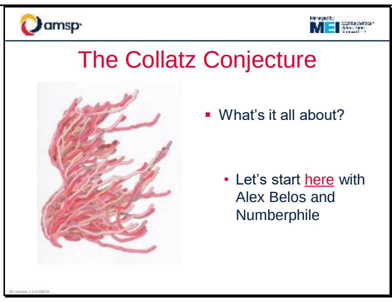
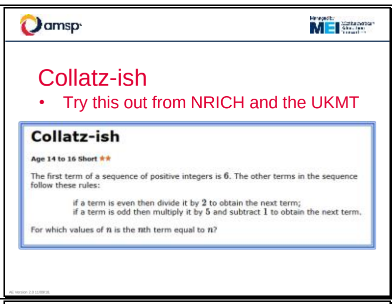
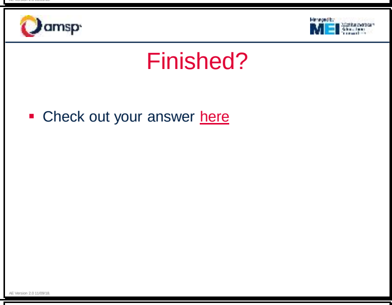
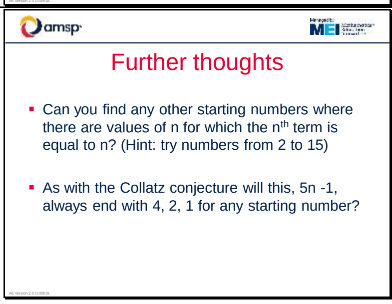
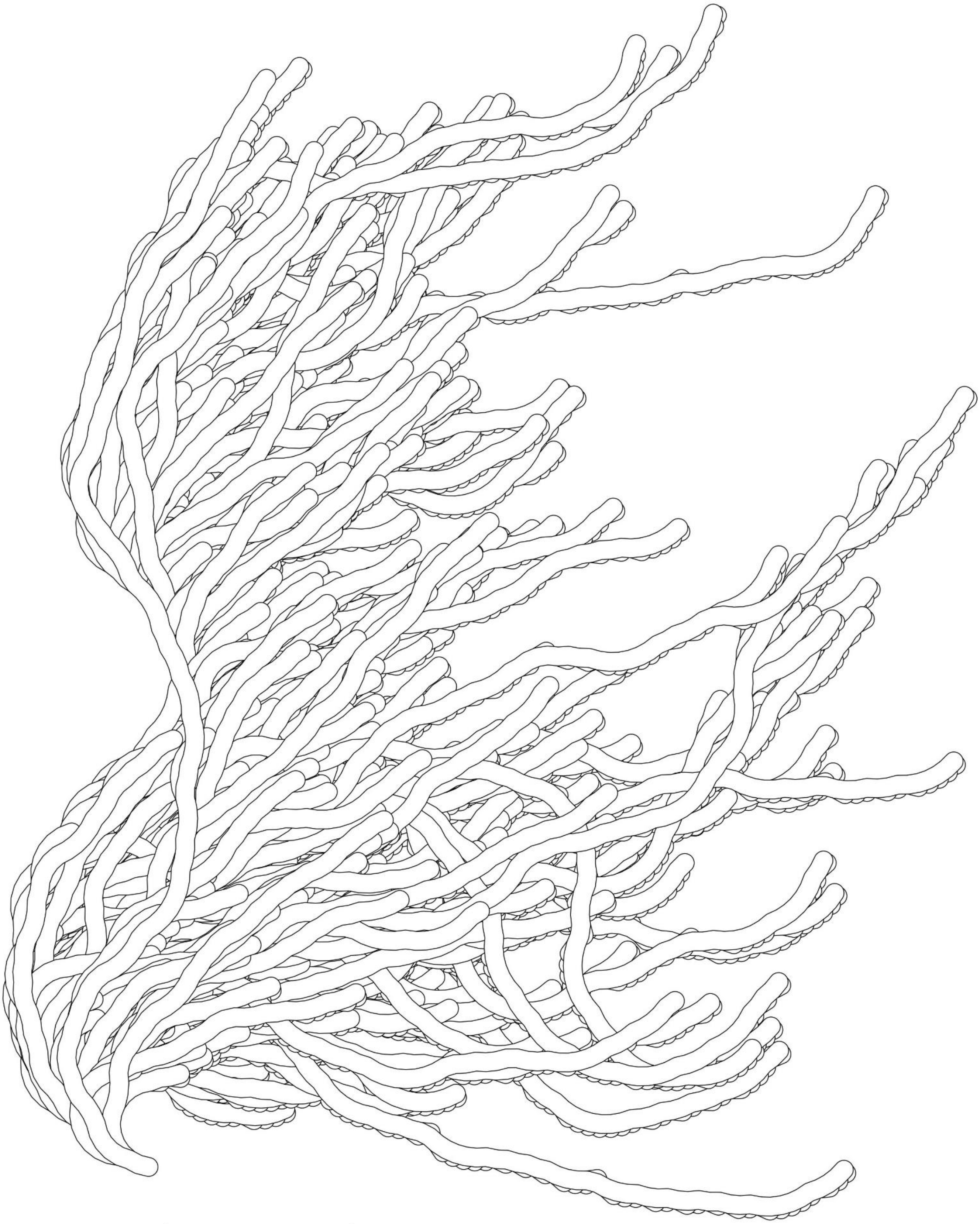
Slide 1	Advanced Mathematics Support Programme	**Teacher notes:** With each slide are some extra details and where appropriate answers to save time! Slides 2 to 4 are the main focus for the enrichment. After this the direction to other activities is at the discretion of the teacher. For instance, slides 8 and 9 might be the next directed steps. Or slide 5, 'further thoughts' followed by slides 8 and 9. Or slides 5, 6 and 7. Or let students choose which activity interests them.
Slide 2		The Collatz Conjecture is based on this sequence: If the number is even divide by 2 to find the next term, if the number is odd then multiply the term by 3 and add 1 to find the next term, i.e. 3n + 1. **The conjecture is that no matter what value of n, the sequence will always reach 1.** The fact that no one has disproved this yet makes it an interesting area for mathematical research! https://en.wikipedia.org/wiki/Collatz_conjecture
Slide 3		A similar problem to the Collatz one, from NRICH and UKMT, but based on 5n – 1 for odd terms. Here are solutions to the question: 6, 3, 14, 7, 34, 17, 84, 42, 21, 104, 52, 26,**13**, 64, 32,**16**, 8, 4, 2, 1, 4, 2,1, … i.e. 13 and 16. So a closed question where the quickest way to find the solution is to generate the sequence.
Slide 4		Answer missing from slides so that it isn't accidentally seen when moving through the pages. Link to the NRICH website so that students can check their answer but also see links to other problems/puzzles.
Slide 5		**Further thoughts** – an initial extension to the original task if required. It would be useful to suggest a time limit if working independently e.g. 20 minutes. A possibility for feedback is to ask students to write a short summary of whether they found the video interesting, their answers and anything else they discovered. For starting numbers from 2 to 15 these are the solutions: Start **4**, terms are 2 and 4. Start **5**, term is 7. Start **12**, term is 3. The following start numbers do not end with 4, 2, 1, … 9, 11, 15, 18, 19 for starting numbers from 1 to 20.

Slide 6	**More thoughts** ▪ What happens if you still divide even numbers by 2 to obtain the next term but change the multiplier for odd terms to -3 and subtract 1 to obtain the next term i.e. -3n – 1 ? (Hint: try start numbers <10) ▪ Why do you think this is what happens? ▪ What is the first start number where this doesn't happen?	**More thoughts** – a variation where negative numbers are involved in the sequence. Again, if required, and would benefit from a maximum time limit. A more open-ended question which would benefit from a teacher suggested time frame. This sequence finishes with this repeating pattern: -4, -2, -1, 2, 1, -4, -2, -1, 2, 1, ………. for these starting numbers: 1, 2, 3, 4, 5, 6, 7, 8, 9, 10, 11, 12 ,13, 14, 16, 18, 20... First number where this doesn't happen is **15** followed by 17 and 19.
Slide 7	**The Collatz Conjecture** ▪ Does it still work for negative start numbers?	For students who have attempted 'more thoughts' an extra question.
Slide 8	**Other things to do** ▪ Why not colour your own 'seaweed picture'? Find a blank copy at the end of this document ▪ Is it possible to do this using the four colour theorem? (more on the four colour theorem) ▪ Why not draw your own 'tree' diagram as Alex Belos did for the -3n -1 sequence for start numbers from 1 to 10?	Other possibilities for further activity as an alternative to some of the 'thoughts'. If working independently students could take a photo of their finished drawing/diagram and submit this to the teacher. Seaweed picture was downloaded from: https://static1.squarespace.com/static/548b5b70e4b0b57ba182907d/t/58da8df81b10e35ee212221a/1490718217324/seaweed_file.jpg See Brady Haran's Blog: https://www.bradyharanblog.com/blog/the-collatz-conjecture-in-colour for more information and ideas. With thanks to Edmund Hariss for permission to use the image from his books: Visions of Numberland https://www.bloomsbury.com/uk/visions-of-numberland-9781408888988/ and Visions of the Universe https://theexperimentpublishing.com/catalogs/fall-2016/visions-of-the-universe/
Slide 9	**Want to know a bit more about the Collatz Conjecture?** ▪ Professor David Eisenbud on the infamous Collatz Conjecture, a simple problem that mathematicians may not be "ready" to crack. ▪ Wikipedia – Collatz Conjecture ▪ The On-Line Encyclopedia of Integer Sequences® (OEIS®) as referenced by Professor David Eisenbud, list of starting values and number of steps here.	Another really interesting video from Numberphile with Professor David Eisenbud on the Collatz Conjecture – worth watching. Links for students if they are interested in finding out more.
Slide 10	**Contact the AMSP** 01225 716 492 *admin@amsp.org.uk* *amsp.org.uk* Advanced_Maths	Stay informed about the AMSP and receive updates: https://amsp.org.uk/subscribe



This image is a sample from the colouring book Visions of the Universe by Alex Bellos and Edmund Harriss
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