Disciplinary Knowledge in Science

	Year 7	Year 8	Year 9	Year 10	Year 11
Overview	Throughout KS3 students learn the importance of scientific enquiry and how it can lead to valid conclusions. Working scientifically allows students to work in similar ways to scientists and our spiral design to the curriculum provides comprehensive coverage of working scientifically. We start with the main goal we want students to accomplish, for example a process like analysing patterns. We break it down into two or three strategies, then the individual skill components for teaching and learning.			During GCSE students will build on the skills developed during the KS3 course to enable them to become fluent scientists in biology, chemistry and physics. Working scientifically is the sum of all the activities that scientists do which involves talking, reading and writing about science along with practical work, as well as representing science both mathematically and using models.	
Scientific Method and Thinking	In Year 7 our learners will begin to develop their methods of scientific thinking. We begin to use the idea of models to express scientific concepts particularly in the topic of the particle model where students learn about the arrangement of atoms in a solid, liquid and gas. Students will experience this when they study both sound and voltage and current where they will have the opportunity to put everyday experiences into scientific practice. **Question:** Identify an observation that could be recorded or measured over time. Write a question in the format 'How does... change over time?' Identify a dependent variable. Identify an independent variable. Write a question linking variables in the form 'How does... affect...?' Identify two variables which may show a correlation. Write a question in the form 'Is there a correlation between' **Theory:** In Year 7 we introduce the Particle Model and explain that all scientific concepts begin as a theory and open to review. Students begin to understand what is meant by a theory and know some examples of theories in science. They understand that theories are founded in scientific evidence and are very different from a scientific hypothesis. Students will go on to learn about the development in our understanding of cell structure and how theories change as new evidence emerges. **Consequences**: In Year 7 we introduce many new scientific concepts including important scientific discoveries. Students will be able to identify groups who could benefit or be harmed positively or negatively by a new discovery or invention. They will also be able to describe how each group could benefit or be harmed by new scientific research. This will be revisited in Year 9 in the units of Interdependence and Earths Resources. They will predict views that different groups will take on the new discovery or invention. They will also be able to describe how the new discovery or invention could affect us, our town and society.	By the time students begin Year 8, they are more confident with their scientific knowledge and understanding. Models and systems are groups of concepts connected in a way that simply describes phenomena. Some of the units taught this year involve concepts that students struggle to visualise such as resistance and light. We encourage students to question and use their skills of scientific enquiry to come up with their own solutions. **Question:** In the unit of separating mixtures students write an observation enquiry question such as how to extract salt from water. They base their understanding in the concepts they have learned throughout the unit to plan a safe and organised practical to achieve the outcome. In the unit of speed, students write a fair test enquiry question and understand what patterns are in data. **Theory:** Students develop their understanding of the role of a theory in science and comprehend that scientific ideas are challenged by peers and have changed over time due to new evidence. In Year 8 students will learn about the theory of the periodic table and be able to use it as an example of a theory that has changed. They are able to begin to understand how the periodic table has developed over time and how theories for the basis of our scientific understanding. **Consequences:** In the unit of interdependence, students will learn about the impact of human activity and be able to identify possible consequences to particular habitats. By the end of the topic students will be able to describe the possible impact human behaviour can have on animals which are dependent on these ecosystems to survive. In addition to this, in the unit of Energy Costs students will be able to identify individuals or organisations who may gain or lose money from a new technology such as nuclear energy. They will be able to describe how it would affect each group financially.	In Year 9 we challenge students to engage with their own independent research project through the unit, QUEST. Here students will draw on their knowledge of the scientific method that they have developed throughout KS3 and implement these skills in a piece of scientific research. They are challenged to work as a team to work scientifically and produce an academic style research poster. **Question:** In Year 9 we give students the opportunity to build on their understanding about questioning in the unit QUEST. Students will be able to design an enquiry is best for answering a given scientific question. They will be able to explain how a given question can be investigated scientifically and work as a team to complete the QUEST project from experimental design to evaluation. **Theory:** This year students will be working on the theory of evolution and begin to be able to evaluate a theory based on scientific evidence. Students will begin to understand that it sometimes takes a long time for a theory to be developed and accepted by a community. They also will be able to explain why argumentation is essential for the development of robust theories and how scientists can peer review to reduce bias when presenting experimental data. **Consequences:** At this stage of Key Stage 3 students will be able to explain why different groups of people might reach different decisions. They will be able to explain whether you think personal or group consequences should take priority. When students look a at the unit of inheritance and engage with the learning on genetic engineering, students will be able to select the choice which maximises the benefits and minimises the harm. When it comes to scientific research students will be able to list relevant 'we should or should not' rules that everyone should follow. In the unit of Earth's Resources students will describe possible consequences to local air quality and describe potential impacts further afield.	In Year 10 students will understand how scientific methods and theories develop over time. For example, understand how microscopy techniques have developed over time and Explain how electron microscopy has increased understanding of sub-cellular structures. They will also be able to use a variety of models to solve problems such as being able to explain the properties of diamond and graphite in terms of its structure and bonding. In both chemistry and physics students will understand the difference between the plum pudding model of the atom and the nuclear model of the atom. In biology students will evaluate the practical risks and benefits, as well as social and ethical issues, of the use of stem cells in medical research and treatments. They will also understand the risks involved in practical science and be able to Evaluate risks related to use of blood products. In physics students will study how radiation dose is a measure of the risk of harm resulting from an exposure of the body to the radiation. Students will be able to explain the technological applications of science. In physics students should be able to explain ways of reducing unwanted energy transfers. In biology students should be able to evaluate the advantages and disadvantages of treating cardiovascular diseases by drugs, mechanical devices or transplant. In physics students will learn that electrical power is transferred from power stations to consumers using the National Grid. In Year 10 students will understand that the results of testing and trials are published only after peer review. A key example of this in biology where students will learn about how to conduct a drug trial to minimise bias.	In Year 11 students will appreciate the power and limitations of science and consider any ethical issues which may arise. Such as consider the environmental issues that may arise from the use of different energy resources. Students will frequently use models to show a scientific concept for example evolutionary trees are a method used by scientists to show how they believe organisms are related. They will also Recognise, draw and interpret diagrams that model diffusion. Students will revisit the technological applications of science in Year 11. Students should be able to describe both positive and negative human interactions in an ecosystem and explain their impact on biodiversity. In chemistry they will learn that formulations include fuels, cleaning agents, paints, medicines, alloys, fertilisers and foods. They will also interpret information about genetic engineering techniques and to make informed judgements about issues concerning cloning and genetic engineering and GM crops. In physics students will evaluate the risk and explain the dangers caused by large decelerations. In biology students will explain the benefits and risks of selective breeding given appropriate information and consider related ethical issues. Students will recognise the importance of peer review of results and of communicating results to a range of audiences. Understand that the scientific consensus about global warming and climate change is based on systematic reviews of thousands of peer reviewed publications.

Experimental Skills and Strategies	In Year 7 we teach our students the importance of becoming good scientists. We firstly allow students to establish their communication skills and understand how to talk about practical work as scientists. We begin with simple practical work such as lighting a Bunsen burner as it allows the students to work as a multidisciplinary team to successfully complete the task. **Collect Data:** Through the year we move on to more complex group practical tasks such as dissecting a flower, requiring manual dexterity. One of the experimental challenges in Year 7 is to investigate Heating and Cooling through a range of insulating materials. This is an excellent practical task to allow students to collect data. Students will be able to choose a suitable range for the independent and dependent variable, gather sufficient data for the investigation and repeat if appropriate. They will prepare a table with space to record all measurements and check that the measuring instruments can record the range of the IV and DV. **Hazards and Risks:** At Carmel student safety is our priority. In the first unit of Year 7, Think Like a Scientist, students learn to identify features of an investigation which are hazardous. As we progress through the academic year learners will be able to determine the nature of the hazard and suggest the level of risk. As the year progresses and skills are developed, students will complete their first dissection of a flower. Students will be taught about hazards and what precautions could be taken to lower the level of risk especially when handling dissection equipment.	By the time students reach Year 8 they have had a wide range of experience in experimental strategy. Each unit in KS3 is based on a required practical activity. The rationale is to introduce students to the concept of required practical work from an early stage in their learning journey to best prepare them for GCSE. Following each required practical, students will often write about their methods of data collection. **Collect Data:** We support students to safely carry out a method carefully and consistently. Once the data is collected, they will see if repeated measurements are close. Students will learn the importance of removing outliers before calculating the mean of repeats. Prior to this year, students are supported in their choice of range, interval, readings. This year they will be able to evaluate the suitability of measuring instrument and be more confident in gathering data in order to minimise errors. **Hazards and Risks:** In Year 8 students will encounter a chicken wing dissection in the Unit Movement. Students will use this as a learning opportunity to identify ways of reducing the hazard particularly when completing the chicken wing dissection. Following this they will be able to verbally identify ways of reducing the risk. This allows the student teacher discussion to evaluate the benefits and risks of completing practical work such as this to enhance scientific understanding.	In Year 9 students complete the unit QUEST. Their experimental skills will be tested as they design and carry out their own research project. They will use all their teamwork skills to plan, complete and conclude their research, presenting their data in the form of a research poster. Throughout this task the scientific method must be reflected upon to generate a successful research project. **Collect Data:** During their study in Year 9 students will encounter the term range and explain why having a large range or many readings leads to accurate data. They will also be able to describe the factors that influence the choice of range and interval for the variables. When students study the unit of Chemical Energy they use a thermometer to measure temperature change in endothermic and exothermic reactions. They understand how the resolution of the equipment is important when taking measurements. This is also evident in the cool pack investigation, where students design a cool pack by conducting their own investigation. In this practical, students will vary the mass of reactants using a balance to create the most effective cool pack. **Hazards and Risks:** In Year 9 students will be responsible for using a wider variety of scientific equipment, which come with their own level of risk. Students will take the time to revisit the concepts taught in ThinkLike a Scientist to prepare them for this new level of challenge. They will be able to suggest how the question being investigated can be safely explored in a school science laboratory and what proportions used to be put in place.	Students will complete the required practical activities and use scientific theories and explanations to develop hypotheses. Year 10 students will plan experiments or devise procedures to make observations, produce or characterise a substance, test hypotheses, check data or explore phenomena. We will embed that the independent variable as the one that is changed or selected by the investigator. The dependent variable that is measured for each change in the independent variable and the control variables and be able to explain why they are kept the same. Students will carry out experiments appropriately having due regard for the correct manipulation of apparatus, the accuracy of measurements and health and safety considerations. During dissection work in biology students retrieve the skills learnt at KS3 to perform a successful dissection of the heart. Students will recognise when to apply a knowledge of sampling techniques to ensure any samples collected are representative. In the biology required practical using amylase students will describe the appropriate sampling technique. And in the photosynthesis practical students will recognise that multiple samples will be needed at each light intensity. In the chemistry required practical In electrolysis make and record observations and measurements using a range of apparatus and methods. They will also be able to evaluate methods with a view to determining whether or not they are valid.	Students will complete the required practical activities and use scientific theories and explanations to develop hypotheses. Year 11 students will explain why a given practical procedure is well designed for its specified purpose. They will be able to explain the need to manipulate and control variables. Students will be more confident to apply a knowledge of a range of techniques, instruments, apparatus, and materials to select those appropriate to the experiment. An example of this is when students utilise light gates in the physics acceleration required practical. In Year 11 students will be able to confidently identify the main hazards in specified practical contexts. They will suggest methods of reducing the risk of harm in practical contexts and be able to explain this in an exam situation. Students will suggest and describe a sampling technique in a given context such as a school playing field. They will also be able to record first-hand observations of organisms and identify them using a key. Students will be able to evaluate methods and suggest possible improvements and further investigations. In Year 11 students will be able to confidently assess whether sufficient, precise measurements have been taken in an experiment.
Safety	***<u>Carmel Science Laboratory Rules</u>*** *Only enter a lab if a member of staff is present. Never eat or drink in the lab at any time. Make sure the floors are clear during practical work. Goggles must always be worn during an experiment. Do not touch any equipment until instructed. Follow instructions and ask for help if you need to. Never attempt to clear broken glass/spills yourself. Wash your hands after practical work. Never take anything out of a lab with you.*				

Analysis, Conclusion, Evaluation and Critique	Throughout KS1 and 2 our students are taught how to collect data in scientific experiments so at KS3 we teach how to present the data effectively. In Year 7 students will learn about Variation and in doing so will be understand more about the way to represent continuous and discontinuous data. Students will also be able to suggest the relationship between variables. **Conclude**: Students will already be familiar with patterns from KS2 but at KS3 they will be able to incorporate the pattern they found into an answer to the enquiry question. In addition to this they will be able to suggest a scientific reason underpinning their findings. They will be able to comment on whether there is a real difference between data and be able to decide if anomalous results can be explained or ignored. We introduce the terms independent and dependent variables Identify variables that you could not control properly. Student will be able to identify aspects of the method that did not go according to plan and suggest better ways to control variables. **Explain**: Students will develop skills in recording the results of an observation. When students record observations, they will use scientific words and be able to decide if a diagram might help the explanation. This can be the case in the unit, Voltage and Current, where students find it useful to present findings in the form of a circuit diagram. **Critique + Peer Review**: Students will begin to understand the importance of critiquing scientific claims. In Year 7, students will begin to identify claims and identify all the evidence that is used. Learners will also comment on whether the evidence is scientifically accurate and relevant to the claim. Students will be able to **Justify**: Being able to justify is a skill which students will be able to state the issue or decision to be made, along with the options. They will then state their opinion with enough detail to be clear. Students will be able to list all the facts, scientific ideas, data, or conclusions that support your opinion whilst acknowledging other options.	Principles are relationships between concepts, such as cause and effect. In the topic Interdependence one principle is: 'population sizes are affected by competition with other species, predation, pollution and disease'. Students understand that data can help scientists to see relationships between concepts. **Conclude**: Year 8 students will become more confident when asked to suggest other possible conclusions that could be drawn from data. This gives learners the opportunity to broaden their minds to grasp new concepts. They will be able to apply any secondary data they may be presented with have which comes to the same conclusion. Students will develop their self-awareness and be able to analyse strengths and weaknesses in an inquiry, suggesting improvements and developments. In the unit Separating Mixtures, students will be challenged to investigate the solubility of solutes at varying temperatures. They must retrieve their understanding of the particle model in Year 7 to support their conclusions. **Explain**: Students encounter some challenging concepts one of which being Resistance. It is important that students are able to suggest a scientific idea that might explain the observation and describe the evidence. With a complex idea such as resistance, models can be useful tools for students to use to help explain why practical evidence supports an idea or scientific concept. **Critique + Peer Review**: Building on the skills learned in the previous year, students will begin to comment on whether the reasoning follows logically from the evidence. Students will learn about how our understanding of the universe has changed over time as a result of scientific development and critique. **Justify**: Students will explain logically how each piece of evidence supports an opinion and why each piece of evidence does not support other opinions. They will understand that critique and peer review is an essential part of the scientific process and be able to replicate this with their peers in class.	At this stage in KS3, students should be confident when analysing their own data following practical work. They should be able to describe how anomalous data affects how easily you can identify a pattern. Progressing from what was learned in Y7, students should be able to interpret a sloping line on a graph to suggest the relationship between variables. **Conclude**: Judge whether the conclusion is supported by the data. Explain how in an investigation in which not all variables could be controlled that a conclusion could still be drawn. Identify further questions arising from the investigation. Describe how the size of the error in an investigation affects the strength of the evidence. Explain why having someone else repeat the experiment could increase confidence in the conclusion. Students will begin to learn GCSE terminology and identify potential sources of random and systematic error, discussing ways to improve the method. Some students could suggest ways to reduce measurement errors and research other scientific explanations for the conclusion. **Explain**: Explain why an explanation is more believable when supported by data from an experiment. Students will understand the value of data but also how it can be used as a tool so show their findings. They will be challenged to present their data from the QUEST investigation in the form of a scientific research poster. **Critique + Peer Review**: At this point in KS3 students will be confident when explaining how believable they think a scientific claim is, by presenting all evidence and reasoning. At the end of the unit QUEST students will reflect on their projects to understand how they could be improved. **Justify**: Explain how you could defend your opinion if someone criticises it. Identify ways in which a different opinion may be valid. Students will justify their projects to a representative from scientific industry when they attend the presentation.	From their understanding at KS3 students will be able to construct and interpret frequency tables and diagrams, bar charts and histograms. They will also be able to plot two variables from experimental or other data. Students will be able to present a graph of amylase activity against pH in biology. In physics students will determine the specific heat capacity of one or more materials and present their data. In biology students will be taught how important it is to process data. They will learn the skill of translating mass data into graphical form. As student progress through GCSE they will be able to use an appropriate number of significant figures in a question and understand the importance of finding the arithmetic mean and range of a set of data. They will confidently construct and interpret frequency tables and diagrams, bar charts and histograms. Students will be able to change the subject of an equation due to the cross curricular links with Maths at KS3. They will also be confident in substituting numerical values into algebraic equations using appropriate units for physical quantities. They will apply the idea that whenever a measurement is made, there is always some uncertainty about the result obtained. Students will be able to use the range of a set of measurements about the mean as a measure of uncertainty. Students will be able to interpret observations and other data, including identifying patterns and trends, making inferences and drawing conclusions. Students should be able to recognise different types of blood cells in a photograph or diagram, and explain how they are adapted to their functions. They should also interpret heating and cooling graphs that include changes of state. During the osmosis practical students will determine the slope and intercept of a linear graph. They will also learn to be objective when evaluating data in terms of accuracy, precision, repeatability and reproducibility and identifying potential sources of random and systematic error.	Students will practice graph drawing throughout Year 11 and be able present their observations and other data using appropriate methods. They will practice exam questions to ensure they are secure in their understanding of how to draw a successful graph. In Year 11 Chemistry students will study the use the Earth's natural resources to manufacture useful products. Here they will be challenged to extract and interpret information about resources from charts, graphs and tables. By Year 11 students will use data to make predictions and be able to recognise or describe patterns and trends in data in other forms. Students will complete to unit Forces in Year 11 and be able to interpret data from an investigation of the relationship between force and extension. Students will comment on the extent to which data is consistent with a given hypothesis and identify which of two or more hypotheses provides a better explanation of data in a given context. *Some of the key terminology students should understand is:* An **accurate** measurement is one that is close to the true value. Measurements are **precise** if they cluster closely. Measurements are **repeatable** when repetition, under the same conditions by the same investigator, gives similar results. Measurements are **reproducible** if similar results are obtained by different investigators with different equipment. Measurements are affected by **random error** due to results varying in unpredictable ways; these errors can be reduced by making more measurements and reporting a mean value. **Systematic error** is due to measurement results differing from the true value by a consistent amount each time. Any **anomalous** values should be examined to try to identify the cause and, if a product of a poor measurement, ignored.

Scientific literacy and numeracy	Students begin to describe how anomalous data affects how easily you can identify a pattern or trend in their results. **Numeracy:** In the topic of Variation students will be able to decide the type of chart or graph to draw based on its purpose or type of data. They will learn the skills of designing a table for the data being gathered. When drawing a graph they will label the x axis with the name of the independent variable and the y axis with the dependent variable. Students will also decide which numbers to start and finish with on each axis ensuring equal intervals on the scale showing what each square of graph paper represents. Students will experience drawing a straight line or a curve of best fit through the points. **Literacy and Communication:** In Year 7 students will learn how to communicate scientifically and write in a style to fit purpose and audience. A skill is to be able to use clear language and well-formed sentences. Students will complete science literacy tasks to support their learning and be able to illustrate ideas with real-life examples. Students may also find that in the unit of the Particle Model adding a diagram can help to make the meaning clearer. Use scientific vocabulary accurately, showing that you know its meaning and use appropriate units and correct chemical nomenclature. **Sources + Peer Review:** Students will understand how the authors of the research are qualified scientists and the research was published in a peer reviewed journal. They will find that research may agree with current scientific thinking, but the researcher or funder might benefit from reporting the finding. The author might have a vested interest which created bias.	In science we work closely with maths to ensure our curriculums are cohesive to the benefit of student leaning and understanding. **Numeracy:** Students will build on their understanding from Year 7 to Interpret a sloping line on a graph to suggest the relationship between variables. They will revisit their understanding of graph drawing in the unit of Speed, preparing students for Speed/Time and distance/time graphs at GCSE. At this stage students will be able to select the best way to display data and draw line graphs to display relationships. At the end of Year 8 maths and science run a combined project where students carry out a practical investigation in their science class and complete the analysis in their maths class. **Literacy and Communication:** Students will be able to give evidence to back up everything you claim to be true. They will be able to make a list of all the points and cover one point in each paragraph then put the paragraphs in a sensible order. This is evident in the topic of Digestion when students describe and explain the movement of food through the digestive system. They will be able to use link words to help the reader connect sentences and paragraphs. Students will include everything necessary for the reader to understand but leave out unimportant details. **Sources + Peer Review**: By the time students are in Year 8 they will understand the importance of the authors of the research are qualified scientists. They will be more confidents in that research can be published in a peer reviewed journal. It is important that the experimenter collected enough data, give a scientific explanation of the findings and ensure that the findings are backed up by other evidence.	The value of good science communication is essential when completing the unit QUEST at the end of the year. **Numeracy:** Explain why different kinds of data are better displayed on different kinds of graphs. Students will be able to explain the choice of starting point for axes, zero or non-zero and explain the choice of a straight line or curve of best fit. Students will encounter new equations for example in the unit Pressure and be expected to rearrange equations calculate pressure, force and area. The skill of rearranging an equation will be retrieved in the unit of Work, equipping students with the skills they need to be successful in GCSE Science. **Literacy and Communication:** We understand that children build up their schema through their understanding of the world from a young age. We teach students to use their everyday and technical understanding of science and apply it to more complex concepts. As learners progress to Year 9 they will be able to describe the strategies used to help communicate ideas better. During the unit QUEST they will be challenged to suggest how the ideas would be communicated for a different audience. Students will also complete literacy tasks throughout the year to support their communication development. **Sources + Peer Review:** In Year 9 students will be able to analyse a research source and explain possible causes of bias from an experimenter or journalist. They will understand how peer review makes a finding more believable.	From KS3 students will have experience of using scientific vocabulary, terminology and definitions. In Year 10 they will understand the concept of Moles and know that chemical amounts are measured in moles. Another example being understanding the concept of limiting reagents. Students will also recognise the importance of scientific quantities and understand how they are determined for example calculating resultant force. In the unit of microscopy students will Use prefixes and powers of ten for orders of magnitude (eg tera, giga, mega, kilo, centi, milli, micro and nano). We have embedded literacy into our curriculum following the EEF guidance on science literacy. We ask students to read text, read aloud and make sense of the root of more complex scientific words. One example of this being students being able to explain the root of the word photosynthesis. In Year 10 students will learn about the MMR vaccination and the harm that can be done as a result of neglecting a thorough peer review procedure. Students will use this as an opportunity to learn about bias in academic research and how it can be avoided.	In Year 11 students will have built a comprehensive bank of key terminology. This can be referred to in student books where they complete a learning route for each topic. This contains a list of words alongside the learning sequence for the topic. It is important that students implement the formula they recall. Students will use SI units (eg kg, g, mg; km, m, mm; kJ, J) and IUPAC chemical nomenclature unless inappropriate. Students will use their understanding of orders of magnitude throughout all their GCSE content. They will also be able to use an appropriate number of significant figures in a calculation. In Year 11 students will build on their science communication. Government reports suggest that improved scientific literacy, including an understanding of scientific evidence and risk, will be enable people to make informed decisions for themselves, their families, and as part of the democratic process. They will be able to contribute effectively to political and ethical debates surrounding such complex issues as GM foods, biometric data, or nuclear energy. We understand that to become competent in the language of science pupils need to be able to comprehend, analyse, and interpret texts and use the language of science to explain ideas and construct evidence-based explanation. GCSE students should be confident in explaining the value of peer review in scientific research and the consequence of untested findings.