Monday, Oct. 20

Syllabus, class notes, and homeworks are at:
www.as.utexas.edu → courses → AST 301, Lacy

Reading for this week: chapter 10

The second exam will be this Friday. If you didn't get a review sheet on Friday, there are more in the homework return boxes.

The Wednesday help session is in GRG 424 at 5:00 (for the entire semester).

Topics for this week

Describe how a star (or protostar) changes if it generates more (or less) energy by nuclear fusion than it radiates from its surface.

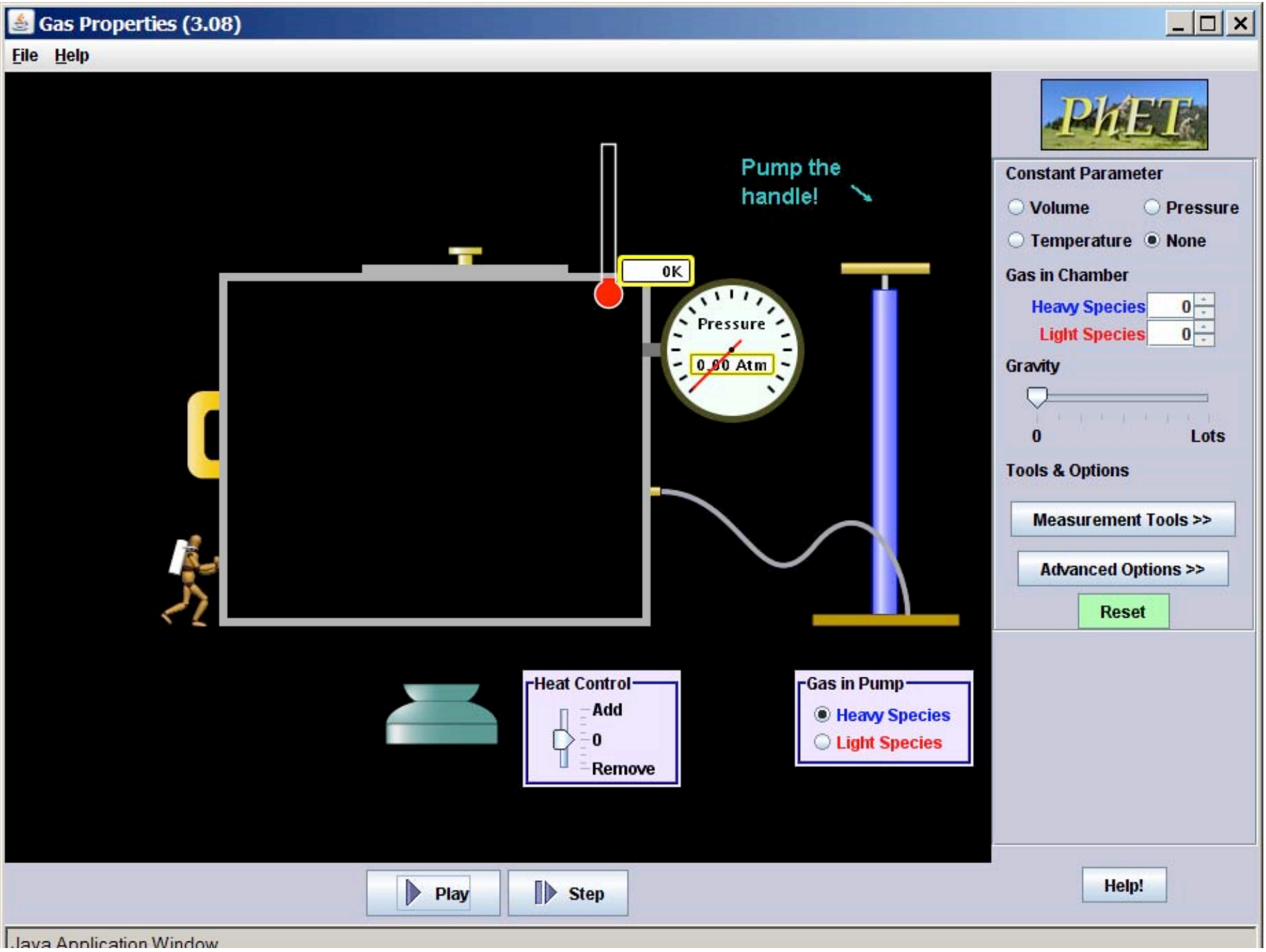
Describe the changes that occur near the center of a star as it changes from a main-sequence star into a red giant.

Describe how a red giant becomes a planetary nebula and a white dwarf.

How does the pressure inside a white dwarf differ from normal gas pressure?

How does nuclear fusion inside of very massive stars differ from the fusion that will occur inside of the Sun?

How do the processes that occur inside of massive stars lead to supernova explosions?


Gas Properties (3.08)
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Lots
Tools & Options
Measurement Tools >>
Advanced Options >>
Reset
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Java Application Window

Thermal Equilibrium in Stars

Protostars are not in thermal equilibrium.

They lose energy by radiation from their surfaces, but they aren't hot enough inside to ignite nuclear fusion to replace the lost energy.

As a result, they contract and heat up.

Once they are hot enough inside (about 10^7 K) fusion can replace the energy they are losing.

They are then in a stable thermal equilibrium; if fusion slowed down, they would contract and heat up causing fusion to speed back up until it balances the energy they are losing.

Because of this stable equilibrium, the Sun will hardly change for 10^{10} years, until it uses up all of the hydrogen in its core.

Quiz

If a star (or a part of a star) loses more energy than it generates, it will …

A. contract and heat up

B. contract and cool off

C. expand and heat up

D. expand and cool off

The loss of energy will cause a loss of pressure, leading to contraction. But contraction will convert gravitational energy to heat energy, and the star will end up hotter than it was at first.

Becoming a Red Giant

(The complete explanation for how a main-sequence star becomes a red giant is complicated, and I'm not really giving you the whole story. But the conclusion is right. Don't worry if you don't follow all of the explanation.)

When all of the hydrogen in the core of a main-sequence star is all turned into helium, fusion will stop in the core, and the core will contract and heat up.

Fusion will continue in a shell around the helium core, and will generate more energy than fusion in the core did.

The extra energy going out from the core+shell will make the envelope expand and cool off.

Red Giants

When the Sun becomes a red giant, its radius will increase to about ½ AU, and it will become more than 100 times more luminous than it is now.

Life will not be pleasant on Earth.

The core of the Sun will be mostly helium, and will continue to contract and heat up.

When the temperature in the core reaches about 10^8 K (about 1 million years after the Sun leaves the main sequence), helium will begin to fuse to make carbon.

A Red Giant with helium fusion

When helium fusion starts generating energy in the core of a red giant, the core expands and hydrogen fusion in the shell around the core slows down.

As a result, less total energy is being generated, and the envelope contracts and warms up some.

But pretty soon all of the helium in the core is converted into carbon and fusion stops again in the core.

Then the core again contracts, surrounded by two shells, one with He → C fusion, and one with H → He fusion.

The envelope again expands and cools off.

Is stellar evolution just a theory?
Or is it even a (scientific) theory?

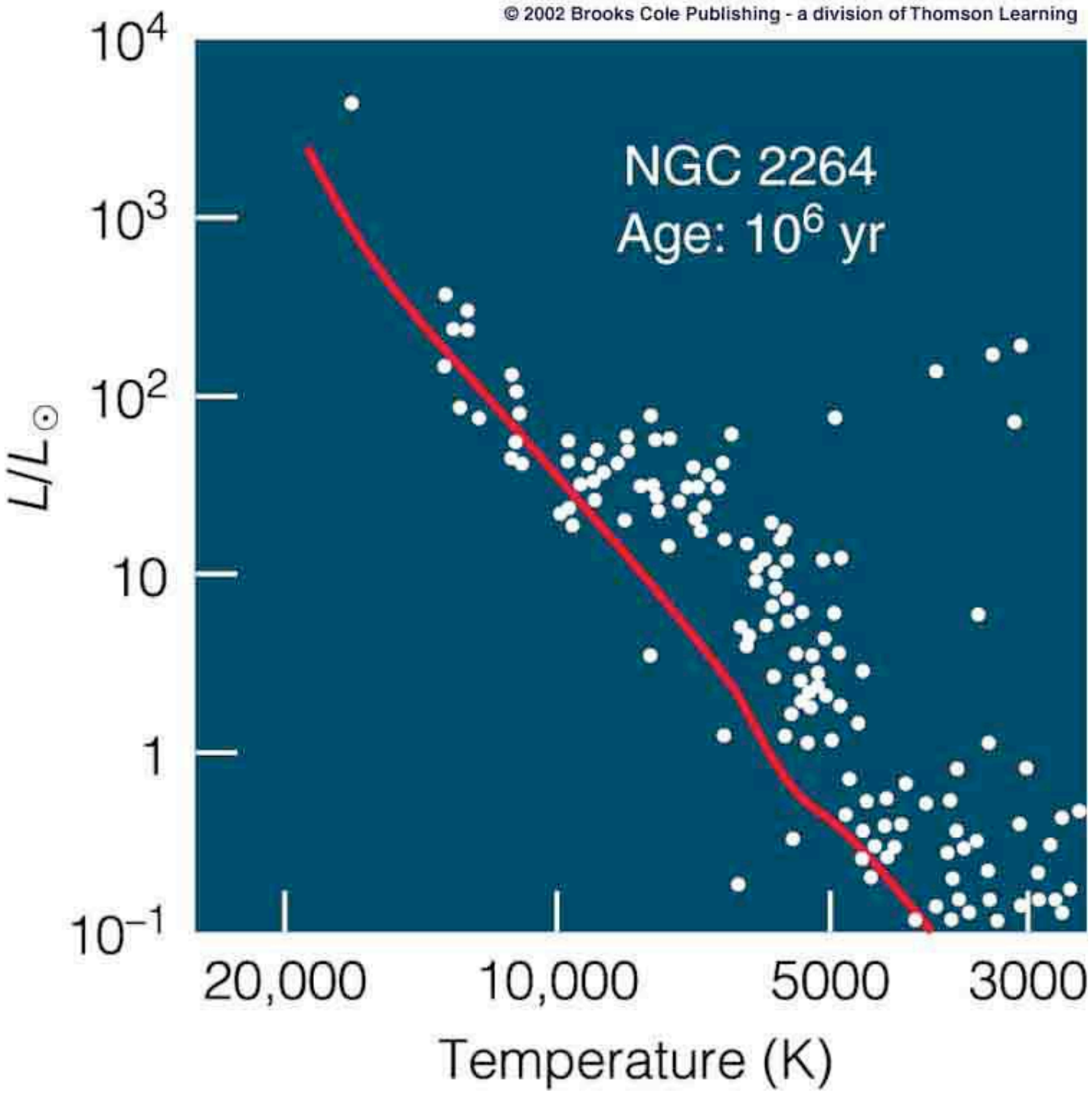
For a hypothesis to be a scientific theory it must be testable.

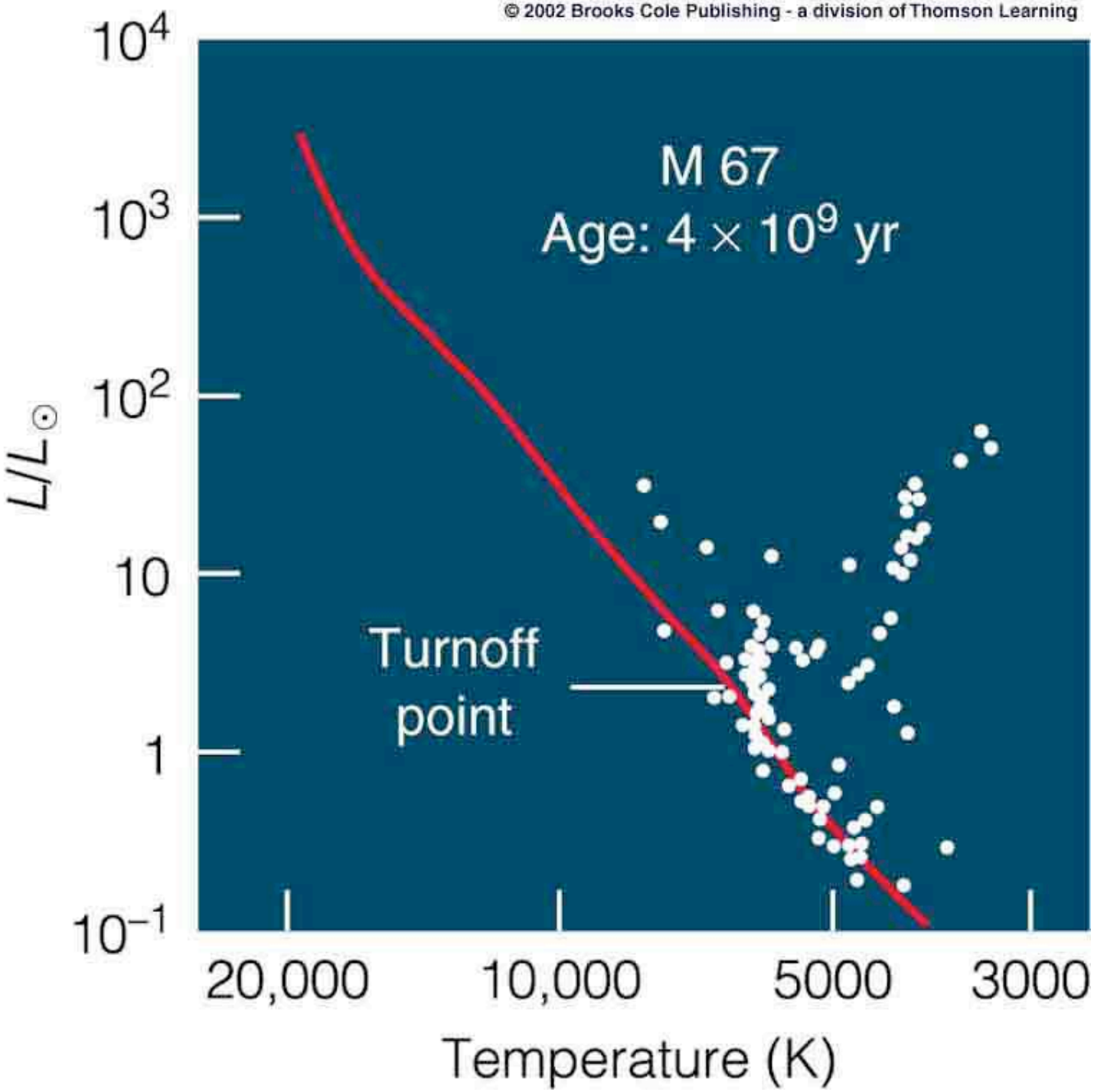
Almost all of stellar evolution occurs so slowly that we cannot watch it happen.

Our tests of stellar evolution must be indirect.

The primary test involves observing stars in a star cluster, which we have reason to believe all formed at the same time, so have the same age.

Stellar evolution theory predicts the pattern they should form on an H-R diagram.





Have we proved the theory right?

The theory of stellar evolution provides a very good explanation for the H-R diagrams of star clusters.

We have tested the theory and it passed the test.

But for a hypothesis to be a scientific theory it must be testable, and a test only makes sense if it is conceivable that the theory will fail.

In that sense, we can never prove a scientific theory right.

If a hypothesis can be proved right, it may be a valid mathematical or logical theorem, but it's not a scientific theory.

We are confident that the theory of stellar evolution is essentially correct, but we will keep testing and refining it.