Teleology and Fitness

Adaptive vs. Adaptation

- Traits are *adaptive* if they are beneficial to an organism in the here and now
- Traits are *adaptations* if they are the product of natural selection
  - They benefited the ancestors of the organism and figured in their selection
- All combinations are possible
  - Some traits are both adaptive and adaptations
  - Some traits are neither adaptive nor adaptations
  - Some traits are adaptive but not adaptations
  - Some traits are not adaptive but adaptations

Biological niches change

- Traits that were adaptive may cease to be
  - Vestigial organs such as the appendix
- Traits that were adaptations may come to serve a different adaptive role
  - Preadaptations or exaptations

Teleology
Aristotle: For the sake of what

- "Democritus, however, neglecting the final cause, reduces to necessity all the operations of nature. Now they are necessary, it is true, but yet they are *for* a final cause and *for the sake of* what is best in each case. Thus nothing prevents the teeth from being formed and being shed in this way; but it is not on account of these causes but on account of the end; these are causes in the sense of being the moving and efficient instruments and the material. …to say that necessity is the cause is much as if we should think that the water has been drawn off from a dropsical patient on account of the lancet alone, not on account of health, for the sake of which the lancet made the incision." Aristotle, Generation of Animals V.8, 789a8-b15

Teleology and functions

- For Aristotle, natural phenomena were teleological
  - Events happened ***to*** produce results
  - "Nature adapts the organ to the function, and not the function to the organ" (*De partib., animal*., IV, xii, 694b; 13)
- The scientific revolution seemed to remove purpose from the world
  - Events happened solely because of prior causes
- But teleological talk is preserved in the language of functions
  - The heart's function is to pump the blood
  - The kidney's function is to filter and remove waste
  - The function of the ribosome is to synthesize proteins

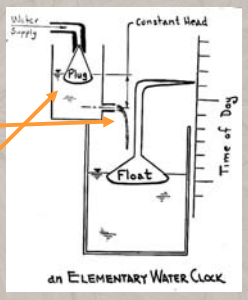
Naturalizing Teleology

- Ground (reduce) teleological notions to natural phenomena
- Show under what conditions a natural system has purposes or goals

1. Negative Feedback and Cybernetics
2. Products of Natural Selection

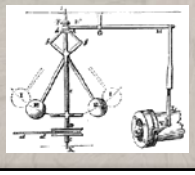
Negative Feedback

- First known example of negative feedback: Water clock designed by Ktsebios in the 3rd century BCE
  - Needed to maintain constant water pressure
  - Employed a float that would halt the inflow from the water supply



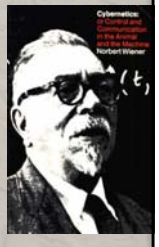
Industrialization and Negative Feedback

- James Watt faced a serious practical challenge
  - How to control the speed of the steam engine so that all appliances would run at the same rate despite different number being on line at a time
  - Devised an elegant mechanism for feedback control



Recognizing the Generality of Negative Feedback

- Challenge: how to control gun fire targeting aircraft
  - Use feedback from the first shot to correct the next
  - Later, heat seeking missiles and beyond
- Recognizing the commonality between control of anti-aircraft fire and control in biological system, Norbert Wiener created an interdisciplinary movement
  - Cybernetics—from the Greek for helmsperson



Functions and Natural Selection

- The etiological strategy: explain the function of something in terms of what it was selected for
  - Treat it as an adaptation
  - Function explained etiologically
- The dispositional strategy: explain the function of something in terms of what role it is playing today
  - Treat it as adaptive
  - Function treated as a propensity
- Third alternative: explain the function in terms of the contribution something makes to an operating system
  - Detach function from natural selection
  - Function in terms of contributions to the operations of a mechanism

Can't Live with Her, Can't Live without Her, So . . .

- "Haldane [in the `30s] can be found remarking, 'Teleology is like a mistress to a biologist: he cannot live without her but he's unwilling to be seen with her in public.' Today the mistress has become a lawfully wedded wife. Biologists no longer feel obligated to apologize for their use of teleological language; they flaunt it. The only concession which they make to its disreputable past is to rename it 'teleonomy'."
  - David Hull (1982)

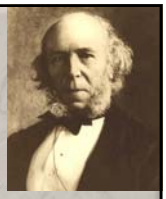
Mayr on Teleology

- "Consider the following statement: `The Wood Thrush migrates in the fall into warmer countries in order to escape the inclemency of the weather and the food shortages of the northern climates'. If we replace the words `in order to' by `and thereby', we leave the important question unanswered as to why the Wood Thrush migrates. The teleonomic form of the statement implies that the goal-directed migratory activity is governed by a program. By omitting this important message the translated sentence is greatly impoverished as far as information content is concerned, without gaining in causal strength."
  - Mayr (1974)

Fitness
Fitness Coefficients

- Start with Hardy-Weinberg
  - If no selection, frequency of AA, Aa, and aa remain constant in the population
  - Expressed in terms of
    - p = percentage of a in the population
    - q = percentage of q in the population
    - p + q = 1
  - $p^2AA + 2pqAa + q^2aa = 1$
- Add a selection coefficient affecting each allelic combination: w_{AA}, w_{Aa}, w_{aa}
  - Mean fitness $w^m = w_{AA}p^2 + w_{Aa}2pq + w_{aa}q^2$
  - New generation $p' = w_{AA}p^2/w^m\, w_{Aa}pq/w^m$

Survival of the Fittest



- Spencer's construal of Darwin posed a problem:
  - What makes an organism fit?
- Population genetics seems to identify fitness with survival
  - Notice how fitness coefficients are defined
  - But this, and Popper recognized, turns natural selection into a tautology
    - The fittest survive and those who survive are the fittest

Structure of R & B's Argument

- ~~Everyone knows the ecological conception of fitness is hopeless~~
- ~~Try out the propensity conception~~
- ~~Try out the subjective probability conception~~
- Maybe we had better make the ecological conception work

Ecological or Engineering Fitness

- Dennett: "*x* is fitter than *y* if and only if *x*'s traits enable it to solve the 'design-problems' set by the environment more fully than *y*'s traits do"
- But how do we identify and assess design problems?
  - Danger: figuring out what were the design problems is most often done after the fact when one wants to know why a trait is present and looks for a problem to which it could have been a solution

The Propensity Conception of Fitness

- Propensities are dispositional properties
    - Sugar has the propensity to dissolve in water
  - It has the propensity whether or not it is ever placed in water
  - The propensity can even be probabilistic
    - Jim has a propensity to get into accidents
    - Smoking has a propensity to cause lung cancer in humans
- Fitness is a propensity that supervenes upon the relations between the properties of organisms and environments
  - *x* is fitter than *y* in *E* = *x* has a probabilistic propensity >.5 to leave more offspring than *y*
- Avoids tautology: the fittest might not survive

Problems with Propensities

- Propensities are introduced as causal intermediates between organisms and reproduction
  - As such, they must be independent of their supposed effects
  - But can propensities be so identified?
- The definition of propensity is false as stated since *x* may be fitter while leaving fewer offspring than *y*
  - The fitter organism may have a propensity to leave fewer immediate offspring but if the variance is high, it may, in the moderately long-term, win out over the population that leaves more immediate offspring.
- Try to patch the propensity account with things like *ceteris paribus* clauses

Revisit the Ecological/Engineering Conception

- If propensities cannot be adequately grounded, worth trying to make a go of the ecological conception
- Seems to be the only way to distinguish selection account from drift or falsification of the theory of natural selection
  - Need to know what the w_{AA}, w_{Aa}, and w_{aa} are so as to predict the frequency in future populations from frequencies
    - Deviations due either to drift or failure of natural selection

When is a trait an adaptation?

- To be an adaptation, a trait must have figured in the reproductive success of ancestors, thereby providing an explanation of the presence of the trait in current organisms
- How common are adaptations?
  - Adaptationism: the default assumption when identifying a trait is that it is an adaptation to some selection forces
    - Heuristic for evolutionary biology—find the selection forces which selected the trait and made it an adaptation
  - Alternative: only some traits are adaptations