Planet 9 or Planet Nein?
Discoveries in the Outer Solar System

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Pluto: The Original Kuiper Belt Object (KBO)

Discovered 62 years before 2nd KBO!

January 23, 1930

January 29, 1930

C. Tombaugh
Pluto: The Original Kuiper Belt Object (TNO)

January 23, 1930

January 29, 1930

1996

2005

2015

Credits (left to right): Alan Stern (Southwest Research Institute), Marc Buie (Lowell Observatory) NASA and ESA; NASA, ESA, H. Weaver (JHU/APL), A. Stern (SwRI), and the HST Pluto Companion Search Team; NASA/APL/SwRI
New Horizons Mission to Pluto
Flyby: July 14, 2015
New Horizons Team
Mountains made of water ice, glaciers made of nitrogen ice
New Horizons Mission to Pluto

New Horizons Team
Pluto:
Not a planet
(neener neener)
Largest known Trans-Neptunian Objects (TNOs)

- **Pluto**: 2377 km
- **Eris**: 2326 km
- **Haumea**: 2100x1680x1074 km
- **Makemake**: 1430 km
- **Gonggong**: 1230 km
- **Sedna**: 995 km
- **2002MS4**: 3476 km
- **Orcus**: 917 km
- **Salacia**: 854 km

Only the Pluto system images are real photographs taken by the New Horizons probe on July 14, 2015. All the other images are artistic impressions.

Rescaled and updated Feb 22, 2020
R. L. McNish, RASC Calgary Centre
Largest known Trans-Neptunian Objects (TNOs)

Hydra, Nix, Styx, Kerberos, Charon, 1212 km, Eris, 2326 km, Namaka, Dysnomia, Haumea, 2100x1600 km, Quaoar, Weywot, 1110 km, 150 km.

Only the Pluto system images are real photographs taken by the New Horizons probe on July 14, 2015. All the other images are artistic impressions.

How I Killed Pluto and Why It Had It Coming
Mike Brown

“Brims with humor and charm… exhilarating”
—Los Angeles Times

“[An] out-of-this-world science memoir… brilliant.”
—Minneapolis Star Tribune

Rescaled and updated Feb 22, 2020
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Pluto: Not a planet
(neener neener)

Go home Pluto...

You’re drunk!
**eccentricity (e):** how elliptical is an orbit?
circle: e=0
parabola: e=1

**TNO = Trans-Neptunian Object**
**KBO = Kuiper Belt Object**

**pericenter (q):** closest point to Sun
**inclination (i):**
how tilted is an orbit from Solar System plane?
semimajor axis (a):
how big is an orbit?

Earth’s Orbit

1 AU
Neptune’s Orbit

30 AU

Earth’s orbit
Neptune’s Orbit

Earth’s orbit

30 AU

Main Kuiper Belt
Sedna’s Orbit

pericenter: 76 AU

Kuiper Belt

936 AU
Sedna’s Orbit

Voyager 1:
149 AU in 43 YEARS
current speed: 61,000 km/hr!

Kuiper Belt
936 AU
Sedna’s orbit

10,000-ish AU to 100,000-ish AU?
Neptune’s Orbit

Earth’s orbit

30 AU
Neptune’s Orbit

Pluto’s orbit

Main Kuiper Belt

30 AU

Pluto’s orbit is eccentric and inclined
Pluto is in a Mean-Motion Resonance

120 kyr integration on Naval Ordnance Research Calculator

NSWC Dahlgren Division

Cohen & Hubbard (1964)
“in the 1970s, women accounted for 59 percent of acknowledged programmers, but just 7 percent of actual authors.”

Hidden dynamicist
Dr. Gladys West

Dung et al. (2019)

Cohen & Hubbard (1964)

Cohen, Hubbard & West (1964)