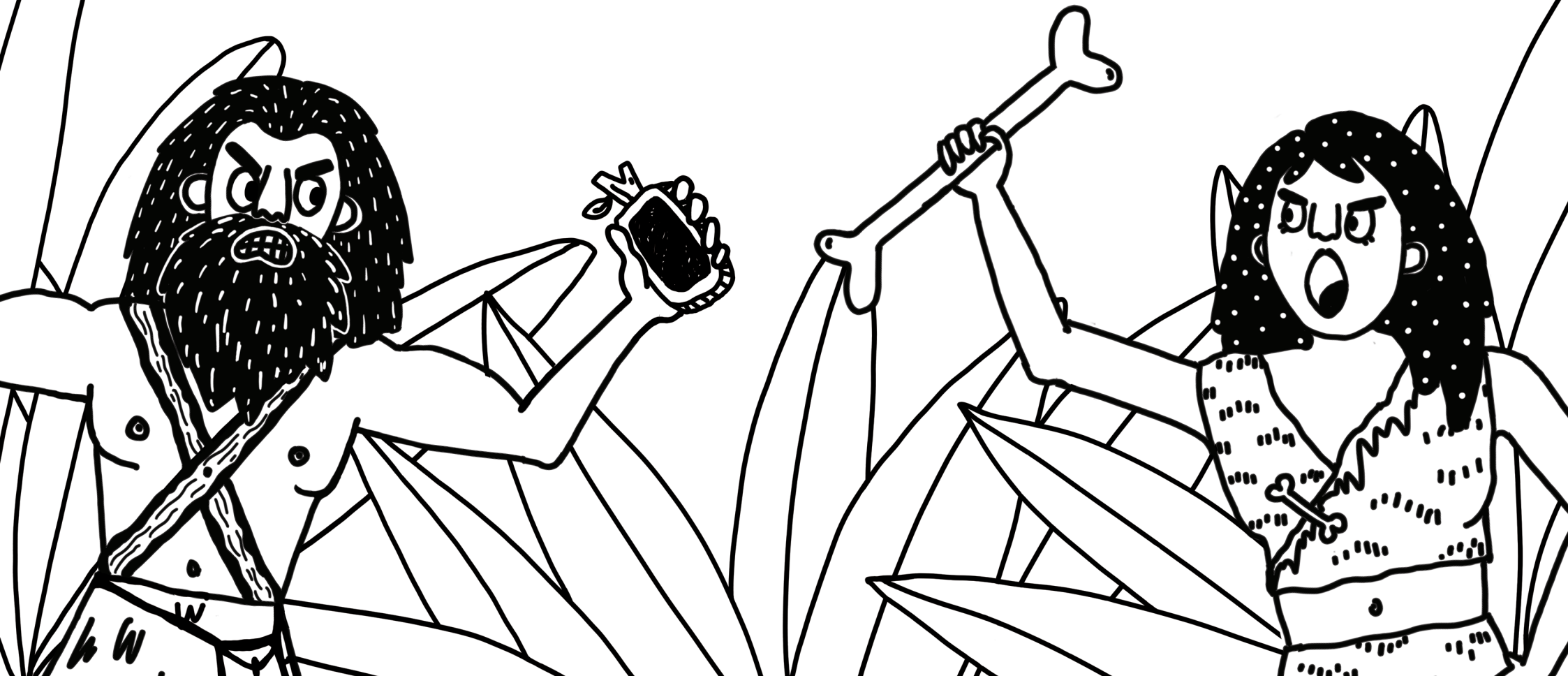


FROM 2 TO 8 PLAYERS - FROM 6 YEARS OLD  
≈ 45 MINUTES

# SMARTSTONE

CHALLENGE YOUR OPPONENTS WITH YOUR SMARTPHONE AND A FLINT



SINCE THE DAWN OF TIME, THE TWO RIVAL CLANS OF THE MAMMOTH VALLEY HAVE COME TOGETHER EVERY YEAR TO COMPETE FOR THE BEST TRIBE CUP. THIS CUP IS THE PRIDE OF THE WINNING TRIBE. THIS YEAR THE TWO TRIBES NEED YOUR HELP TO CONFRONT EACH OTHER. ARE YOU UP TO THE CHALLENGE?





OFFICIAL SPONSOR OF FIGHTING TRIBES

# SMARTSTONE

## THE INTELLIGENT STONE

FIRST, DOWNLOAD  
PHYPHOX TO FACE  
YOUR OPPONENTS!



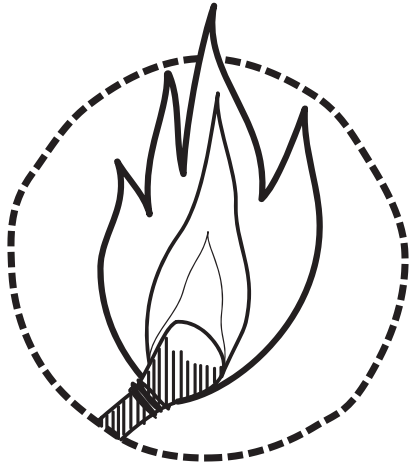
PHYPHOX IS THE MOST DOWNLOADED  
PALEOLITHIC APPLICATION ! IT'S  
AVAILABLE FOR FREE ON THE APP  
STORE AND GOOGLE PLAY AND WILL  
USE YOUR SMARTPHONE'S SENSORS  
TO TAKE LOTS OF MEASUREMENTS!



# WHO'S THE BEST?

FOUR EVENTS, FOUR MEDALS TO WIN!

WATCH  
YOUR HEAD



WINNING TEAM :

.....

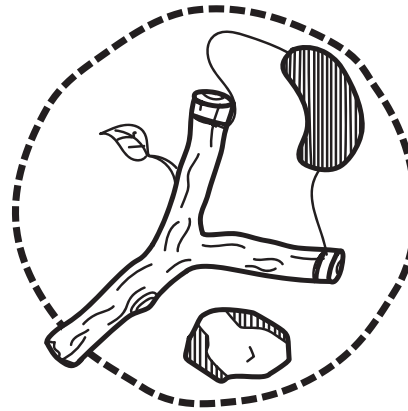
THE CAVESTONE  
LESSON



WINNING TEAM :

.....

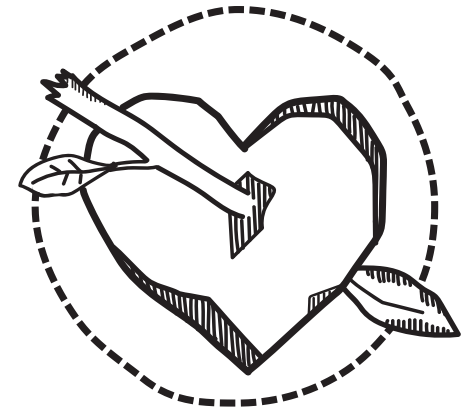
CRUSH THE  
T-REX



WINNING TEAM :

.....

YOU'VE GOT  
THE RHYTHM



WINNING TEAM :

.....



LIGHT  
YOUR FIRES

ROUND 1

**WATCH YOUR HEAD**



# INSTRUCTIONS



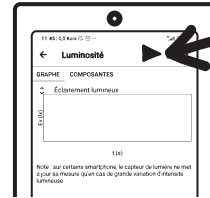
EACH TEAM HAS A GAME SHEET FOR THE MAZE AND PLAYERS COMPETE IN PAIRS. THERE ARE AS MANY ROUNDS AS THERE ARE PLAYERS PER TEAM.

## GAME SETUP

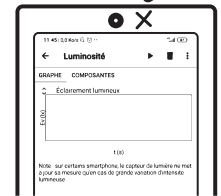
- ① Select « **Light** » in Phyphox . (If you have an iPhone see the box).



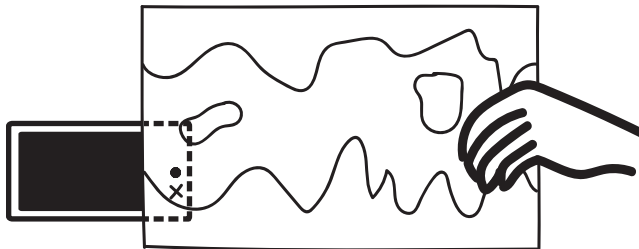
- ② Press **play** to start the measurement. From now on, your phone **measures the amount of light it receives.**



- ③ The **light sensor** is usually located next to the front camera.

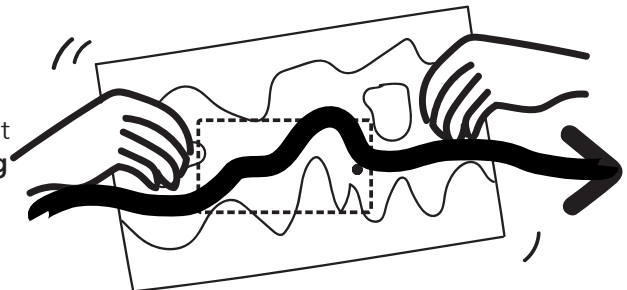


- ④ Place your smartphone on a table and **place the game sheet on top** as shown in the figure



## COURSE OF THE GAME

- ⑤ **Move the maze** so that your phone's sensor comes out of it **without encountering any obstacles.**

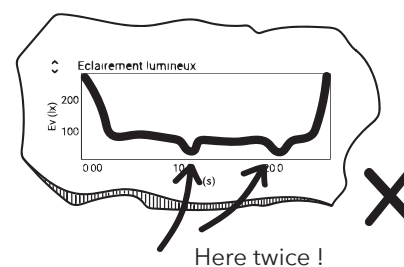
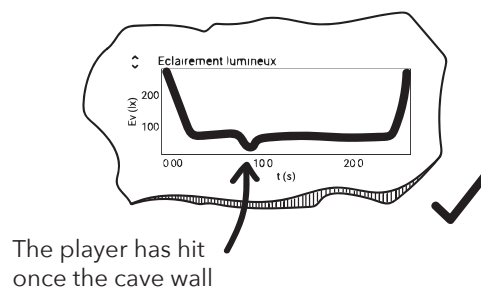


## HOW TO WIN

- ⑥ Press **pause** and compare the result with other players



- ⑦ The winner is the player whose graph shows the **fewest "peaks" down.**

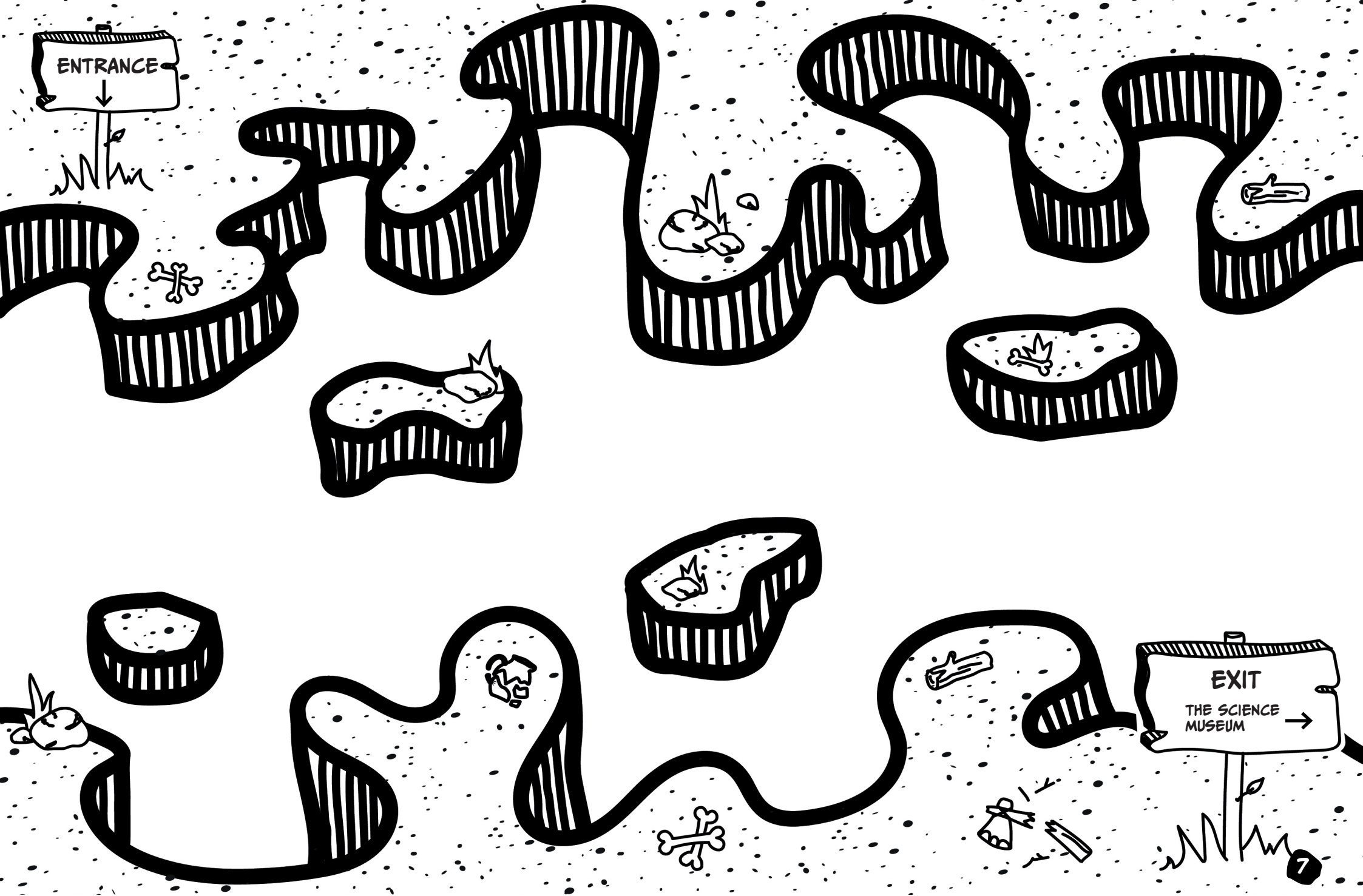


### WHAT IF YOU HAVE AN IPHONE ?

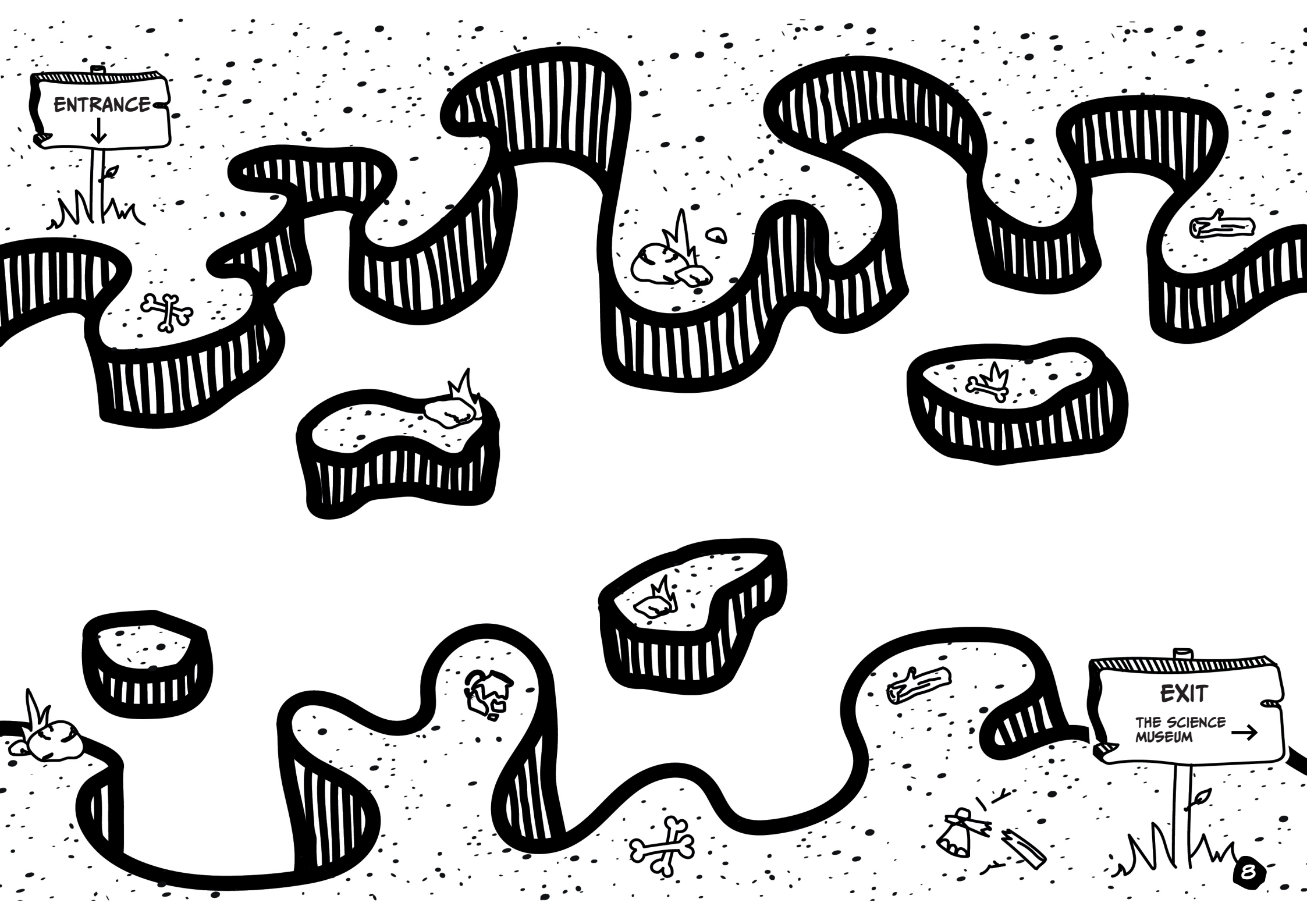
The game is the same but instead of using Phyphox , **record a video with your phone's front camera** and start at step ④ . Then watch the video : when you see black it means that you have encountered an obstacle.

ENTRANCE

NW



EXIT  
THE SCIENCE  
MUSEUM



ENTRANCE

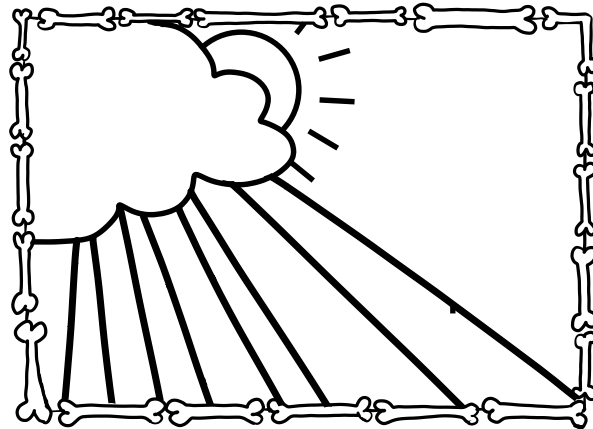
Nm

EXIT  
THE SCIENCE  
MUSEUM

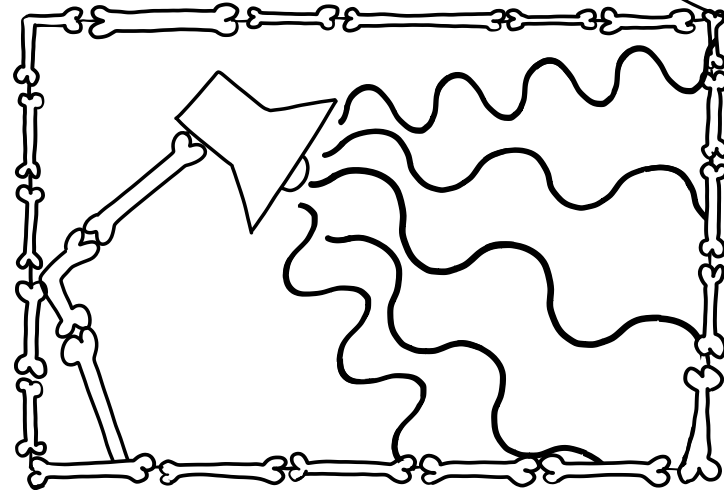


WELCOME TO THE CAVESTONE  
SCIENCE MUSEUM !

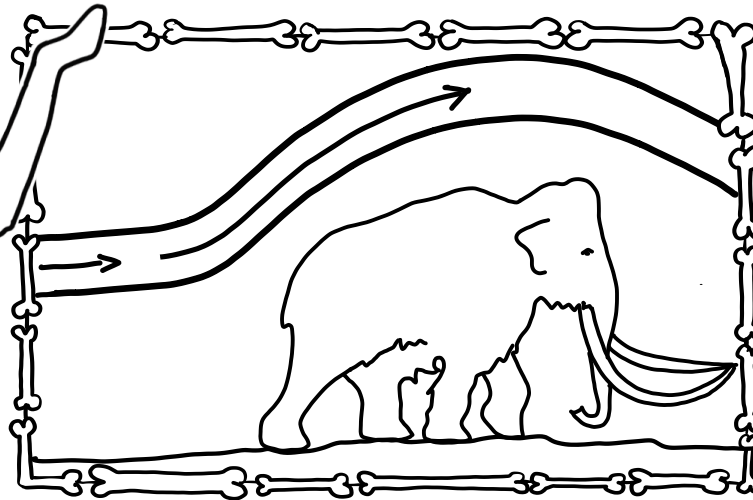
WHAT DO YOU THINK LIGHT IS ?



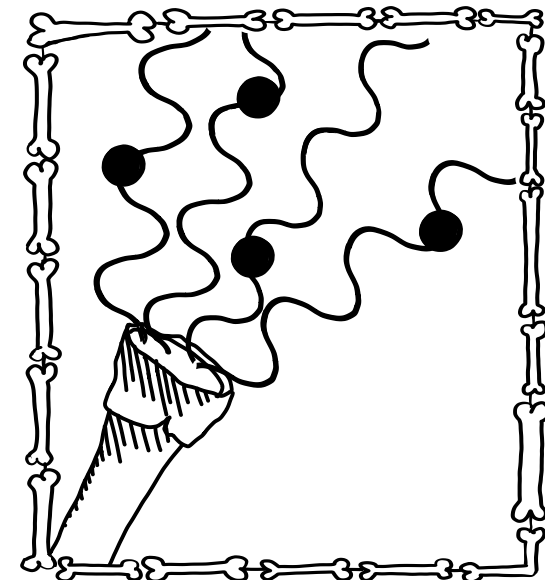
① LIGHT IS MADE  
OF GEOMETRIC RAYS



② LIGHT IS AN ELECTROMAGNETIC WAVE WHICH  
ADVANCES AT 300 000 KM / S



③ LIGHT INHABITS A RELATIVISTIC SPACE-TIME  
DISTORTED BY ~~MAMMOTH'S~~ MASS



④ LIGHT IS MADE UP  
OF QUANTUM PHOTONS

Answer : All of these definitions of light are correct !  
It all depends on the scale at which we observe it.



ROUND 2  
**THE CAVESTONE LESSON**





# INSTRUCTIONS



- 1 Choose one of the three cavemen music sheets and start the **Audio Amplitude** on Phyphox. Press **play**. Your phone now measures the **intensity of your voice**.



- 2  Start **screaming the sounds**, trying to reproduce the shape of the graph as closely as possible.

Start **screaming the sounds**, trying to reproduce the shape of the graph as closely as possible.

- 3 Compare the **graph** obtained on Phyphox with the original one. The team which has the **closest graphs** wins the round.

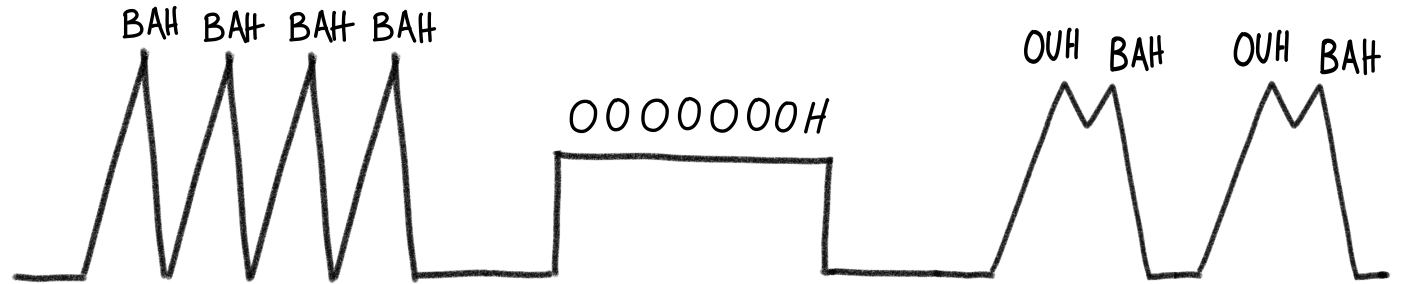


## FOR INFORMATION

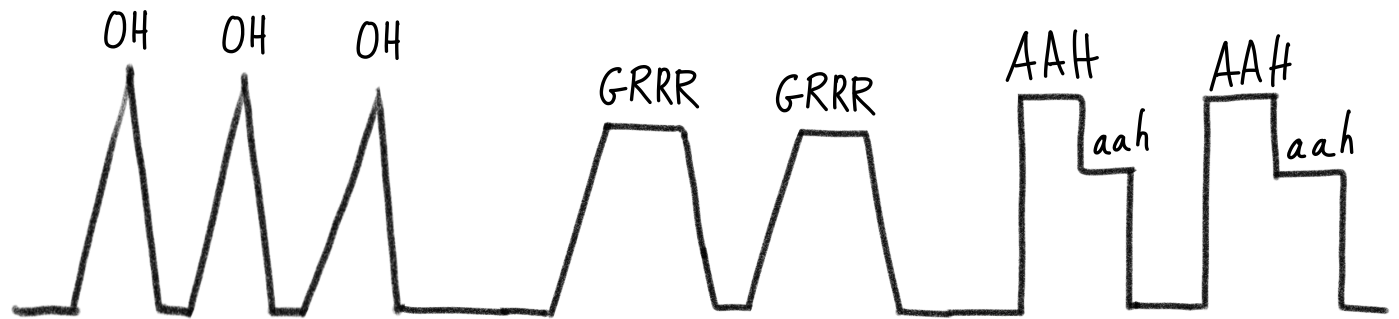
Strong sound  weak sound

short sound  long sound

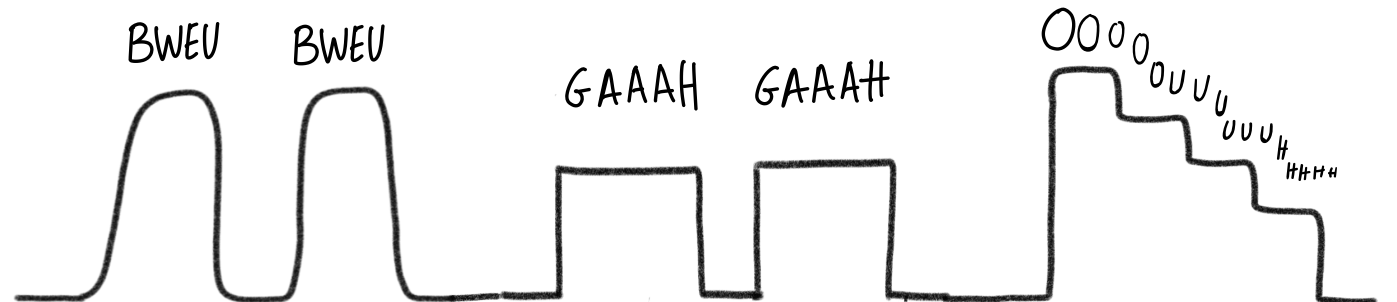
MUSIC SHEET 1



MUSIC SHEET 1 2



MUSIC SHEET 1 3



# WHAT HAPPENS WHEN YOU SHOUT "AAAHHH" ?



YOUR VOCAL CORDS  
ARE VIBRATING.

THIS VIBRATION PROPAGATES THROUGH THE AIR BY  
COMPRESSING OR EXPANDING IT. THESE COMPRESSIONS  
PROGRESS AT ABOUT 340 M / S.

THEY MAKE THE MEMBRANE OF  
THE SMARTPHONE'S MICROPHONE  
VIBRATE AND IT TRANSFORMS INTO  
AN ELECTRICAL SIGNAL DETECTED  
BY PHYPHOX .



ROUND 3

**CRUSH THE T-REX**



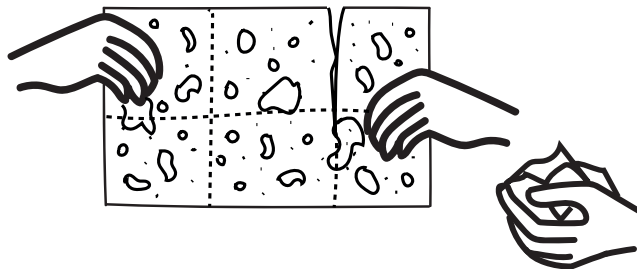
# INSTRUCTIONS



EACH TEAM HAS TWO PAGES WITH STONES AND A T-REX PAGE. THEY PLAY SIMULTANEOUSLY.

## GAME SETUP

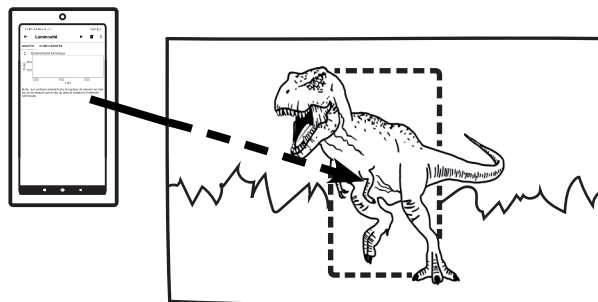
- ① Prepare your ammunition by tearing the sheets along the dotted lines into small paper balls (6 per page).



- ② Launch the « Acceleration sensor (with g) » on Phyphox and press **play**. Your smartphone now measures **its own acceleration**. Click on the lower curve in yellow. As soon as the ball hits the smartphone, it will measure a small acceleration.

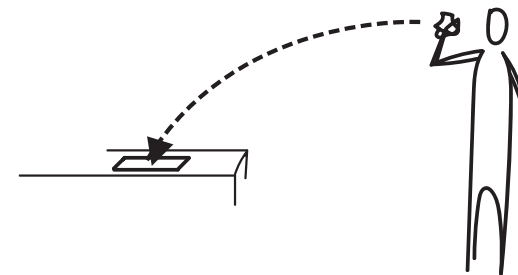


- ③ Put your smartphone on a table and **place the T-rex sheet on top**. Your smartphone must be **under the dotted area**.



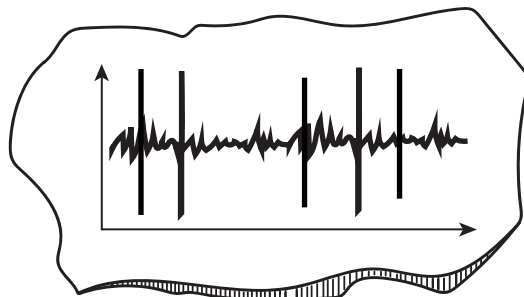
## DÉROULÉ DU JEU

- ④ Place yourself **about 2 meter from the target**. Attack the T-rex with your team by throwing the 12 paper balls at it.



## HOW TO WIN ?

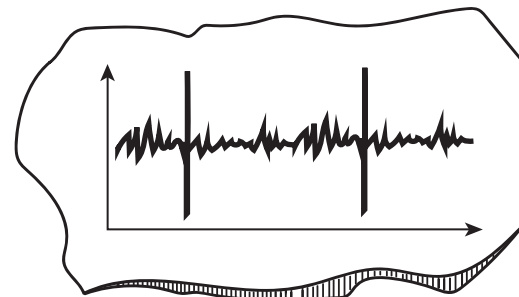
- ⑤ Count the number of **peaks** on your graph, these correspond to the **number of balls that touched the T-rex**. The team with the most wins.



5 peaks = 5 balls



WON



2 peaks = 2 balls



LOST

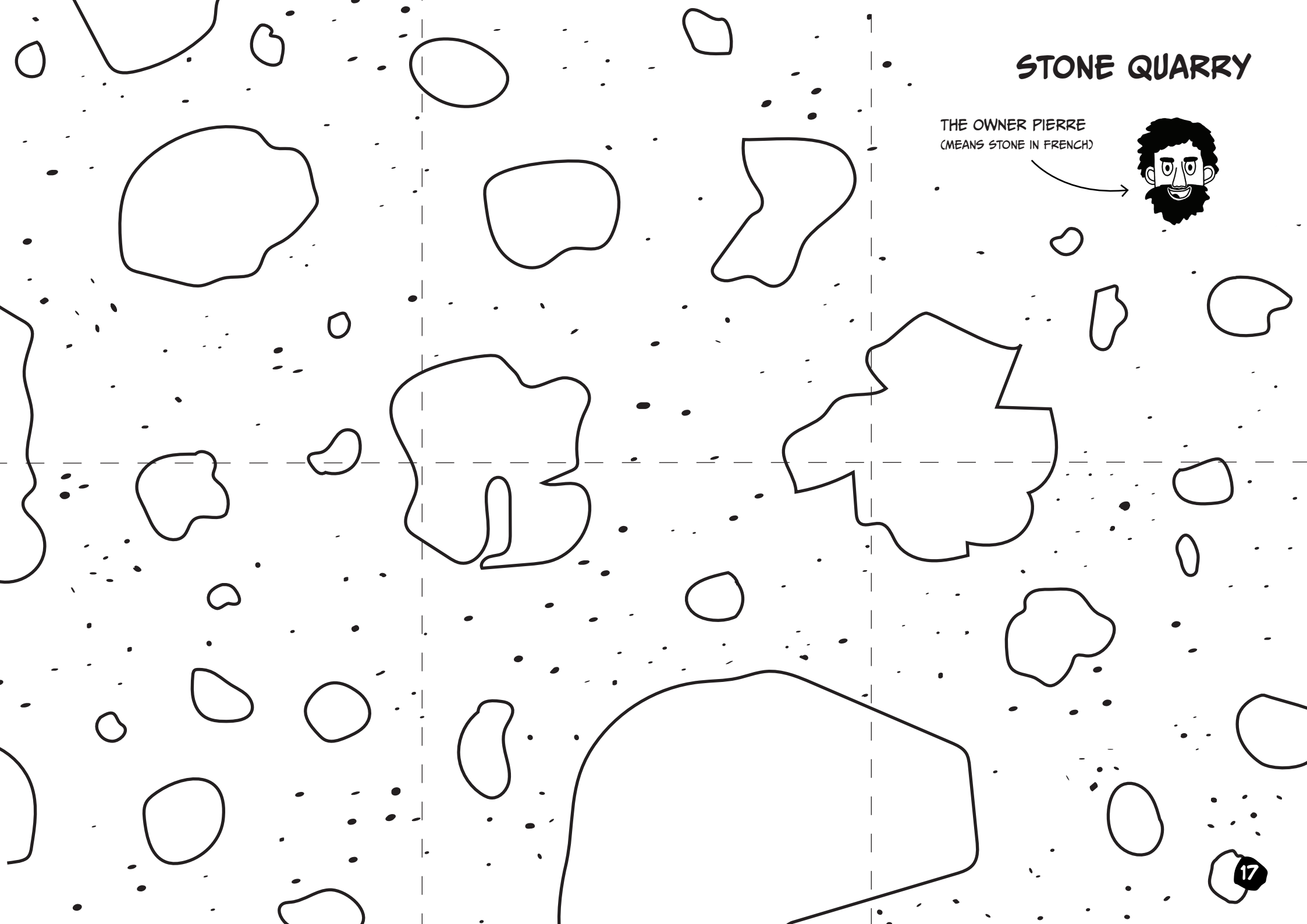
# STONE QUARRY

THE OWNER PIERRE  
(MEANS STONE IN FRENCH)



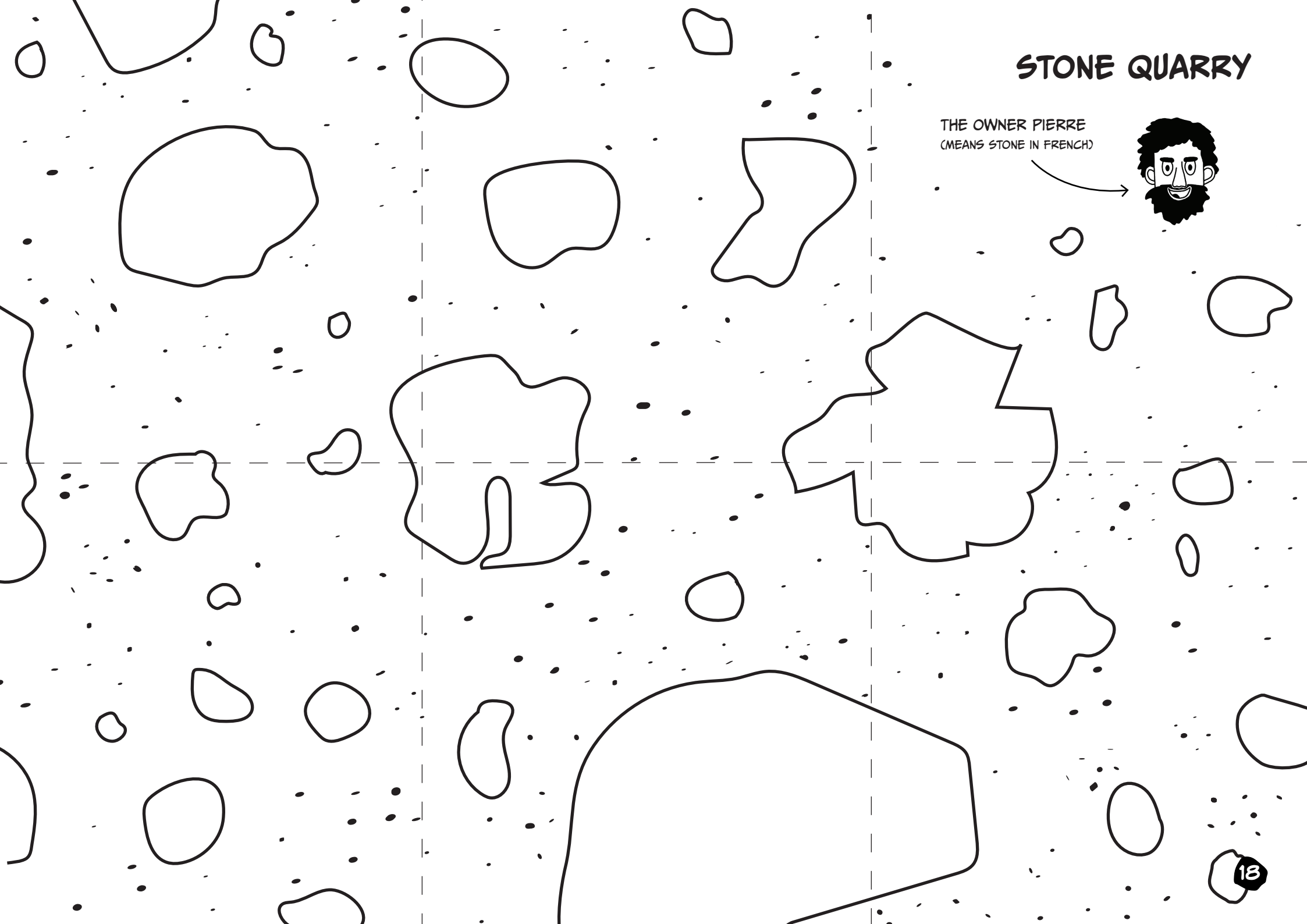
# STONE QUARRY

THE OWNER PIERRE  
(MEANS STONE IN FRENCH)



# STONE QUARRY

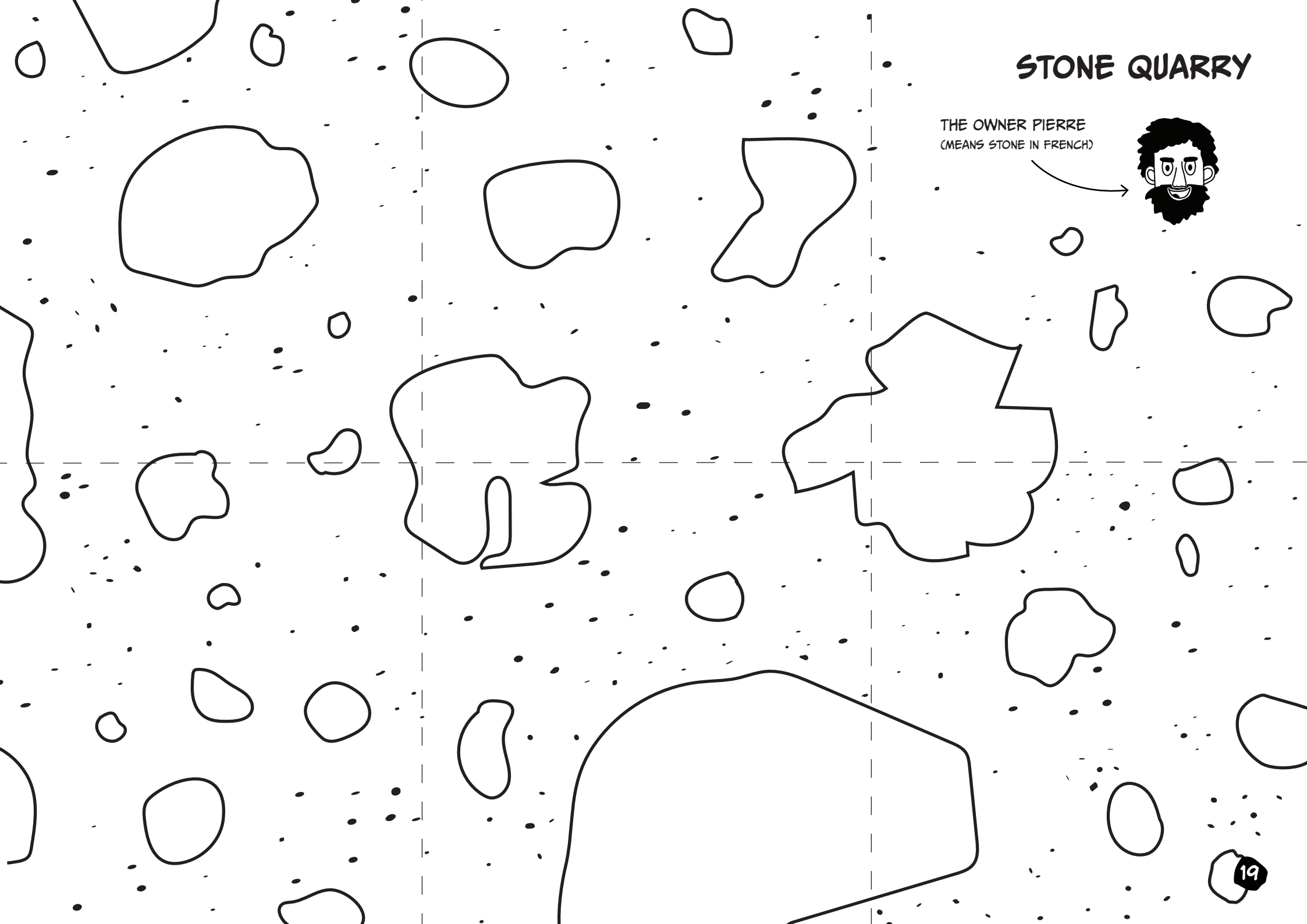
THE OWNER PIERRE  
(MEANS STONE IN FRENCH)

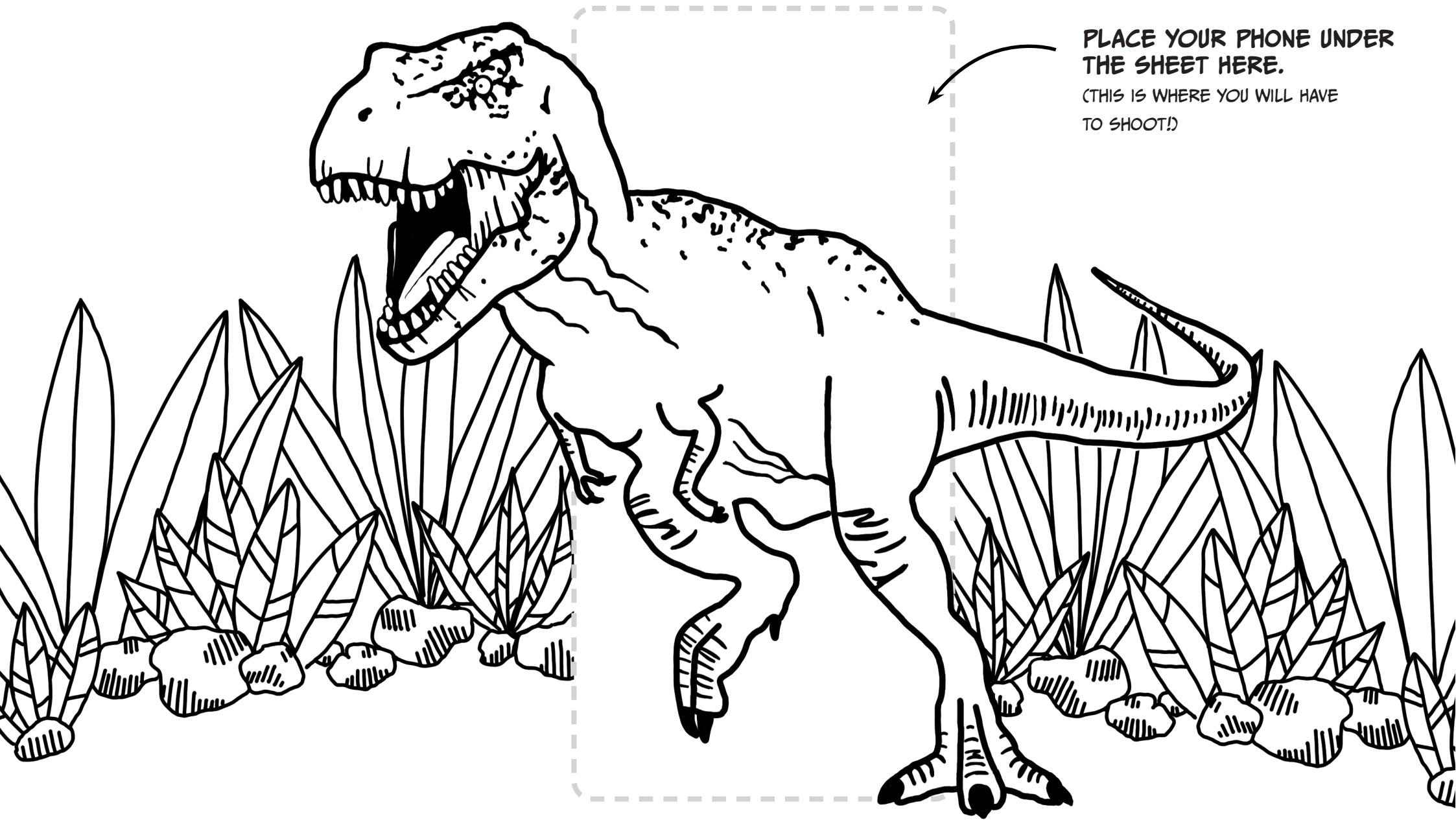




# STONE QUARRY

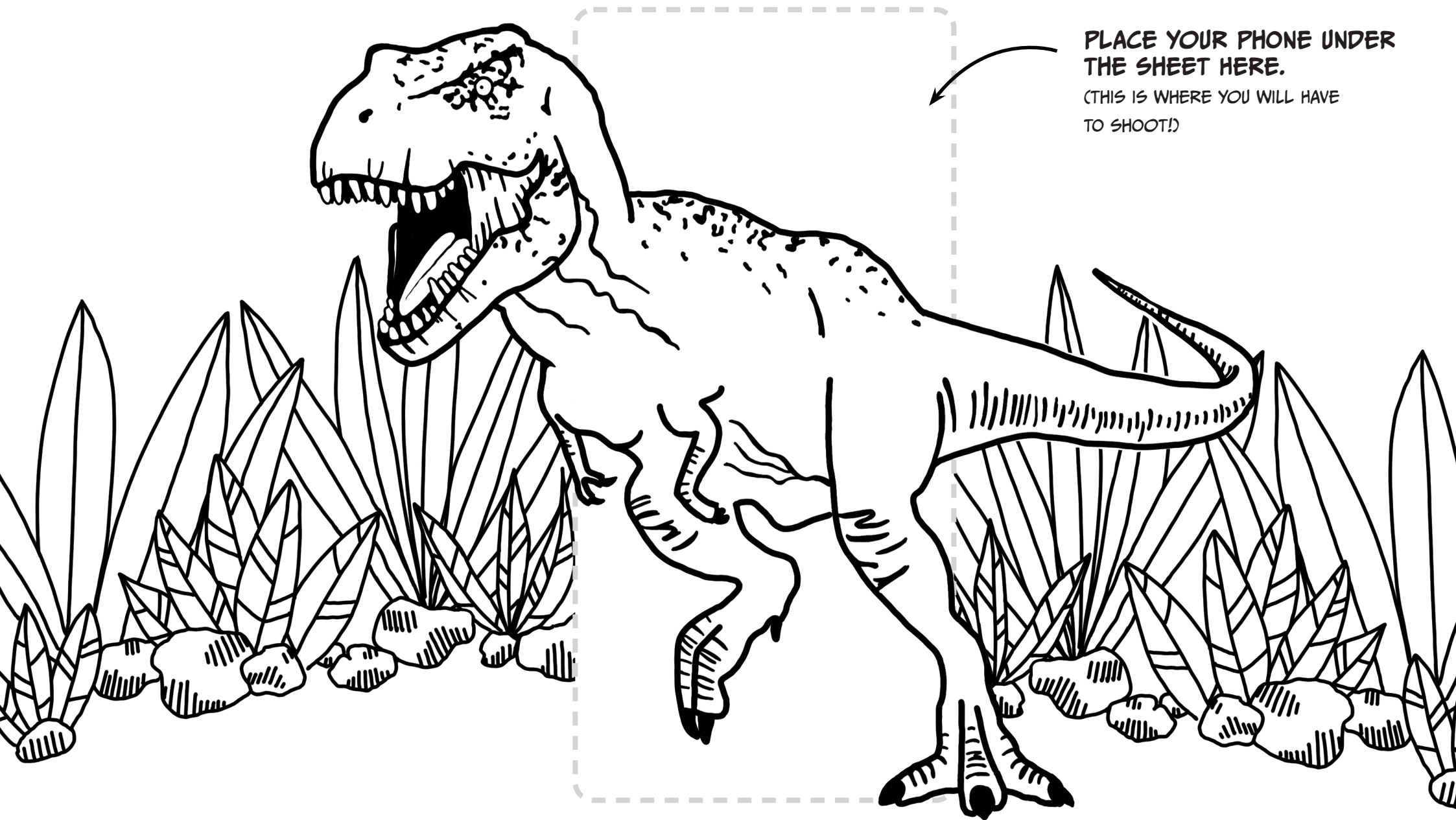
THE OWNER PIERRE  
(MEANS STONE IN FRENCH)





**PLACE YOUR PHONE UNDER  
THE SHEET HERE.**

(THIS IS WHERE YOU WILL HAVE  
TO SHOOT!)



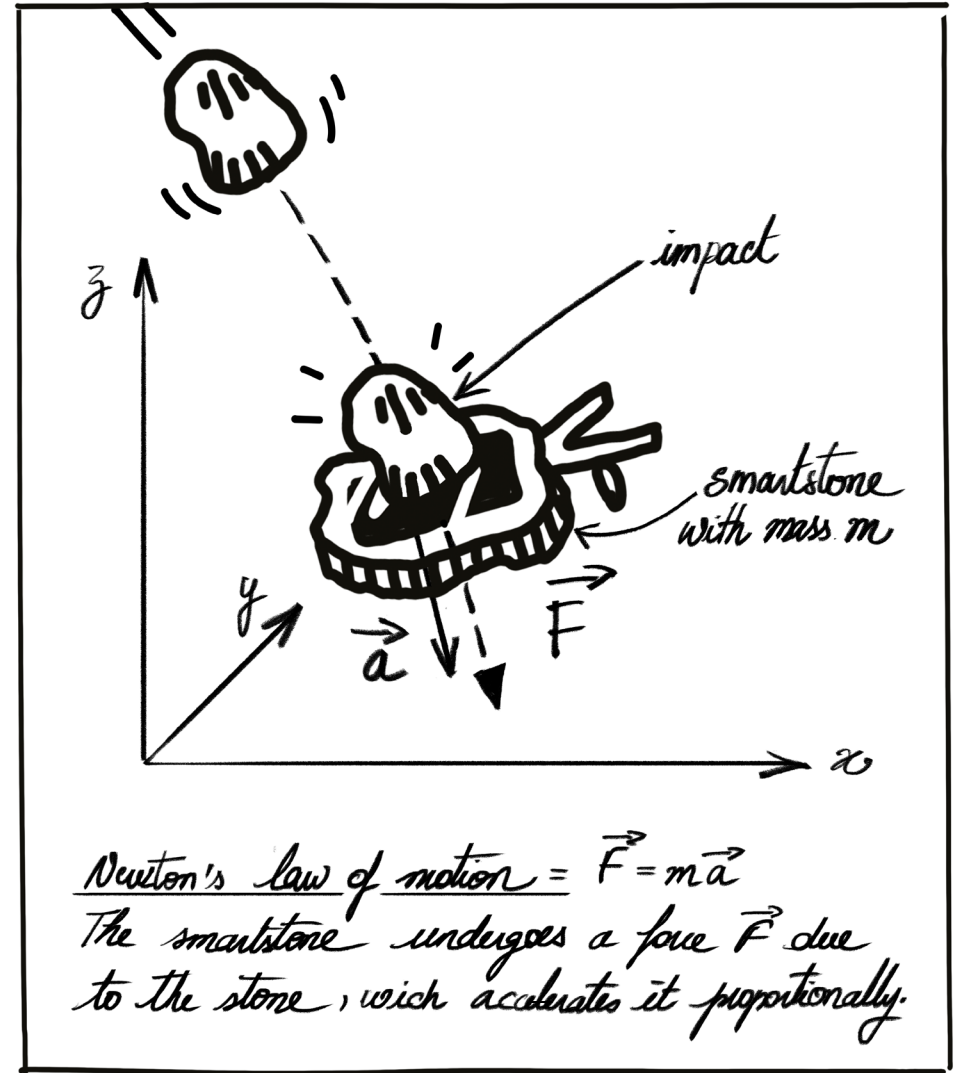
PLACE YOUR PHONE UNDER  
THE SHEET HERE.

(THIS IS WHERE YOU WILL HAVE  
TO SHOOT!)

WHAT A CAVESTONE  
- LIKE YOU AND ME - SEES:



WHAT A PHYSICIST CAVESTONE SEES:







HEY, YOU'RE  
STONE-CUTE!

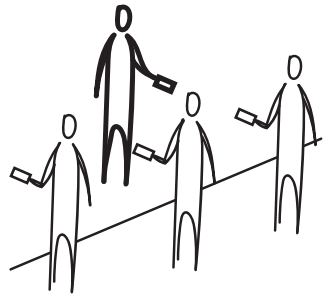
ROUND 4

**YOU'VE GOT THE RHYTHM**

# INSTRUCTIONS



① A **dancing leader** is chosen in each team. He chooses a **choreography** and stands in front of the other players of his team.



② Whether you are leader or follower, **hold your phone flat** in your hand.

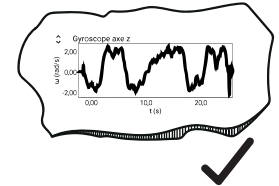
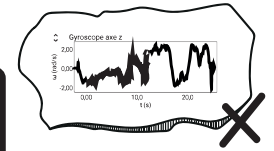
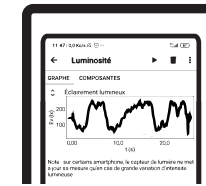
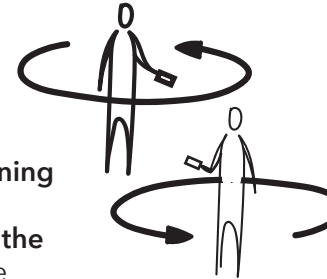


③ All players choose the **Gyroscope** on Phyphox and press **play**. The smartphone will measure the **speed and direction of rotation** of each player.

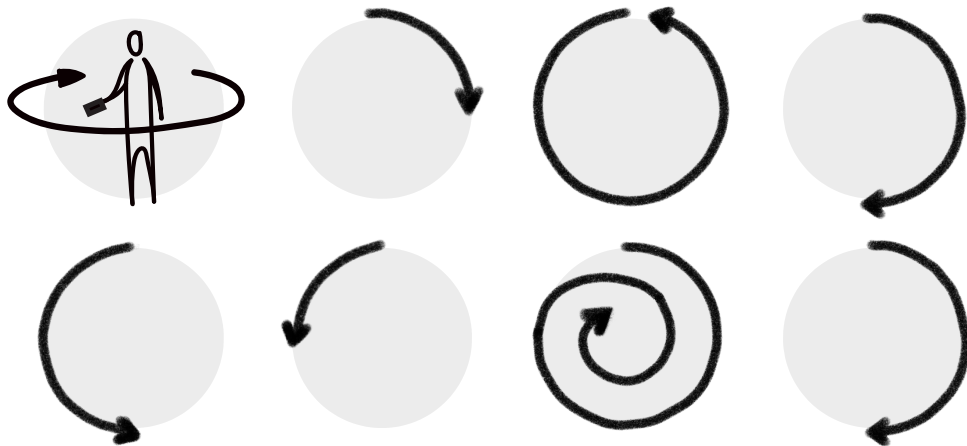


⑤ The followers compare the graph **along z (the 3rd)** they obtained with that of the leader. The team **with graphs most alike wins**.

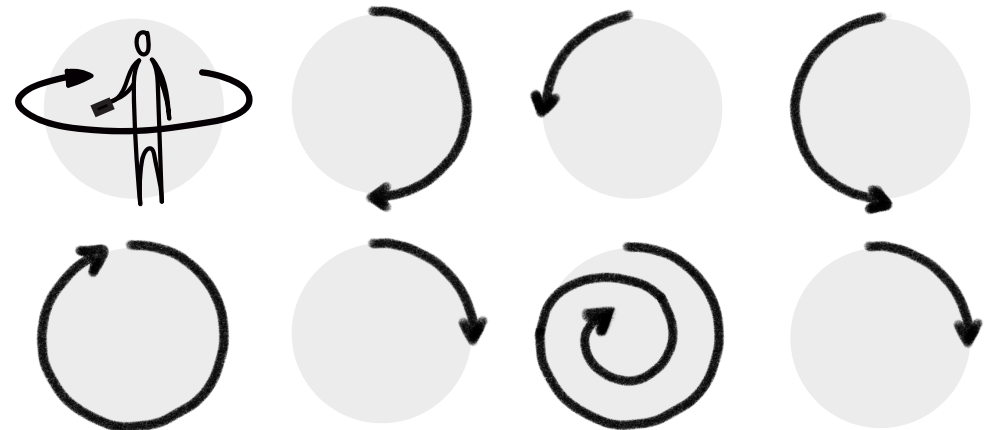
④ The leader follows the symbols of the choreography **by turning on himself**. The followers **turn in the same direction** as the leader (beware of mirror effects).



CHOREOGRAPHY 1



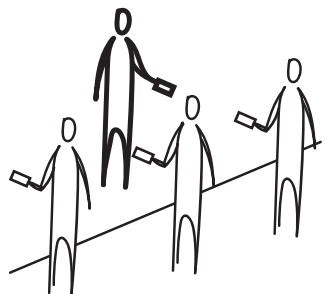
CHOREOGRAPHY 2



# INSTRUCTIONS



① A **dancing leader** is chosen in each team. He chooses a **choreography** and stands in front of the other players of his team.



② Whether you are leader or follower, **hold your phone flat** in your hand.

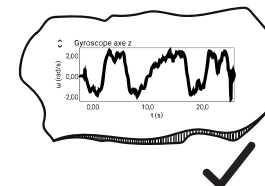
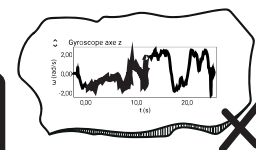
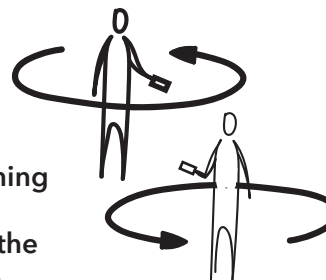


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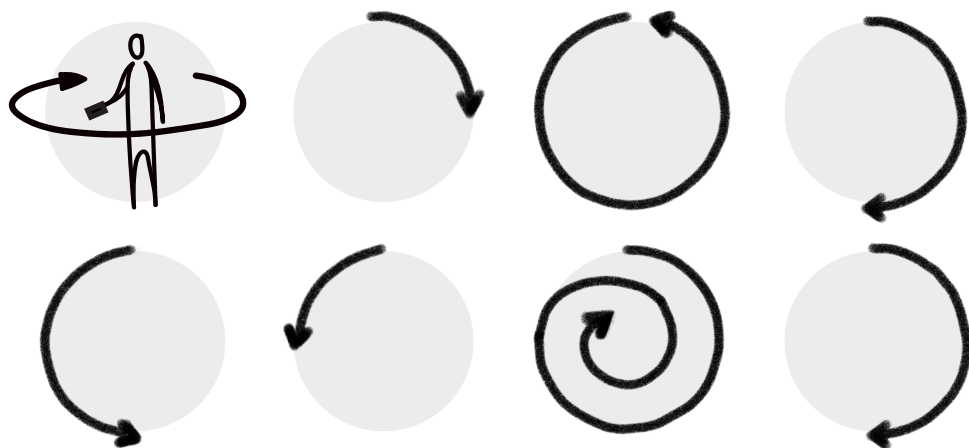


⑤ The followers compare the graph **along z (the 3rd)** they obtained with that of the leader. The team **with graphs most alike wins**.

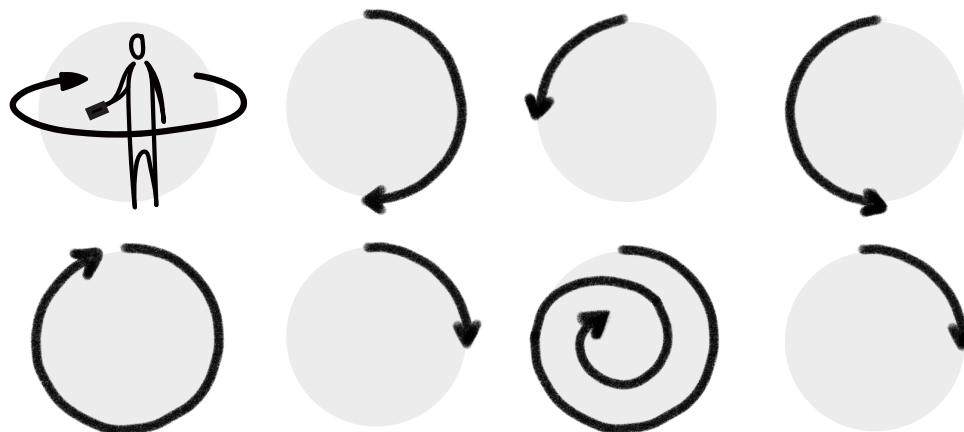
④ The leader follows the symbols of the choreography **by turning on himself**. The followers **turn in the same direction** as the leader (beware of mirror effects).



CHOREOGRAPHY 1



CHOREOGRAPHY 2



# WHAT IS THE WORLD RECORD FOR THE HIGHEST ROTATIONAL SPEED ?

AMONG THE CAVEMEN



THIS CAVEMAN HAS BEEN TRAINING FOR 6 YEARS, HE NOW REACHES A SPEED OF 1.2 LAPS PER SECOND .

IN THE FUTURE (IN 2018)

*physicists levitated  
a 100 nanometer nano-dumbbell*

*then they made it spin*

PHYSICAL REVIEW LETTERS 121, 033603 (2018)

Featured in Physics

**Optically Levitated Nanodumbbell Torsion Balance and GHz Nanomechanical Rotor**

Jonghoon Han,<sup>1</sup> Zhujing Xu,<sup>2</sup> Jaehoon Bang,<sup>1</sup> Yu-Hao Deng,<sup>3</sup> Thai M. Hoang,<sup>2,\*</sup> Qinkai Han,<sup>1</sup> Ren-Min Ma,<sup>3,5,6</sup> and Tongcang Li<sup>1,2,6,7,8</sup>

<sup>1</sup>School of Electrical and Computer Engineering, Purdue University, West Lafayette, Indiana 47907, USA  
<sup>2</sup>Department of Physics and Astronomy, Purdue University, West Lafayette, Indiana 47907, USA  
<sup>3</sup>State Key Lab for Mesoscopic Physics and School of Physics, Peking University, Beijing 100871, China  
<sup>4</sup>The State Key Laboratory of Tribology, Tsinghua University, Beijing 100084, China  
<sup>5</sup>Purdue Quantum Center, Purdue University, West Lafayette, Indiana 47907, USA  
<sup>6</sup>Collaborative Innovation Center of Quantum Matter, Beijing 100871, China  
<sup>7</sup>Birck Nanotechnology Center, Purdue University, West Lafayette, Indiana 47907, USA

(Received 18 April 2018; published 20 July 2018)

Levitated optomechanics has great potential in precision measurements, thermodynamics, macroscopic quantum mechanics, and quantum sensing. Here we synthesize and optically levitate silica nanodumbbells in high vacuum. With a linearly polarized laser we observe the mechanical properties of an optically levitated nanodumbbell. This levitated nanodumbbell provides a sensitive platform to study the quantum nature of a balance, and provides rare access to the nanomechanical rotor realized to date. Smaller silica gravity as proposed recently with the 100-nm-diameter nanodumbbell to rotate by  $1.1 \text{ GHz}$  is the fastest nanomechanical rotor realized to date. Smaller silica nanodumbbells can be used to study the quantum nature of a balance and the quantum nature of a material property.

**WORLD RECORD:  
2.2 BILLIONS TURNS PER SECOND!!!**

DOI: 10.1103/PhysRevLett.121.033603

(a)

(b)



COUNT YOUR MEDALS ... WHO'S THE WINNER?

NAME OF THE WINNING TRIBE:

.....

**CONGRATULATIONS.**  
**YOU ARE THE TRIBE OF THE YEAR !!!**

STONE-SIGNATURES OF THE MEMBERS:

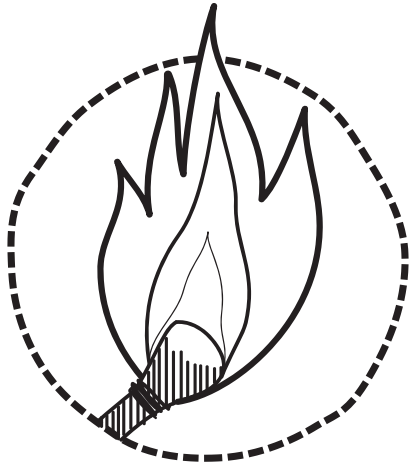


THIS PROJECT WAS CARRIED OUT BY AGATHE LACOMBE AND IRIS LAUMER IN COLLABORATION WITH THE "PHYSICS REIMAGINED"  
TEAM (PARIS-SACLAY UNIVERSITY , CNRS ).

It benefited from the support of the Chair « La Physique Autrement », supported by the Paris-Saclay Université Foundation supported by the Air Liquide group.  
We want to thank The Institut Villebon-Georges Charpak for its welcome and help. You can find the project on [www.vulgarisation.fr](http://www.vulgarisation.fr).

# BONUS : WHICH CAVEMAN ARE YOU ?

IT'S GOOD TO WIN, BUT EVEN BETTER TO KNOW YOUR STRENGTHS AND WEAKNESSES. THE CAVEMAN PROFILE THAT SUITS YOU IS THE ONE ASSOCIATED WITH THE EVENT IN WHICH YOU STOOD OUT!



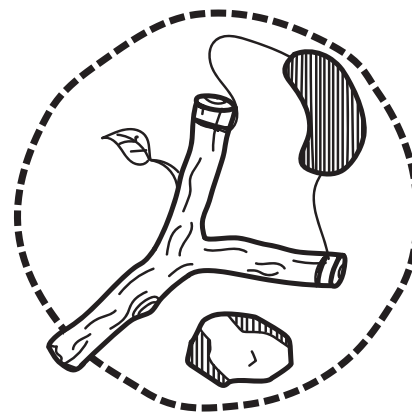
## THE SKILLFULL

CROSS A DARK CAVE WITHOUT BUMPING INTO THE WALLS? EASY ! YOU ARE SKILLED, THAT'S WHY MEMBERS OF YOUR TRIBE REGULARLY CALL ON YOU WHEN THEY FAIL TO DO A TASK THAT REQUIRES SKILL LIKE CARVING A FLINT OR MAKING HARPOONS.



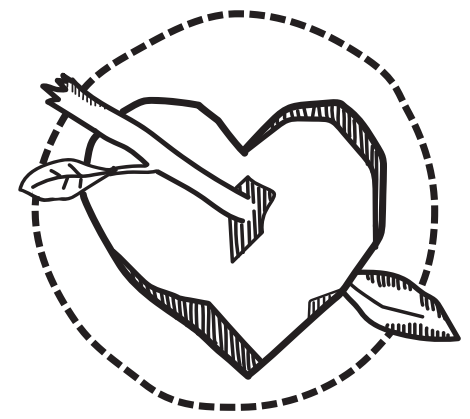
## THE NERD

YOU WERE ALWAYS THE FIRST AT CAVEMAN'S SCHOOL. YOU ARE A MASTER OF ELOQUENCE: "GROUH GROUH BAAAAAGAAH BWEEUHH", THIS IS WHAT MAKES YOU THE THINKING HEAD OF YOUR TRIBE. EVERYONE LISTENS TO YOU AND YOUR IDEAS ARE OFTEN CHOSEN.



## THE INTREPID

WHAT YOU LIKE BEST IS THE GREAT OUTDOORS AND THE PHYSICAL EFFORT. YOU NEVER MISS AN OPPORTUNITY TO GO HUNTING MAMMOTHS AND YOU NEVER MISS YOUR TARGET. RATHER LONELY, YOU CAN ALSO COMBINE YOUR STRENGTHS WITH THOSE OF YOUR TRIBE WHEN IT IS (REALLY) NECESSARY.



## THE PARTY GUY

YOU LIKE TO PUT A GOOD ATMOSPHERE AROUND YOU. WHEN YOUR TRIBE IS IN A MOODY MOOD YOU MANAGE TO MAKE THEM SMILE AGAIN. YOU DON'T HESITATE TO THROW PARTIES TO RE-MOTIVATE THE TROOPS. WITH THE EXCEPTION OF MR. GRRR-UMPY EVERYONE LOVES YOU.