

# Building Knowledge Panels on the Cheap

Nathan Wiegand

Work by: Sizhu Cheng, Max Allen, and Brandon Chong



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Bose Noise Cancelling Headphones 700

\$300+ ★ 4.5 (17672)

wirecutter + 3>  
Our pick



Apple AirPods Pro

\$200+ ★ 4.5 (14514)

cnet CNET + 3>  
Best headphones for true wireless noise canceling



Jabra Elite 75t

\$130+ ★ 3.8 (1514)

wirecutter + 2>  
Our pick



## Apple AirPods Pro

\$199.99



AMAZON

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## Expert Reviews

Best headphones for true wireless noise canceling ▾

cnet CNET

Best for Apple Users ▾

PCMag

The new king of AirPods ▾

Tom's Guide

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PC Mag

## The Best Headphones for 2021 | PCMag



BEST FOR VOICE ASSISTANT USERS

Noise Cancelling Headphones 700

"The wireless Bose Noise Cancelling Headphones 700 off...

\$399.00+ 1 OF 10



BEST IN AUDIO  
Sony

"Sony's headph...

\$348

cnet CNET · Jan 12, 2021

## The best headphones for 2021 - CNET

## Customer Reviews

Amazon 14514

★★★★★ 4.5

★★★★★ List of Features/Changes compared to...



More images

# Albert Einstein



Theoretical physicist

Albert Einstein was a German-born theoretical physicist, widely acknowledged to be one of the greatest physicists of all time. Einstein is known for developing the theory of relativity, but he also made important contributions to the development of the theory of quantum mechanics. [Wikipedia](#)

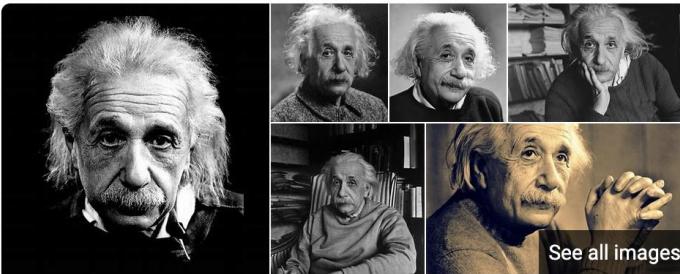
**Born:** March 14, 1879, Ulm, Germany

**Died:** April 18, 1955, Penn Medicine Princeton Medical Center, NJ

**Children:** Eduard Einstein, Hans Albert Einstein, Lieserl Einstein

**Spouse:** Elsa Einstein (m. 1919–1936), Mileva Marić (m. 1903–1919)

**Education:** University of Zurich (1905), ETH Zürich (1896–1900), [MORE](#)



[See all images](#)

## Albert Einstein

Theoretical Physicist

Albert Einstein was a German-born theoretical physicist, widely acknowledged to be one of the greatest physicists of all time. Einstein is known for developing the theory of relativity, but he also made important contributions to the development of the theory of quantum mechanics. Relativity and quantum mechanics are together the two pillars of mod... [+](#)



[Wikipedia](#)



[Official site](#)

**Lived:** Mar 14, 1879 - Apr 18, 1955 (age 76)

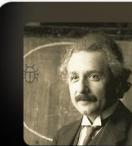
**Height:** 5 feet 9 inches

**Spouse:** [Elsa Einstein](#) (m. 1919 - 1936) · [Mileva Marić](#) (m. 1903 - 1919)

**Education:** [University of Zurich](#) · [Aargau Cantonal School](#) (1895 - 1896) · [ETH Zurich](#) · [Luitpold Gymnasium](#)

**Siblings:** [Maja Einstein](#) (Sister)

**Awards:** [Nobel Prize](#) (1) · [Max Planck Medal](#) (1) · [Matteucci Medal](#) (1) · [Other awards](#) (3)



## Albert Einstein

German-Born theoretical physicist; developer of the theory of relativity (1879–1955)

Albert Einstein was a German-born theoretical physicist, widely acknowledged to be one of the greatest physicists of all time. Einstein is known for developing the theory of relativity, but he also made important contributions to the development of the theory of quantum mechanics. Relativity and quantum mechanics are together the two pillars of modern physics...

[Read More](#)

Wikipedia

Official Website

Facebook

IMDB

**Born** March 14, 1879

**Died** April 18, 1955

**Spouse** [Elsa Einstein](#) (1919–1936) · [Mileva Marić](#) (1903–1919)

**Children** [Hans Albert Einstein](#) · [Eduard Einstein](#) · [Lieserl Einstein](#)

**Parents** [Hermann Einstein](#) · [Pauline Koch](#)

**Notable work** [Special Relativity](#) · [General Relativity](#) · [Photoelectric Effect](#) · [More Notable work](#)

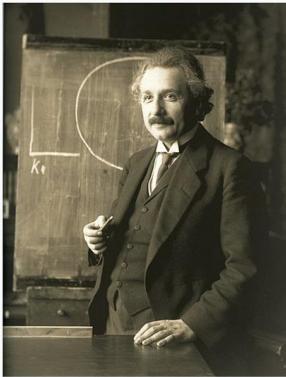


# Where to get the Data?



**WIKIPEDIA**  
The Free Encyclopedia





Einstein in 1921

# Wikipedia

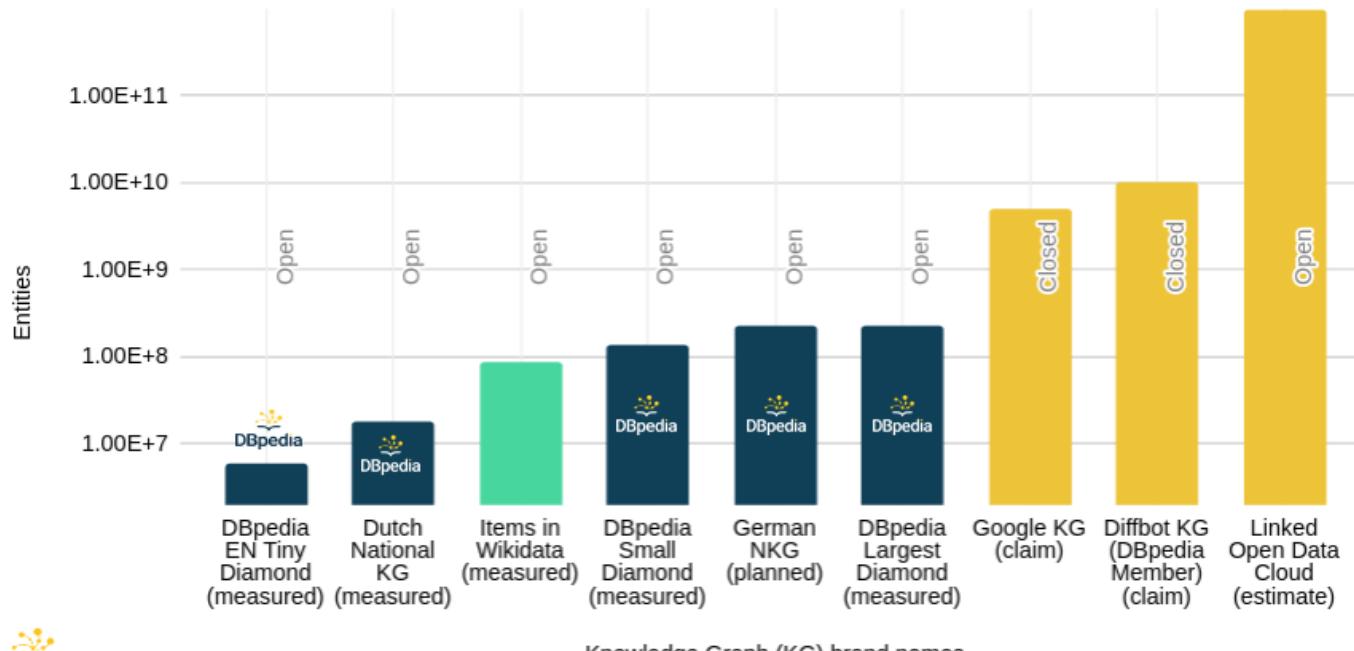
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| image = Einstein 1921 by F Schmutzler - restoration.jpg
| caption = Einstein in 1921
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| death_date = {{Death date and age|df=yes|1955|4|18|1879|3|14}}
| death_place = {{nowrap|[[Princeton, New Jersey]], U.S.}}
| children = {{plainlist|
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*[[Hans Albert Einstein]]
*[[Einstein family#Eduard "Tete" Einstein (Albert's second son)|Eduard "Tete" Einstein]]}}
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| citizenship = {{plainlist|
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* [[Statelessness|Stateless]] (1896–1901)
* [[Switzerland]] (1901–1955)
* [[Cisleithania|Austria]], part of the [[Austro-Hungarian Empire]] (1911–1912)
* [[Kingdom of Prussia]], part of the German Empire (1914–1918)<ref group="note" name="GECitizen" />
* [[Free State of Prussia]] ([[Weimar Republic]], 1918–1933)
* [[United States]] (1940–1955)
}}
| fields = [[Physics]], [[philosophy]]
| workplaces = {{plainlist|
* [[Swiss Patent Office]] ([[Bern]]) (1902–1909)
* [[University of Bern]] (1908–1909)
* [[University of Zurich]] (1909–1911)
* [[Karl-Ferdinands-Universität|Charles University in Prague]] (1911–1912)
* [[ETH Zurich]] (1912–1914)
* [[Prussian Academy of Sciences]] (1914–1933)
* [[Humboldt University of Berlin]] (1914–1933)
* [[Kaiser Wilhelm Institute]] (director, 1917–1933)
* [[German Physical Society]] (president, 1916–1918)
* [[Leiden University]] (visits, 1920)
* [[Institute for Advanced Study]] (1933–1955)
* [[Caltech]] (visits, 1931–1933)
* [[University of Oxford]] (visits, 1931–1933)
}}
| education = {{plainlist|
* [[ETH Zurich|Federal polytechnic school]] in [[Zurich]] (Federal teaching diploma, 1900)
}}
```

<b>Born</b>	14 March 1879 Ulm, Kingdom of Württemberg, German Empire
<b>Died</b>	18 April 1955 (aged 76) Princeton, New Jersey, U.S.
<b>Citizenship</b>	Kingdom of Württemberg, part of the German Empire (1879–1896) <sup>[note 1]</sup> Stateless (1896–1901) Switzerland (1901–1955) Austria, part of the Austro-Hungarian Empire (1911–1912) Kingdom of Prussia, part of the German Empire (1914–1918) <sup>[note 1]</sup> Free State of Prussia (Weimar Republic, 1918–1933) United States (1940–1955)
<b>Education</b>	Federal polytechnic school in Zurich (Federal teaching diploma, 1900) University of Zurich (PhD, 1905)

# DBpedia

Sep 2020: Current entity size of selected KGs (open and closed), log-scale



# Wikidata

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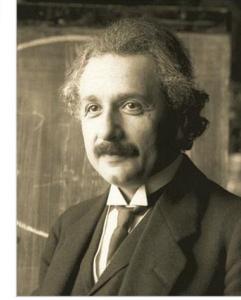
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  "datavalue": {
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## image



Einstein1921 by F Schmutz 2.jpg  
1,182 x 1,475; 392 KB

## ► 1 reference

male

country of citizenship

## German Empire

start time 14 March 1879 Gregorian  
end time 28 January 1896 Gregorian

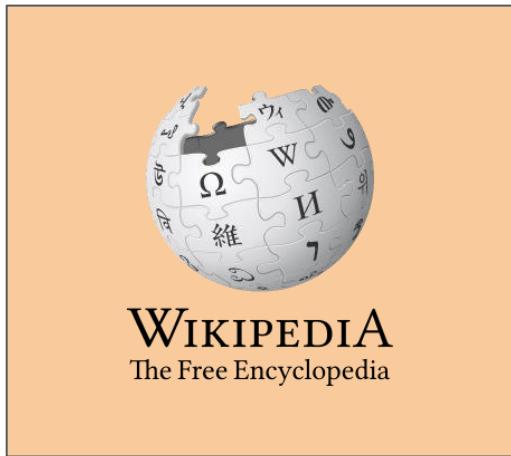
### ► 3 ref

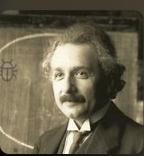
no value

Switzerland      start time 21 February 1901 *Gregorian*

8 of 6

# Where to get the Data?





**Albert Einstein**  
German-Born theoretical physicist; developer of the theory of relativity (1879–1955)

Albert Einstein was a German-born theoretical physicist, widely acknowledged to be one of the greatest physicists of all time. Einstein is known for developing the theory of relativity, but he also made important contributions to the development of the theory of quantum mechanics. Relativity and quantum mechanics are together the two pillars of modern physics...

▽ [Read More](#)

[W Wikipedia](#) [🌐 Official Website](#) [Facebook](#) [IMDB](#)

Born	March 14, 1879
Died	April 18, 1955
Spouse	<a href="#">Elsa Einstein (1919–1936)</a> · <a href="#">Mileva Marić (1903–1919)</a>
Children	<a href="#">Hans Albert Einstein</a> · <a href="#">Eduard Einstein</a> · <a href="#">Lieserl (Einstein)</a>
Parents	<a href="#">Hermann Einstein</a> · <a href="#">Pauline Koch</a>
Notable work	<a href="#">Special Relativity</a> · <a href="#">General Relativity</a> · <a href="#">Photoelectric Effect</a> · ▽ <a href="#">More Notable work</a>

Wikipedia

Wikidata

# Requirements

- P0: Low latency at serve time
- P0: Customizable templates (weight matters for boxers and football players)
- P1: Pretty pictures
- P1: Concise summaries
- P1: Maps for Cities/States
- P2: Real time updates
- P2: Complex categorical pivots (e.g. List of notable people from some city)

# Achieving Low Latency

- Build vs Serve
  - flatten as much of the entity into in intermediate form in build time
  - do last minute formatting (e.g. unit conversion) at serve
- Serve from KV Store
  - we use Scylla
  - key by wikipedia url
  - value is our own intermediate representation

# Requirements

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    value : Einstein, Al  
},  
{
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    "value": "A. Einstein"
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]} }

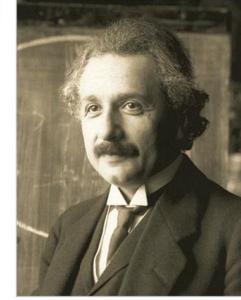
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    "property": "P1280",
```

```
    "hash": "3316c978734  
    "datavalue": {
```

## image



Einstein1921 by F Schmutz 2.jpg

1,182 x 1,475; 392 KB

## ► 1 reference

male

## German Empire

start time 14 March 1879 *Gregorian*

end time 28 January 1896 *Gregorian*

### ► 3 reference

Orthodox Liturgy      Orthodox.com      Gregorian

end time

## Switzerland

start time 21 February

```
- !!python/tuple
  - Human
    name: Human
    predicates:
      - Obj: Q5          # human
        Pred: P31        # instance of
    rules:
      - Pred: P569        # date of birth
        Shape: Singleton
        field: Born
      - Pred: P570        # date of death
        Shape: Singleton
        field: Died
      - Pred: P26          # spouses
        Shape: List
        field: Spouse
      - Pred: P40          # children
        Shape: List
        field: Children
      - Pred: P800         # notable works
        Shape: List
        field: Notable work
      - Pred: P69          # educated at
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    ...
  
```

```

"entities": {
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    "ns": 0,
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    "lastrevid": 1408521558,
    "modified": "2021-04-25T19:06:37Z",
    "type": "item",
    "id": "Q937",
    "labels": {
      "en": {
        "language": "en",
        "value": "Albert Einstein"
      }
    },
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        "value": "German-born theoretical physicist; developer of"
      }
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          "value": "Einstein, Albert"
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        {
          "language": "en",
          "value": "A. Einstein"
        }
      ]
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    },
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      "value": "Einstein, Albert"
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      "language": "en",
      "value": "A. Einstein"
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      "type": "statement",
      "id": "Q937$2271da52-4ee1-6a74-8d99-294bc3f6c7de",
      "rank": "normal"
    }
  ]
}
}

```



```

- !?python/tuple
- Human
  name: Human
  predicates:
    - Obj: Q5          # human
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      Shape: List
      field: Spouse
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      Shape: List
      field: Children
    - Pred: P800         # notable works
      Shape: List
      field: NotableWork

```

Born	March 14, 1879
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Parents	Hermann Einstein · Pauline Koch
Notable work	Special Relativity · General Relativity · Photoelectric Effect ·
	✓ More Notable work

Generate Expansions

Name	Free Software
Predicate	instanceOf <input type="button" value="Q341"/> + <input type="button" value="Get Examples"/>
Fields	
Founded	Field Predicate (options) P571
Developers	Field Predicate (options) P178
Programming Language	Field Predicate (options) P277
Copyright License	Field Predicate (options) P275
sridhar 9/15/2020	

Q4705216

Book  
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Wikidata

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Community portal

Project chat

Create a new item

Recent changes

Random item

Query Service

Nearby

Help

Donate

Lexicographical data

Item

## OpenStreetMap (Q936)

freely editable world geographic database

OSM | Open Street Map | [openstreetmap.org](#)

▼ In more languages

Language	Label	Description	Also known as
English	OpenStreetMap	freely editable world geographic database	OSM Open Street Map <a href="#">openstreetmap.org</a>

All entered languages

Matching rules: Free Software · Organization

**Q936**

**OpenStreetMap**

freely editable world geographic database

Founded [FactValue(is\_entity=False, property\_id=2004', url=None)]  
[FactValue(is\_entity=True, property\_id=url='https://en.wikipedia.org/wiki/Java')]  
Programming Language [FactValue(is\_entity=False, property\_id=url=None), FactValue(is\_entity=True, property\_id=text='Ruby', url='https://en.wikipedia.org/wiki/Ruby')]  
[FactValue(is\_entity=True, property\_id=Database License', url='https://en.wikipedia.org/wiki/Open')]  
Copyright License [FactValue(is\_entity=False, property\_id=url=None)]



Open Map ↗



## California

State of the United States of America



Directions

California is a state in the Western United States. With over 39.5 million residents across a total area of approximately 163,696 square miles, it is the most populous and the third-largest U.S. state by area. It is also the most populated subnational entity in North America and the 34th most populous in the world. The...

▼ [Read More](#)

W [Wikipedia](#)

🌐 [Official Website](#)

Founded [September 09, 1850](#)

Population [39,250,017 \(2016\)](#)

Area [163,696 mi<sup>2</sup>](#)

Governor [Gavin Newsom \(Since 2019\)](#)

Capital [Sacramento](#)

Senator [Dianne Feinstein · Alex Padilla](#)

# Dianne Feinstein

## position held



United States senator

edit

parliamentary term

117th United States Congress

electoral district

California Class 1 senate seat

parliamentary group

Democratic Party

start time

3 January 2021

elected in

2018 United States Senate election  
in California

# California Class 1 senate seat

## located in the administrative territorial entity



California

edit

▼ 0 references

add reference

- EdgePath:
  - P39 # position held
  - Q4416090 # United States senator
  - P768(q) # electoral district
  - P131 # in the administrative territorial entity
- IsInstance: Q5 # Human
- Shape: Invert
- field: Senator

# Requirements

- P0: Low latency at serve time
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# Getting pretty pictures



wd:Q134773 wdt:P18 ?pic

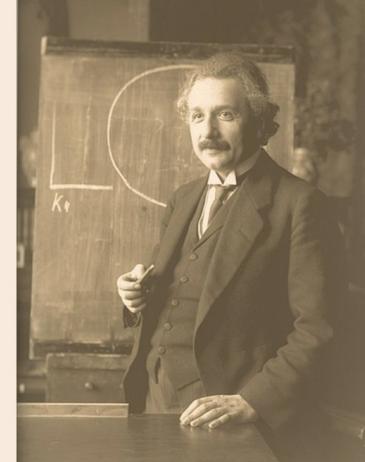


[en.wikipedia.org/wiki/Forrest\\_Gump](https://en.wikipedia.org/wiki/Forrest_Gump)

# Getting pretty pictures

**Albert Einstein** (/aɪnˈstæɪn/ *EYEN-styne*;<sup>[4]</sup> German: [albɛɐ̯t ˈaɪnʃtaɪn] (listen); 14 March 1879 – 18 April 1955) was a German-born theoretical physicist,<sup>[5]</sup> widely acknowledged to be one of the greatest physicists of all time. Einstein is known for developing the [theory of relativity](#), but he also made important contributions to the development of the theory of [quantum mechanics](#). Relativity and quantum mechanics are together the two pillars of [modern physics](#).<sup>[3][6]</sup> His mass–energy equivalence formula  $E = mc^2$ , which arises from relativity theory, has been dubbed "the world's most famous equation".<sup>[7]</sup> His work is also known for its influence on the [philosophy of science](#).<sup>[8][9]</sup> He received the 1921 [Nobel Prize in Physics](#) "for his services to theoretical physics, and especially for his discovery of the law of the photoelectric effect",<sup>[10]</sup> a pivotal step in the development of quantum theory. His intellectual achievements and originality resulted in "Einstein" becoming [synonymous](#) with "genius".<sup>[11]</sup>

In 1905, a year sometimes described as his [annus mirabilis](#) ('miracle year'), Einstein published [four groundbreaking papers](#).<sup>[12]</sup> These outlined the theory of the photoelectric effect, explained [Brownian motion](#), introduced [special relativity](#), and demonstrated mass-energy equivalence.

Albert Einstein	
	
Einstein in 1921	
<b>Born</b>	14 March 1879 Ulm, Kingdom of Württemberg, German Empire
<b>Died</b>	18 April 1955 (aged 76) Princeton, New Jersey, U.S.
<b>Citizenship</b>	Kingdom of Württemberg, part of the German Empire (1879–1896) <sup>[note 1]</sup> Stateless (1896–1901)

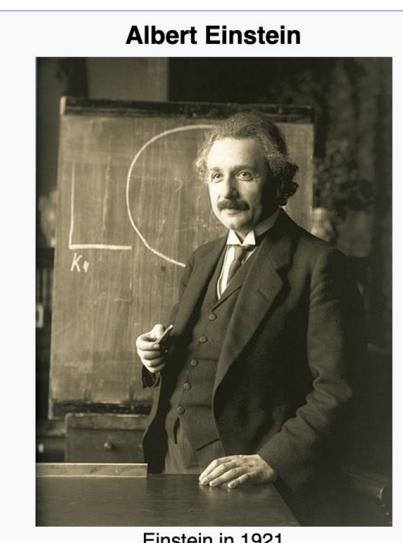
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- P2: Complex categorical pivots (e.g. List of notable people from some city)

# Getting concise summaries

**Albert Einstein** (/*ɛɪnstaɪn/ EYEN-styne;<sup>[4]</sup> German: [ˈalbɛɐ̯t ˈɛɪnʃtaɪn] (listen); 14 March 1879 – 18 April 1955) was a German-born **theoretical physicist**,<sup>[5]</sup> widely acknowledged to be one of the greatest physicists of all time. Einstein is known for developing the **theory of relativity**, but he also made important contributions to the development of the theory of **quantum mechanics**. Relativity and quantum mechanics are together the two pillars of **modern physics**.<sup>[3][6]</sup> His **mass–energy equivalence** formula  $E = mc^2$ , which arises from relativity theory, has been dubbed "the world's most famous equation".<sup>[7]</sup> His work is also known for its influence on the **philosophy of science**.<sup>[8][9]</sup> He received the 1921 **Nobel Prize in Physics** "for his services to theoretical physics, and especially for his discovery of the law of the **photoelectric effect**",<sup>[10]</sup> a pivotal step in the development of quantum theory. His intellectual achievements and originality resulted in "Einstein" becoming **synonymous** with "genius".<sup>[11]</sup>*

In 1905, a year sometimes described as his **annus mirabilis** ('miracle year'), Einstein published **four groundbreaking papers**.<sup>[12]</sup> These outlined the theory of the photoelectric effect, explained **Brownian motion**, introduced **special relativity**, and demonstrated mass–energy equivalence.



Einstein in 1921

<b>Born</b>	14 March 1879 Ulm, Kingdom of Württemberg, German Empire
<b>Died</b>	18 April 1955 (aged 76) Princeton, New Jersey, U.S.
<b>Citizenship</b>	Kingdom of Württemberg, part of the German Empire (1879–1896) <sup>[note 1]</sup>

# Requirements

- P0: Low latency at serve time
- P0: Customizable templates (weight matters for boxers and football players)
- P1: Pretty pictures
- P1: Concise summaries
- P1: Maps for Cities/States
- P2: Real time updates
- P2: Complex categorical pivots (e.g. List of notable people from some city)

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<a href="#">population</a>	64403
<a href="#">population:date</a>	2010
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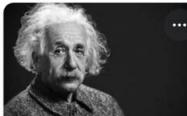
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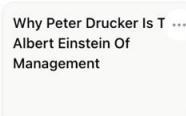
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### Einstein's Early Life

Born on March 14, 1879, in the southern German city of Ulm, Albert Einstein grew up in a middle-class Jewish family in Munich. As a child, Einstein became fascinated by music (he played the violin), mathematics and science. He dropped out of school in 1894 and moved to Switzerland, where he resumed his schooling and later gained...



## Albert Einstein

German-Born theoretical physicist; developer of the theory of relativity (1879-1955)

Albert Einstein was a German-born theoretical physicist, widely acknowledged to be one of the greatest physicists of all time. Einstein is known for developing the theory of relativity, but he also made important contributions to the development of the theory of quantum mechanics. Relativity and quantum mechanics are together the two pillars of modern physics...

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# Summary

- Shift work from serve time to build time
  - Used PySpark for build processing over Wikidata JSON dumps
- Build scrappy tools for defining presentation layer
  - Defined a simple DSL for representing the transforms
  - Complex transforms (inversions) require preprocessing
  - Built a WYSIWYG editor for defining tools to minimize effort in adding rules
- Serve super fast
  - Used Scylla for key/value lookup by wikipedia URL
  - Transform the intermediate representation last minute using locale and device info
- Fill in gaps with other datasets
  - Wikipedia for thumbnails and summaries
  - OpenStreetMaps for political boundaries

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- Email me: [nathan@neeva.co](mailto:nathan@neeva.co)
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