Lesson One
AI Meets Sharks:
Artificial Intelligence and Computational Thinking
(5th Grade)

Acknowledgement:

This lesson was collaboratively designed by CS Everyone Center for Computer Science Education and UFTeach at the University of Florida. We thank Dr. Meize Guo, Dr. Yongju Jeon, and Dr. Michael Johnson from the CS Everyone Center, as well as Dr. Kristen Apraiz and Dr. Gayle Evans from UFTeach at the University of Florida, for their valuable contributions in designing and reviewing the teaching materials and instructional activities for this project. We also thank Dr. Maya Israel from the CS Everyone Center for Computer Science Education for her expertise and guidance in K-12 AI education.

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Overview of the Lesson

Name of Lesson	AI Meets Sharks: Artificial Intelligence and Unplugged CT
Optional Activities	We prepared multiple materials for various students' backgrounds. **Please consider your students' background knowledge and adjust accordingly.**
Summary of STEM Concepts	**Artificial intelligence** (AI) is a machine-based system that can, for a given set of ***human-defined objectives***, make predictions, recommendations, or decisions influencing real or virtual environments. **Machine learning** is how computers recognize patterns and make decisions without being explicitly programmed. **Machine learning progress** includes (1) implying a machine learning model in the training data set and receiving feedback, (2) finding patterns in the training data and coming up with features, and (3) making predictions and classifying in the test data set. **Sharks have 6-8 fins,** including a vertical caudal fin, rigid pectoral fins, and a dorsal fin with a straight trailing edge. **Sharks have 5-7 gill slits on the side.** The majority of sharks have 5 gill slits on the side, different from rays' gill slits, which are on the bottom. **Sharks have many rows of teeth.** If they lose a tooth, a new tooth will grow back as fast as within 24 hours. **Shark's skin has** tiny tooth-like structures called dermal denticles.
Performance Based Learning Objectives	By the end of this section, the students will be able to: 1. Read/memorize/define the terms in their own language. 2. Describe/explain the machine learning steps. 3. Follow the instructions in the abstraction table or decision tree to classify the cards as sharks and non-sharks.
Materials Needed	Printing materials were listed in Section 2 **Materials are varied. Customize as you need.**

NGSS / MAFS /CS Standards:

The K12 AI guidelines were adopted from ai4k12.org

Standard	Description
Big Idea #3:	Definition of Machine Learning: Machine learning allows a computer to

Learning	acquire behaviors without people explicitly programming those behaviors. The Role of Training Data: Large amounts of training data are required to narrow down the learning algorithm's choices when the reasoning model is capable of a great variety of behaviors. Learning Phase vs. Application Phase: The reasoning model constructed by the machine learning algorithm can be applied to new data to solve problems or make decisions.

ENGAGE (Time: 6 minutes)

How will you invite students into the lesson, access prior knowledge, and excite them?

Goal	What will you say/do	Expected student responses/actions
Introduce the scenario of sea animals. Play the circling game and talk about distinguishing similar sea animals via visual recognition.	**Circling Game** Game: Circling the Dogs	**Answer:** Answer Sheets
	After Game Discussion ● Can you distinguish sharks from other similar ocean animals, such as rays, skates, and dolphins? And how? ● What makes a shark a shark?	**Highlights** ● Fins' number ● Gill slits number and location ● Teeth characters ● Skin characters
Link to AI/Machine Learning/Visual Recognition **Background knowledge for teachers:** 1. **How AI was used by biologists?** 2. **How does AI work? Machine Learning**	When you have many photos of sea animals that need to be categorized, it is exhausting to let people check them individually. However, AI can do this kind of job quicker and more accurately than humans. AI can help us distinguish and identify information, like images, in real life. What comes to mind when you think of AI? What does AI mean to you? How has AI been used in real life? Artificial intelligence (AI) most often refers to a device or program designed to mimic aspects of human intelligence to complete complex	AI is artificial intelligence, which uses a lot of data. It is fake intelligence because artificial means fake. AI will take over the world.

	tasks such as learning, problem-solving, and decision-making (Twist the language as needed). A typical AI used daily is visual recognition, which includes facial and image recognition. For example, cell phone face ID and face recognition payments use facial recognition; Google allows users to search via images, which employs image recognition. Marine biologists can use AI to observe and identify sea animals. For example, they can use AI to learn about sharks, their total number, whether they are growing or shrinking, their nursery and habitat, and their living environment. Today, we will learn how AI visual recognition works.	

EXPLORE (Time: 12 minutes)

How will you organize student activities and thinking as they explore the STEM concepts in this lesson?

Goal	What will you say/do	Expected student responses/actions
Recognize patterns and make decisions as a machine learning program would.	**Activity: Group data** Give each group 12–18 sea creature cards. Ask them to sort the cards into 3–5 groups based on one common feature/single feature per group. Write those features down on the worksheet. Then, share with the class what features groups used to sort on.	Student responses may include the number of fins or gills. Students might also sort just by "animal," which is not a single feature. In these cases, ask them what makes a creature that type of animal.

	Activity: Train A Model Give each group 12 sea creature cards, or have them draw 12 at random. These 12 cards serve as *training data*. Each group uses the cards to make up 3–5 rules to classify them as "shark" and "non-shark". Write down their rules on the worksheet. When all rules are satisfied, the creature should be a shark.	**Highlights:** Students may find some images of creatures they know are sharks that don't fit within their rules, possibly if the image is at a bad angle or misleading.
	Activity: Test A Model After creating the rules, set aside the initial 12 cards. And use the remaining six cards as new data. Using their rules, classify the remaining six images as "shark" or "non-shark." Discuss with the class if their rules worked well or not.	**Highlights**: The students may find that their rules work well for their training data but not for their testing data.

EXPLAIN (Time: 10 minutes)

How will you help students make sense of the experiences they had in the exploration?

Goal	What will you say/do	Expected student responses/actions
Traditional programming and machine learning.	Traditional programming requires programmers to create detailed step-by-step instructions for computers to follow to solve a problem. Think about the progress in visual recognition. It is time-consuming to write programs for each image for the computer to process. So, we want computers to learn by themselves through experience, as we call machine	Students might refer to the algorithm when they hear "step-by-step instruction."

	learning.	
Explain the progress of machine learning.	Machine learning is a little different from traditional programming. It starts with data. Programmers choose a machine learning model and implicitly embed the model within a training data set. They let the computers find patterns and describe each pattern as a feature. Then, computers use features to classify or make predictions about new test data. Machine learning is a branch of AI that creates programs that improve over time or learn when they process data. Let's think like a machine about how we would classify images.	Students might need differentiations between the training data and the test data. Training data means programmers (humans) know the correct answers. For example, in the training data, humans can tell which image is a shark and which image is a dolphin. Test data means programmers (humans) do not know the correct answers yet and hope computers/machines can help identify them.
Make connections to the shark case: the patterns used to describe sharks are the features. Optional for Students: Shark Anatomy Shark External Anatomy	There are more than 400 species of sharks in the world, but there are some common features that make sharks special and different from other sea animals. Optional to show the Shark Anatomy or Shark External Anatomy depending on the student's background, introduce the fusiform body shape of a shark, and more details below. 1. **Fins (6-8 fins)** a. direction of caudal fin (shark - vertical caudal fin; whale and dolphin - horizontal caudal fin) b. shape of dorsal fin (shark - straight trailing edge; dolphin - curved trailing edge)	Students might use these features to check the game cards again and test them out. Some explanation about the card images might be involved. For example, what do you mean by a vertical caudal fin? How can you tell the pectoral fins are rigid? What do you mean by gills on the side? According to the card images, the students might ask additional

	c. rigid pectoral fins (sharks can not back forward and only swim forwards because their pectoral have limited maneuverability) **2. Gill Slits (5-7 on the side)** a. location (on the side, rays' gill slits are on the bottom) b. numbers (majority of sharks have 5 gill slits) **3. Teeth** a. Many rows of teeth that are not in their jaw bone (no bones/) are replaced quickly, up to 24 hours. **4. Skin** a. Tiny tooth-like structures (dermal denticles) - relatively smooth and not covered in scales (bony fish - larger overlapping scales)	questions. What are the holes in front of the shark's eyes? Are they noses? Why do some of the sharks have dots on their skin?

ELABORATE (Time: 12 minutes)

How will you connect this experience with other ideas or real-world applications?

Goal	What will you say/do	Expected student responses/actions
Real-world application of classifying similar animals via visual recognition.	**Activity: Decision Tree** Decision Tree Move Card Worksheet Print out the Decision Tree Move Cards Worksheet, and put the card stack on the top of the father question. Answer the questions in the decision tree, and move the card from top to bottom one by one. AI uses the machine learning approach to observe a lot of data and learn from the data. AI can make predictions about the common patterns in the data and transfer these common patterns into binary questions, which can be	Follow the instructions in the decision tree, move and locate the cards to find the sharks. Example Answer

	answered by only Yes or No. And describe the common patterns as features of data. These data features help biologists identify and classify sharks.	
	Activity: Construct Binary Questions Decision Tree Construct Binary Question Worksheet Based on the features identified during the explain phase, teachers and students review the common patterns or key features that distinguish the sea animals and the game cards together. Then, teachers and students **construct binary questions** that correctly classify the animals according to these features. Binary questions should be specific criteria that can be answered as 'yes' or 'no.' ● Ex: "Does the creature have gills?" ● Ex: "How many gills does the creature have?" Fill in the blanks in the provided decision tree with the binary questions. Randomly select game cards to test if the classification results are correct. AI uses the machine learning approach to observe a lot of data and learn from the data. AI can make predictions about the common patterns in the data. Transfer these common patterns into binary questions, which can be answered by only Yes or No. To construct these questions, it is necessary to simplify complex choices by breaking them down into smaller,	Follow the instructions in the decision tree, move and locate the cards to find the sharks. Example Answer

	logical steps.	
More explanation that helps link the activity to CT concepts and practices	Artificial intelligence uses various methods to classify objects, one of which is the decision tree algorithm. A decision tree breaks down complex classification problems into a series of questions and answers. You first need to understand the key characteristics of sea animals like sharks, dolphins, rays, and skates. Based on these characteristics, you can answer binary questions like "Does it have gills?" or "Is the caudal fin vertical or horizontal?" to classify the animals. Logical thinking and sequential reasoning are important in this process, and decision trees are useful visual tools for solving classification problems.	

EVALUATE (Time: 5 minutes)

How will you assess the extent to which learning goals are met during/by the end of the lesson?

Goal	What will you say/do	Expected student responses/actions
The students can identify the image of sharks from other sea animals.	Do you remember the four features that can be used to identify the sharks?	Fins, Gills, Teeth, Skin. (with detailed explanation)
The students can describe the progress of machine learning.	Do you remember how machines learn by themselves to make decisions?	Giving training data, making decisions, and receiving feedback. Come up with patterns or features depending on the feedback. Using the patterns or the features to classify the

		new test data.
Open-end Discussion	What are the advantages and challenges of using AI?	Convenient, fast, accurate, etc. Data privacy, ethics and equity, technical issues, resources, etc.

Section 2 Worksheets Index

[ENGAGE] Game: Circling The Dog

- Chihuahua
- Sheepdog
- Answer Sheet

[EXPLORE] Card Game

- Cards - Small
- Grouping Cards Worksheet
- Training and Testing Cards Worksheet
- Card - Large (separate PDF doc)

[ELABORATE] Decision Making

- Decision Tree - Move Cards
- Decision Tree - Construct Binary Questions
- Decision Tree - Example Answer

Game: Circling the Dogs (Chihuahua)

Can you circle out the Chihuahua dog in the image below?

Game: Circling the Dogs (Sheepdog)

Can you circle out the sheepdogs in the image below?

Answer Sheet: Circling the Dogs

Grouping Cards - Answer Sheet

Group the sea creature cards into 3–5 categories based on one specific feature for each. Write down the features of each category below.

1. _____
2. _____
3. _____
4. _____
5. _____

Training and Testing Cards - Answer Sheet

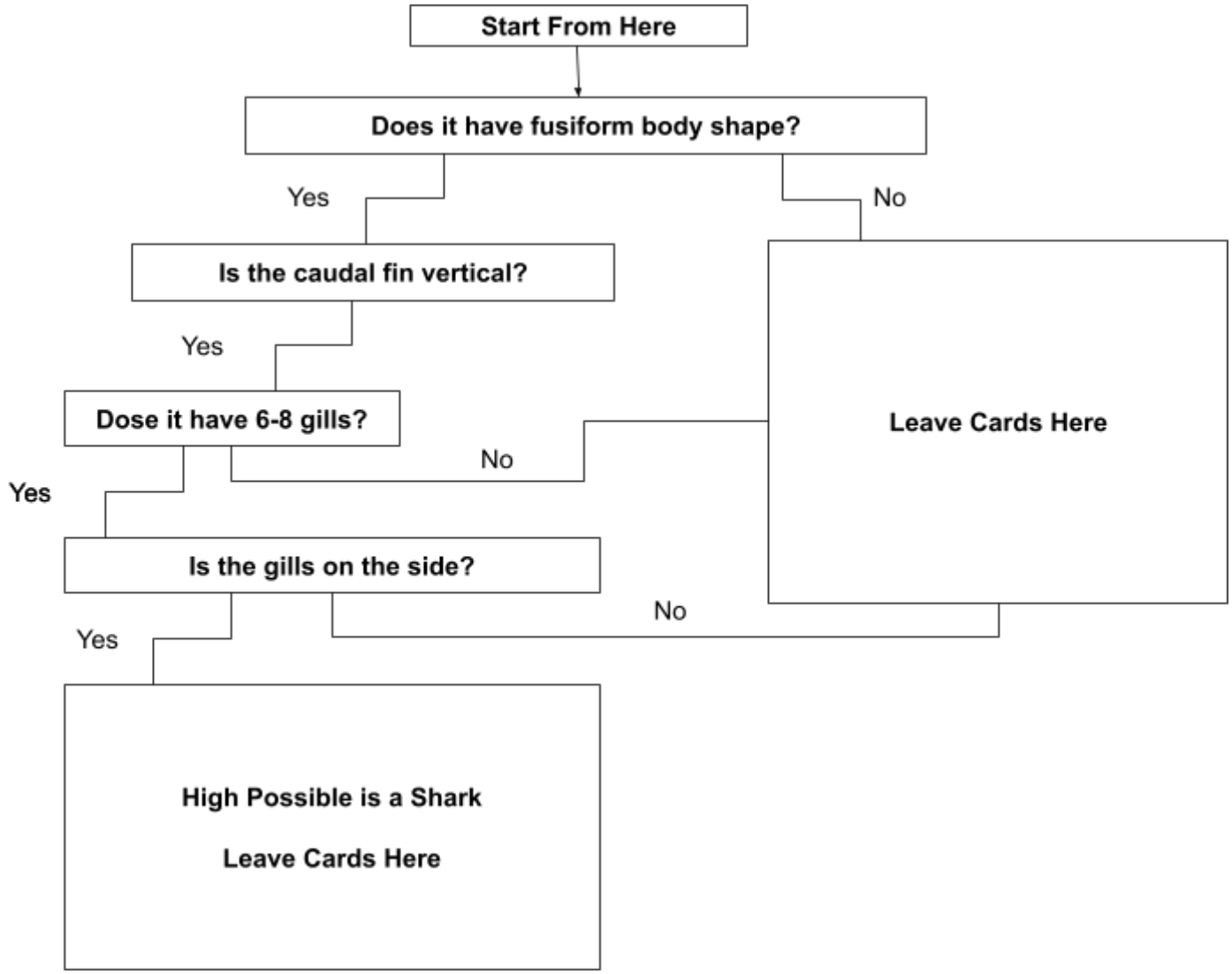
Looking at 12 sea creature cards, create 3–5 rules to classify them as “shark” and “non-shark.” Rules should be specific criteria that can be answered ‘yes’ or ‘no,’ and a creature should be considered a shark when all rules are satisfied.

Write down your rules below.

1. _____
2. _____
3. _____
4. _____
5. _____

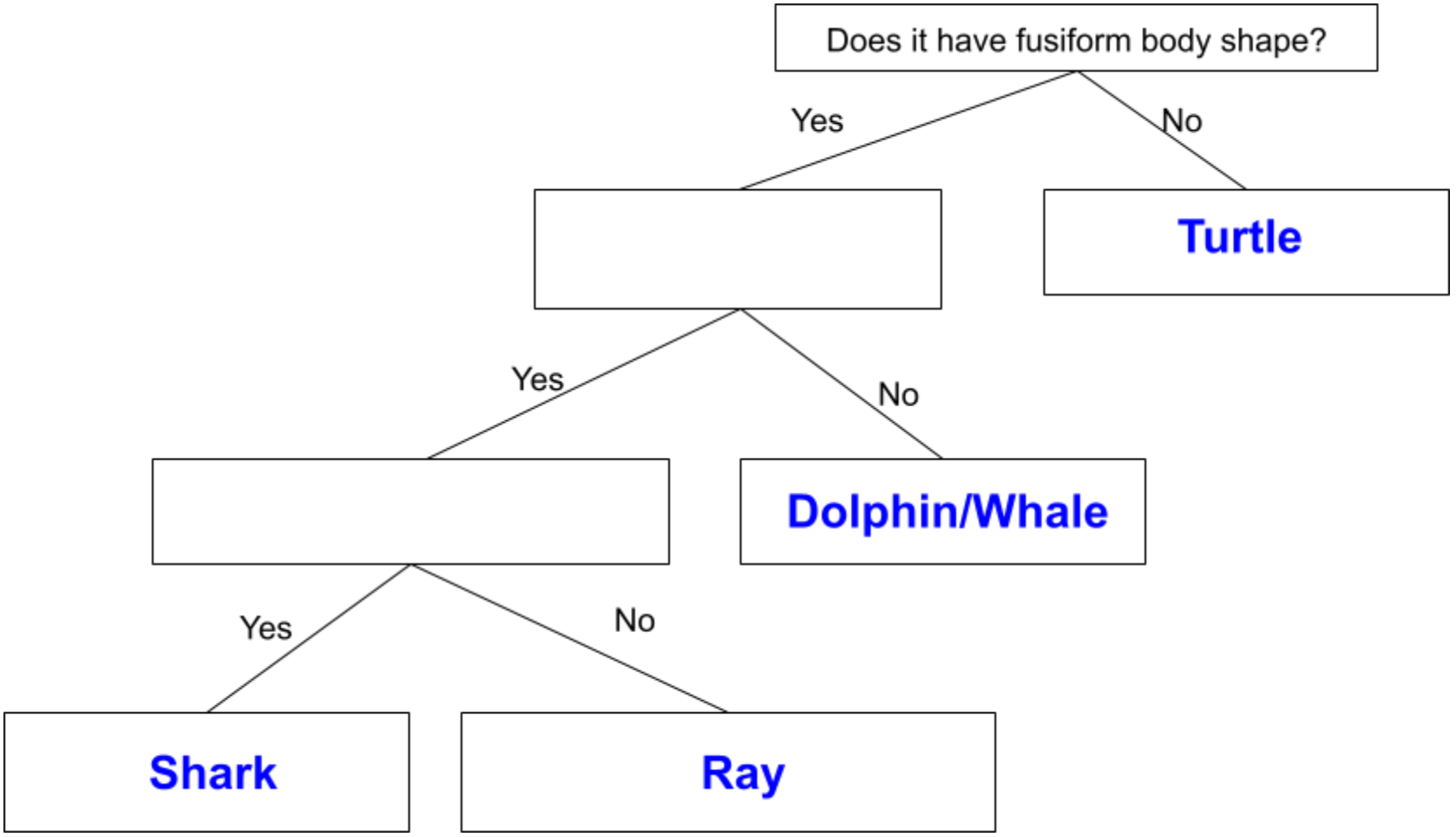
Decision Tree - Move Cards

Put your cards at the start point, and use the questions for specific features to classify the cards.

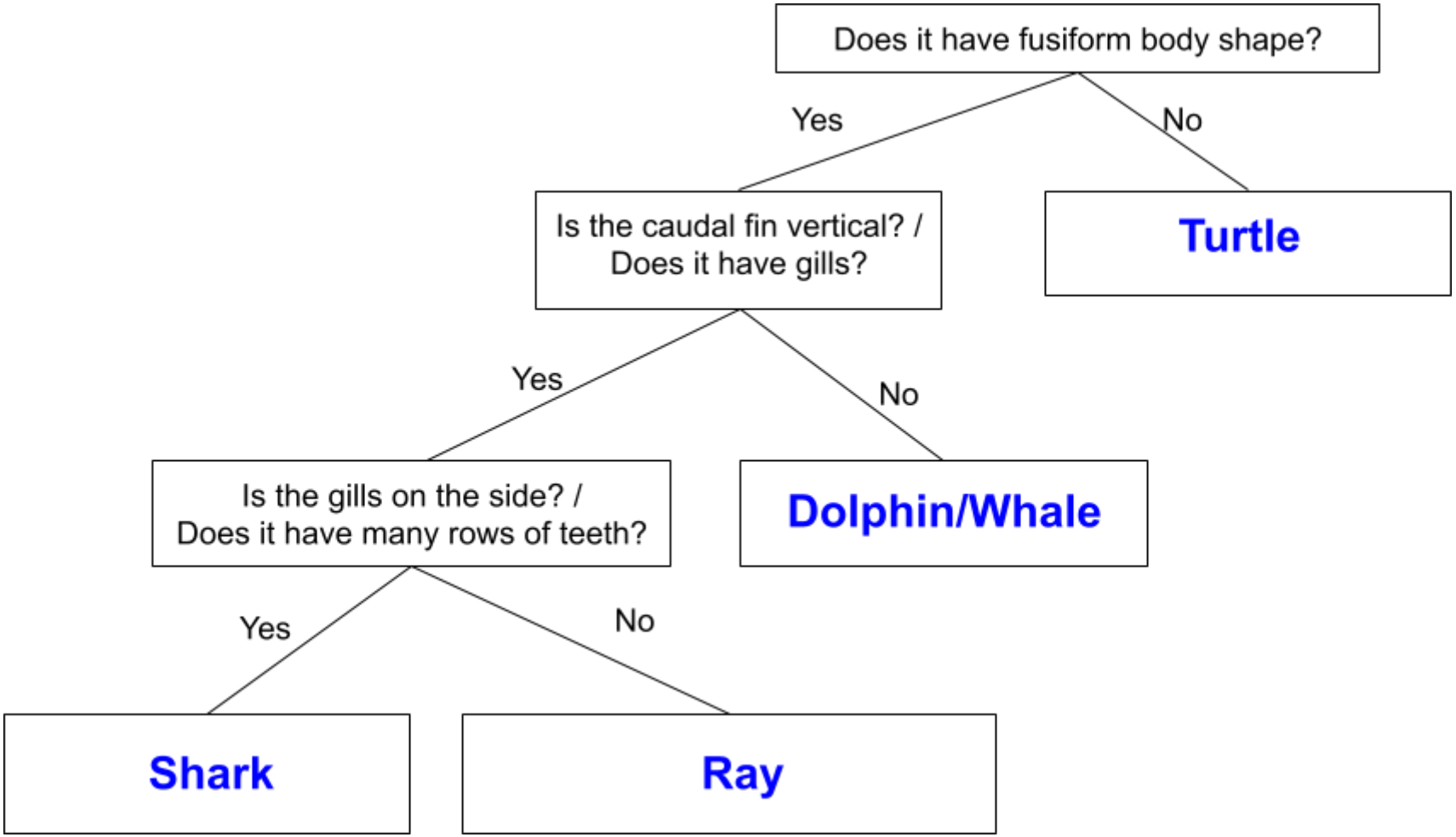


Decision Tree - Construct Binary Questions

Transfer the features/common patterns into binary questions based on the classified results of sea animals. Write your binary questions in the rectangle. Randomly pick game cards to test out your questions.



Decision Tree: Example Answer



Exploration Cards Small

Image 1

Image 2

Image 3

Image 4

Image 5

Image 6

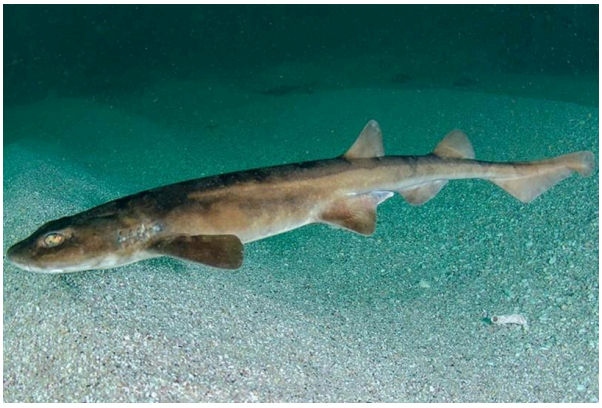


Image 7

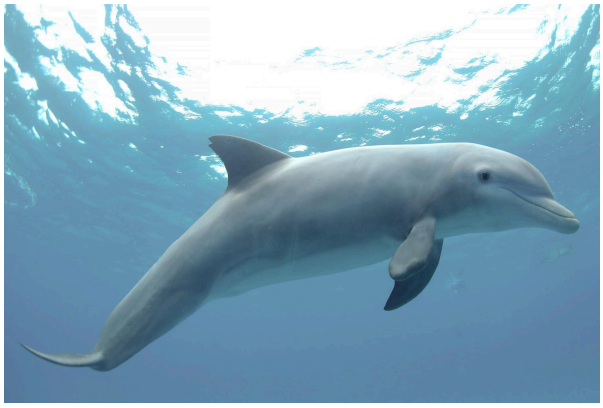


Image 8

Image 9

Image 10

Image 11

Image 12

Image 13

Image 14

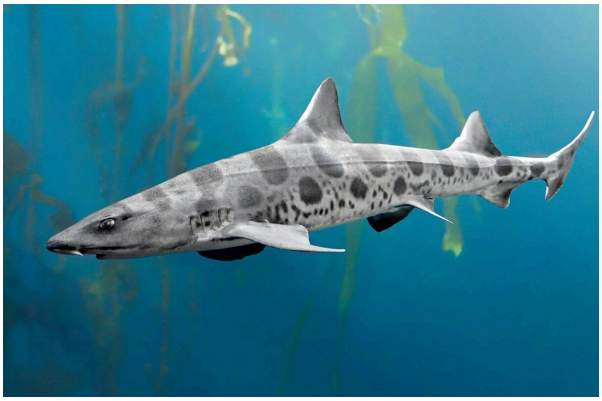


Image 15

Image 16

Image 17

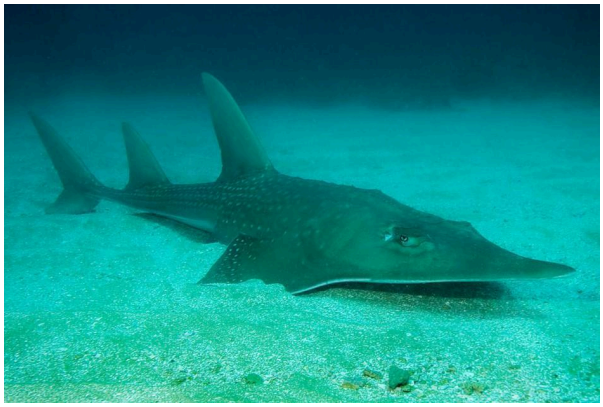


Image 18

Exploration Cards Answers

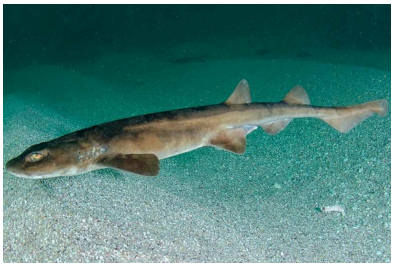
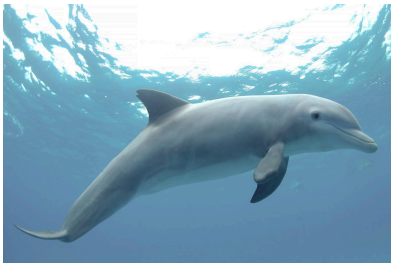
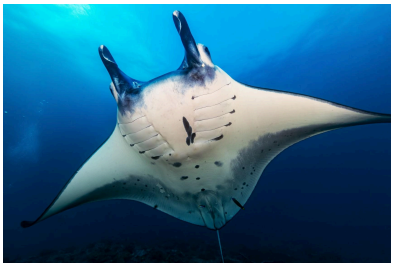
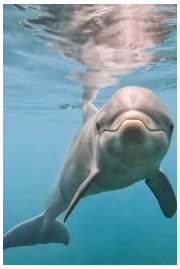
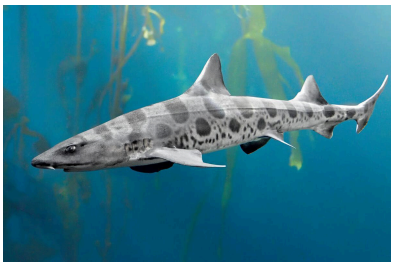
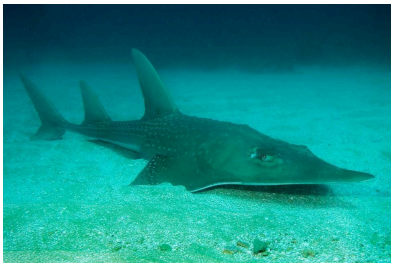
 **Image 1:** shark	 **Image 2:** shark	 **Image 3:** dolphin
 **Image 4:** whale	 **Image 5:** shark	 **Image 6:** dolphin
 **Image 7:** shark	 **Image 8:** dolphin	 **Image 9:** shark
 **Image 10:** ray	 **Image 11:** dolphin	 **Image 12:** shark

 **Image 13:** sea turtle	 **Image 14:** shark	 **Image 15:** shark
 **Image 16:** dolphin	 **Image 17:** whale	 **Image 18:** ray

Section 3

References:

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Shenkman, C., Thakur, D., Llansó, E. (2021) Do You See What I See? Capabilities and Limits of Automated Multimedia Content Analysis. Center for Democracy & Technology. 10.48550/arXiv.2201.11105

The Bowers Institute. (2024, September 10). *Machine Learning Unplugged*. TheTech.org. https://www.thetech.org/media/x5bgn0mj/lesson-machinelearningunplugged.pdf

Brown, S. (2021, April). *Machine learning, explained.* MIT management slogan school. https://mitsloan.mit.edu/ideas-made-to-matter/machine-learning-explained

Background Knowledge Videos/Images:

How was AI used by biologists? https://www.youtube.com/watch?v=QwhK3SBHdcY
How does AI work? Machine Learning: https://youtu.be/OeU5m6vRyCk
Shark External Anatomy from https://marinewaters.fish.wa.gov.au/

Exploration Cards' Image Credits:

1) Shark 1: https://cdn.britannica.com/79/65379-050-5CF52BAC/Shortfin-mako-shark-seas.jpg
2) Shark 2: https://www.hsi.org/wp-content/uploads/2018/09/SHARK_GREAT_WHITE_SIDE_VIEW_VANESSA_MIGNON___-e1687389553617.jpg
3) Dolphin 1: https://cdn.vallarta-adventures.com/sites/default/files/2021-08/dolphin-facts.jpg
4) Whale 1: https://worldanimalfoundation.org/wp-content/uploads/2023/08/Blue-Whale-Facts-1.jpg
5) Shark 3: https://static.wikia.nocookie.net/allspecies/images/0/04/G.H.S.jpg/revision/latest?cb=20230606190339
6) Dolphin 2: https://www.georgiaaquarium.org/wp-content/uploads/2018/08/common-bottlenose-dolphin.jpg
7) Shark 4: https://www.bigfishexpeditions.com/wp-content/uploads/2019/07/Dark_Shyshark_005.jpg

8) Dolphin 3: https://images.squarespace-cdn.com/content/v1/57c8fb18ebbd1ada66ecff91/1545336234645-PPDAN3331JG6JL7DW9PD/dolphin+2.jpg
9) Shark 5: https://cdn.mos.cms.futurecdn.net/yBBaWKG8MiNNAVfE4Z2aRJ.jpg
10) Ray 1: https://i0.wp.com/www.australiangeographic.com.au/wp-content/uploads/2023/03/shutterstock_2184217905.jpg?fit=1800%2C1201&ssl=1
11) Dolphin 4: https://i.natgeofe.com/n/935127ed-8987-44ae-8194-ff94643a794d/DQ_Camera-1_3x4.jpg
12) Shark 6: https://www.oceanactionhub.org/storage/2024/01/Great-White-Shark-Facts.jpg
13) Sea Turtle 1: https://natureconservancy-h.assetsadobe.com/is/image/content/dam/tnc/nature/en/photos/t/n/tnc_765560001.jpg?crop=0%2C233%2C4000%2C2200&wid=4000&hei=2200&scl=1.0
14) Shark 7: https://www.bigfishexpeditions.com/wp-content/uploads/2023/04/Oceanic-Whitetip-Shark-Diving-23-150.jpg
15) Shark 8: https://animals.sandiegozoo.org/sites/default/files/2017-04/%20leopard_shark_01.jpg
16) Dolphin 5: https://alchetron.com/cdn/commersons-dolphin-a710c39f-de01-4eda-91e1-fae5c9d6c60-resize-750.jpeg
17) Whale 2: https://c02.purpledshub.com/uploads/sites/62/2016/05/GettyImages-912769276-c96f25b.jpg
18) Ray 2: https://www.iucnssg.org/uploads/5/4/1/2/54120303/rhynchobatus-djiddensis-matthewdpotenski-proteabanks-southafrica_orig.jpg