ASTR 311 Tutorial 3: Properties of Stars

Stars come in all colours and sizes, masses and brightnesses, ages and distances. How can we possibly learn how stars work when each one appears to be unique? What we need are some relationships between the characteristics of stars.

We already know that the colour of a star is directly related to the temperature of the star: red stars are cool, blue stars are hot. That means we don't have to measure both colour and temperature – we get one from the other. Are there any other relationships? What does a "relationship" look like, anyway? And what does a relationship tell us about how stars work?

In this tutorial, you'll see what it means for characteristics to be related (or not related) and then see how to use the relationships.

The Pleiades star cluster

Part 1: Finding Relationships

Each star in your collection has

ID identification number (on the lid)

name star's name

type star's evolutionary stage (main sequence, red giant, white dwarf, etc.))

spectral type stars spectral type (0 B A F G K M) which characterizes colour and temperature

luminosity star's luminosity compared to the Sun which has luminosity 1 L_{Sun}

mass star's mass compared to the Sun which has luminosity 1 M_{Sun}

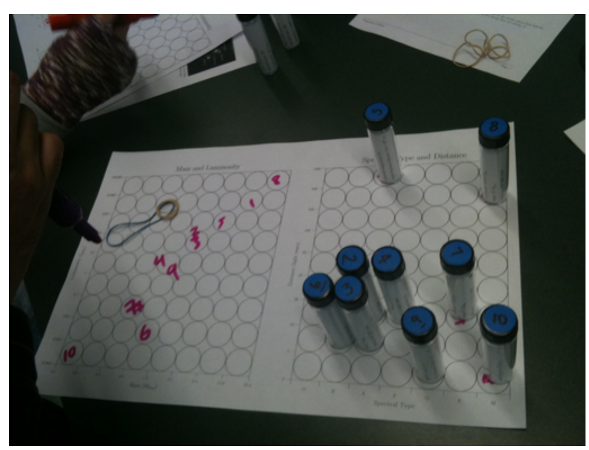
distance number of light years to the star

apparent magnitude how bright the star appears to us: smaller magnitude means brighter, larger magnitude means fainter

main sequence lifetime how long a main sequence star lives on the main sequence

Create each graph by placing the stars in the circles where they best fit. Before moving onto the next graph, write the ID numbers of the stars in the circles they are sitting on.

When you've created all 5 graphs, move on to Part 2.



Part 2: What does "related" mean, anyway?

Remember, the goal of collecting information about stars is to look for patterns and relationships between their properties. What do astronomers look for to say "these two properties are related" or "those properties have nothing to do with each other"? And how do we take advantage of the relationships that exist?

Use your graphs to complete this Table by describing the "shape" of the data in the graph. Then use the graph to find the missing values. If you can't determine the missing value, explain why not.

Graph	What is the "shape" of the data?	Values and Explanations
Main Sequence Lifetime and Mass		A star with main sequence lifetime 10^{11} years has mass ___________. A star with mass 5 M_{Sun} has main sequence liftime ___________.
Spectral Type and Distance		A star with spectral type B has distance ___________. A star at distance 15 light years has spectral type ___________.
Spectral Type and Luminosity		A main sequence star with spectral type M has luminosity ___________. A star with luminosity 0.005 L_{Sun} has spectral type ___________.

Describe what you can do if you discover Property A and Property B are related.

Describe what you can't do if you discover Property A and Property B are *not* related.

Name ______________________________ ID No. _________________ Tutorial Day/Time ________________

Part 3: Questions

Please hand in this worksheet when you are finished.

1. Some properties of stars are related and some are not. Which ones? What are the relationships, if any? Looking at the graphs you made earlier, decide if the two properties are related, might be related or have nothing to do with each other. If there is a relationship, describe it with a sentence like, "the bigger the gas tank, the bigger the cost to fill it" or "the bigger the price, the smaller the cell phone you can buy". Can you think of reasons the properties are related that way?

Properties	Relationship	Reason(s)
Mass and Luminosity (main sequence stars only)		
Spectral Type and Distance		
Main Sequence Lifetime and Mass		
Spectral Type and Luminosity		
Luminosity and Apparent Magnitude		

2. We can't travel to a star to directly measure its mass or luminosity. The only things we can measure from here on Earth is the star's spectral type and apparent magnitude. The power of the relationships between the properties, though, is that if you know one property, you know the other – without having to measure it directly.

   Astronomers have found a new star, Wayne 99. Use the relationships you found earlier to estimate the missing properties and complete the description of the star.

   name Wayne 99

   type main sequence

   spectral type A6

   luminosity ____________________

   mass ____________________

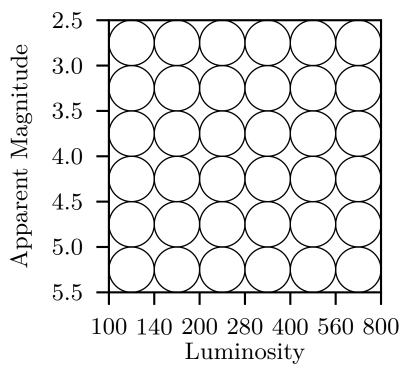
   main sequence lifetime ____________________

   apparent magnitude 5.8

   distance ____________________

3. One of the graphs you made showed there is *not* a relationship between the luminosity of a star (how much energy it releases) and its apparant magnitude (how bright it appears in the sky). Plot these properties for the 7 bright stars (the "Seven Sisters") in The Pleiades star cluster:

Star	Luminosity (L_{Sun})	Apparent Magnitude
Pleione	100	5.1
Taygeta	210	4.3
Merope	240	4.1
Maia	310	3.9
Electra	360	3.7
Atlas	390	3.6
Alcyone	790	2.9



What is so special about the stars in the Pleiades that luminosity and apparent magnitude *are* related?

star 1: Spica
type: main sequence
spectral type: B1
luminosity: 23 000 L_{Sun}
mass: 11 M_{Sun}
distance: 260 light years
apparent magnitude: 0.9
main sequence lifetime: 4.8×10^6 yr

star 2: Altair
type: main sequence
spectral type: A7
luminosity: 10.5 L_{Sun}
mass: 1.7 M_{Sun}
distance: 16.7 light years
apparent magnitude: 0.8
main sequence lifetime: 1.6×10^9 yr

star 3: Sirius
type: main sequence
spectral type: A1
luminosity: 26 L_{Sun}
mass: 2 M_{Sun}
distance: 8.6 light years
apparent magnitude: -1.4
main sequence lifetime: 7.7×10^8 yr

star 4: Procyon
type: main sequence
spectral type: F5
luminosity: 7.4 L_{Sun}
mass: 1.5 M_{Sun}
distance: 11.4 light years
apparent magnitude: 0.4
main sequence lifetime: 2.0×10^9 yr

star 5: Feles Major
type: main sequence
spectral type: B7
luminosity: 150 L_{Sun}
mass: 3.5 M_{Sun}
distance: 770 light years
apparent magnitude: 6.4
main sequence lifetime: 2.0×10^8 yr

star 6: Sirius B
type: white dwarf
spectral type: B1
luminosity: 0.0025 L_{Sun}
mass: 1 M_{Sun}
distance: 8.6 light years
apparent magnitude: 8.4
main sequence lifetime: n/a

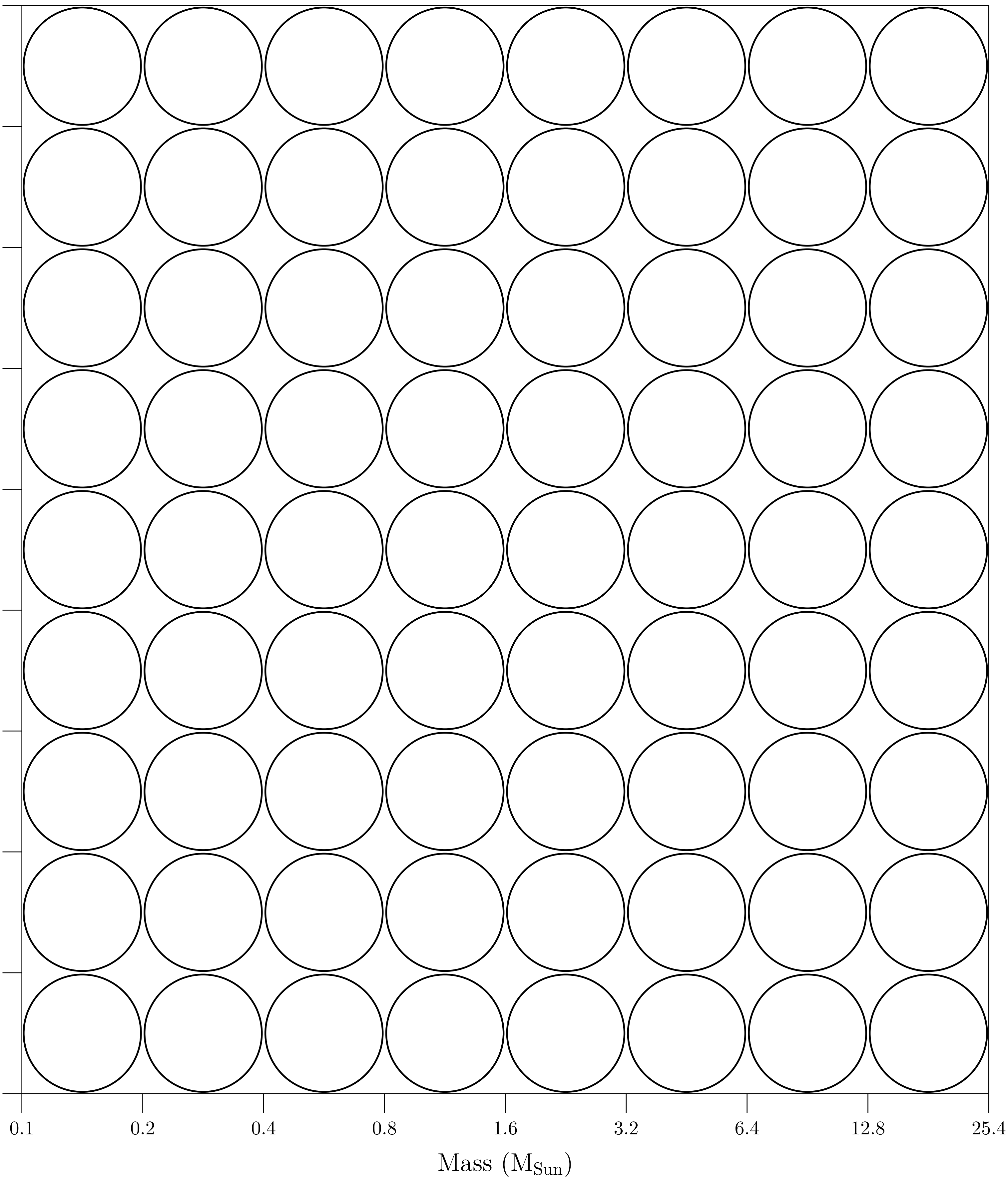
star 7: 61 Cygni
type: main sequence
spectral type: K5
luminosity: 0.085 L_{Sun}
mass: 0.7 M_{Sun}
distance: 11.4 light years
apparent magnitude: 5.2
main sequence lifetime: 8.2×10^{10} yr

star 8: Betelgeuse
type: red giant
spectral type: M2
luminosity: 38 000 L_{Sun}
mass: 20 M_{Sun}
distance: 427 light years
apparent magnitude: 0.4
main sequence lifetime: n/a

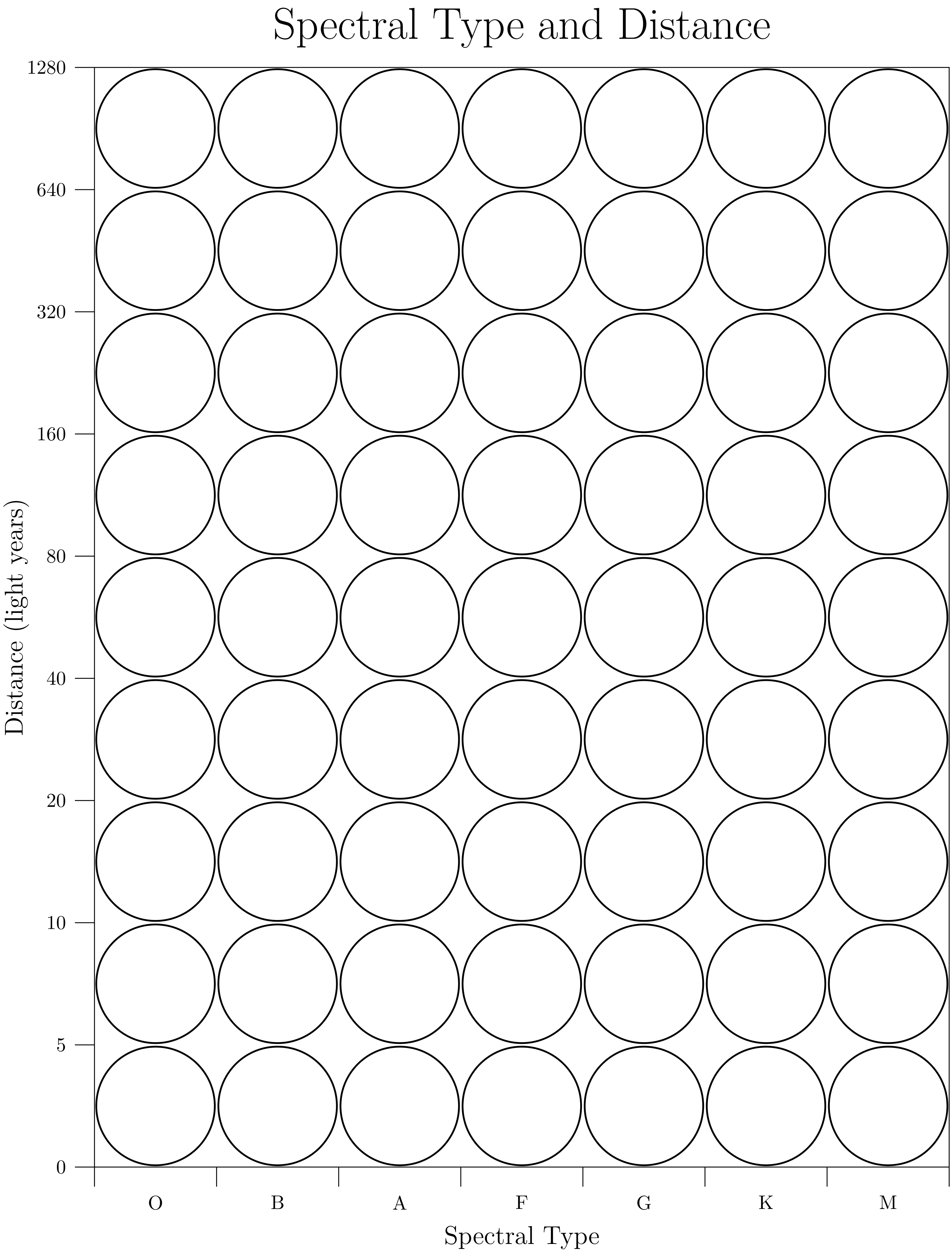
star 9: Alpha Centauri
type: main sequence
spectral type: G2
luminosity: 1.6 L_{Sun}
mass: 1.1 M_{Sun}
distance: 4.4 light years
apparent magnitude: 0
main sequence lifetime: 6.7×10^9 yr

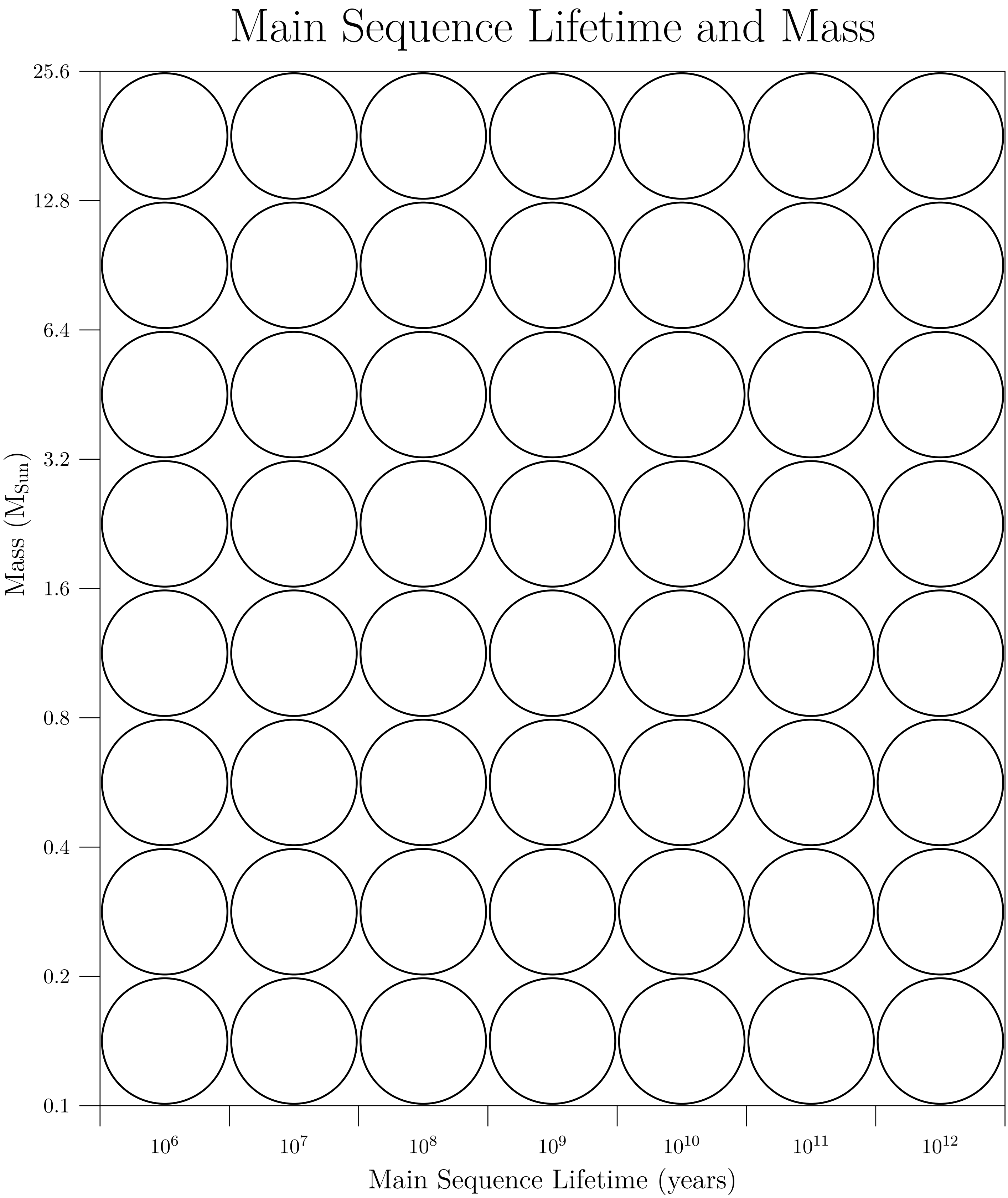
star 10: Proxima Centauri
type: main sequence
spectral type: M5
luminosity: 0.0006 L_{Sun}
mass: 0.1 M_{Sun}
distance: 4.2 light years
apparent magnitude: 11
main sequence lifetime: 1.7×10^{12} yr

Mass and Luminosity

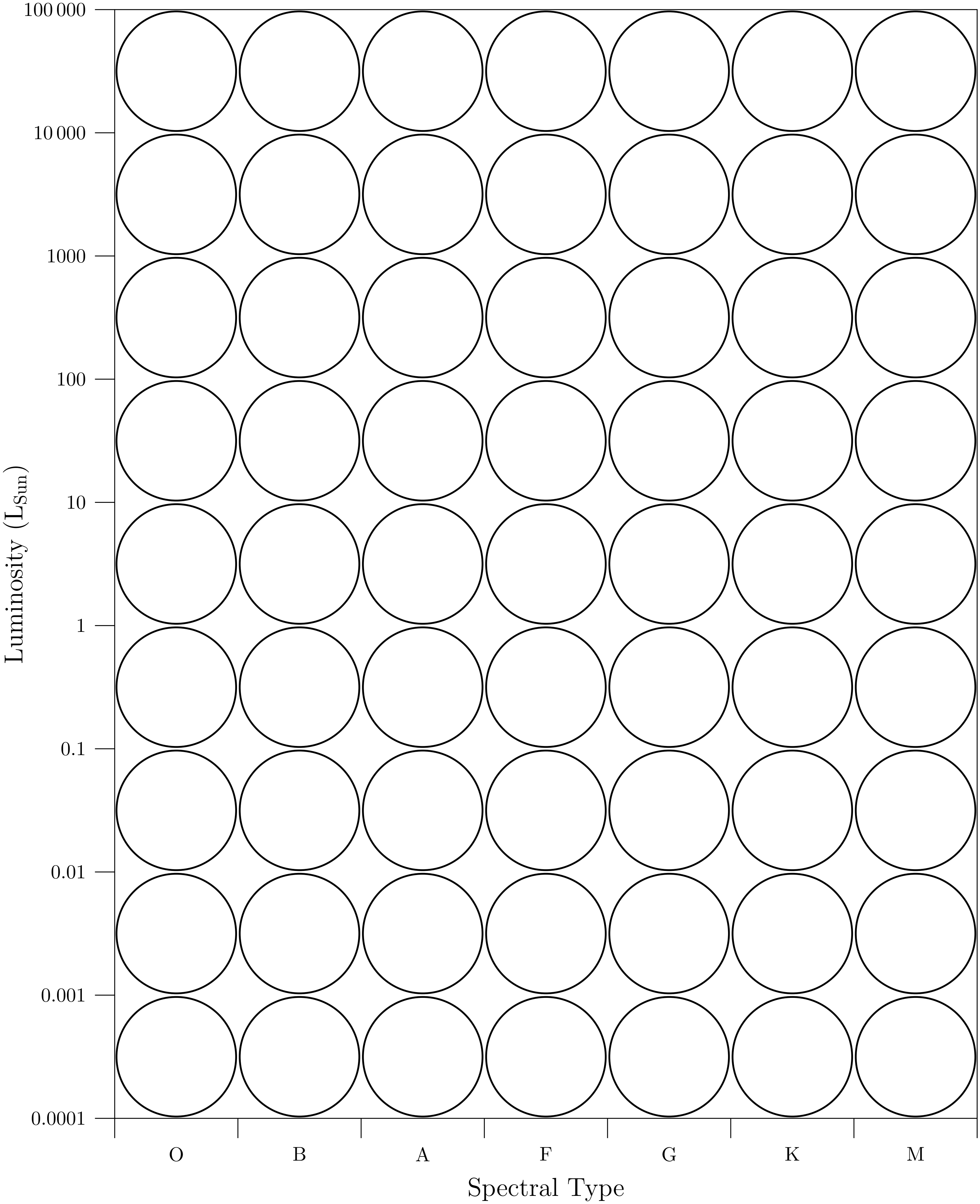


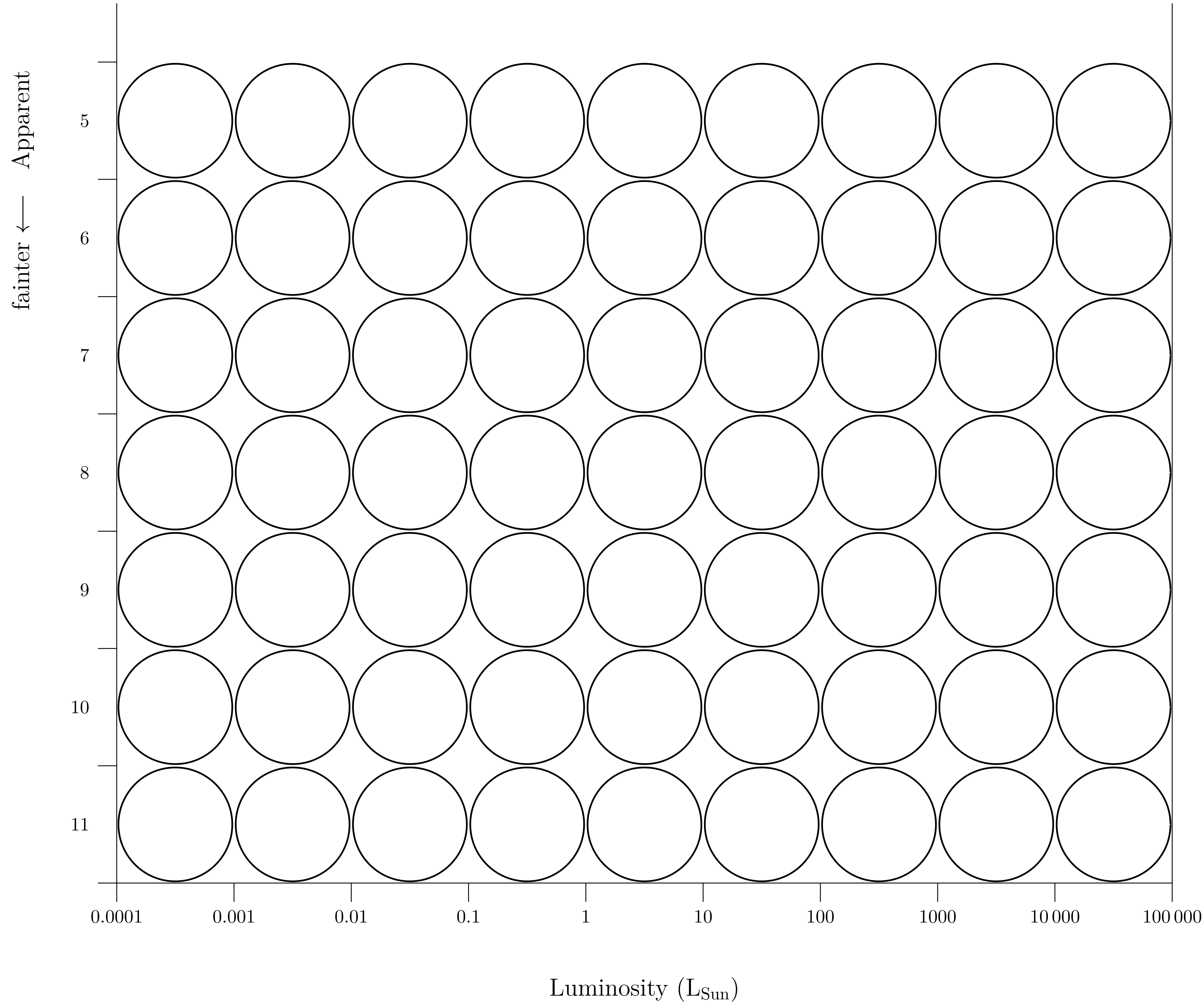
100 000
10 000
1000
100
Luminosity (L_{Sun})
10
1
0.1
0.01
0.001
0.0001


Spectral Type and Distance
1280
640
320
160
80
40
20
10
5
0
Distance (light years)
O
B
A
F
G
K
M
Spectral Type


Main Sequence Lifetime and Mass
Mass (M_{Sun})
25.6
12.8
6.4
3.2
1.6
0.8
0.4
0.2
0.1
10^6
10^7
10^8
10^9
10^{10}
10^{11}
10^{12}
Main Sequence Lifetime (years)

Spectral Type and Luminosity





Apparent
fainter ⟵
5
6
7
8
9
10
11
0.0001
0.001
0.01
0.1
1
10
100
1000
10 000
100 000
Luminosity (L_Sun)

Luminosity and Apparent Magnitude