

Teleology and Function

"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)

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

2

The Spookiness of Teleology

- For Aristotle, natural phenomena were teleological
 - Events happened **to** achieve ends
 - These results explain the events even though they come after the events
 - "Nature adapts the organ to the function, and not the function to the organ" (*De partib. animal.*, IV, xii, 694b; 13)

3

Clicker Question

What is it about talk of purposes according to Buller that makes it problematic in modern biology?

Our inability to understand how having ends might produce effects

The fact that it seems to involve backwards causation: purposes generating what achieves them

Only humans have goals or ends, nature does not

Ends are too subjective to be considered in the context of a scientific inquiry

4

Teleology—Hard to Kill

- The scientific revolution seemed to remove purpose from the world
 - Events happened solely because of prior causes
 - Captured by the quest for mechanisms in biology
 - Mechanisms explained their effects in terms of preceding, efficient causes
- But teleological talk lives on in the language of functions in biology
 - 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
- Evident most clearly in the willingness to say that something is malfunctioning—to malfunction is to fail to perform a function

5

Human Purposive Action

- The idea of acting for goals is something we are familiar within in the case of ourselves
 - We think of ourselves as setting goals and then selecting actions to achieve them
- In our case, there is also a ready way to account (at least in outline) for how this is accomplished
 - We represent (e.g., in language) the goal we seek to accomplish, and then that representation can play a role in determining our action
- But this account cannot readily be extended to biology generally unless we also posit an intelligent agent planning all purposive biological activities

6

Naturalizing Teleology

- If teleology (talk of functions) is to be legitimate in science, it should be grounded in natural phenomena
 - This requires showing under what conditions a natural system has purposes or goals
- Three naturalizing strategies:
 - Causal role theories
 - Etiological theories
 - Biological organization theories

7

Causal Role Accounts of Functions

Cummins claims that the statement

"The heartbeat in vertebrates has the function of circulating the blood through the organism."

is appealed to in explaining circulation (the function)

- That is, we start with circulation, and identify something as having that function in the context of explaining it
- And we may explain the advantage of the heartbeat by identifying the activity it facilitates
 - This is different than explaining the existence of the heartbeat

8

Dispositions and the Analytic Strategy

- Functions and dispositions: "to attribute a function to something is, in part, to attribute a disposition to it. If the function of x in s to Φ , then x has a disposition to Φ in s "
- Dispositions require explanation:
 - "if x has [disposition] d , then x is subject to a regularity in behavior special to things having d , and such a fact needs to be explained."
- The appropriate explanatory strategy: Analytic strategy:
 - Analyze "d of a into a number of other dispositions $d_1 \dots d_n$, had by a or components of a such that programmed manifestation of the d_i results in or amounts to a manifestation of d "

9

Analytic Strategy in Biology

- “The biologically significant capacities of an entire organism are explained by analyzing the organism into a number of ‘systems’—the circulatory system, the digestive system, the nervous system, etc.—each of which has its characteristic capacities. These capacities are in turn analyzed into capacities of component organs and structures. Ideally, this strategy is pressed until pure physiology takes over, i.e., until the analyzing capacities are amenable to the subsumption strategy.”
- This should seem familiar: mechanism in biology exemplifies this approach
 - Parts perform functions that explain what the whole does

10

Discussion Question

Does a gene that has been identified as resulting in schizophrenia have the function of producing schizophrenia?

Yes, if that is what the gene in question causes, then that is its function

Yes, assuming that is the only thing the gene does

Yes, but only if it can be shown that schizophrenia has or once benefitted people

No, schizophrenia is a malfunction and it makes no sense to attribute a function to the gene that causes it

11

Criticisms of Causal Role Theories

- Many things have effects that do not seem to be their functions
 - The structure of your nose enables it to support glasses
 - But is supporting glasses the function of the nose?
- Makes the notion of function redundant to effect within a mechanism
- Fails to capture the normative aspect of function
 - A function is something that should be performed
 - Something malfunctions if it fails to perform its function

12

Teleology and Darwin

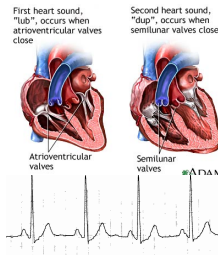


- Recall Darwin's high regard for Paley
 - Biological organisms are complex systems that are highly adaptive (functional) in their environments
- Darwin offered an explanation for traits that had seemed to require design—they are the products of natural selection
 - Does natural selection remove the last vestige of teleology from science? or
 - Does natural selection license teleological discourse in biology?
 - The function of a trait is that effect of it on which natural selection operated—that caused ancestors with the trait to reproduce more successfully

13

Wright's Distinction Between a Trait's Function and Other Effects

"Very likely the central distinction of this analysis is that between the *function* of something and other things it does which are *not* its function (or one of its functions). . . . The function of the heart is pumping blood, not producing a thumping noise or making wiggly lines on electrocardiograms, which are also things, it does. This is sometimes put as the distinction between a function, and something done merely 'by accident'."
(Wright, p. 141)



Wright: Functions as Explanatory

- "Merely saying of something, X, that it has a certain function, is to offer an important kind of explanation of X."
 - To ask "what is the function of X?" is comparable to asking "Why do C's have X's (or do X)?"
- The sought for explanation specifies how X came to be—it came to be because of its function
- But remember the challenge: the function is realized only after X
 - How could what comes later explain what came earlier?

15

Natural Selection as an Explanation

- If an organ has been naturally differentially selected-for by virtue of something it does, we can say that the reason the organ is present in a current organism is that it was present in an ancestor and that ancestor was selected because that organ did that thing
 - animals have kidneys because they eliminated metabolic wastes from the bloodstream of ancestors;
 - porcupines have quills because they protected their ancestors from predatory enemies;
 - plants have chlorophyll because chlorophyll enabled their ancestors to perform photosynthesis;
 - the heart beats because in ancestors such beating pumped blood
- **The function of X is Z means**
 - (a) X is there because it does (did) Z
 - (b) Z is a consequence (or result) of X's being there



16

Discussion Question

What implications does Gould and Lowontin's critique of adaptationism have for the etiological account of function?

None. They were concerned with adaptation, not function

It could severely limit what count as functions. If something isn't an adaptation, then it doesn't have a function on the etiological account

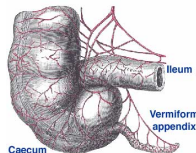
It shows that it is difficult to assign function on the etiological account since it is difficult to show that something is an adaptation

It shows that the etiological account has too narrowly characterized functions by requiring that functions be the product of natural selection

17

Challenges for the Etiological (Explanatory) Account

- Cave fish have remnants of an eye
 - What is its function?
 - It was originally selected for sight
 - Is that still its function?
- What is the function of the human appendix?
 - Darwin: used by other primates to digest leaves
 - Is that its function in us?
- Must we know the evolutionary history of a trait in order to know its function?



Caecum

Vermiform appendix

Ileum

Causal Role versus Etiology

- The causal-role strategy: explain how something is able to perform a function
 - Treat functions as dispositions of things
 - Decompose the disposition into sub-dispositions
 - Objections:
 - Treats any effect as a function
 - Fails to provide any normative standard for functions
- The etiological strategy: explain the function of traits in terms of what how they were selected
 - Treat traits as adaptations
 - Function explained etiologically
 - Objections
 - Only looks to the past, not the present
 - Denies functions to anything that is not an adaptation

Discussion Question

What do you think accounts for the fact that the function of your heart is to pump blood

Simply that it does so

That is what it was selected to do

That it serves other physiological activities that ultimately keep me alive

It has no function. Biology is best rid of all function talk

20

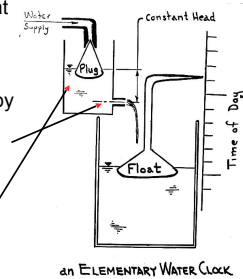
A Third Alternative

- Think back to Bichat's argument for vitalism: living organisms resist death in that they perform operations that counter the forces in the environment that would otherwise destroy them
- Recast this in modern terms:
 - According to the third law of thermodynamics, *in a closed system* entropy (equal distribution) always increases
 - When put into statistical terms, on average, entropy increases
 - Allows for situations in which it decreases locally
 - Organisms are *not* in equilibrium with their environments and to remain alive they must maintain their non-equilibrium state
- On this alternative, the goal for organisms is to maintain themselves in a **non-equilibrium** relation with their environment. This view
 - Detaches function from natural selection and makes it local to the organism

21

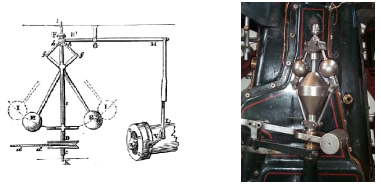
Self-Maintaining Systems

- Focus on mechanism designs that maintain order such as negative feedback
- First known example of negative feedback: Water clock designed by Ktesibios in the 3rd century BCE
 - Need to maintain constant water pressure
 - Employed a float that would start or halt the inflow from the water supply, maintaining a constant level
- The function of the plug is to maintain a constant flow of water



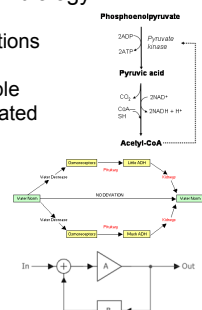
Industrialization and Negative Feedback

- 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



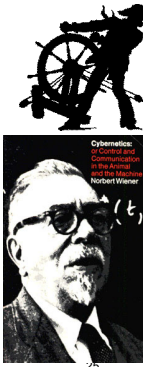
Negative Feedback in Biology

- Negative feedback is widespread in biology
 - Biochemical systems: products of reactions feed back to slow reactions earlier in the pathway
 - Physiological systems: when variable deviates from norm, processes initiated to restore it to normal
 - Motor systems: when action misses the mark, change to guide it to the target
- Walter Cannon: homeostasis
 - Mechanisms that function to maintain conditions



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
- Cybernetic systems are goal directed



The Seeming Insufficiency of Negative Feedback

- Humanly designed negative feedback systems all involve a designer
 - Who so arranged the parts of the system so that it would reach the target?
- The designer imposed the goal on the system
 - But where is the designer of biological systems? How did the organism become so organized that it could compensate for deviations?
- Natural Selection is a tempting answer, but do we need to answer the question?
 - Perhaps it is enough to show that an organism in which negative feedback and other mechanisms for self-maintenance and self-repair fail dies

26

Life Far From Thermodynamic Equilibrium

- Energy is far from equally distributed in the universe, although given the Second Law of Thermodynamics the trajectory is towards equilibrium
- Far from equilibrium systems dissipate energy
 - And in the process sometimes generate complex organization
 - Example:
 - Bénard cells: sets of molecules constrain each other



Maintaining a System Far From Equilibrium

- A system like a Bénard cell can only be maintained as long as there is a source of free energy
- Many systems, such as fires and storms, perform operations that constrain the flow of free energy in a way that allow themselves to maintain themselves
 - But typically these are relatively short-lived
- Biological organisms, as far from equilibrium systems, must also recruit free-energy or die
 - The fact that life on earth seems to have continued since the first cell indicates that organisms have been effective in maintaining themselves far from equilibrium

28

A Characterization of Life: Closure of Constraints

- Constraints restrict what processes can occur
 - Blood vessels constrain the flow of blood
 - Enzymes constrain the direction of chemical reactions
- In human made machines, humans supply the constraints and maintain them
- Assuming that there is not an agent maintaining living organisms, they must maintain their own constraints
- Proposal: in living organisms constraints form a closed set such that one serves to maintain another that maintains another until the cycle is closed

29

Cyclic organization of constraints: A key feature of life

- Needed so that the system can control its own operations—guide the flow of energy through the system so as to generate its own components as needed
- Kauffman: “Constraint begets work begets constraint”
- Specific components of the system dynamically constrain other components within the system
- Tap specific exergonic reactions as needed to support other energy consuming activities

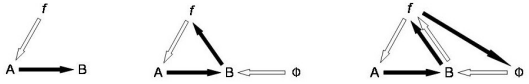
30

Externally Designed Artifacts

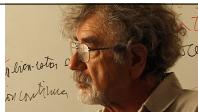
vs.

Self-constructing/maintaining systems

- All organized systems require repair
 - Why?
- Almost no human made artifacts can repair themselves
- Rosen's account of metabolism-repair or (M,R)-systems
 - Closed to efficient causation
 - black arrows—material causation—open
 - white arrows—efficient causation—closed



Autopoiesis and Teleology



- Start from the fact that given the degenerating effects of an environment, organisms must continually maintain and repair themselves or die
- Maturana and Varela
 - An autopoietic machine is a machine organized . . . as a network of processes of production . . . which: (i) through their interactions and transformations continuously regenerate and realize the network of processes . . . that produced them; and (ii) constitute it (the machine) as a concrete unity . . .
- The processes that maintain an autopoietic machine can be understood as teleological—serving its own maintenance

32

Biological Organisms as Autonomous Systems



- Maintaining the organization of a living organism requires constraining the flow of energy to locally decrease, not increase entropy
- Moreno characterizes such systems as autonomous
 - “a far-from-equilibrium system that constitutes and maintains itself establishing an organizational identity of its own, a functionally integrated (homeostatic and active) unit based on a set of endergonic-exergonic couplings between internal self-constructing processes, as well as with other processes of interaction with its environment”
 - » Kepa Ruiz-Mirazo, Juli Peretó and Alvaro Moreno, A Universal Definition Of Life: Autonomy And Open-ended Evolution
 - These self-maintaining processes appear as teleological

33

Assessing the Maintenance of the Organism Account

- Like the causal role account, it treats causal effects of operations within an organism as functions
 - But it supplies a normative perspective: when those effects serve to maintain the organism in a non-equilibrium relation to its environment
- Like the etiological account, it provide a normative perspective
 - But it does not require us to turn to history to identify functions
- But it may not provide a clear-cut account of function
 - Which is the organism?
 - the cancer cell or a person?
 - the bee or the bee colony?

34

35

36
