Virus has powerful mini-motor to pack up its DNA

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Viruses are particles so tiny that they can't be seen by an ordinary light microscope, but only under an electron microscope. Viruses come in many different sizes, shapes and designs, and they operate in diverse ways. They are composed of DNA (or RNA in the case of RNA viruses, including retroviruses) and protein.

They are not living organisms because they cannot carry out the necessary internal metabolism to sustain life, nor can they reproduce themselves. They are biologically inert until they enter into host cells. Then they start to propagate using host cellular resources. The infected cell produces multiple copies of the virus, then often bursts to release the new viruses so the cycle can repeat.[1]

One of the most common types is the bacteriophage (or simply 'phage') which infects bacteria. It consists of an infectious tailpiece made of protein, and a head capsule (capsid) made of protein and containing DNA packaged at such high pressure that when released, the pressure forces the DNA into the infected host cell.

How does the virus manage to assemble this long information molecule at high pressure inside such a small package, especially when the negatively charged phosphate groups repel each other? It has a special *packaging motor*, more powerful than any molecular motor yet discovered, even those in muscles. Douglas Smith, an assistant professor of physics at UCSD, explained the challenge:

> 'The genome is about 1,000 times longer than the diameter of the virus. It is the equivalent of reeling in and packing 100 yards of fishing line into a coffee cup, but the virus is able to package its DNA in under five minutes.'[2]

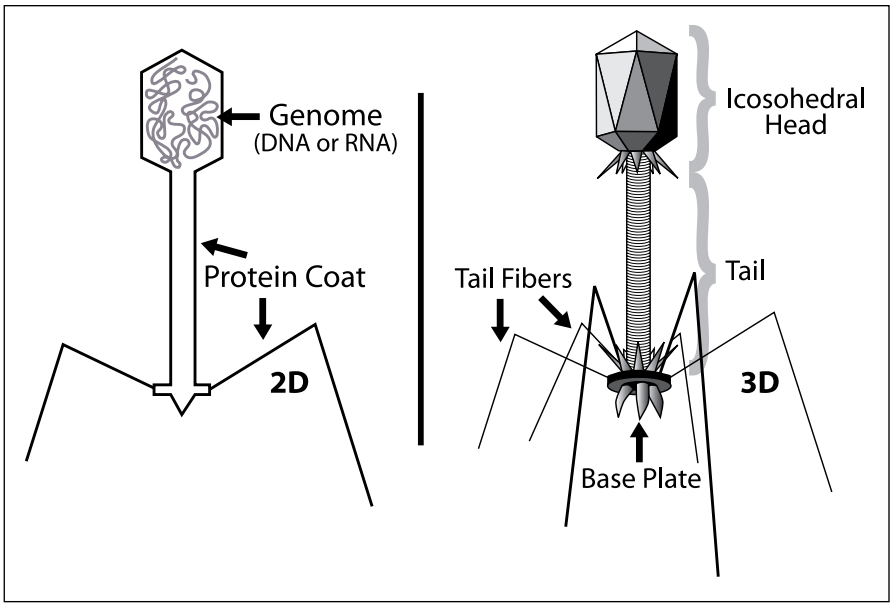

Illustration by Mike Jones, courtesy www.wikipedia.org

The T4 phage is a virus that infects *E. coli* bacteria. Its packaging motor exerts a force that for its size is twice as powerful as a car engine.

Dr Smith and some colleagues at UCSD joined researchers from the American Catholic University (Washington, DC) to solve the problem.[3] They analysed the bacteriophage T4—a virus that infects *E. coli* bacteria, the type that inhabit human intestines—using 'laser tweezers' to hold onto a single molecule of DNA, and measure the force exerted upon it by the virus's packaging motor.

They showed this motor exerts a force of > 60 piconewtons. This sounds small (6×10^{-11} N), but for its size, it's twice as powerful as a car engine. So the motor, a terminase enzyme complex, 'can capture and begin packaging a target DNA molecule within a few seconds.'[2] Such a powerful motor must use a lot of energy, and in one second, this one goes through over 300 units of life's energy currency. This energy currency is the molecule ATP (adenosine triphosphate),[4] and this itself is generated by a remarkable molecular motor, ATP synthase.[5] The virus has a complementary motor-enzyme, ATPase, built into its packaging engine, to release the energy of the ATP.[6]

And not only is the packing motor powerful, it can change its speed as if it had gears. The researchers say that this is important, because the DNA fed to it from the cell is likely not a straightforward untangled thread. Dr Smith said:

> 'Just as it is good for a car to have brakes and gears, rather than only being able to go 60 miles per hour, the DNA-packaging motor may need to slow down, or stop and wait if it encounters an obstruction.'[1]

A report said:

> 'It may permit DNA repair, transcription or recombination—the swapping of bits of DNA to enhance genetic diversity—to take place before the genetic material is packaged within the viral capsid.'[1]

Other vital machines

This motor is just another example of the complexity required even for sub-life forms such as viruses to exist, let alone real life. Since life requires long molecules to store information and pass it on to the next generation, there must also be machinery just to deal with its awkward physical properties before life can even get started by chemical evolution.

Here are two more machines just to deal with the long thready properties of DNA, so that life can function.

Separating the double helix

For replication, the two strands must be separated so a copy can be made. The strands are separated by a molecular motor called *helicase*. This is a ring-shaped molecule that lies on the replication fork, where the two strands separate. Helicase pulls one strand through its hole, while the other strand is shuttled away.[7]

Helicase also doesn't need to wait passively for the fork to widen; rather, researchers from Cornell University show that it opens the fork *actively*.[8] One of them, Michelle Wang, said, 'Basically, it is an active unwinding motor.'[9] However, the unwinding is much faster in cells than in the test tube, so Dr Wang suggested, 'accessory proteins are helping the helicase out by destabilizing the fork junction.'[3,6,8]

Since replication is vital for life, helicases are vital to all living organisms. Dr Wang's colleague Smita Patel pointed out also, 'Helicases are involved in practically all DNA and RNA metabolic processes'. Further, as Dr Patel explained, 'Defects in helicases are associated with many human diseases, ranging from predisposition to cancer to premature aging.' So the origin of such elaborate machinery and the energy source is just one more problem for chemical evolution to solve.

Transcription and the scrunching machine

DNA is double stranded and only one strand is copied to mRNA which is sent into the ribosomes to make proteins. So it must be unwound for copying. The copying machine, called RNA polymerase (RNAP), first locks on to the start of the gene (i.e. protein-coding sequence). The anchored RNAP then reels in the DNA—a process termed *scrunching*. This unwinds the double strand so the mRNA copy can be formed off one of them. Also, the unwinding process stores energy, just like winding the rubber band of a rubber-powered airplane. And just like the toy plane, this energy is eventually released, with the machine then breaking free of its starting point and shooting forward. This also rewinds the unwound DNA ('unscrunching') which then escapes from the back of the machine.[10]

Conclusion

Life depends upon the long double-thread information molecule DNA, and it could not function without machines capable of dealing with such long double-threaded molecules. Yet the information for these machines is coded on the threads! These machines require the ATP synthase motor to generate and use their energy, yet this motor is also coded on the DNA. The code needs the machines, and the machines need the code. Life presents us with many such 'chicken-and-egg' problems for which naturalistic theorists have no answer. Creationists do have an answer—in the beginning, God created a fully functional chicken, which then laid an egg. Problem solved!

References

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10. See Sarfati. J., More marvellous machinery: 'DNA scrunching', *Journal of Creation* **21**(1):4–5, 2007.

Errata

Journal of Creation 21(2)

- Borger, P. and Truman, R., Ultraconserved sequences pose megaproblems for evolutionary theory. On page 8, second column, the sentence 'Using a new sequencing technique, Berezikov *et al*. examined miRNAs expressed in human and adult brains …' should instead read 'Using a new sequencing technique, Berezikov *et al*. examined miRNAs expressed in human and chimpanzee brains …'
- Cserháti, M., Creation aspects of conserved non-coding sequences. On page 101, first column, the sentence, 'According to other estimates, 26–56% of all mammalian non-coding space is conserved.' should instead read 'According to other estimates, 26–56% of the noncoding regions of 77 genomic mouse/human orthologous genes are conserved.'

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- Silvestru, E., Naracoorte Caves: an archive in the dark. On page 6, the first sentence should read, 'Naracoorte Caves in Victoria, Australia …'