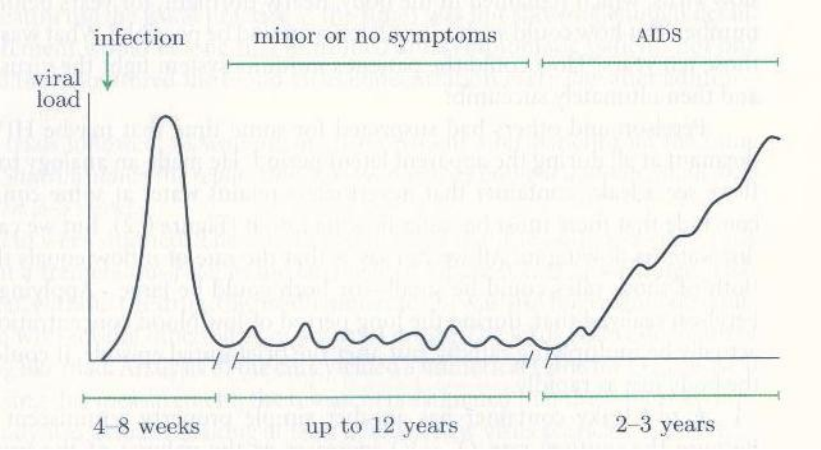
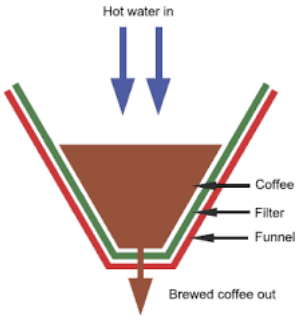
HIV and AIDS: A physics perspective.

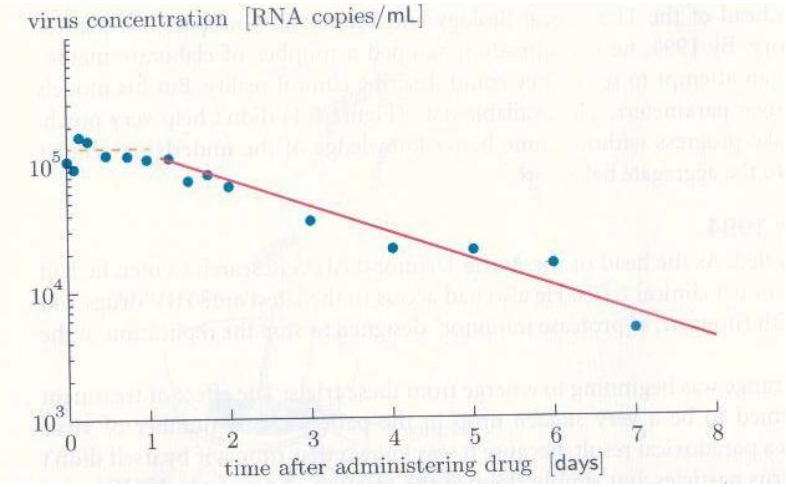
HIV is a virus that attacks the human immune system (CD4 + T cells). When the CD4 cell count becomes too low (after say 12 years) the patient develops SAIDS. When a person is infected with the HIV virus he quickly becomes ill for a period of a few weeks, but after that period he may appear healthy for many years, before succumbing to AIDS. See figure below:



In the above figure the viral load is the concentration of virus detected in the blood of patients infected with HIV. The period of about 12 years with no symptoms is correlated with low and steady viral load. Initially it was is postulated that during this period the virus is dormant – present but not reproducing, or causing too much harm. In the 1990s, Alan Perelson, the head of the theoretical biophysics group at Los Alamos, has been unable to explain the clinical data, using his many mathematical models.



Is it possible that the HIV virus is not dormant, but simply exists in a steady state inside the body? This is illustrated by the coffee percolator on the left, where virus is steadily multiplying in the body, just like water is poured into the funnel. But just as quickly the viruses are somehow cleared by the body of the patient, just as water drips through the bottom of the percolator. The value of the viral load is steady, just like the steady volume in the funnel.



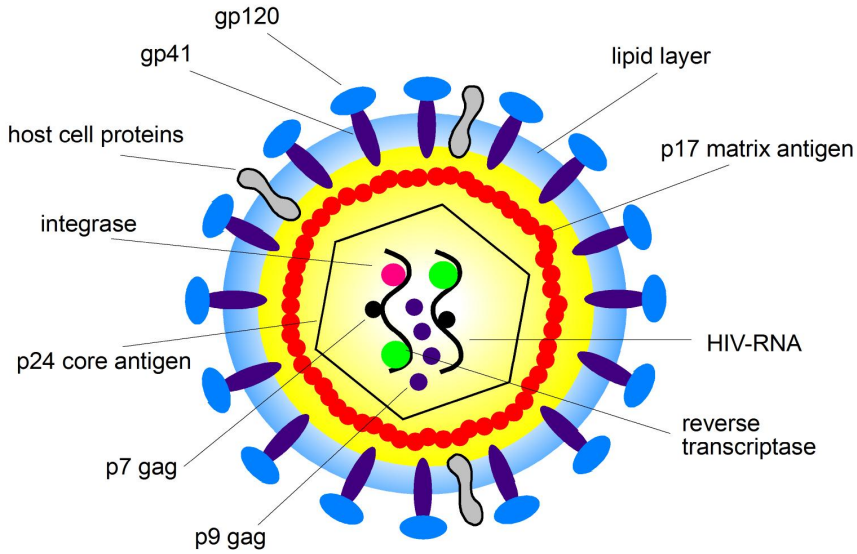
In 1994, David Ho, the head of the Aaron Diamond AIDS Research Center has conducted clinical trials with **ritonavirs**, **antivirial** drugs that **do not destroy viral particles**, but prevents new one from being produced. The results are shown on the left.

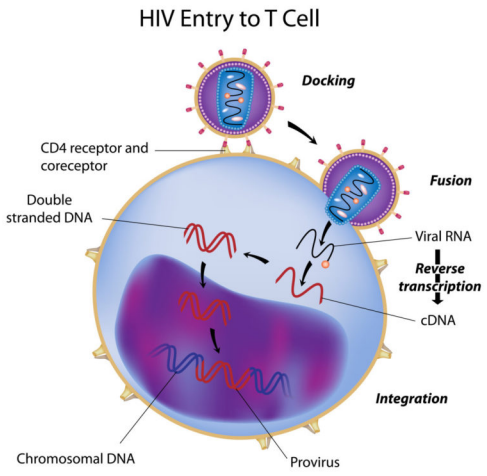
The result is paradoxical. If the viruses are in a dormant state, ritonavirs should not kill the virus already in the patients. It is also well known that patients who treated with ritonavirs got better but only for a short period. Perelson and Ho postulated the following:

1. During the dormant period, HIV viruses multiply at a rapid rate in the human body
2. The Human body is able to clear the HIV particles as they are produced..
3. Ritonavirs stops production of new viral particles, the viral counts go down. The patient feels better because his CD4 cells are not being killed.
4. HIV viruses can evolve (mutate) to drug resistant form very quickly, after which the viral load grows again.

Ritonavir is a "protease inhibitor" that blocks a specific "reproductive" gene of a HIV virus. If two Ritonavirs that blocks two different genes are used simultaneously to treat a patient, then it would take longer for the virus to evolve to a form that is resistant to both drugs. As shown in problem 4.2 of the textbook, HIV can be suppressed for a lifetime using **three** antivirial drugs.

Appendix on HIV and HIV infection mechanisms of C4 + T cells





1. Gp41 and GP120 proteins (enzymes) binds to a human T cell.
2. A pore is opened to facilitate deposition of HIV RNA.
3. A cDNA is formed integrated into the host T cell.
4. The T cell's machinery (i.e. ribosomes, …) are then used to produced new virions (virus particles).
5. When the cell burst as many as several 1000s of HIV virions are produced.

See link below:
http://book.bionumbers.org/how-many-virions-result-from-a-single-viral-infection/