Star formation is among the major unsolved problems of astrophysics.
We understand few of the details (e.g. why stars have the masses they do, why so many are binaries), but at least we can see them doing it, so we know that at least the basic picture is OK:

> Essentially, gravity pulls gas together into a star. Since the cloud is rotating, angular momentum conservation flattens it into a disk, just like the Solar Nebula.
>
> Proplyds = protoplanetary disks: over 150 discovered in the Orion Nebula with *Hubble Space Telescope*.
>
> T Tauri stars = stars just like the Sun, only newly formed.
> T Tauri itself is a G5V (versus G2V, for the Sun), but only 1 million years old.
> Its rotation is rapid (P = 1 day; recall that for the Sun, P = 25 days)

The prospects for improving our understanding of star formation are good, because of improving technology for observing radio and infrared radiation, which has wavelengths longer than the dust grains that obscure our view, so it goes right through the dust.

The dust therefore causes <u>reddening</u> of starlight: since only the red light gets through, stars obscured by dust often look much redder than they really are.

> → This is also why sunsets are red: because of dust in Earth's atmosphere, which we look through a lot of, when the Sun is low in the sky.

Nebulae (clouds in interstellar space) come in several distinctive physical types:

(1) **Dark clouds**, which are full of dust. This dust comes in a wide variety of types: <u>silicates</u> (rocks), <u>carbon</u> (graphite, soot, diamonds), and many types of molecules, especially <u>organic molecules</u>, including the "brown organic tarry gunk" (polycyclic aromatic hydrocarbons) found all over the Outer Solar System.
Dark clouds are very dense, and so are often where stars are forming. This makes observing star formation difficult: the young stars are surrounded by dense dust cocoons.

(2) Bright-line, **emission nebulae**: these are the glowing <u>red</u> clouds, lit up by starlight, just like the fluorescent lights above you. Most planetary nebulae (thrown off when stars like the Sun die) are emission nebulae, lit up by their central stars (which are very hot, because they were once a star's nuclear furnace). Many star-forming regions (e.g. the Orion Nebula) are also emission nebulae, because their, hot, bright, young, O and B stars are also very hot, and light them up.

(3) **Reflection nebulae**: these are the <u>blue</u> clouds. They shine by reflected starlight (like planets), but they become blue because they <u>scatter</u> light. <u>This is the same reason the Earth's sky is blue</u> (or oceans, or glaciers): blue light scatters more than any other color, because air molecules (or interstellar dust grains, or water or ice molecules) are about the same size as the wavelength of blue light.

Also, *very hot*, thin, **coronal gas** surrounds the hot, warm, and cold gas and dust. This very hot gas is from supernova explosions, and pervades the plane of the Milky Way. We know the coronal gas is there because it's so hot, it emits X-rays.