Preface.

The quintessence of Darwinism: “... non-random reproduction, where there is hereditary variation, has consequences that are far-reaching if there is time for them to be cumulative.” (xi)

Unfortunately, the timescales involved are much longer than ones we are attuned to by ordinary experience and for ordinary purposes.

- The universe is about 13.7 billion years old. (± 100 million years: Hartle).
- The earth is about 4.5 billion years old.
- The first life on earth appeared about 3.5 billion years ago.
- The oldest hominid fossils are 6-7 million years old.
- The oldest distinctly modern human fossils are about 160,000 years old.

Chapter 1: Explaining the very improbable.

What is improbable is the existence of “complicated things” or complex (biological) structures or systems. These systems “have some property that is specified in advance.” They are “statistically
improbable in a direction that is specified not with hindsight.” (15)

Perhaps this property is something different for different kinds of systems: ability to fly or to run swiftly. Perhaps this property is generic: e.g., resistance to being in equilibrium with its surroundings. (Homeostasis)

Such a system is *explained* by dividing it into sub-components whose workings reproduce the abilities of the system. Then these subcomponents can themselves be further explained in terms of sub-sub-components, and so on, till we hit elementary particles. Dawkins calls this “hierarchical reductionism.”

We look at a human eye as an example of a complex structure.

**Chapter 2. Good design.**

“A living body or organism is well designed if it has attributes that an intelligent and knowledgeable engineer might have built into it in order to achieve some sensible purpose, such as flying, swimming, seeing, eating, reproducing, or more generally, promoting the survival and replication of the organism’s genes.” (21)

We learn about echolocation in bats.
“Animals give the appearance of having been designed by a theoretically sophisticated and practically ingenious physicist or engineer, but there is no suggestion that the bats themselves know or understand the theory in the same sense as a physicist understands it. The bat should be thought of as analogous to the police radar trapping instrument, not to the person who designed the instrument.” (36) [And we should be thought of in the same way with regard to our own sensory systems.]

RD notes the prevalence of The Argument from Personal Incredulity. It proves little, even if true, since unexplained ≠ inexplicable.

There are two other barriers to appreciating the power of evolution.

• The lack of appreciation of timescales. [Darwin published Origin in 1859, but got the ideas in the 1830’s. In the early 1830s his friend Lyell published a classic text in geology that began to appreciate geological timescales.]
• The probabilistic argument that complex adaptations often involve several independent, necessary features (as in the Cuckoo’s life cycle, for instance). The probability of these independent features occurring jointly is the product of small probabilities of each separate feature, and so must be (it is reasoned) incredibly small.
• But while it is claimed that the joint occurrence of the features is necessary for them to be adaptive,
that claim is false. The partial evolution of the various features typically confers some advantage.

Chapter 3. Accumulating Small Change.

Here is the basic idea of Darwinian evolution:

“We have seen that living things are too improbable and too beautifully ‘designed’ to have come into existence by chance. How, then, did they come into existence? The answer, Darwin’s answer, is by gradual, step-by-step transformations from simple beginnings, from primordial entities sufficiently simple to have come into existence by chance. Each successive change in the gradual evolutionary process was simple enough, relative to its predecessor, to have arisen by chance. But the whole sequence of cumulative steps constitutes anything but a chance process, when you consider the complexity of the final end product relative to the original starting point. The cumulative process is directed by nonrandom survival.” (43)

It is important to grasp the difference between cumulative selection (in which each improvement, however slight, is used a basis for the next round of selection) and single-step selection (in which each try starts from the same initial point).

It is extremely unlikely that single-step selection will generate wonderfully adapted complex structures. Cumulative selection can achieve this surprisingly
efficiently. This thesis is illustrated with the use of a simple computer model that generates shapes—Biomorph Land.

Chapter 4. Making Tracks through Animal Space.

Recall the estimate that the first life on earth appeared about 3.5 billion years ago. That is 3.5 thousand million years, or 3,500,000,000 years ago, or $3.5 \times 10^9$ years ago.

Suppose that a “generation” is about 10 years. That’s short for us, but long for our earliest ancestors, no doubt, so perhaps a good average period. Then there are 350,000,000 generations between our earliest ancestors and us. That is: three hundred and fifty million generations (or $3.5 \times 10^8$).

Could a complex system like the human eye have evolved or developed in that many generations by a process of cumulative selection? Why not?

3. Is there a continuous series of Xs connecting the modern human eye to a state with no eye at all?

One is allowed to have up to (roughly) $3.5 \times 10^8$ steps in this series.

Then RD argues that the tiny steps in such a series would provide tiny increments of advantage (though of course many changes in any given generation would be disadvantageous and would, in aggregate, die off faster). So, for instance, tiny advances in
mimicry would provide an organism an advantage in some marginal situations.