

PATTERNS: FIRST LESSON ([link to lesson](#))



Standards alignment:
Common Core:
[6.G.A.3](#),
[HSG.MG.A.3](#),
[HSG.MG.A.1](#),
[HSS.MD.B.6](#)

Summary/Overview:

In this lesson, you will learn about the geometry of dinosaur scales. You'll make your own skin model using something called a "Voronoi partition", which is a way of applying randomness to create organic looking geometry.

Lesson Structure: This lesson contains 7 videos and 4 exercises which alternate back and forth. One way to run this is to watch and discuss all videos as a group (using a screen at the front of the room) while letting students return to their computers to do the exercises when required.

Total Time Recommended:

Approximately 60 minutes to complete the videos and exercises.

Age: Grade 5 - infinity and beyond!

Objectives:

In this lesson, students will:

- Explore the geometry behind the creation of dinosaur skin.
- Create a model for their own dinosaur skin using a Voronoi partition.

Materials Needed:

- Indoor classroom, lab, or open space with seating and access to the Internet. Space should have enough seating, ideally facing a teacher/facilitator's projection screen.
- Teacher/facilitator should have a computer connected to a large monitor or projector and speakers.
- This lesson assumes that each student or pair of students will require a device to access the lessons online.

VIDEO 1: Introduction to Patterns (length: 3 mins)

Instructions: Have everyone sit where they can see the screen. From the lesson page, play the video “Introduction to Patterns.” When the video ends, start a discussion with your group using questions below.

Key terms / Vocabulary:

- **Shading** - creating the surface appearance (shiny, sticky, smooth, rough...) of three-dimensional objects.

Discussion questions (5 mins):

- **Q:** True or false: Shaders try to re-create reality.
- **A:** False, they are only trying to capture the essential qualities of a surface that make it feel believable.
- **Q:** Why do you think it’s important for shaders to look at reference images, or things from the real world?
- **A:** It helps them understand how surfaces reacts to light, and how bumpy or smooth it is.
- **Q:** What does a pattern need in order to feel organic?
- **A:** Randomness

VIDEO 2: What are shading packets? (length: 4 mins)

Instructions: Introduction to shading packets. Have everyone sit where they can see the screen. From the lesson page, play the video “What are shading packets?” When the video ends, start a discussion with your group using questions below.

Key terms / Vocabulary:

- **Shading packet** - a collection of drawings and images that guides the process of creating believable surface texture.
- **Extrude** - to stick out

Discussion Questions (3-4 minutes):

- **Q:** What are some of the dino leg shader packet items?
- **A:** Some reference images, some color specs, and some real reference. Those are for the claws.
- **Q:** Why do you think it’s helpful to use a real claw?
- **A:** To see how the surface reacts to light
- **Q:** Can you think of other textures in real life that could be studied to create dinosaur skin? What are a few?
- **A:** Broccoli, cauliflower, leather, tree bark, blackberries, raspberries, lizard skin, to name a few...

EXERCISE 1: Shading Packets (5-10 mins)

9 problems covering some key concepts

Instructions: We've been presented with this reference for the dinosaur leg. Let's warm up with this before moving onto real shading packets. After students are nearly finished, check for understanding before moving on to the next video (remind students they can find help in the hints for each question):

Exercise Questions:

- **Q:** What did you learn about shading packets in this exercise?

VIDEO 3: Voronoi Partition (length: 3 mins)

Instructions: Have everyone sit where they can see the screen. From the lesson page, play the video "Voronoi Partition." When the video ends, start a discussion with your group using questions below.

Note: You can explore the interactive program used in this video [here](#).

Key terms / Vocabulary:

- **Voronoi pattern** - irregular pattern found in nature
- **Sites** - bubble centers
- **Cell** - bubble regions
- **Vertex** - point wherever three lines meet

Discussion Questions (4-5 mins):

- **Q:** In the voronoi pattern, what is the main difference between SITES and CELLS
- **A:** SITES are in the center of CELLS, CELLS are shapes defined by the borders
- **Q:** What happens to bubbles when they blow up next to other bubbles?
- **A:** They collide at a single point, which grows into a line where they squish together.
- **Q:** Can you think of other Voronoi patterns in nature?
- **A:** Turtle shells, mudd, shells, pedals on a rose, snakeskin, leopard spots...

EXERCISE 2: Constructing a Voronoi partition (length: 15 mins)

9 problems covering some key concepts

Instructions: After students are nearly finished, check for understanding before moving on to the next video (remind students they can find help in the hints for each question):

Exercise Questions (2-3 Mins):

- **Q:** If you used hints, were there any terms that you didn't understand?
- **A:** See what comes up, and if someone can't answer it, let us know!

(piab@khanacademy.org)

VIDEO 4: Distributing Sites Randomly (length: 3 mins)

Instructions: What is the best way to distribute our points? Have everyone sit where they can see the screen. From the lesson page, play the video “Distributing Sites Randomly.” When the video ends, start a discussion with your group using questions below.

Note: You can explore the interactive program used in this video [here](#) and [here](#).

Key terms / Vocabulary:

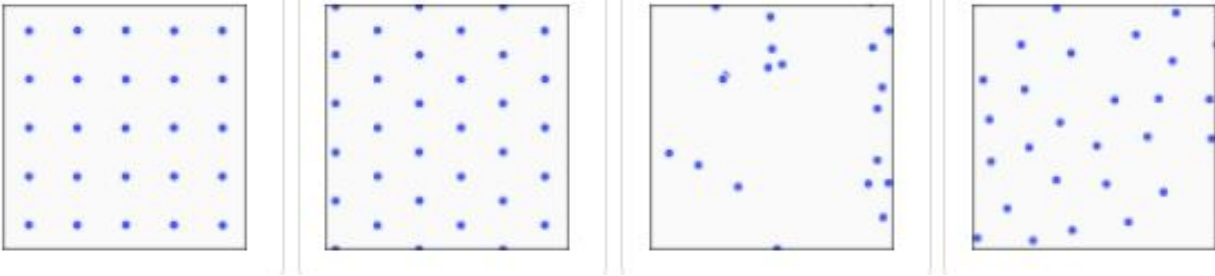
- **Poisson Disk Process** - A smooth way of distributing points where a minimum site distance is established.

Discussion Questions (2-3 mins):

- **Q:** Can you think of some other things in nature that have randomness?
- **A:** Generate a list from contributors
- **Q:** Can a pattern be too random to look believable?
- **A:** Yes, that’s why you use the Poisson Disk Process
- **Q:** How does the Poisson Disk Process help make patterns look more believable?
- **A:** It helps prevent clumping and spaces out the points more evenly.

EXERCISE 3: Poisson Disc Process (length: 5-10 mins)

5 problems



Instructions: After students are nearly finished, check for understanding and see if everyone was able to answer the questions (remind students they can find help in the hints for each question.)

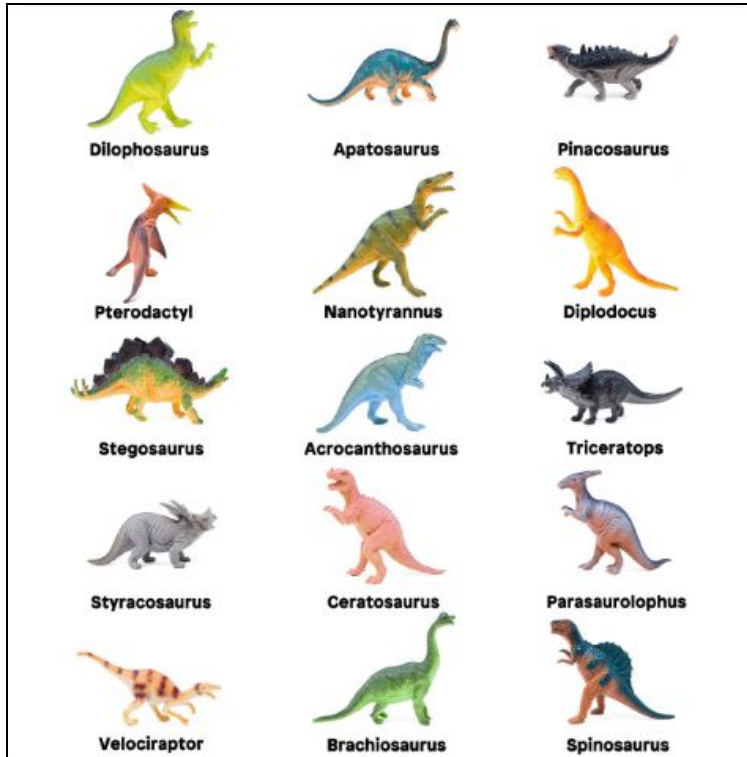
VIDEO 5: Modeling Dino Skin (length: 3 mins)

Instructions: Create a basic model for your dino skin. Have everyone sit where they can see the screen. From the lesson page, play the video “Modeling Dino Skin.” When the video ends, start a discussion with your group using questions below.

Discussion Questions 3-5 mins:

- **Q:** True or false: The gap between scales should be the same thickness everywhere.
- **A:** False, that doesn't look natural. Increase the Jitter number to create more believable skin.
- **Q:** How does it help to have separate color controls for both the skin and the scales?
- **A:** If you use different colors, it helps to define each area by creating contrast
- **Q:** Which usually comes first, the model or the shading?
- **A:** Usually, the model comes first, but sometimes the model changes after shading has already started

EXERCISE 4: Make Your Own Dino Skin 1 (length: 5-10 mins)



Instructions: Use this program to design your own pattern for a dinosaur's leg. Have students decide on a dinosaur type before beginning using references if available. When they're happy with the result, press the Render in 3D button to see how it would look.

Note: There is no export feature for the final results, but students can share screens or take a screenshot and send it to you.

Exercise Prompts (5 mins):

- **Q:** What type of dinosaur did you create skin for?
- **Q:** Where would you add sites to create more flexibility in the characters' leg?
- **A:** Wherever the characters' leg bends
- **Q:** What does deleting sites do to the pattern?
- **A:** Makes the existing sites bigger.
- **Q:** What happens to the appearance of your dino skin when you put extrude at 0?
- **A:** It looks flat, lacks depth

VIDEO 6: Getting to know Ana (length 5 mins)

Instructions: Have everyone sit where they can see the screen. From the lesson page, play the video “Getting to know Ana.” When the video ends, start a discussion with your group using questions below.

Discussion Questions (5 mins):

- **Q:** What inspired you about Ana’s experience?
- **Q:** What did Ana mean by “I’m kind of a right brain, left brain” person?
- **A:** She likes arts AND engineering, which are two very different ways of thinking typically affiliated with the left and right side of the brain.
- **Q:** Can you think of any other careers that combine arts and engineering?
- **A:** Architecture, video-games, amusement parks, city planning, set-design...
- **Q:** What does a shader do?
- **A:** Create the material qualities for models and objects
- **Q:** Does anything about Ana’s advice ring true for you?

VIDEO 7: Getting to know Beth (length 3 mins)

Instructions: Have everyone sit where they can see the screen. From the lesson page, play the video “Getting to know Beth.” When the video ends, start a discussion with your group using questions below.

Discussion Questions (5 mins):

- **Q:** What inspired you about Beth’s path?
- **Q:** What jobs do you think will exist when you grow up that don’t exist now?
- **Q:** Did anything about Beth’s advice spark an interest in you?