, lesson on circuits, this is likely to prevent pupils from seeing how related knowledge is organised. Interleaving works best to illustrate differences between related but distinct knowledge e.g. melting and dissolving. |

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| | **Pupils do not record their work in science.**<br><br>This can be problematic for pupils who would otherwise benefit from opportunities to be able to look at what was learned in previous lessons. |
| **Inspector question 8:**<br>Are there opportunities for pupils to read about science?<br>**School-friendly questions:**<br>▪ Do class library areas have books about science?<br>▪ Where in your curriculum do pupils read about science?<br>▪ How does your curriculum support pupils to read science?<br>▪ How do you ensure pupils have the opportunity to read science beyond the classroom? | |
| **Teachers regularly ensure pupils read text in lessons and promote wider reading.** Where pupils cannot yet read, e.g. early years, there is plenty of opportunity to listen to storybooks, poems and non-fiction texts, as well as sing songs that systematically introduce core scientific vocabulary.<br><br>**Texts are carefully chosen that challenge pupils but are still accessible.** The degree of challenge will be influenced by the interplay of pupils' prior knowledge and vocabulary and the difficulty of the context/content.<br><br>Teachers should know how to make a scientific text more accessible – e.g. glossaries, explicit teaching of underpinning knowledge and key vocabulary as well as meanings of equations, symbols, diagrams and figures.<br><br>**This includes teaching pupils scientific vocabulary and other academic language such as 'whereas' or 'function'.**<br><br>**Leaders ensure that pupils have access to texts to encourage reading about science beyond the classroom.** E.g. through libraries. | **Pupils are not reading or listening to text that is rich in vocabulary.** Pupils' reading in science is always restricted to simple worksheets or very short extracts of text. Texts are always simplified as opposed to teaching pupils necessary component knowledge to read.<br><br>**Textbooks are viewed as 'bad'.**<br>High-quality textbooks (that don't overly focus on exam preparation) are valuable pupil resources as these provide detailed explanations of scientific ideas. They also can free up teachers' time.<br><br>**Teachers only teach pupils about scientific vocabulary.**<br>They neglect other academic words that are needed to understand the text. |
| **Inspector question 9**<br>**SEND:** How do you ensure those pupils who find it most difficult to learn science (e.g. some pupils with specific SEND) are given the best chance to keep up? | |

**School-friendly questions:**

- Which bits of content are absolutely key that all pupils, including those with SEND, need to take away from this specific unit?
- How have you adapted your curriculum to ensure all pupils are able to be successful?
- How do you ensure teaching assistants have sufficient knowledge of the curriculum to support their pupils?

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| **The curriculum identifies the most important concepts and procedures for pupils to know. These will ensure pupils with SEND are successful in learning future knowledge.**<br>This may involve prioritising certain knowledge that will be necessary to secure progression onto the next stage. For example, it is more important that Year 3 pupils know the parts and requirements of plants for life, than what fertiliser is.<br><br>**Teachers recognise the aspects of science that are especially challenging and specifically address these challenges:**<br>▪ science involves learning lots of new words that have different meanings to everyday language<br>▪ the abstract nature of scientific knowledge<br>▪ the counterintuitive nature of science<br>▪ the need to manipulate fiddly apparatus.<br><br>**The curriculum addresses these challenges by:**<br>▪ being clear on the key concept pupils are learning and ensuring pupils are carefully guided (not random discovery)<br>▪ ensuring explanations use concrete items pupils can see and are familiar with as the starting point<br>▪ explicitly teaching the most important scientific vocabulary using pictures, diagrams and lots of practice where pupils say aloud the words<br>▪ ensuring appropriate access to practical work and demonstrations. This may involve making adjustments so that pupils can access the full science curriculum. | **Answers to overcoming barriers for pupils with SEND do not consider the curriculum.**<br>There is no consideration that particular pupils with SEND might need further practise in learning specific knowledge, for example abstract concepts like state changes and electricity.<br>The school expects particular pupils with SEND to move through the curriculum before they are secure in the key components of knowledge they need, especially the knowledge that will enable them to grasp subsequent knowledge.<br><br>**Pupils with SEND have less access to the teacher and their subject knowledge.**<br>It is important that pupils with SEND get as much opportunity to interact with the classroom teacher as other pupils. There is a risk that, because pupils have a teaching assistant, they have less subject-specific input. |

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| **Teaching assistants who work with pupils with SEND are clear on the curriculum intent for the lesson and have the necessary subject knowledge to support pupils' subject learning.** | |

**Inspector question 10**
**Early Years:** How well does the curriculum identify the knowledge children need to secure each early learning goal?

**School-friendly questions:**
- What are the most important concepts pupils learn during the early years?
- Show me where pupils learn about (choose one or more): animals, plants, different environments, seasons or changing states of matter. What specific knowledge and vocabulary are they learning?
- Using a specific example from your curriculum, can you show me how what pupils learn in the early years prepares them for Year 1?

How does your curriculum help close the school-entry gap in vocabulary and knowledge of basic scientific facts, such as the names and features of animals and plants?

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| **The foundations for learning science begin in the early years classroom.**<br>This is because learning about the natural world provides a number of rich contexts for pupils to learn a range of foundational, science-specific vocabulary e.g. different environments and seasons.<br><br>**In early years, the focus is on pupils acquiring substantive knowledge about objects and phenomena that scientists study.**<br>This includes the names and descriptions of plants, animals, everyday materials and seasonal changes. These foundational terms help pupils to makes sense of and categorise the world. This vocabulary forms the beginnings of scientific concepts that will be developed in Year 1 and beyond. It also supports reading comprehension across different domains e.g. a pupil who knows the words 'tree', 'shrub', 'flower' and 'plant', as well as the features that unite them as a concept, will be more likely to comprehend literature that features these words in the text. | **The curriculum begins in Year 1 (or later).**<br>Check that the curriculum builds from and includes early years provision. Leaders should have a clear rationale for how knowledge taught in the early years underpins learning science in Year 1.<br><br>**The setting's policy is to wait for pupils to be 'ready' to learn scientific words and concepts.**<br>Leaders should be aware that pupils will not naturally develop the words to describe scientific concepts such as melting or evaporation. This vocabulary should be carefully taught using interesting pictures and books, and helping pupils to use new words to describe the world around them.<br><br>**The curriculum sequences early learning goals without identifying component knowledge.**<br>Leaders have not given enough thought as to what children need to know by the end of the early years foundation stage. They may, for example, say pupils |

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| **Leaders have a clear idea as to the most valuable component knowledge underpinning the early learning goal for 'The Natural World'.**<br><br>The component parts are identified and sequenced so that teachers and pupils are clear on what, when and how this content will be learned. Leaders assure themselves that what is learned in the early years will engineer successful learning in Year 1 and beyond.<br><br>**Pupils benefit from learning new vocabulary as part of hearing stories, poems and learning songs.** For example, 'Heads, shoulders, knees and toes' is a classic song that helps pupils to learn the basic names of body parts. | are learning about seasons or plants, but are not clear about exactly what component knowledge they are learning.<br><br>**Leaders have identified and sequenced core content to be learned, but few pupils learn and remember this content.**<br><br>At this age, children will be forming early, rough schemata for scientific concepts. There should be some evidence that *all* children have gained valuable knowledge directly from teaching in early years. Phase leaders should have a proactive approach in place that ensures that scientific learning is available to all, and not only those children already interested who choose it.<br><br>**Pupils are learning about topics such as 'the jungle', but have no frame of reference.**<br><br>Frequently, curriculum plans are modified to accommodate the outside interests of pupils in the classroom. It is not uncommon for this curricular approach to be used to engage pupils with behavioural concerns or who are generally disengaged. Leaders should, however, ensure that pupils' learning is built on solid foundations. For example, if pupils are learning about 'the jungle', they should have learned about 'the countryside' in order to be able to understand what it is that makes 'the jungle' special.<br><br>**Pupils are 'playing' with scientific equipment.**<br><br>Leaders should be mindful that pupils are not expected to work out how to use specific equipment through play. Pupils should be carefully taught how to use equipment and this knowledge should prepare pupils for the working scientifically demands of Year 1.<br><br>**Pupils are already acquiring misconceptions in the absence of proactive plans for learning.**<br><br>A common example of this is where pupils do not know about the life cycle of common animals or how this links to the food they eat. Pupils who do not know |

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| | the names of body parts or the language and concepts of bodily processes may struggle to articulate when they are in pain or feeling unwell. |

| **Focus area 2: The extent to which teaching supports the goals of the science curriculum** |
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| **Outline of potentially stronger practice in terms of intent, implementation and impact**<br>NB: answers will take many forms. Below are common findings to look out for | **Outline of weaker practice in terms of intent, implementation and impact**<br>NB: answers will take many forms. Below are common findings to look out for |
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| **Inspector question 11:**<br>What is the rationale for the teaching approaches chosen for sequences of lessons?<br><br>**School-friendly questions:**<br>▪ Tell me a bit about the teaching approaches you have chosen in this sequence of lessons – what made them suitable for the content that you were teaching?<br>▪ What was the purpose of the activity when… ?<br>▪ How do you make sure pupils link their knowledge together so they see important relationships between concepts? | |
| **Activities are carefully chosen to focus pupil attention on learning the curriculum intent.** This includes sufficient time for practising using the knowledge.<br><br>**Teacher explanations are clear and build on what pupils already know.** They make use of diagrams, models, animations and graphs and lots of examples.<br><br>**Teaching explicitly shows pupils what conceptual level they are learning about:** macroscopic, submicroscopic, cellular or symbolic. This ensures pupils develop a sense of scale and can | **When there is a lack of clarity about the intended goal of the lesson, this can lead to pupils being engaged or busy 'doing' but learning little.**<br>This can be especially true for practical work. Inspectors should check that the activities pupils are completing are appropriate in achieving the curriculum intent.<br><br>**Activities distract from the content being taught.**<br>The purpose of the activity should be to focus pupils' attention on the important features of the science they are learning about. It should reveal the intrinsically interesting aspects of science and not distract pupils using 'external hooks'. |

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| organise their knowledge in a meaningful way to reflect what is being studied.<br><br>**Teachers with strong subject knowledge use questioning to great effect by:**<br>▪ reviewing prior knowledge and establishing what pupils currently know<br>▪ supporting pupils to use challenging vocabulary within appropriate contexts to articulate scientific ideas<br>▪ eliciting and correcting misconceptions, helping pupils see why the misconception is wrong<br>▪ checking pupil understanding and providing feedback – paying particular attention to use of vocabulary<br>▪ encouraging pupils to connect concepts together.<br><br>**Terms are used with careful attention to their scientific meaning and truncated answers from pupils are not accepted.**<br>E.g. melting point is not 'when it turns into a liquid', it is 'the temperature at which a substance in its solid state forms a liquid'.<br><br>**Teachers discuss and debate the best ways to teach concepts and procedures.**<br>Good practice would see a dialogue between leaders and teachers to agree what the best and most effective teaching approaches are to teach a specific aspect of science. Often this best practice will be captured in the curriculum. | **Activities overload pupils' working memory because they are too complex.**<br>Activities should be designed to maximise cognitive effort in relation to thinking about and remembering the curriculum intent. Overly complex tasks can easily overload pupils, especially when pupils have little prior knowledge.<br><br>**Pupils do not have a sense of scale about what they are learning.**<br>For example, they have no idea that the Moon is smaller than the Sun.<br><br>**Pupils have disconnected knowledge.**<br>For example, pupils are building electrical circuits but have no idea that wires are made from metal because the link has not been made clear by the teacher.<br><br>**'Guess the answer in the teacher's head' questioning.**<br>It is problematic if lesson time is taken with pupils guessing answers. Teacher questioning should be used with a clear purpose. Pupils should have sufficient prior knowledge to think about questions so they are not guessing.<br><br>**Teachers' language is not clear and precise.**<br>Terms should be used with careful thought to their scientific meaning. For example, evaporation and boiling are not the same; animals do not choose to adapt; precise readings are measurements that are close to the mean value. |
| **Inspector question 12:**<br>What approaches do teachers use to ensure that key content is remembered long term? How do teachers ensure that pupils remember that which they have been taught? | |

**School-friendly questions:**

- How do you make sure pupils remember long term what has been taught? How do you ensure this is the right knowledge?
- Can you show me some examples of approaches your school uses to support pupils remembering what's on the science curriculum over time?

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| **There is clarity in what pupils need to know and do and the curriculum and pedagogical choices support pupils to remember this knowledge in meaningful ways by connecting new knowledge to what is already learnt.**<br><br>This might include:<br>▪ use of retrieval practice, including retrieval of knowledge from previous years. Note: this doesn't always have to involve retrieval quizzes but could take place through a variety of different ways<br>▪ opportunity for pupils to practise what has been taught to automaticity<br>▪ focus on the precise use of scientific terms through careful questioning and feedback<br>▪ opportunity for pupils to bring together, and use, knowledge from previously learnt substantive content areas with newly learnt knowledge. This may form part of a scientific enquiry.<br><br>**Teachers regularly check that knowledge makes sense to pupils and that they remember it.**<br>Pupils are more likely to remember knowledge if it makes sense. Teaching should therefore check that pupils are able to connect appropriate knowledge to new knowledge. In this way schemata of related knowledge build over time. | **There is insufficient time to practise content in the lesson.**<br>New knowledge is introduced but the teacher moves on without providing time for pupils to practise using that knowledge or to check what has been learnt.<br><br>**Previously used vocabulary is not revisited or reinforced, and pupils are not expected to use, orally or in writing, correct terminology previously learned.**<br><br>**Inappropriate use of retrieval practice breaks up the narrative of the learning and asks pupils to retrieve incorrect and/or irrelevant knowledge**<br>Strategies such as low-stakes quizzing should support learning. If they are used inappropriately, e.g. too often in lessons, they can break up the narrative of the lesson, preventing pupils from seeing the overall structure of the discipline. Careful attention should be given to 'what' pupils are being asked to retrieve and whether this privileges the right content.<br><br>**The school does not assess pupil knowledge in science.**<br>Schools must check that pupils are building secure knowledge of key content. If schools do not assess scientific knowledge, or focus only on assessing pupils' 'scientific skills', they will not be able to identify and address knowledge gaps or misconceptions. |

**Inspector question 13:**
How is practical work used to support learning of science?

**School-friendly questions:**

**For teachers**

- Why did you decide to do this practical activity?
- What did you want pupils to learn?
- How were pupils prepared for this practical? How have you made sure they are thinking about the science and not just doing?
- How does the practical help pupils to develop their knowledge of… ?
- Why have you decided to carry out this practical activity as a whole-class practical and not as a teacher demonstration (or vice versa)?
- What are pupils going to do with the knowledge they learnt from the practical activity?

**For pupils:**

- Can you tell me why you are carrying out this practical? What are you learning about?
- Can you tell me some of the names of the pieces of equipment you are using? Why are you using X and not Y?

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| **Pupils encounter the objects of study and/or their effects in the classroom.**<br>This involves observing phenomena they have never previously experienced. This might, for example, include the use of teacher demonstrations or hands-on practical work.<br><br>**There is a clear and sound rationale for why any practical work is undertaken.**<br>It is not assumed that more practical work is necessarily better. Neither is the importance of practical work denied.<br><br>**Some possible purposes of practical work may include:**<br>▪ to help pupils learn a disciplinary procedure e.g. to use a thermometer<br>▪ to help pupils learn a disciplinary concept. This could include demonstrating a precise measurement<br>▪ to help pupils to learn substantive knowledge. This could include confirming some aspect of substantive knowledge i.e. practical to confirm melting temperature of a substance | **Pupils don't get to encounter the objects of study or through videos only.**<br>For example, pupils are learning about chemical changes, but don't get the opportunity to see one. Or the scientific encounters just look to confirm relevance, e.g. using everyday items in science classrooms such as Rennie tablets. Videos should not come to replace pupils doing practical work or teachers carrying out demonstrations.<br><br>**Leaders and teachers are not clear on their rationale for undertaking practical work.**<br>Subject leaders and teachers should be clear on the purposes of practical work they carry out in relation to achieving specific curriculum intent. Inspectors should ask pupils and teachers about why they are carrying out a specific practical. What is being learnt? Are pupils aware? Being on the curriculum is not sufficient justification.<br><br>**Teachers have an 'inductive view' of science and expect substantive knowledge to emerge easily from taking part in hands-on activities.**<br>Check that any activity helps pupils to arrive at the scientific conception and does not encourage misconceptions to form or expect scientific ideas to simply emerge from the data/observations. |

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| ▪ the opportunity to engage in the whole activity of a scientific enquiry (see item 7).<br><br>**It is important that teachers carefully scaffold any practical activity, so pupils are able to link theory to observation.** It should not be assumed pupils will pick up substantive or disciplinary knowledge just by completing a practical activity. Time should be dedicated before and after a practical to ensure pupils have learnt the intended content.<br><br>**Teachers justify why a specific practical is carried out as a teacher demonstration or as a whole-class practical activity.** This decision takes account of what is being learnt.<br><br>**Given the cognitive demands of completing practical work and building schemata, careful attention must be taken to ensure pupils have sufficient prior knowledge to carry out and learn from the practical activity without cognitive overload.**<br><br>**Safety in science**<br><br>**Pupils' experience of practical work is not be restricted by unnecessary risk aversion.**<br><br>Ofsted is not a health and safety authority and is not responsible for auditing health and safety standards within the learning environment. However, inspectors have a duty to take prompt and proportionate action and to report any significant health and safety risks affecting learners that are identified during an inspection (see appendix for details). | **Pupils are unclear of what to do in a practical lesson and/or are unable to use apparatus or perform procedures.**<br>Inspectors should **not** assume that poor performance in a practical activity is only a consequence of poor planning/teaching *that* lesson. The issue could be a curriculum one i.e. pupils have not been previously taught necessary component knowledge.<br><br>**Pupils follow a 'cookbook' style method but are unable to link theory to what they are doing when questioned**<br>Ask pupils what they are doing when carrying out practical work. Can they name the apparatus? Can they explain what they are doing?<br><br>**Practical work takes place at the end of term, after the SATs are over.**<br>This will mean pupils are taught a distorted version of science, where disciplinary knowledge has been artificially separated from substantive knowledge. It will also limit the amount of time that pupils have had to learn specific procedures.<br><br>**Pupils complete the practical activity and write up the whole process for homework.**<br>Check that practical activities are not seen as an end in themselves. There should be sufficient time after the practical for pupils to interpret and explain the observations and measurements made. This could take place in a second lesson but is likely to need teacher guidance so should not just be left for homework.<br><br>**Pupils do not have the opportunity to develop expertise in disciplinary practices because of limited resources.**<br><br>Because of a lack of practical resources, pupils may not have the opportunity to work individually, or at least in pairs. This means they won't have the opportunity to develop confidence in using apparatus through first-hand experience. Where this is the case, subject and school leaders should have plans in place to remedy this. Large group sizes for practical work should not become the norm. |

| Focus area 3: The effectiveness of assessment in science |
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| **Outline of potentially stronger practice in terms of intent, implementation and impact**<br>NB: answers will take many forms. Below are common findings to look out for | **Outline of weaker practice in terms of intent, implementation and impact**<br>NB: answers will take many forms. Below are common findings to look out for |
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| **Inspector question 14:**<br>What do subject leaders consider to be the most effective way to assess pupils' progress in science?<br><br>**School-friendly questions:**<br>▪ Tell me a bit about what your school thinks is the most effective way to assess pupils' progress in science.<br>▪ Which bits of the curriculum do you prioritise when you construct assessments for pupils? Why do you prioritise these?<br>▪ What have results from the latest assessment taught you about your curriculum? What needs to change? What is working well?<br>▪ Can you show me an assessment that assesses pupils' knowledge of science and working scientifically? How does this relate to the curriculum? | |
| **Different forms of assessment are deployed appropriately for different purposes.**<br>Leaders distinguish between:<br>▪ assessment AS learning: to embed key knowledge in memory e.g. through quizzing<br>▪ assessment FOR learning: formative assessment which is most useful in the lesson sequence to identify missing components/misconceptions<br>▪ assessment OF learning: summative assessment that samples from a domain of complex composites (end goals).<br><br>**The curriculum is the progression model i.e. it describes what it means to get better at science. Assessments check that the necessary curriculum components have been learnt and remembered.** | **Discussions of assessment immediately become discussions of data, rather than curriculum.**<br>It is worth checking how much care has gone into ensuring the assessment maps to the curriculum intent i.e. is it checking what has been taught has been learnt?<br><br>**The school does not assess substantive knowledge.**<br>Schools must check that pupils are building secure knowledge of key content. If schools do not assess scientific knowledge or focus only on assessing pupils' 'scientific skills' they will not be able to identify and address knowledge gaps or misconceptions.<br><br>**Assessments only assess substantive knowledge.**<br>Considering that the NC requires that working scientifically (disciplinary knowledge) should be taught through, and clearly related to, the substantive |

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| **Assessments check that pupils have learnt the most fundamental knowledge** i.e. the knowledge that must be in place to enable future learning. This will involve assessing knowledge of:<br>- substantive concepts and procedures<br>- disciplinary concepts and procedures<br>- substantive knowledge and disciplinary knowledge together.<br><br>**Effective feedback is focused on the science content and not on generic features.** This feedback is selected to help pupils make progress in the subject, not just on that piece of work. Pupils understand this feedback and know how to action it.<br><br>**Results from assessments are used to inform teaching and curriculum development.** For example, if pupils struggle on a specific question about habitats, because they confused habitats with ecosystems, then the curriculum is updated to avoid this from happening in the future.<br><br>**Leaders support teachers to make accurate decisions when assessing pupils' work from composite tasks.** This includes ensuring processes are in place for standardising assessment decisions involved in teacher assessments. | content, it is worth reviewing a selection of assessments to review how effectively leaders have taken this into account.<br><br>**'We have regular topic tests to check that knowledge has been learnt.'**<br>Do tests and mark schemes, together with any feedback given, help pupils to identify missing knowledge? If assessment is of composites only, this is less likely. It is worth exploring whether feedback on assessment enables pupils to clarify knowledge gaps and misunderstandings as opposed to just adding mark scheme points to answers.<br><br>**Pupils and parents are not fully aware of progress and attainment in science because of generic progress statements.**<br>Generic comments about skills and progress in relation to 'can do' statements, such as 'I can describe a range of animal adaptations', do not give sufficient detail about what pupils do and do not know.<br><br>**The school tracks progress through half-termly data drops.**<br>Our handbook suggests more than two or three data drops a year is rarely justifiable. Problems with summative assessment progress models may be more indicative of senior leadership weakness/expectations. |

| **Focus area 4: The extent to which there is a climate of high expectations where a love of science can flourish** |
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| This focus may well help explain the success of some schools, but a lack of evidence for 'climate where a love of the subject could flourish' could NOT reasonably be deployed to explain weakness given the challenge of identifying this during inspection. |

| **Outline of potentially stronger practice in terms of intent, implementation and impact**<br>NB: answers will take many forms. Below are common findings to look out for | **Outline of weaker practice in terms of intent, implementation and impact**<br>NB: answers will take many forms. Below are common findings to look out for |
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**Inspector question 15:**
What is science's profile within the school compared to other subjects?

**School-friendly questions:**

- Tell me a bit about how people in the school – pupils, other teachers, parents – perceive science. Why do you think this is?
- How would you describe the way that pupils perceive science compared to other subjects, such as maths and English?

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| **Science has a profile within the school that reflects its status as a core subject.**<br><br>This is underpinned by a broad science curriculum that engenders feelings of being good at science and a wonder about the material world.<br><br>**Pupils, leaders and teachers recognise the intrinsically awesome and wonderful aspects of science, as well as its value to wider society and employment.**<br><br>Pupils appreciate the personal significance of scientific knowledge and develop positive attitudes towards science. | **Science is being squeezed out of the curriculum by an over-focus on English and maths.**<br><br>This can occur more often if science is not taught as a discrete subject. Scientific knowledge can make a significant contribution to other areas, e.g. reading comprehensions, but pupils must also learn about science in its own right.<br><br>**A lot of pupils find science 'too hard'.**<br><br>Is there an assumption that science is not accessible for all pupils? What is the school doing to ensure all pupils build and secure the prior knowledge they need to learn new material in science lessons? |

**Inspector question 16:**
Does the school ensure that there are high expectations of children and that they respond to these expectations?

**School-friendly questions:**

- How do you ensure pupils rise to your high expectations? For example, what actions do you take to ensure all pupils put their best effort into written work?
- Tell me how pupils with special educational needs might fare studying your science curriculum?

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| **The school has high expectations of all pupils in science and is particularly alert and attentive to the needs of pupils with SEND.** | **The school pays little attention to supporting pupils with SEND to access and develop their knowledge of the science curriculum.**<br><br>See question 9 on SEND. |

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| See question 9 on **SEND:** How do you ensure those pupils who find it most difficult to learn science (e.g. some pupils with specific SEND) are given the best chance to keep up?<br><br>**Expectations of pupils are communicated through the curriculum content the school expects pupils to learn and the procedures pupils are expected to carry out.**<br><br>**Achievement in the subject is celebrated consistently.**<br>This should be for pupils of all abilities, and should include opportunities to share pupils' successes with parents. Achievement awards should reflect genuine achievement in the subject.<br><br>**Schools have developed mechanisms to act when pupils display low effort, for example in written work or homework.**<br>By the time pupils reach KS2 they have built the habits necessary to study independently, taking their own responsibility for revision. | **The school has high expectations for all, but…**<br>There is an underlying assumption that certain content is too hard for pupils to access and so they are always given easy work. Are pupils routinely provided with text well below their reading ages or limited text of any sort? Are pupils expected to show no independence during practical work? Are some pupils given choice that allows them to opt out of science in the early years?<br><br>**'In year 3 and 4 we focus on making science exciting and engaging.'**<br>Inspectors should be particularly alert to science being associated with only 'bangs', 'smells' and 'flashes'. Pupils already find these aspects of the world interesting. Inspectors should check that 'making science fun' doesn't mean underestimating what pupils can achieve or involves focusing on 'fun activities' rather than on learning ambitious and meaningful content.<br><br>**Pupils are ill-prepared for independent learning and examination revision, in part, because the curriculum has not prepared them with the necessary components to succeed.**<br>E.g. pupils' independent learning and examination revision are hampered by a lack of subject-specific vocabulary. As a result, they are unable to access relevant literature and textbooks and are unable to deploy that vocabulary in their written work. |
| **Inspector question 17:**<br>How does the school enrich the curriculum beyond classroom learning?<br><br>**School-friendly questions:**<br>▪ Tell me a bit about what happens on the science curriculum outside of the classroom.<br>▪ Are there any science-specific experiences linked to the curriculum that take place outside of the science classroom? How do they link to the curriculum sequence?<br>▪ In what ways do pupils who are very keen on your subject get to share their enthusiasm? | |
| **Additional enrichment opportunities are there to augment an already rigorous and ambitious curriculum.** | **Subject leaders develop a programme of activities outside the classroom for pupils, but pupils are not sufficiently prepared for them;** |

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| This might include:<br><br>▪ enrichment activities such as clubs, trips, visits and speakers<br>▪ after-school clubs<br>▪ participations in challenges including at regional and national level<br>▪ involvement in British Science Week.<br><br>**Leaders are clear on the purposes for these activities. They make sure that as many pupils as possible get to experience science beyond the classroom.** | **teachers do not have a clear idea of what they want pupils to take from these experiences.**<br><br>**Leaders are not aware of the impact of any work to promote the sciences.**<br><br>What has been the impact of this work over time? This will need triangulating with pupil and parent feedback, newsletter articles, uptake of different courses and progression to post-16 courses and apprenticeships etc. It is important that all enrichment activities are inclusive and that these are not always restricted to always the same pupils. |

**Focus area 5: The quality of systems and support for staff development**

| **Outline of potentially stronger practice in terms of intent, implementation and impact**<br>NB: answers will take many forms. Below are common findings to look out for | **Outline of weaker practice in terms of intent, implementation and impact**<br>NB: answers will take many forms. Below are common findings to look out for |
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| **Inspector question 18:**<br>What do the strengths and weaknesses already identified indicate about the school's capacity to function effectively?<br><br>**School-friendly questions:**<br>▪ What do you see are the strengths of science in this school?<br>▪ What do you see are the areas that need addressing?<br>▪ Do you feel that you have what you need to implement the changes you want? | |
| **Much of the evidence already gathered will indicate whether the subject lead has strong leadership with functioning systems in place.**<br><br>Broadly this means that there is a clear connection between an ambitious curriculum and what pupils have learnt over time.<br><br>Leaders should be able to readily explain and qualify the strengths and weaknesses in science teaching in the school. Any actions they | **There may be disconnects between the intended curriculum and curriculum implementation, resulting in poor impact of the curriculum impact due to one or more reasons:**<br><br>▪ poor staff subject knowledge<br>▪ poor staff professional knowledge about pedagogy<br>▪ high proportion of inexperienced, non-specialist staff<br>▪ weak mechanisms for feedback and renewal leading to curriculum development |

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| are taking should be having a demonstrable impact on addressing any weaknesses.<br><br>Check that new staff are given sufficient support (see question 20) | ▪ lack of knowledge of wider developments in science<br>▪ lack of provision of practical equipment and resources. |
| **Inspector question 19:**<br>How does the school go about the process of science curriculum construction, debate and renewal?<br><br>**School-friendly questions:**<br>▪ Who is responsible for developing the science curriculum?<br>▪ Tell me a bit about how the curriculum is designed in your school. Is it tweaked? If so, who decides on the changes?<br>▪ Tell me about opportunities that staff have to feed back to you about whether the sequence of the science curriculum is working.<br>▪ How do you quality assure the scientific accuracy of resources used to teach science? | |
| **There is a culture of reflectivity around the curriculum, continually seeking teachers' views on how it can be improved and developed.**<br><br>There is evidence of reflection on the schemes of work and clear mechanisms for curricular construction and renewal when necessary e.g. this has happened after discussion in meetings.<br><br>**Appropriate mechanisms are in place to support curriculum design and renewal (as necessary).**<br><br>Check who has responsibility for ensuring the science curriculum is of high quality. What support have they been given to develop their subject knowledge and engage in debates around curriculum construction with other professionals?<br><br>**Curriculum designers have a secure knowledge of the National Curriculum and of wider debates about curriculum.**<br>These might be staff within the school, or from a MAT or elsewhere but school leaders must satisfy themselves that appropriate expertise has been applied to the development of the school's science curriculum. | **Leaders have not evaluated the quality of the science curriculum.**<br><br>E.g. a school which has an 'off-the-peg' curriculum but where leaders have not considered the appropriateness or effectiveness of this curriculum.<br><br>E.g. the curriculum has been developed by someone without a science background, but leaders have not considered the appropriateness or effectiveness of this.<br><br>**Quality of internally and externally made resources.**<br><br>Inspectors should check that processes are in place to quality assure science resources. How, for example, do leaders ensure that worksheets contain appropriate science and do not contain factual errors? How do they ensure that resources sourced on external websites do not undermine curriculum coherence? |
| **Inspector question 20:**<br>How are all staff in the school encouraged to develop their subject knowledge and knowledge of how to teach science? | |

**School-friendly questions:**

- Do you think that staff in your school are aware of their subject knowledge areas of expertise and areas for development?
- What opportunities do staff have to grow in knowledge and confidence about the topics that they teach?
- What place does subject knowledge have within the school's programme for CPD in science?
- Are there any barriers that are preventing staff from developing their subject knowledge and teaching expertise?

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| **Leaders encourage and support all teachers (and technicians) to develop their subject knowledge.**<br><br>**Curriculum leaders are aware of their teachers' subject knowledge and degree specialism, so they know who to support**.<br><br>It should not be assumed that a degree in one subject will necessarily equip a teacher to teach all sciences to the same level. Where sufficient expertise is not available within the school to support with training there is time and resource allocated to external CPD.<br><br>**Carefully planned SoW are in place to support new or struggling staff.** This should match to the school's science curriculum and model good practice in terms of planning and teaching.<br><br>**Systems and policies actively help reduce workload for teachers rather than create unnecessary work.** For example, there are not burdensome tracking documents.<br><br>**Support draws on experienced staff members.** There are formalised mechanisms for these colleagues to work with more inexperienced colleagues.<br><br>Support is proactive and might involve:<br><br>▪ Sharing high-quality lesson resources | **Any support is focused on generic pedagogy or behaviour management.**<br><br>The school is therefore not clear about the importance of subject knowledge and pedagogical content knowledge. Generic training will not support new and non-specialist teachers to develop expertise in teaching **science**.<br><br>**Teachers' own partial subject knowledge and limited pedagogical content knowledge means they perpetuate pupils' misconceptions.**<br><br>Inspectors can investigate whether the curriculum leader checks for issues caused by limited teacher expertise, is aware of the gaps in the knowledge of staff and supports non-specialists e.g. supporting a specialist physics teacher as they teach biology.<br><br>**Teachers/technicians are only offered internal CPD when there isn't sufficient expertise in the school to deliver this.**<br><br>Confirm that when CPD is only offered internally, there is sufficient expertise to deliver it. For physics this may not be the case in all schools. Why are senior leaders not supporting external opportunities? Many of these can receive funding support e.g. National STEM centre.<br><br>**Teaching resources and curriculum documents are not shared widely between teachers.**<br><br>Teachers who need help should have access to the planning and carefully sequenced materials written by more experienced colleagues. This will avoid pupils experiencing a weak curriculum and avoid excessive workload. |

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| ▪ co-planning lessons together<br>▪ team teaching<br>▪ in-lesson coaching<br>▪ tutoring<br>▪ peer lesson observations.<br><br>Induction and training should be in place to ensure staff are competent and confident to assess risk and perform practical work safely. | |

| **Focus area 6: The extent to which whole-school policies affect the capacity for effective science education** |
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| This section is crucial to identify where the quality of education is influenced by the activities of the school and where the quality of education provided can be attributed to senior leadership. |

| **Outline of potentially stronger practice in terms of intent, implementation and impact**<br>NB: answers will take many forms. Below are common findings to look out for | **Outline of weaker practice in terms of intent, implementation and impact**<br>NB: answers will take many forms. Below are common findings to look out for |
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| **Inspector question 21:**<br>To what extent do whole-school policies reflect statutory obligations for science in the school?<br><br>**School-friendly questions:**<br>▪ If there were a parent of a new pupil asking about your school, would you say that science is taken seriously here? Why?<br>▪ Do all pupils in every year group have the opportunity to access a high-quality science curriculum? | |
| All local-authority-maintained schools in England must teach science as laid out in the National curriculum.<br><br>Academies and free schools don't have to follow the National Curriculum. They must, however, offer a broad and balanced curriculum that covers science. This would include teaching content from biology, chemistry and physics. | **School leaders and subject leaders do not take seriously the requirement that science must be taught to all pupils at every key stage.**<br><br>Science is not taught to all pupils in every key stage, and pupils therefore cannot 'know more and remember more' science. |

<table>
<tr><td></td><td>An over-focus on English and maths inappropriately reduces the time available to teach science.</td></tr>
<tr><td colspan="2">Inspector question 22:<br>How do school-wide policies, such as marking or CPD, support the school’s needs?<br><br>School-friendly questions:<br>▪ Tell me a bit about how whole-school decisions affect science.<br>▪ Is there anything about whole-school policies that limits or holds back the science curriculum and assessment of it?</td></tr>
<tr><td>Whole-school decisions and policies provide sufficient flexibility for science to adapt in subject-specific ways.<br>Overall, general and common policies do not erode subject specificity. For example:<br>▪ generic marking or teaching and learning policies do not undermine the importance of discipline specific pedagogy<br>▪ subject-specific CPD needs identified by teachers and technicians are supported<br>▪ time is available for the development of curriculum and teaching within science rather than administrative, generic tasks<br>▪ there is adequate budget and resourcing for practical work.</td><td>The whole-school assessment requires the subject to report using generic measures which do not map well onto science assessment.<br>This is problematic. Pupil responses in science should be judged by, and feedback should focus on, their knowledge of the science content they have studied.<br><br>Whole-school policy limits subject-specific curricular thinking.<br>‘Top-down’ systems prevent the delivery of a quality science education. These systems should allow enough flexibility that best practice subject teaching is enabled.<br>Excessive marking requirements.<br>Whole-school marking policies should not require excessive levels of personalised written feedback and leaders should put in place steps to mitigate workload issues that arise from giving feedback.<br><br>Lack of resources to carry out high-quality practical work.<br>E.g. due to shortage of resources, group sizes are large so pupils do not learn from the activity.</td></tr>
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## Appendix: Safety in science

Ofsted is not a health and safety authority and is not responsible for auditing health and safety standards within the learning environment. However, inspectors have a duty to take prompt and proportionate action and to report any significant health and safety risks affecting learners that are identified during the course of an inspection. Putting this into context, during inspection activity in science, inspectors should keep a keen eye on safety protocols and procedures, including how effectively pupils are made aware of any potential hazards. Should any concerns arise, the lead inspector should inform the headteacher and then direct the team to gather more evidence through meeting with key staff and checking that departmental policies and procedures meet COSHH regulations. Inspectors could also ask whether the school subscribes to CLEAPPS and how they use the guidance they provide to assess risk. This will give inspectors further evidence to triangulate with lesson observations, pupil interviews, accident and behaviour logs etc. Depending on the balance of what inspectors find, then the handbook will allow for any serious concerns in this area to contribute to the judgements relating to leadership and management and safeguarding.

**Glossary**

| **Term** | **Description** |
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| **Automaticity** | Ability to recall and deploy (facts, concepts, and methods) with **accuracy and speed** and without using conscious memory; frees the working memory for higher-order processes that require holding a line of thought. |
| **Components** | The building blocks of knowledge or sub-skills that a pupil needs to understand, store and recall from long-term memory in order to be successful in a complex task. See Automaticity. |
| **Composites** | The more complex knowledge which can be acquired or more complex tasks which can be undertaken when prior knowledge components are secure in a pupil's memory. A practical science activity is a composite task. |
| **Cumulative dysfluency** | Educational failure caused when pupils do not have enough opportunities to recall knowledge to gain automaticity with the use of that knowledge. Over time this may cause many gaps in pupils' knowledge which prevent or limit pupils' acquisition of more complex knowledge. |
| **Cumulative subjects** | These are subjects where there are many possible content choices from which teachers can select e.g. English literature of history. In cumulative subjects, progression over time comes in part from the cumulative addition of more content areas being learned by pupils. The notion of cumulative sufficiency is particularly important when considering curriculum quality in cumulative subjects. Cumulative subjects are usually set in contrast to hierarchical subjects. |
| **Cumulative sufficiency** | When the sum totality of curriculum content can be considered an adequate subject education. This notion is particularly useful when considering the quality of the curriculum in subjects where there are many possible content options. |
| **Deep structure** | The different ways a principle can be applied that transcend specific examples. When a principle is first learned, it is used inflexibly as the learner will tie that knowledge to the particulars of the context in which the principle has been learned (the 'surface structure'). As a learner gains expertise through familiarity with the principle and its |

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| | applications, their knowledge is no longer organised around surface forms, but rather around deep structure. This means that experts can see how the deep structure applies to specific examples and that is an important goal of education. For example, in science, pupils will learn that a number of different looking structures such as lungs, leaves and elephants' ears are actually connected by having a large surface area to volume ratio. |
| **Disciplinary knowledge** | Methods and conceptual frameworks used by specialists in a given subject to establish knowledge. In science, this involves knowing how scientific enquiry establishes and grows knowledge. 'Working scientifically' sections of the National Curriculum outline what disciplinary knowledge (concepts and procedures) pupils need to know. |
| **Hierarchical subjects** | Subjects where content has a clear hierarchical structure and there is often less debate about content choices than for cumulative subjects. This is because there are core components of knowledge that you must know in order to be able to progress within the subject. Science is a hierarchical subject. |
| **Long-term memory** | Where knowledge is stored in integrated schema, ready for connecting to and for use without taking up working memory. See schema. |
| **Pedagogical content knowledge** | Pedagogical content knowledge is the integration of subject expertise and skilled teaching of that particular subject. It was first developed by Lee Shulman in 1986. Teachers' expertise involves combining content with pedagogy. |
| **Phonics** | The study of the relationship between the spoken and written language. Each letter or combination of letters represents a sound or sounds. The information is codified, as we must be able to recognise which symbols represent which sounds in order to read the language. |
| **Progression model** | The planned curriculum path from the pupil's current state of competence to the school's intended manifestation of expertise. |
| **Schema/schemata (plural)** | A mental structure of preconceived ideas that organises categories of information and the connections between them. |
| **Scientific enquiry** | Refers to the systematic and context-dependent approaches used by scientists to answer their questions of interest. It encompasses a range of methods and should not just be taken to mean 'data collection', but instead refers to the full process that involves, planning, implementing, analysing and drawing conclusions. Pupils should learn about how scientific enquiry generates scientific knowledge and, as part of this, will take part in increasingly complex scientific enquiries whilst at school. This should not be confused with enquiry-approaches to teaching science which are a pedagogy. |
| **Substantive knowledge** | Subject knowledge; often that carries considerable weight in a given subject domain, such as significant concepts. In science, substantive knowledge involves knowledge of the products of science such as Darwin's theory of evolution by natural selection or the names of parts of a flower. |

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| **Understanding** | We are using the cognitivist model in which understanding describes pupils' interconnected knowledge e.g. of concepts and procedures in science. Understanding describes a certain schematic pattern of knowledge and is not qualitatively different from knowledge.. Mental schemata can be viewed as network node diagrams, where nodes represent knowledge (facts, concepts, processes, features) and arcs the relationships between them. Understanding in this model is a function of the quantity of appropriate nodes and the quantity of appropriate arcs - more knowledge, and more connections between them leads to more understanding. A knowledge schema can always be developed further and this is synonymous with deepening understanding. In this sense a curriculum plan articulates the degree of understanding intended.<br><br>In everyday life, the question 'do you understand?' invites a binary yes/no response. This implies that understanding is something that is finite and can be possessed absolutely. This is incorrect and leads us into many traps, such as trying to 'teach for understanding' as an absolute when understanding can be viewed as a continuum and the nature and degree of understanding sought should be part of a teacher's articulated curricular intent. |
| **Working (short-term) memory** | Where conscious processing or 'thoughts' occur. Limited to holding four to seven items of information for up to around 30 seconds at a time. |
| **Working scientifically** | This specifies the knowledge, as outlined in the National Curriculum, that pupils need to know about how knowledge in science becomes established through scientific enquiry. This knowledge relates to the *performance of scientific enquiry* e.g. knowing how to measure a specific variable **and** knowledge *about scientific enquiry* e.g. knowing why experiments need controls. |