

# The Quest for Unification:

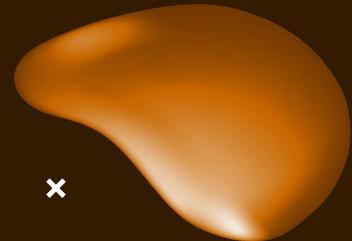
A Survey of Hardware-Agnostic  
Machine Learning Systems

Paul Dutton



x

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Two Language Problem,  
Competing Frameworks,  
Hardware

## 02 “The Hardware Lottery”

Hardware / software  
chicken and egg

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Frameworks, Compilers,  
IRs, DSLs

## 04 Ad for Chris Lattner

Modular / Max / Mojo

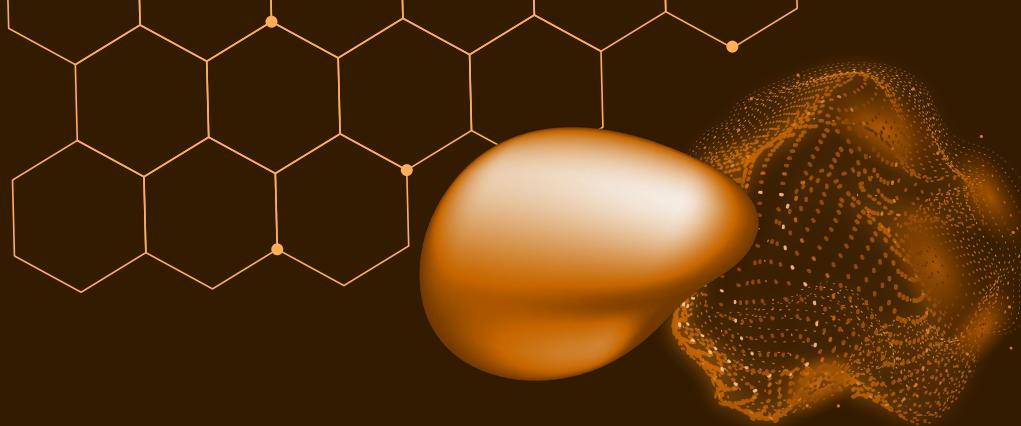
## 05 Takeaways & Questions

Why care? What's the  
future?

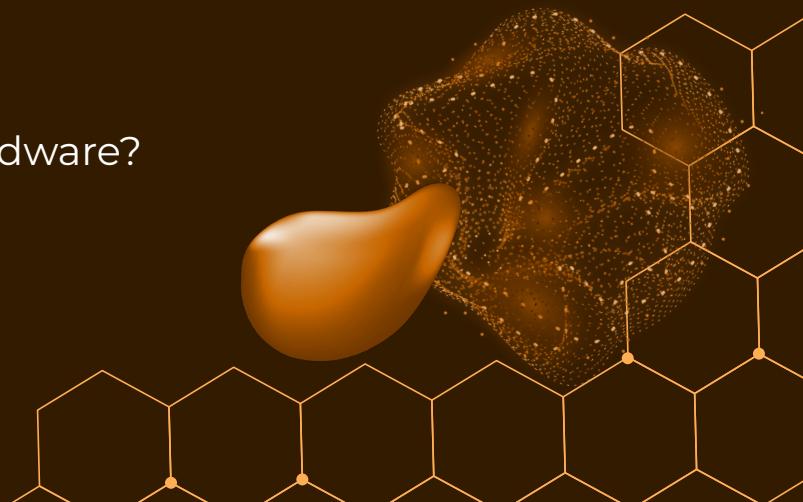
# 01

## Introduction

What is the current state of AI software and hardware?



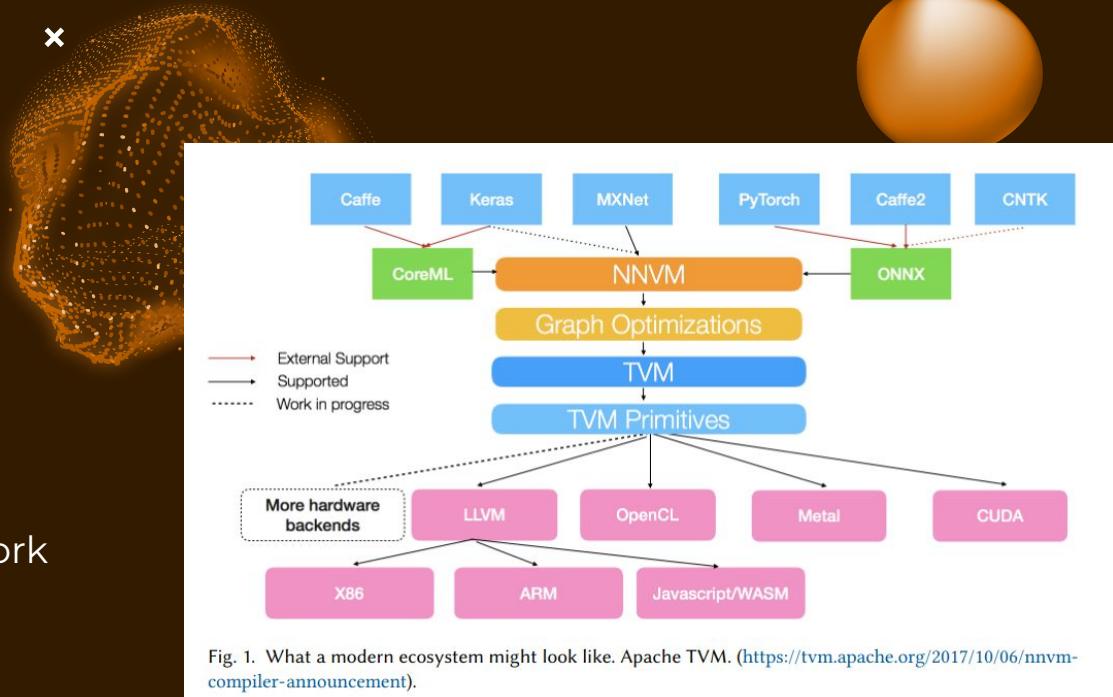
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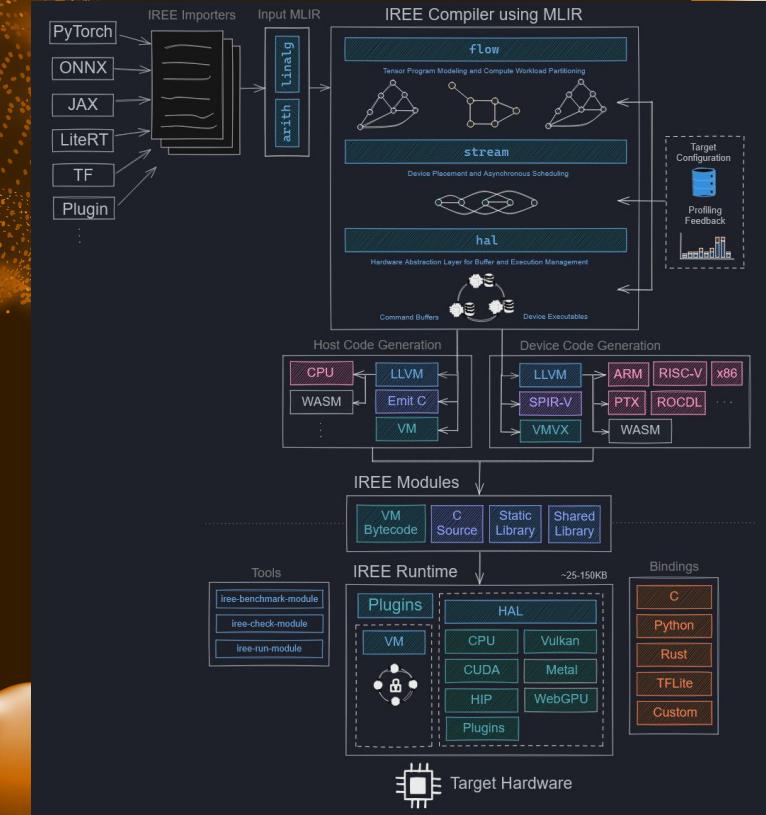
**It's a black  
box and/or  
hot glue**

# Apache TVM Path From Software To Hardware

Apache TVM: Compiler Framework



# IREE: Path From Software To Hardware



# Two Language Problem



## Python

High level, easy  
SUPER SLOW  
Calls into C++/ etc.

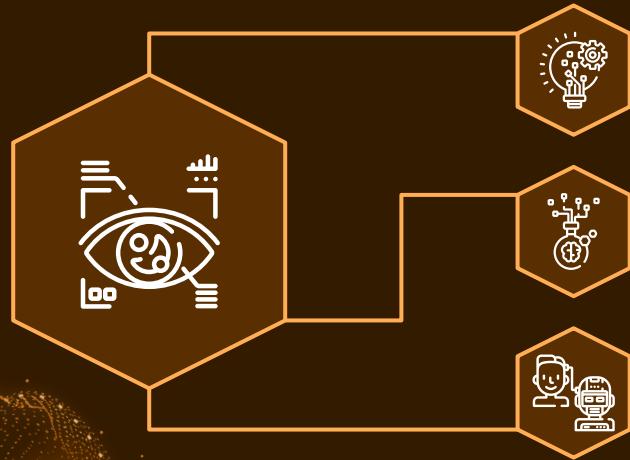


## C++ / CUDA / PTX

Requires good  
programming skills,  
powerful, tedious

FLOPs go BRRR

# New Hardware



**TPUs, LPUs**

x  
Google, Groq

**Intel Loichi**

SNNs, not  
tensors

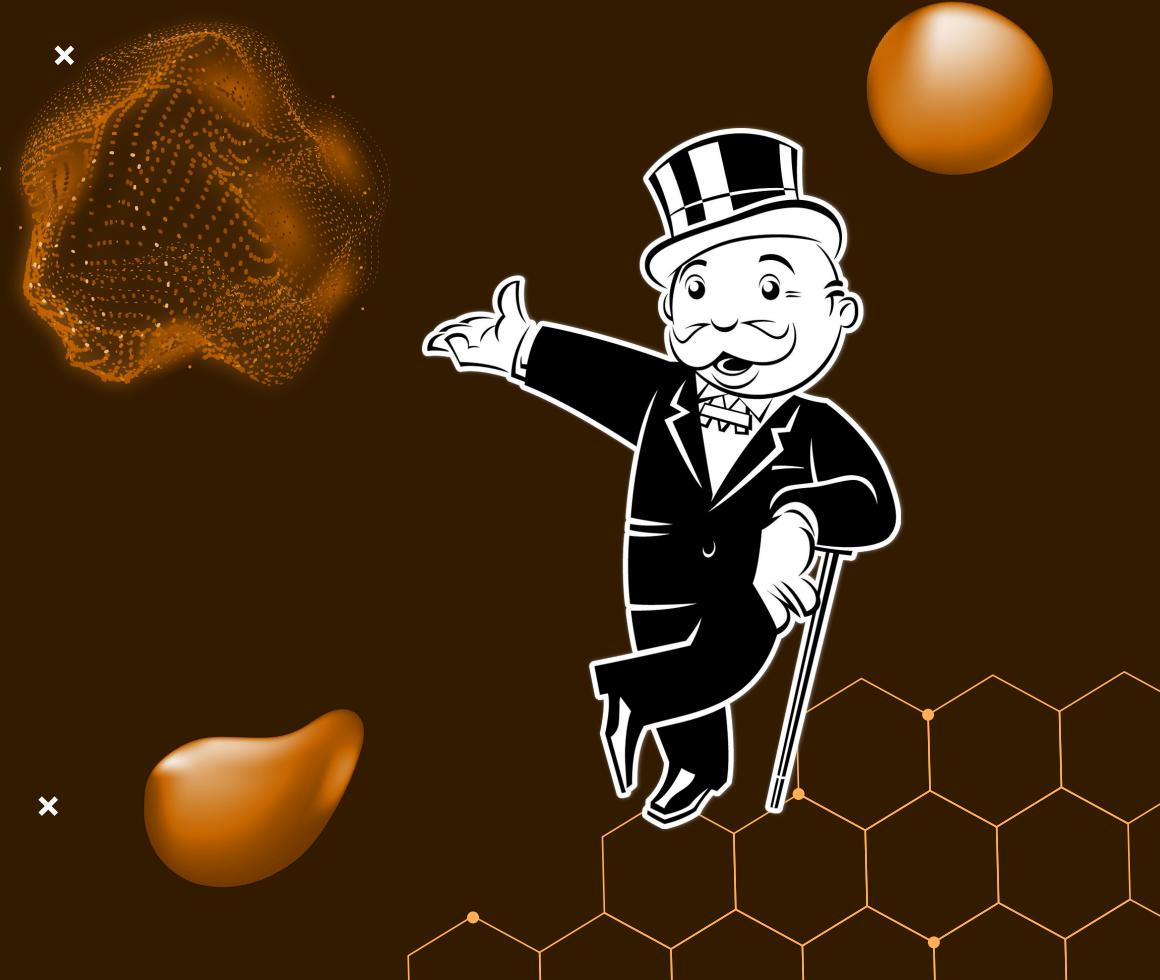
**Who  
knows?**

x  
We should  
future proof!

# How has monopoly shaped our industry?

Lack of competition

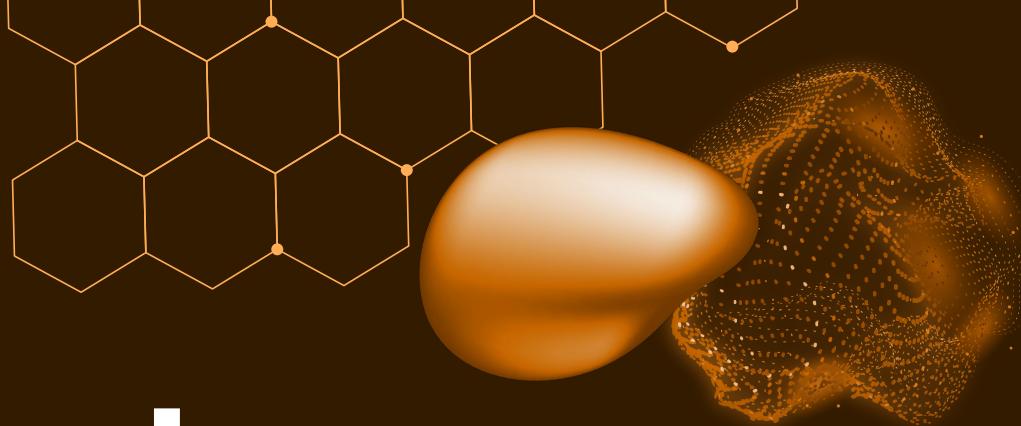
Shared space



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# “The Hardware Lottery”

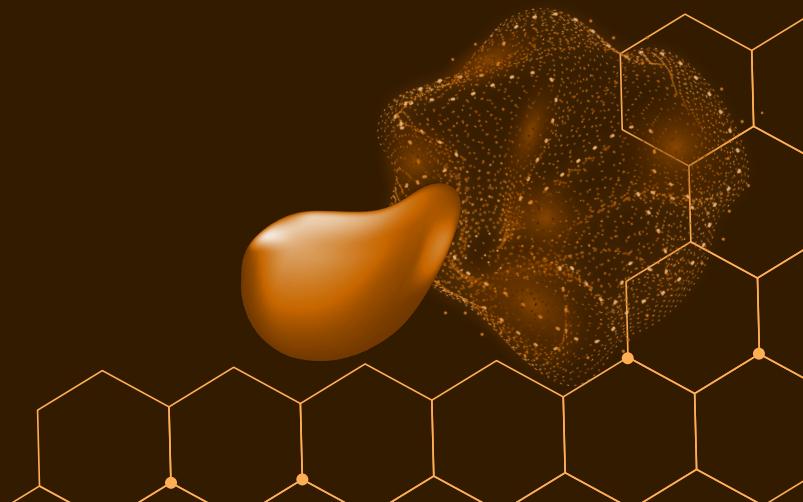
How has hardware shaped research?



\*



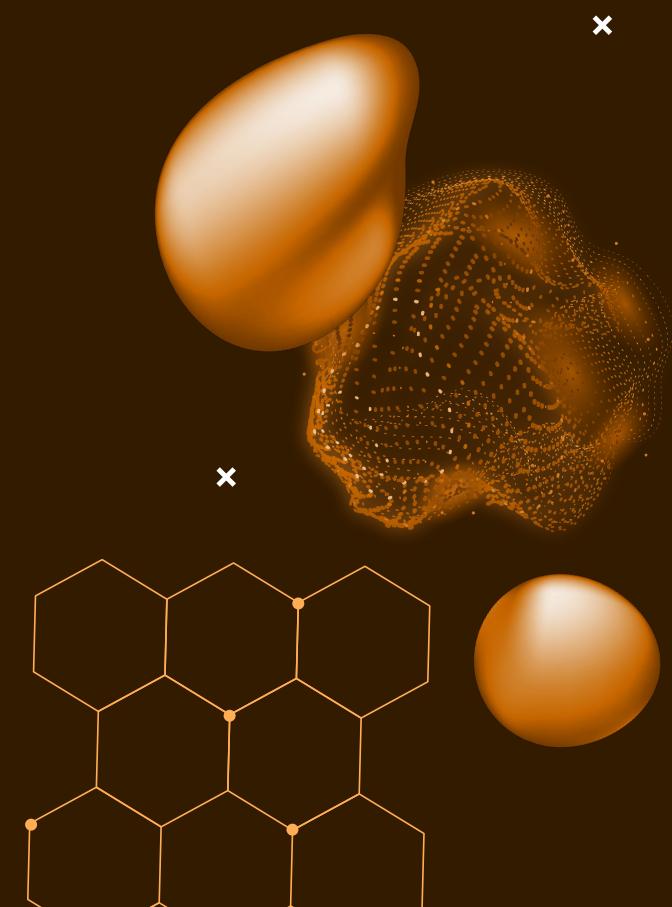
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“This essay introduces the term hardware lottery to describe when a research idea wins because it is suited to the available software and hardware and not because the idea is superior to alternative research directions”

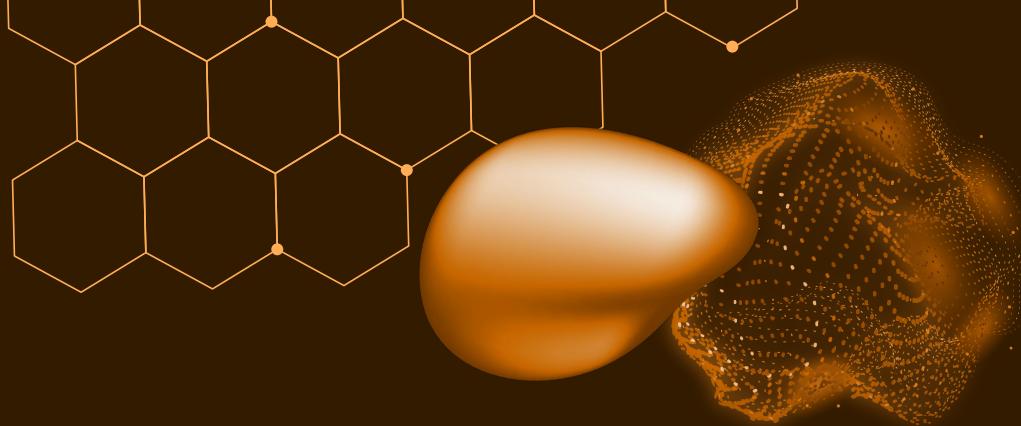
**—Sara Hooker,  
Google Brain 2020**



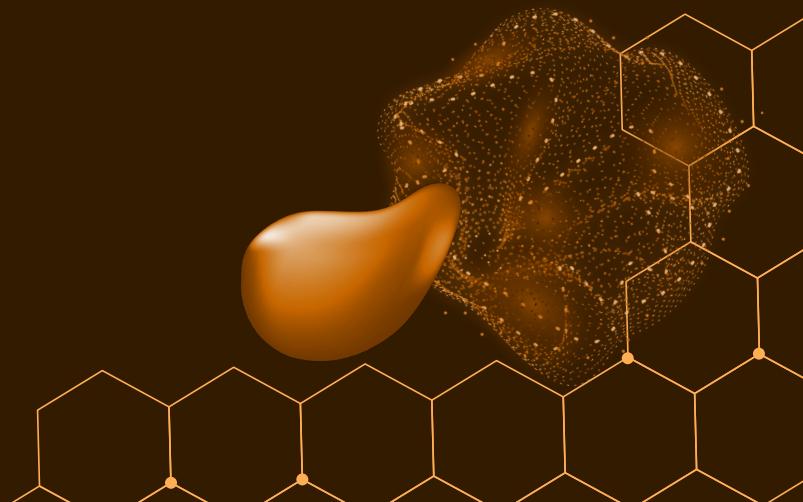
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# 3 Current State

How do we deal with this now?



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# Compilers

IRs like MLIR, Auto-Tuning

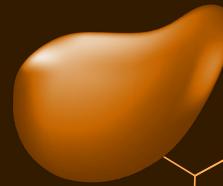
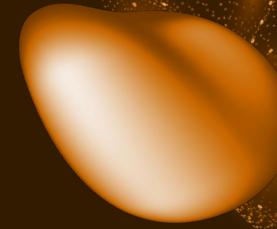


# [e]DSLs

Domain Specific Languages like Triton

# Open Source

Design by committee failures, coordination  
failures, fragmentation



## HOW STANDARDS PROLIFERATE: (SEE: A/C CHARGERS, CHARACTER ENCODINGS, INSTANT MESSAGING, ETC)

SITUATION:  
THERE ARE  
14 COMPETING  
STANDARDS.

14?! RIDICULOUS!  
WE NEED TO DEVELOP  
ONE UNIVERSAL STANDARD  
THAT COVERS EVERYONE'S  
USE CASES.



SOON:

SITUATION:  
THERE ARE  
15 COMPETING  
STANDARDS.

# This Means Vendor Lock-In

x

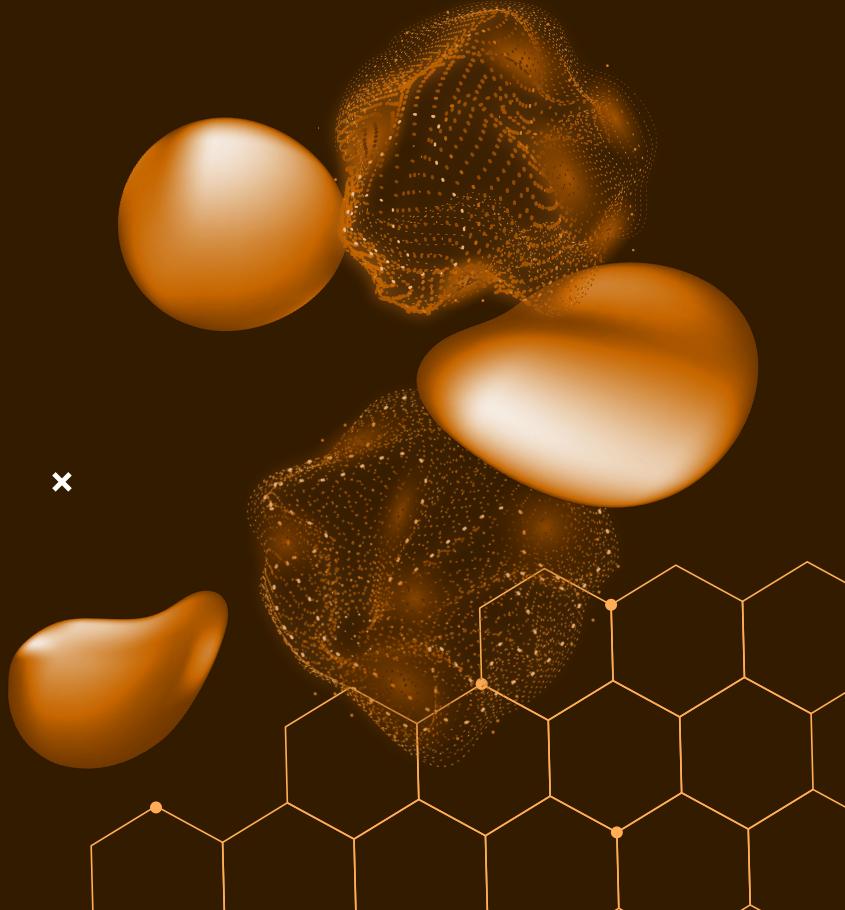
PTX for a single Nvidia GPU

OpenCL example - no Tensor Core support

Switching frameworks

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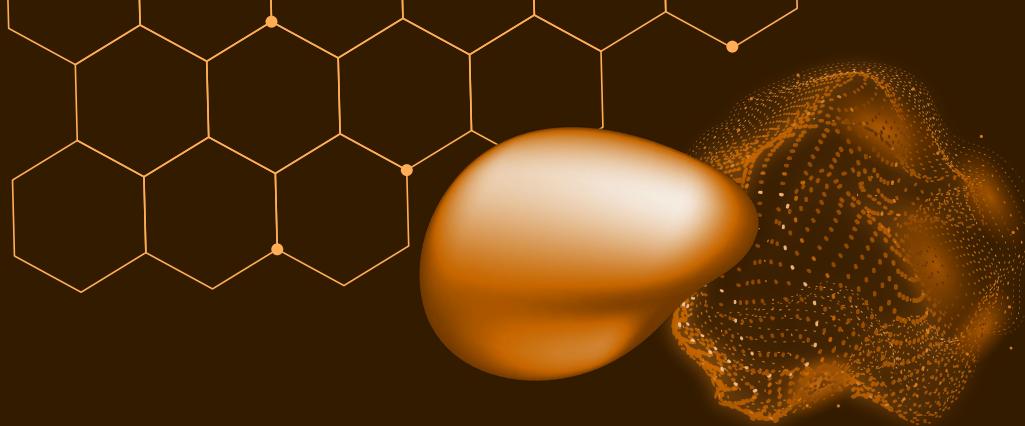
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# Modular / MAX / Mojo

Chris Lattner



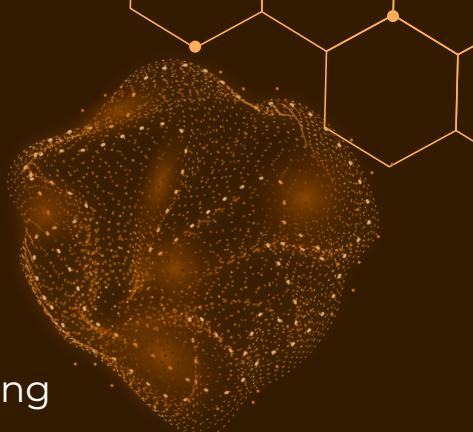
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# Chris Lattner



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**2000 LLVM**

IR, Clang

**2010 Swift**

Replaced Obj-C

**2017 TF & TPU**

Google

x



**Compilers**



**Languages**



**Hardware**

# Modular

x

Scheduling, Batching,  
Cloud or Local  
Deployment

Graph compilers,  
libraries, tools

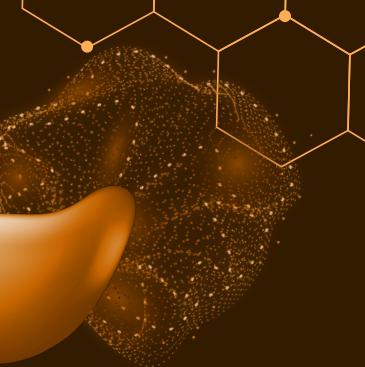
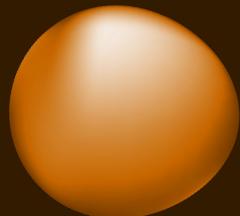
Python Superset - FAST

**Max**  
**Serve**

**Max**  
**Engine**

**Mojo** 🔥

x



# Python Superset

No need to learn C++ / Rust / CUDA. Use  
Python libraries!

**Typed,  
Compiled!**

"Up to 65,000x faster than Python"

Mojo 

# MLIR Coherency

Optimizations are easy across ALL stages



# Easy to write code! Performant!

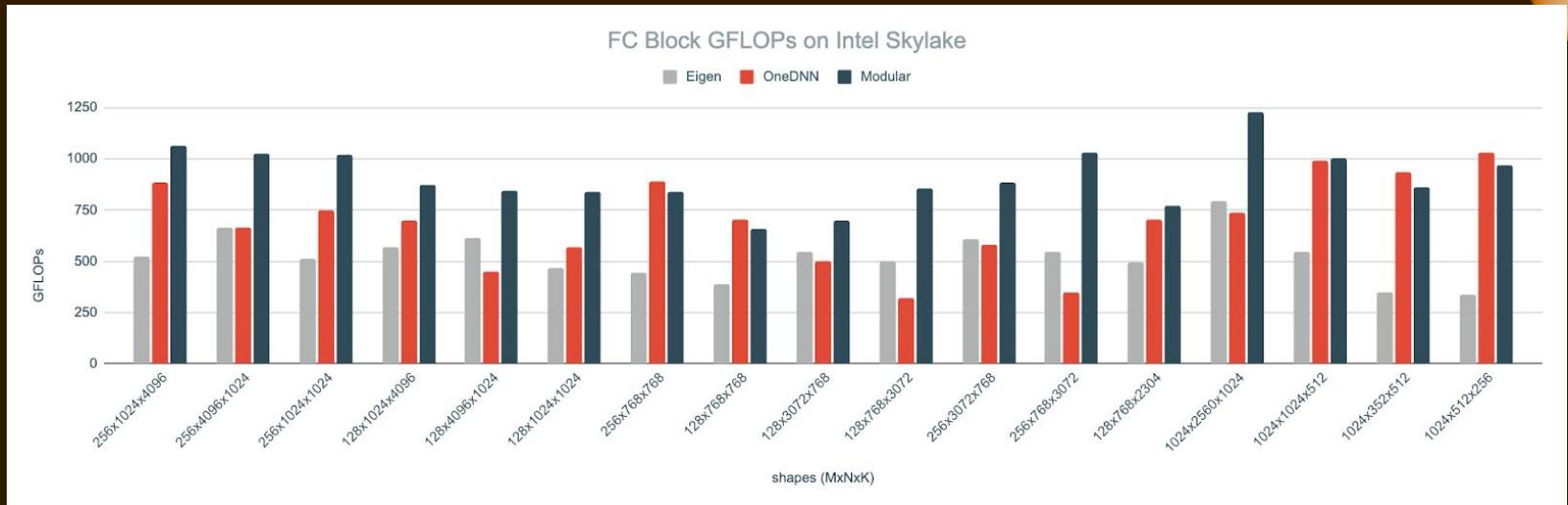
Auto vectorizing  
Auto parallelizing  
Native SIMD  
Easy tiling  
GPU support just added  
Only \*slightly\* verbose

```
44 # Perform 2D tiling on the iteration space defined by end_x and end_y
43 fn tile[tiled_fn: Tile2DFunc, tile_x: Int, tile_y: Int](end_x: Int, end_y: Int):
42     for y in range(0, end_y, tile_y):
41         for x in range(0, end_x, tile_x):
40             tiled_fn[tile_x, tile_y](x, y)
39
38
37 # Use the above tile function to perform tiled matmul
36 # Also parallelize with num_workers threads
35 fn matmul_tiled(mut C: Matrix, A: Matrix, B: Matrix):
34     var num_workers = C.rows
33
32     @parameter
31     fn calc_row(m: Int):
30         @parameter
29         fn calc_tile[tile_x: Int, tile_y: Int](x: Int, y: Int):
28             for k in range(y, y + tile_y):
27
26                 @parameter
25                 fn dot[nelts: Int](n: Int):
24                     C.store(
23                         m,
22                         n + x,
21                         SS
20                         + A[m, k] * B.load[nelts](k, n + x),
19                         )
18
17                 vectorize[dot, nelts, size=tile_x]()
16
15             tile[calc_tile, tile_n, tile_k](C.cols, B.rows)
14
13     parallelize[calc_row](C.rows, num_workers)
12
11
10 fn bench_tiled():
9     var a = Matrix[dim, dim].rand()
8     var b = Matrix[dim, dim].rand()
7     var c = Matrix[dim, dim].rand()
6
5     var start_time = time.perf_counter_ns()
4     matmul_tiled(c, a, b)
3     var end_time = time.perf_counter_ns()
2     print("tilled", (end_time - start_time) / 1000.0, "us")
```

# Matrix Multiplication 1024 x 1024

Language / Compiler	Notes	MicroSeconds
Python 3.12	Naive	50,800,000
Python 3.12	Numpy, Transpose	1,175,000
Mojo	Vectorized, Parallelized	8,300
C / Zig CC	Naive	1,950,000
C / Zig CC	-O3, OpenMP, Transpose	27,000

# SOTA: MatMul & Relu



# Critiques

## “Ownership”

This memory management paradigm can be tough

## Parameters

Separation of comptime is new to most

## New Keywords

Mojo is “Python ++” & WIP

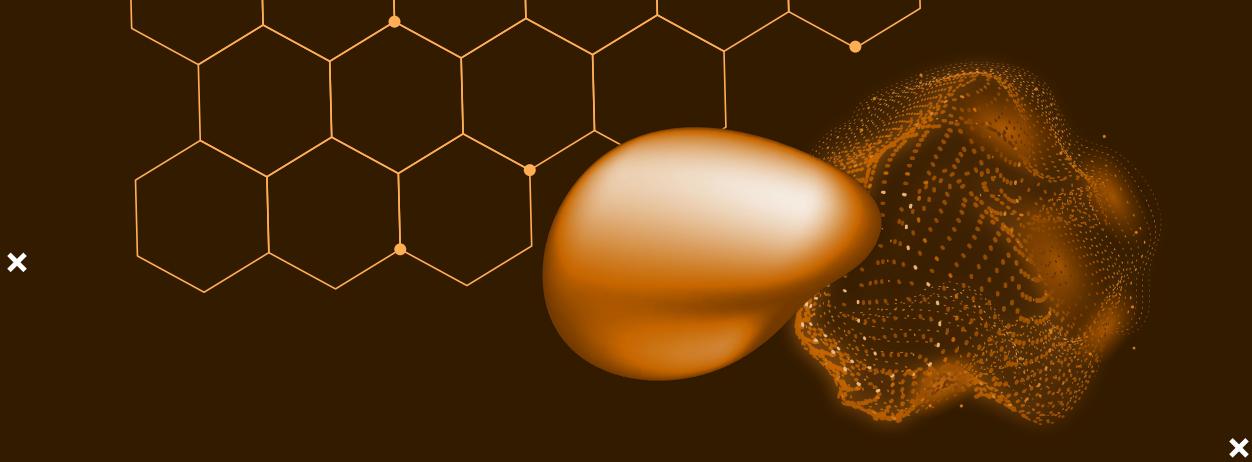
## MAX System

Graph building here is a new system / library to learn

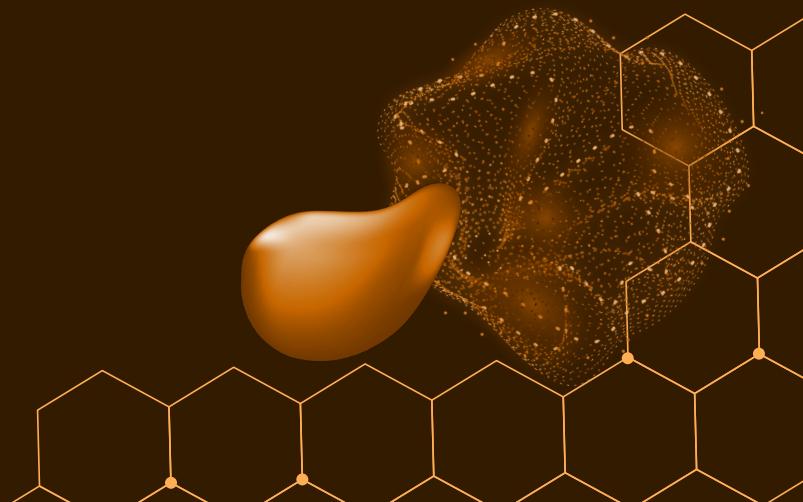
# 05

# Takeaways

Chris Lattner-senapai notice me :3 UwU



+



# Takeaways

## Hardware

The Hardware  
Lottery



## Ergonomic



## Unification

How do we UNITE  
research?



## Future?



What's coming  
next?



Developer  
Experience

# THANKS!

DO YOU HAVE ANY QUESTIONS?  
[paul.dutton@my.utsa.edu](mailto:paul.dutton@my.utsa.edu)



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# References

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Sara Hooker, "The Hardware Lottery". 2020.  
<https://arxiv.org/abs/2009.06489>

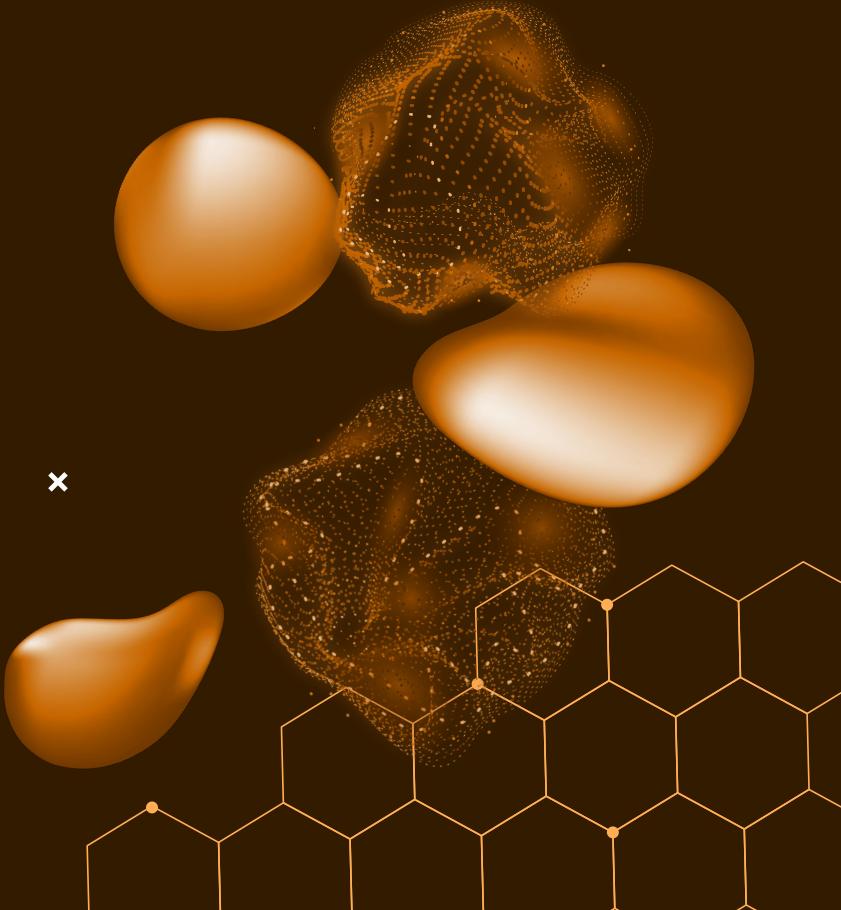
[https://tvm.apache.org/2017/10/06/hnvm-compiler-anno  
uncement](https://tvm.apache.org/2017/10/06/hnvm-compiler-annotation.html)

<https://iree.dev/#project-architecture>

<https://xkcd.com/927/>

[Modular: The world's fastest unified matrix  
multiplication](#)

[https://static.wikia.nocookie.net/monopoly/images/4/41/  
Monopoly\\_2D\\_Art\\_Render.png/revision/latest?cb=2020  
109225628](https://static.wikia.nocookie.net/monopoly/images/4/41/Monopoly_2D_Art_Render.png/revision/latest?cb=2020109225628)



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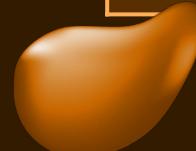
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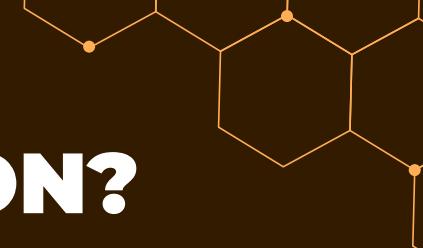
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# OUR COMPANY

Mercury is the closest planet to the Sun and the smallest one in the Solar System. This planet's name has nothing to do with the liquid metal, since Mercury was named after the Roman messenger god



# WHAT ARE WE WORKING ON?

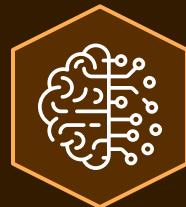
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## DEVELOP

Mercury is the closest planet to the Sun and the smallest of them all

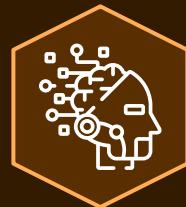
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## IMPROVE

Venus has a beautiful name and is the second planet from the Sun

\*



## EXCELL

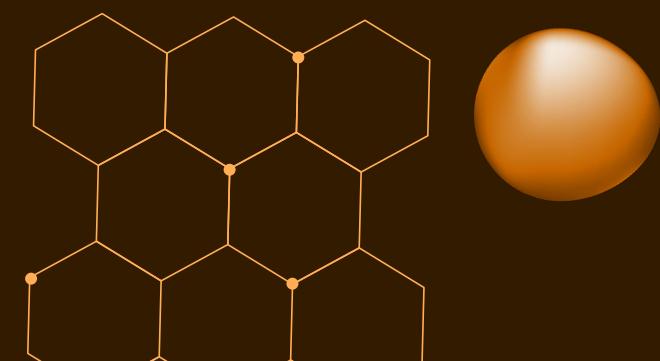
Despite being red, Mars is actually a cold place. It's full of iron oxide dust





“This is a quote, words full of wisdom that someone important said and can make the reader get inspired.”

—**SOMEONE FAMOUS**



# OUR ASPIRATIONS



## NOW

Earth is the third planet from the Sun and the only one that harbors life in the Solar System. This is where we all live on



## FUTURE

Despite being red, Mars is actually a cold place. It's full of iron oxide dust, which gives the planet its reddish cast

# MAYOR REQUIREMENTS

## SKILLS

Mercury is the closest planet to the Sun

## INTELLIGENCE

Venus is the second planet from the Sun

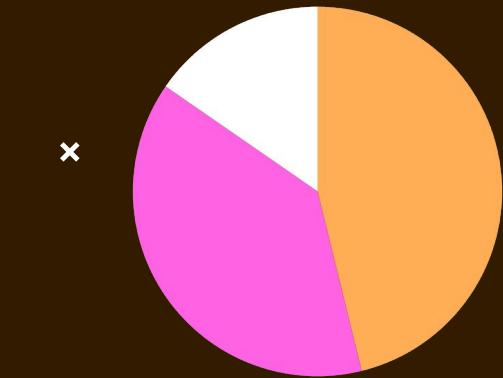
## ADAPTABILITY

Earth is the third planet from the Sun

## FOCUS

Despite being red, Mars is very cold

# BUDGET



0  
\$10,000,000



**ASSEMBLE**



**BUILDING**

**46% MARS**

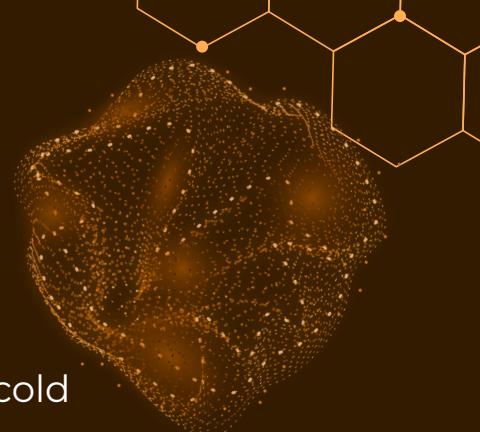
Mars is cold

**38% VENUS**

Venus is hot

**15% JUPITER**

Jupiter is big



Follow the link in the graph to modify its data and then paste the new one here. [For more info, click here](#)



**5,000,000**

Big numbers captivate your audience's attention

**9h 55m 23s**

Jupiter's rotation period

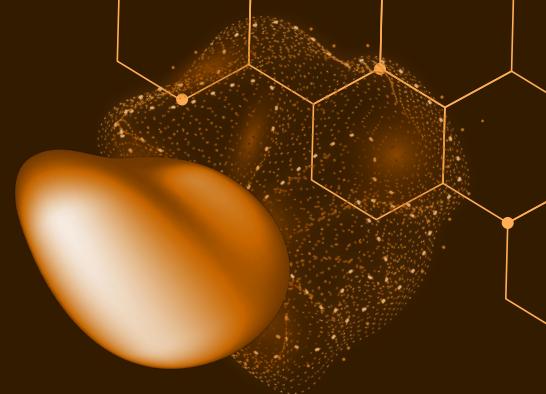


**333,000**

The Sun's mass compared to Earth's

**386,000 km**

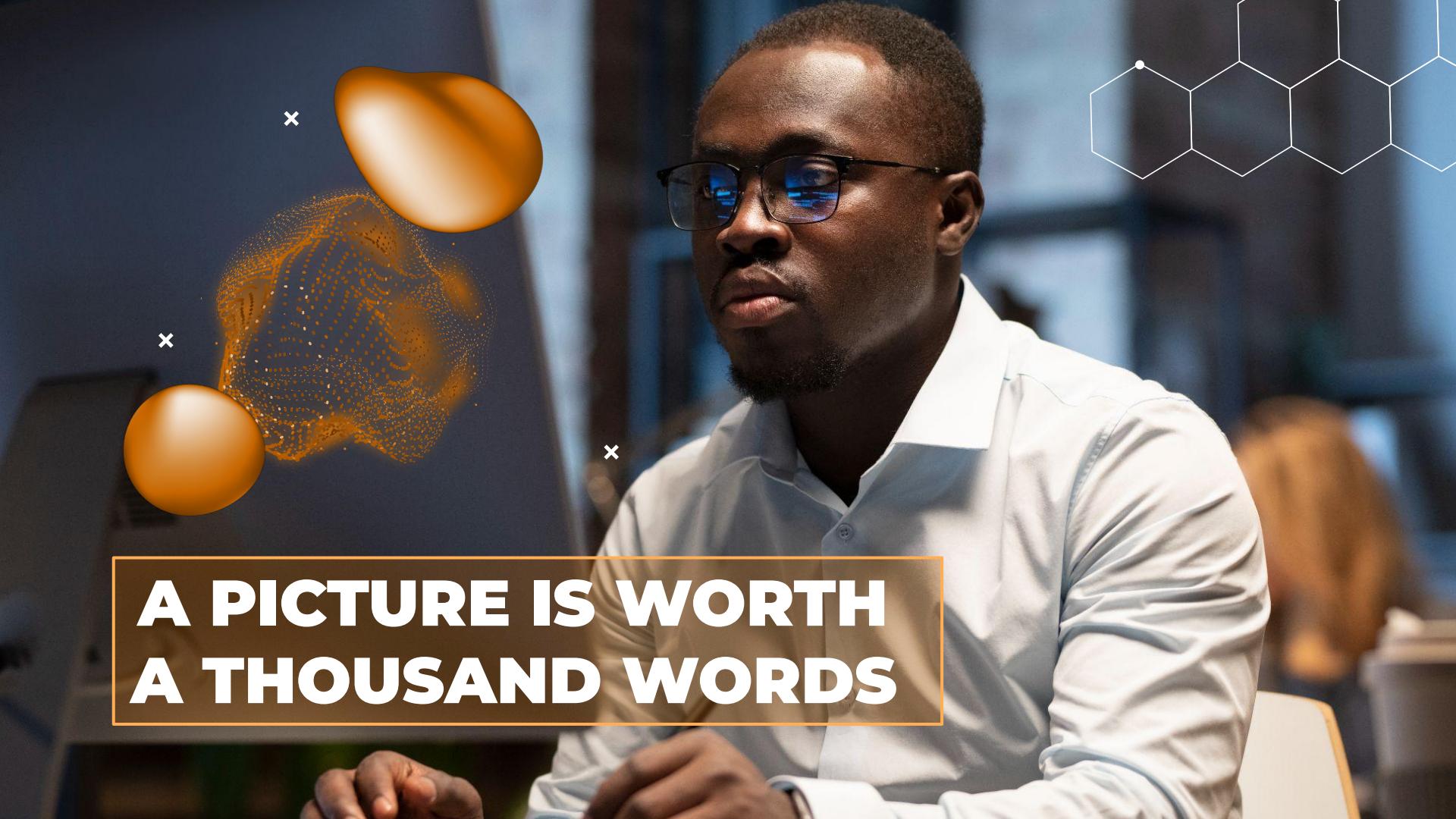
Distance between Earth and the Moon



# AN IMAGE REINFORCES THE CONCEPT

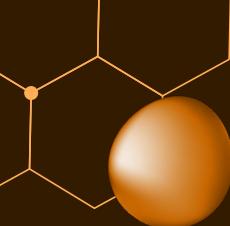
Images reveal large amounts of data, so remember: use an image instead of a long text. Your audience will appreciate it





A man in a white lab coat and glasses is looking down at something off-camera with a serious expression. In the background, there's a glowing orange 3D brain model and a molecular structure diagram. A text overlay in the bottom left corner reads "A PICTURE IS WORTH A THOUSAND WORDS".

**A PICTURE IS WORTH  
A THOUSAND WORDS**



# OUR NUMBERS

\*



**50%**

## MANPOWER

Mercury is the closest planet to the Sun and the smallest of them all



**30%**

## DEVELOPMENT



\*

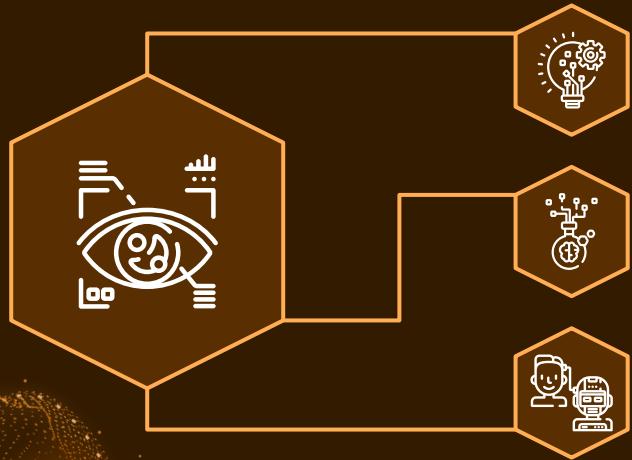


**20%**

## EXPANSION

Despite being red, Mars is actually a cold place. It's full of iron oxide dust

# PROJECT GOALS



**GOAL 1**

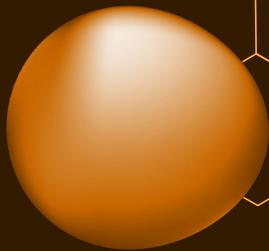
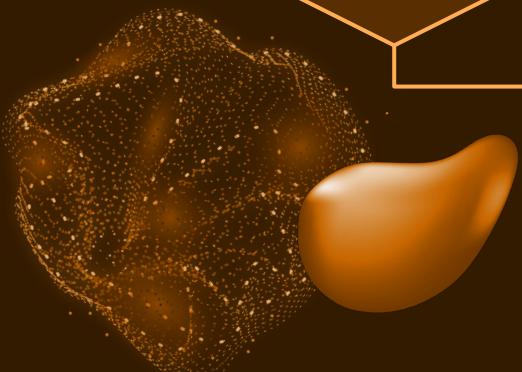
Mercury is the closest planet to the Sun

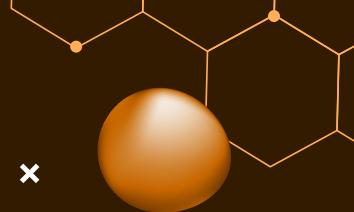
**GOAL 2**

Venus is the second planet from the Sun

**GOAL 3**

Earth is the third planet from the Sun





# PREDICTED RESULTS



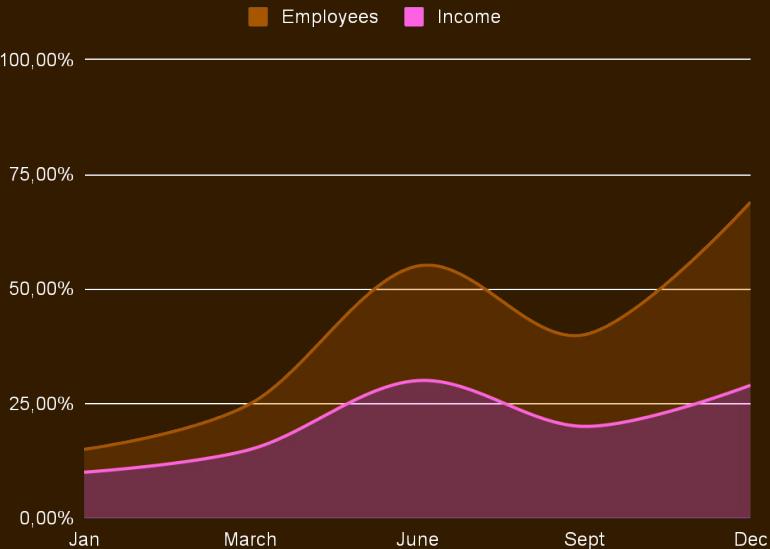
**300**

New employees next year



**\$30,000**

Expected income for 20XX



Follow the link in the graph to modify its data and then paste the new one here. **For more info, click here**

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# AI IN A NUTSHELL

Do you know what helps you make your point crystal clear?

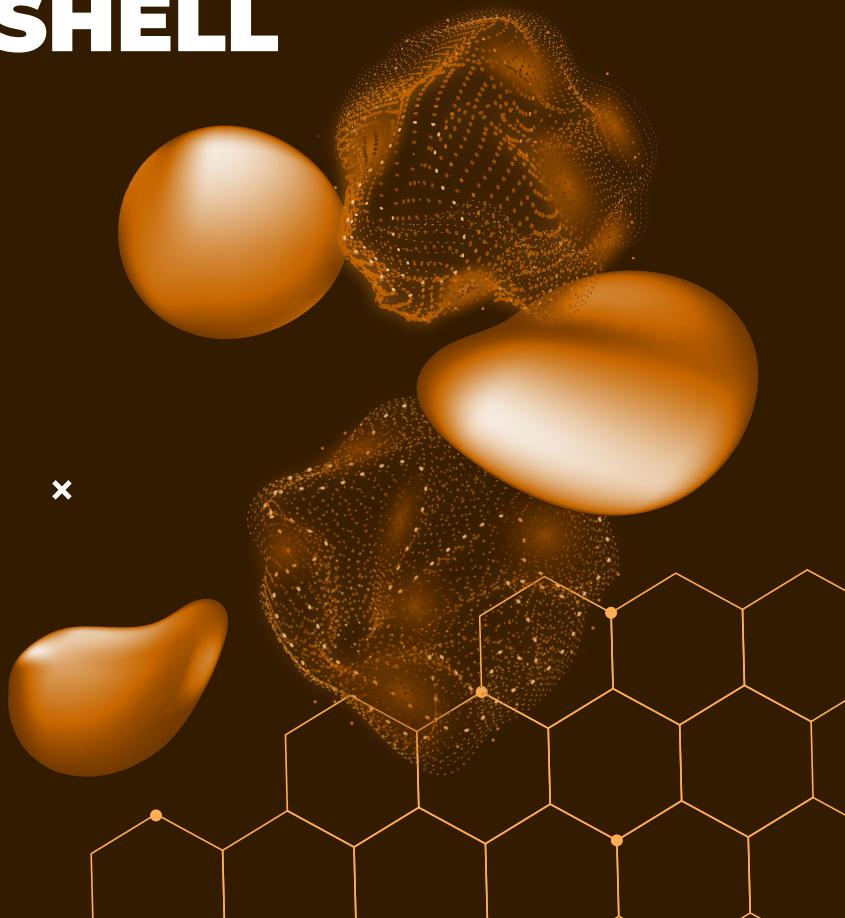
Lists like this one:

- ◆ They're simple
- ◆ You can organize your ideas clearly
- ◆ You'll never forget to buy milk!

And the most important thing: the audience won't miss the point of your presentation

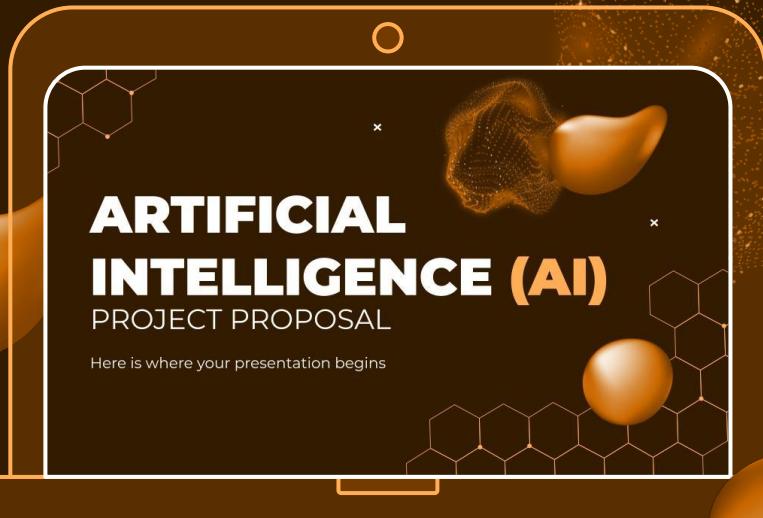
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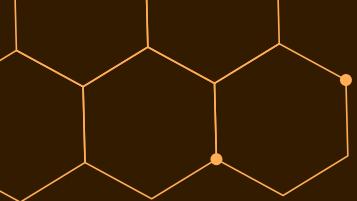
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# DESKTOP MOCKUP

You can replace the image on the screen with your own work. Just right-click on it and select “Replace image”



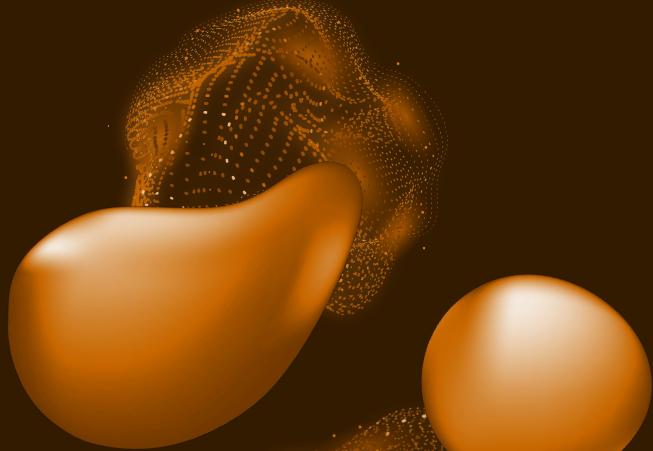


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# SNEAK PEEK

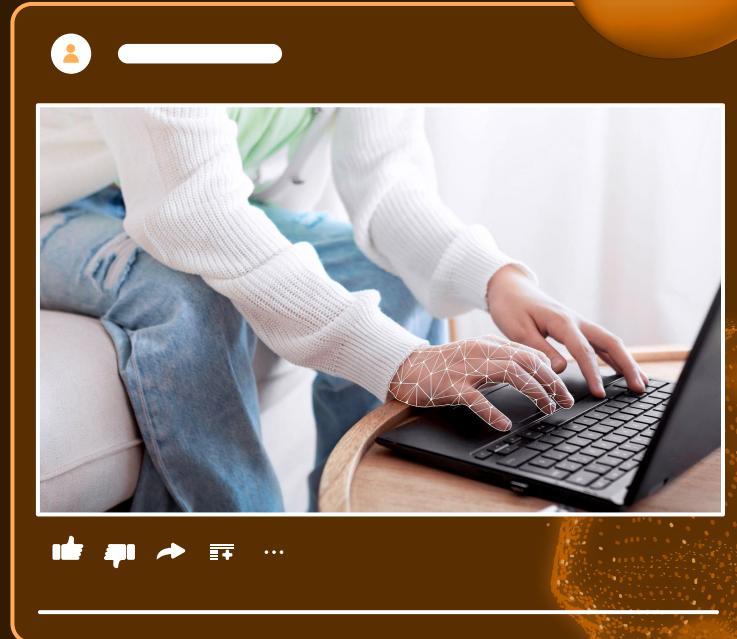
Mercury is the closest planet to the Sun and the smallest one in the Solar System—it's only a bit larger than the Moon. The planet's name has nothing to do with the liquid metal, since Mercury was named after the Roman messenger god

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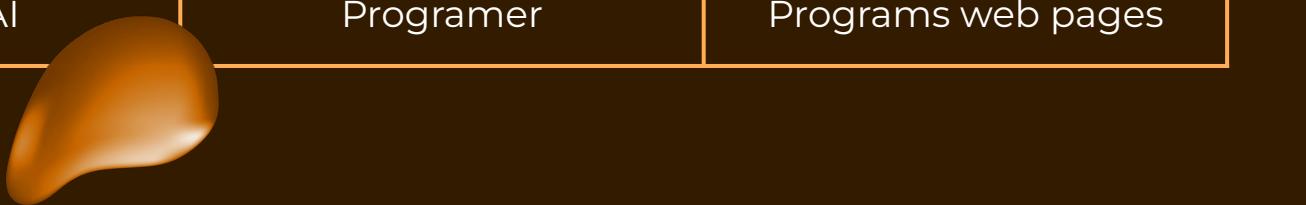
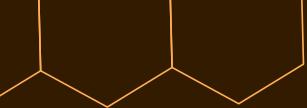
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# SNEAK PEEK

You can replace the image. Just right-click on it and select “Replace image”



# **TYPES OF AIs**

<b>NAME</b>	<b>TYPE</b>	<b>FUNCTION</b>
My Journey	Artistic	Creates images
Super Desk	Writer	Creates texts
Solver	Mathematician	Solves complex problems
Develop AI	Programmer	Programs web pages

# PROJECT STAGES

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Venus is the second planet from the Sun

Despite being red, Mars is very cold

Jupiter was named after a Roman god

## STAGE 1



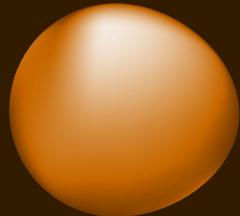
## STAGE 2



## STAGE 3



x



# TIMELINE

**DAY 1**

Despite being red,  
Mars is a cold place



**DAY 2**



**DAY 3**

Jupiter doesn't  
have a solid surface



**DAY 4**



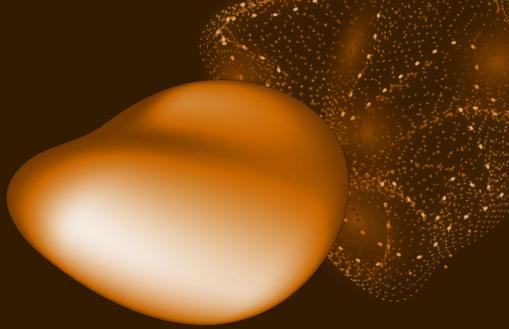
Saturn is a  
ringed planet





x

# OUR PARTNERS



## JOHNSON

The Moon is Earth's  
only natural satellite



## TECH PEK

Earth is the planet  
where we all live

x

## DOE'S

Mars was named  
after a god

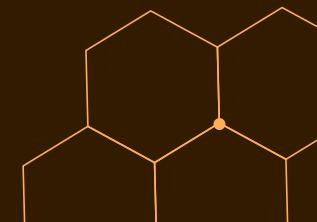
## PETPER

Jupiter doesn't have  
a solid surface

x

## ENGEEN

Saturn was named  
after a Roman god



## MERIDIAN

Neptune is far away  
from us

# OUR LOCATION



**SILICON VALLEY,  
SF**

Despite being red, Mars is actually a cold place. It's full of iron oxide dust, which gives the planet its reddish cast

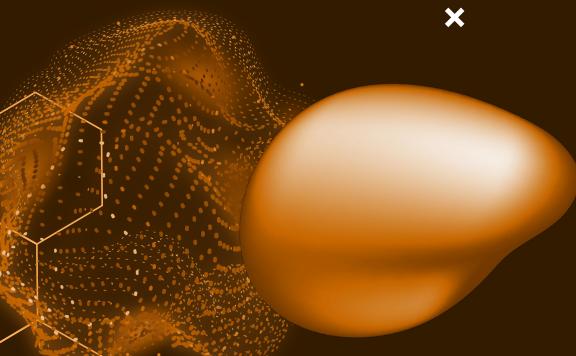
# OUR TEAM



## TIMMY JIMMY

You can speak a bit about  
this person here

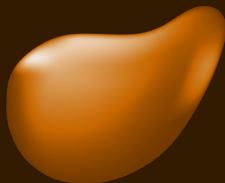
x



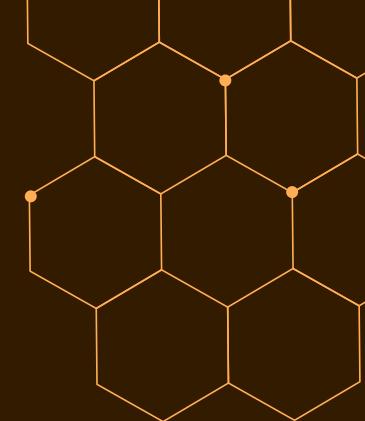
## DANA JONES

You can speak a bit about  
this person here

x



x



# THANKS!

DO YOU HAVE ANY QUESTIONS?

[youremail@freepik.com](mailto:youremail@freepik.com)

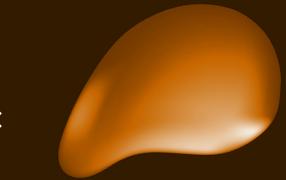
+34 654 321 432

[yourwebsite.com](http://yourwebsite.com)



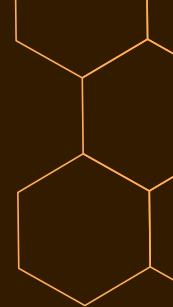
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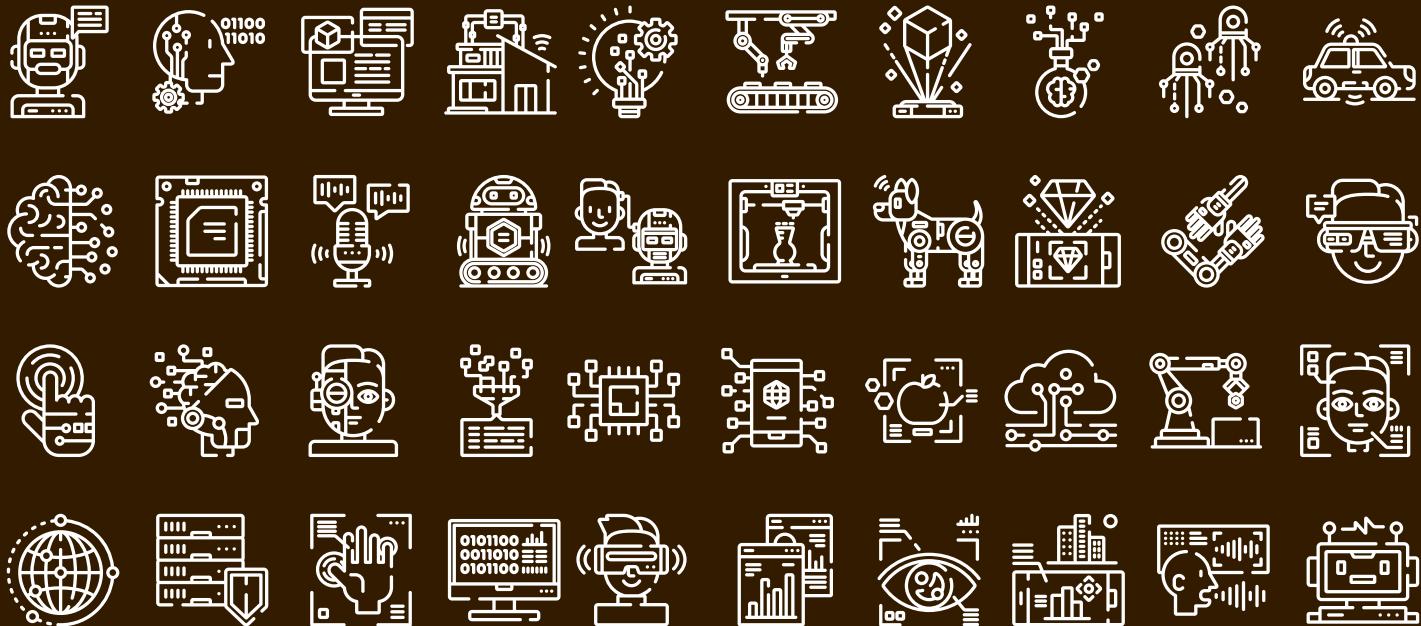


# ICON PACK

x



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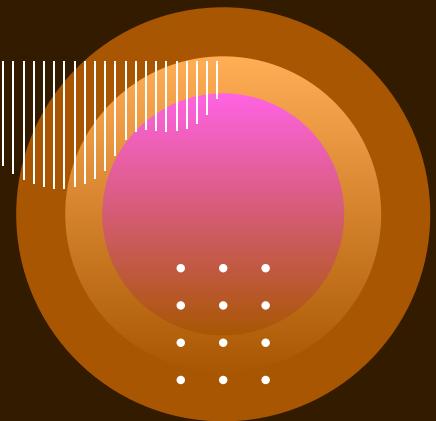
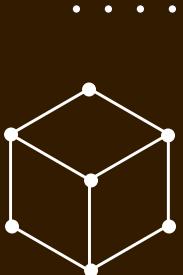
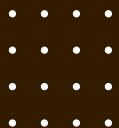


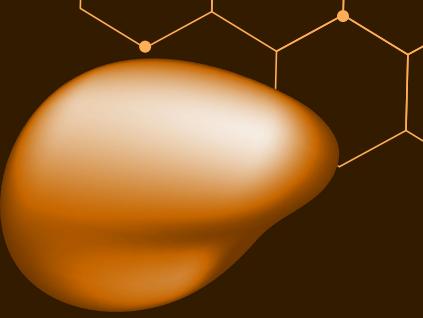
# ALTERNATIVE RESOURCES

Here's an assortment of alternative resources whose style fits the one of this creative template:

## VECTORS

- ◆ [Gradient metaverse concept twitch banner](#)





# RESOURCES

Did you like the resources on this template? Get them for free at our other websites:

## VECTORS

- ◆ [Futuristic ai tech instagram posts collection](#)

## ICONS

- ◆ [Icon pack: Artificial intelligence](#)

## PHOTOS

- ◆ [Black man working with a computer](#)
- ◆ [Male technician repairing computer motherboard on wooden desk](#)
- ◆ [Close up smiley man with glasses](#)
- ◆ [Front view smiley woman holding book](#)
- ◆ [Hands typing on laptop keyboard](#)

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# Fonts & colors used

This presentation has been made using the following fonts:

**Montserrat**

(<https://fonts.google.com/specimen/Montserrat>)

#ffffff

#331b00

#ffae56

#a85601

#ff62e3

#f35495

# Storyset

Create your Story with our illustrated concepts. Choose the style you like the most, edit its colors, pick the background and layers you want to show and bring them to life with the animator panel! It will boost your presentation. Check out [how it works](#).



Pana



Amico



Bro



Rafiki



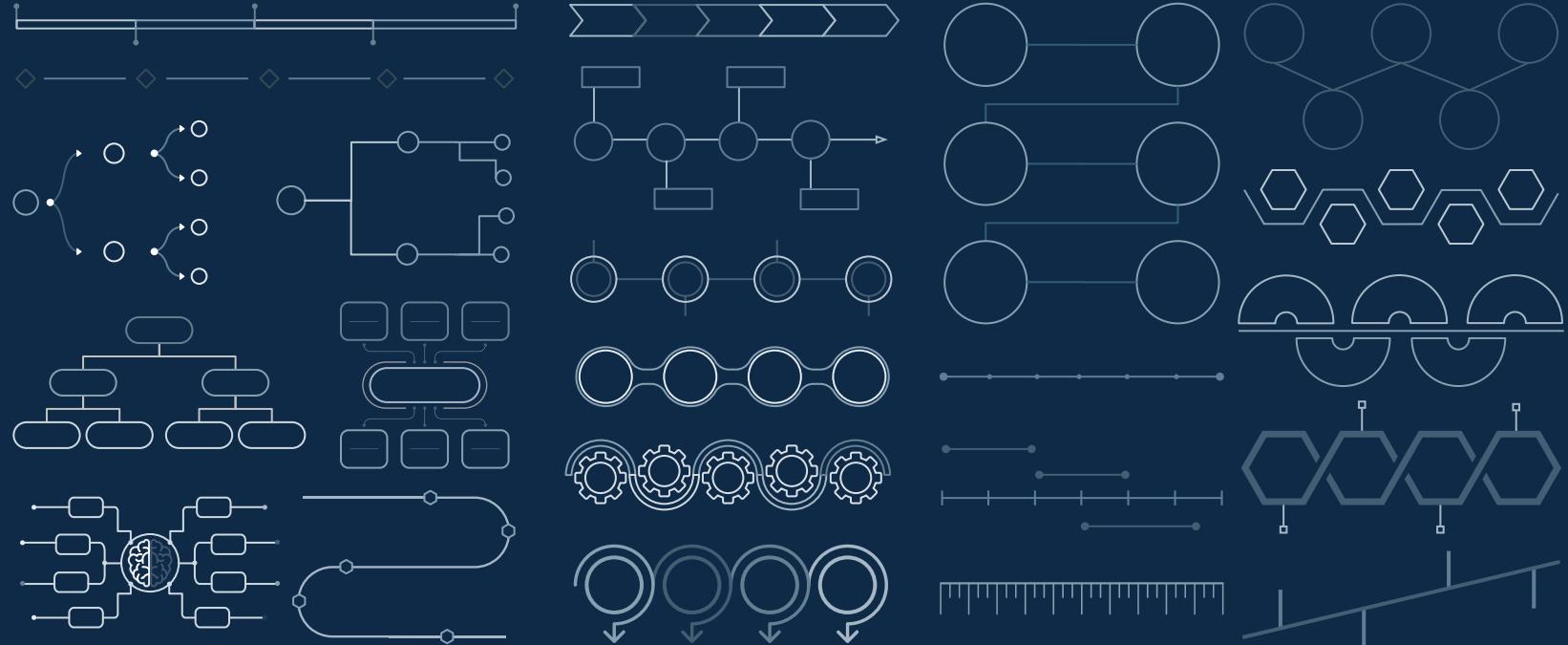
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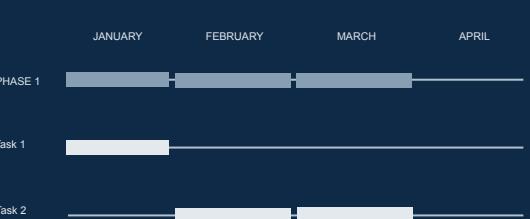
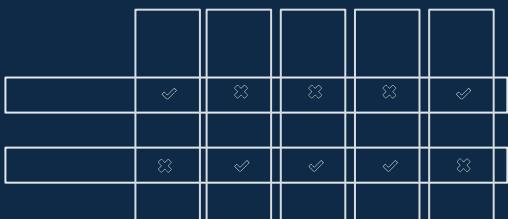
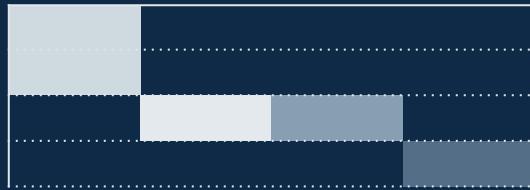
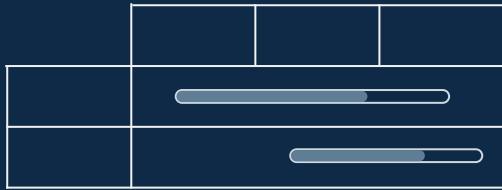
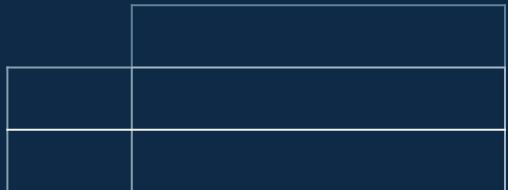
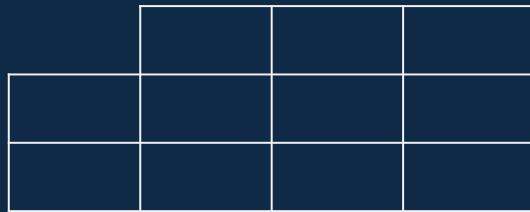
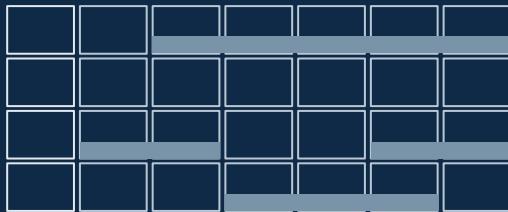
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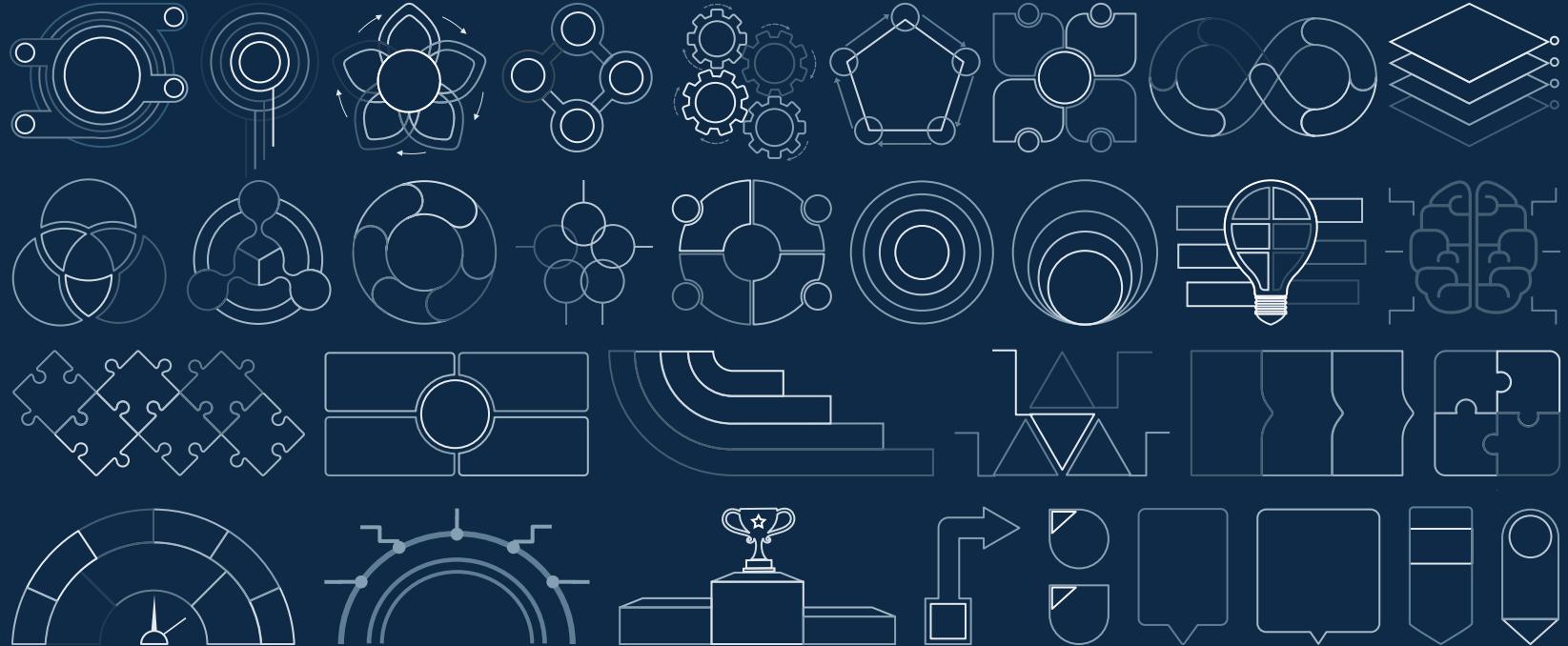
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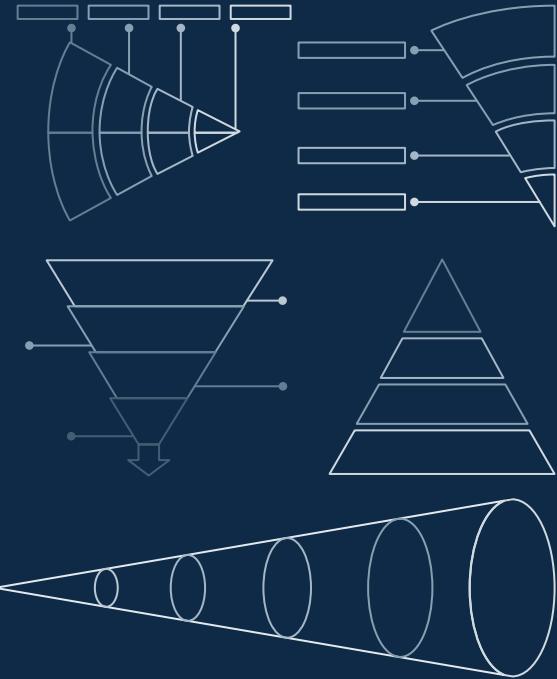
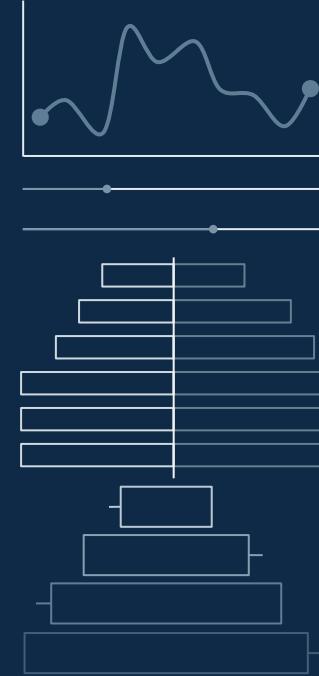
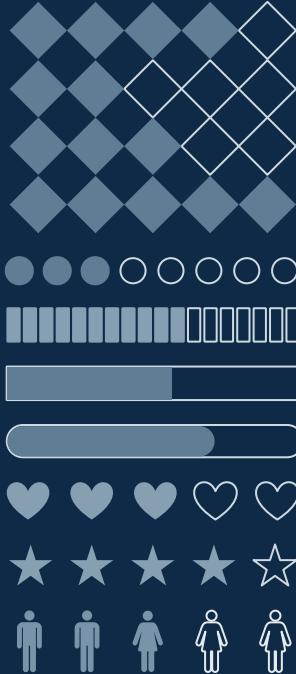
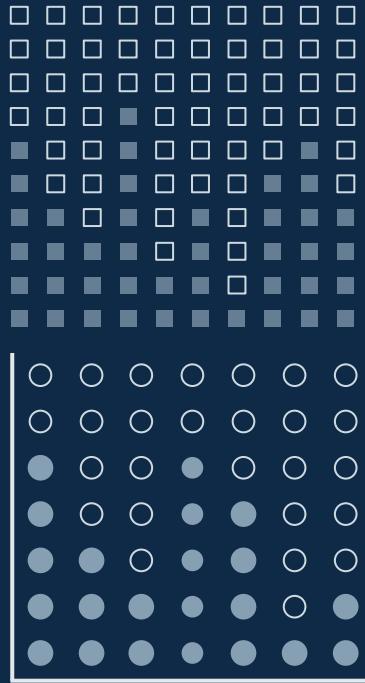












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# Educational Icons



# Medical Icons



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# Teamwork Icons



# Help & Support Icons



# Avatar Icons



# Creative Process Icons



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