Introduction to Decision Analysis

Decisions Under Certainty

- State of nature is certain (one state)
- Select decision that yields the highest return

Examples:
- Product Mix
- Diet Problem
- Distribution
- Scheduling

Decisions Under Uncertainty (or Risk)

- State of nature is uncertain (several possible states)

Examples:
- Drilling for Oil
- Developing a New Product
- Newsvendor Problem
- Producing a Movie

Oil Drilling Problem

Consider the problem faced by an oil company that is trying to decide whether to drill an exploratory oil well on a given site. Drilling costs $200,000. If oil is found, it is worth $800,000. If the well is dry, it is worth nothing. However, the $200,000 cost of drilling is incurred, regardless of the outcome of the drilling.

	State of Nature	
Decision		

Payoff Table

Which decision is best?

"Optimist":

"Pessimist":

"Second-Guesser":

"Joe Average":

Bayes' Decision Rule

Suppose that the oil company estimates that the probability that the site is "Wet" is 40%.

Payoff Table and Probabilities:

Decision	State of Nature Wet	Dry
Drill	600	-200
Do not drill	0	0
Prior Probability	0.4	0.6

All payoffs are in thousands of dollars

Expected value of payoff (Drill) =

Expected value of payoff (Do not drill) =

Features of Bayes' Decision Rule

- Accounts not only for the set of outcomes, but also their probabilities.
- Represents the average monetary outcome if the situation were repeated indefinitely.
- Can handle complicated situations involving multiple and related risks.

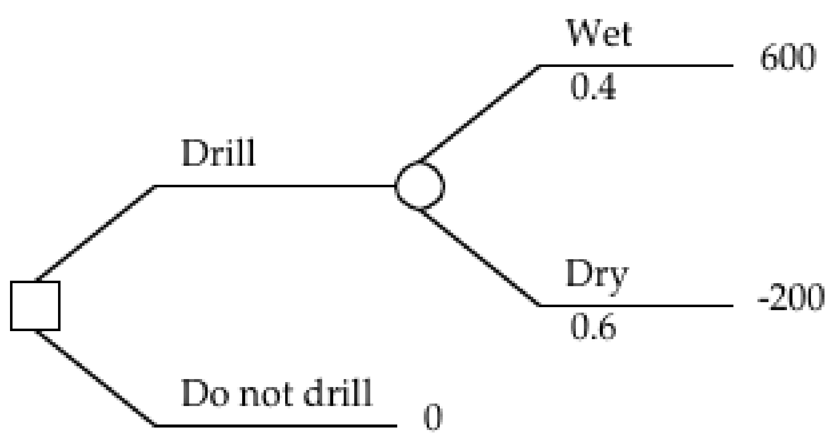
Using a Decision Tree to Analyze Oil Drilling Problem

Payoff Table and Probabilities:

	State of Nature	
Decision	Wet	Dry
Drill	600	-200
Do not drill	0	0
Prior Probability	0.4	0.6

All payoffs are in thousands of dollars

Decision Tree:

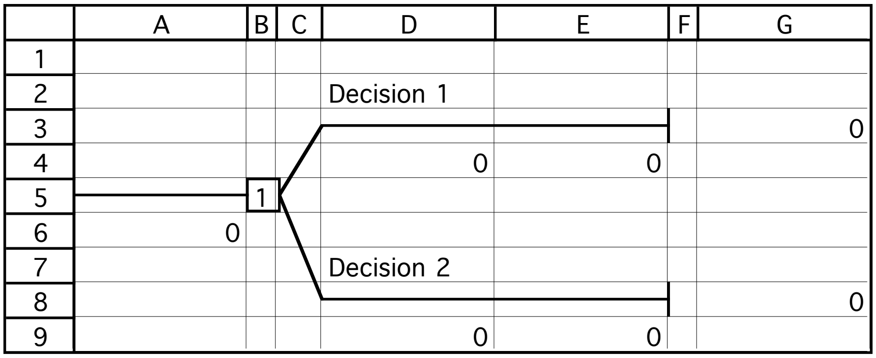


Folding back:

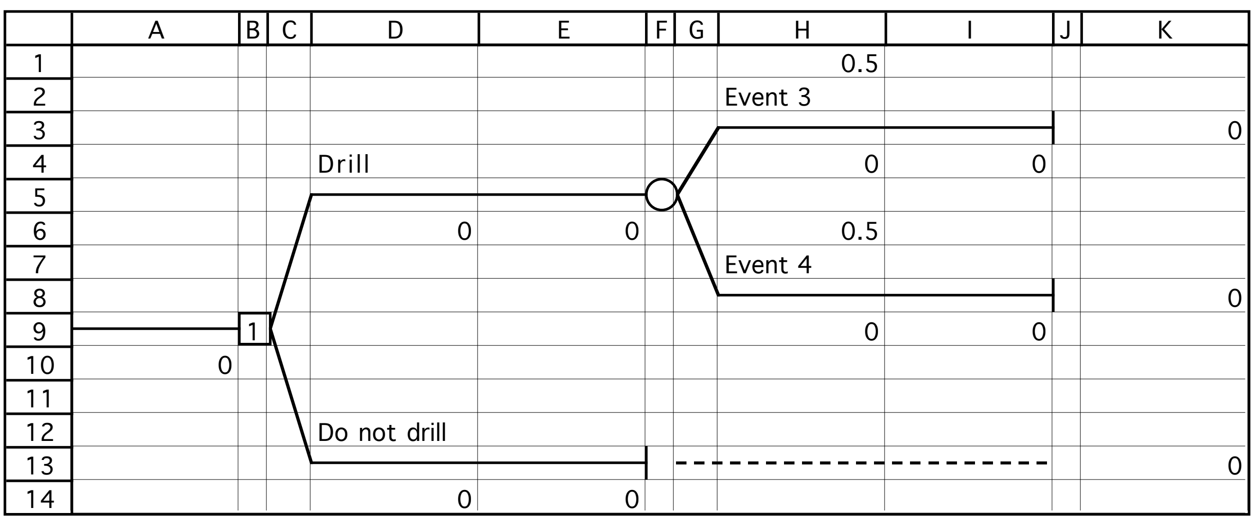
- At each event node (circle): calculate expected value (SUMPRODUCT of payoffs and probabilities for each branch).
- At each decision node (square): choose "best" branch (maximum value).

Using TreePlan to Analyze Oil Drilling Problem

1. Choose Decision Tree under the Tools menu.
2. Click on "New Tree" and it will draw a default tree with a single decision node and two branches, as shown below.

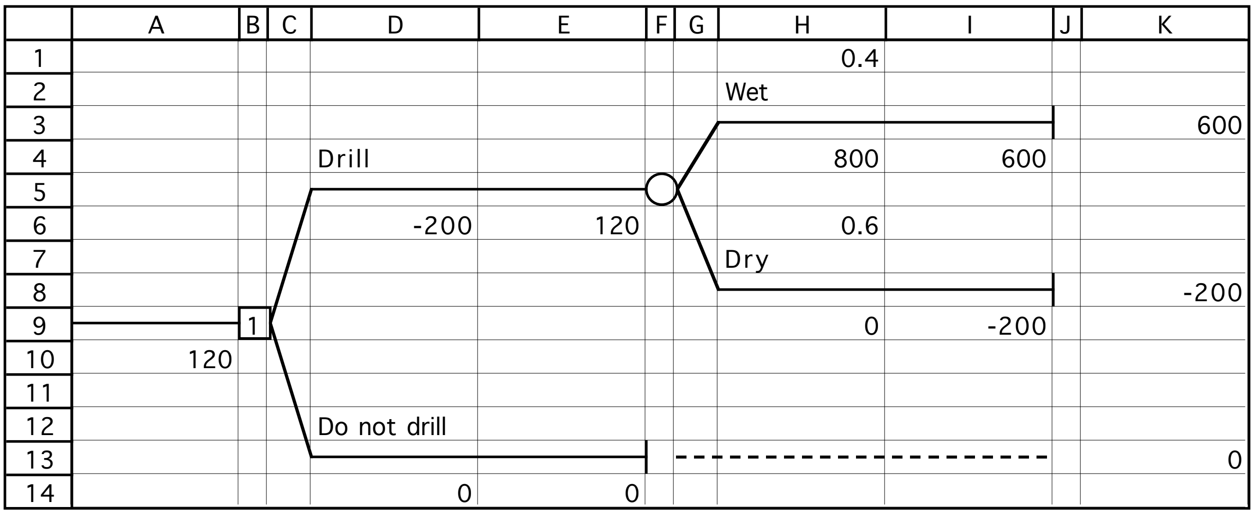


3. Label each branch. Replace "Decision 1" with "Drill" (cell D2). Replace "Decision 2" with "Do not drill" (cell D7).
4. To replace the terminal node of the drill branch with an event node, click on the terminal node (cell F3) and then choose Decision Tree under the Tools menu. Click on "Change to event node," choose two branches, then click OK. TreePlan draws the tree below.



5. Change the labels "Event 3" and "Event 4" to "Wet" and "Dry", respectively.
6. Change the default probabilities (cells H1 and H6) from 0.5 and 0.5 to the correct values of 0.4 and 0.6.
7. Enter the partial payoffs under each branch: (-200) for "Drill" (D6), 0 for "Do not Drill" (D14), 800 for "Wet" (H4), and 0 for "Dry" (H9). The terminal value cash flows are calculated automatically from the partial cash flows.

Final Decision Tree



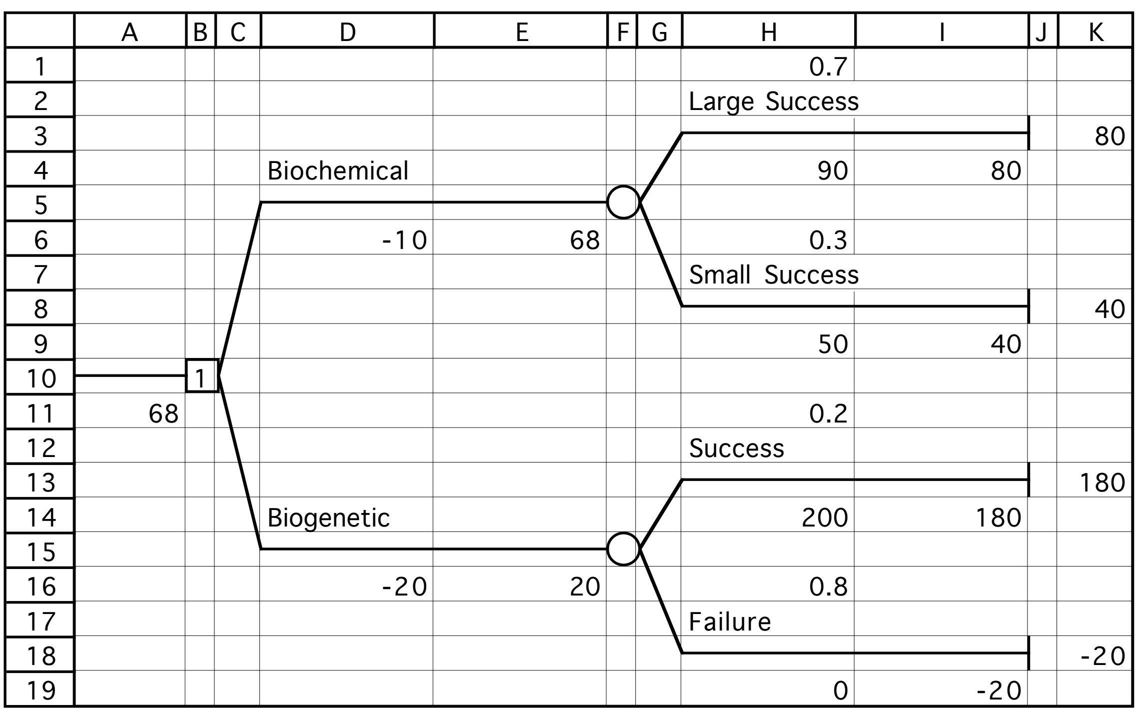
Features of TreePlan

- Terminal values (payoff) are calculated automatically from the partial payoffs (K3=D6+H4, K8=D6+H9, K13=D14). Alternatively, they can be entered directly (in which case the partial payoffs are ignored).
- Foldback values are calculated automatically (I4=K3, I9=K8, E6=H1*I4+H6*I9, E14=K13, A10=Max(D6,D14)).
- Optimal decisions are indicated inside decision node squares (labeled by branch number from top to bottom, e.g., branch #1 = Drill, branch #2 = Do not drill).
- Changes in the tree can be made by clicking on a node, and choosing Decision Tree under the Tools menu (change type of node, # of branches, etc.)
- Clicking "Options…" in the Decision Tree dialogue box allows the choice of Maximize Profit or Minimize Cost.

Making Sequential Decisions

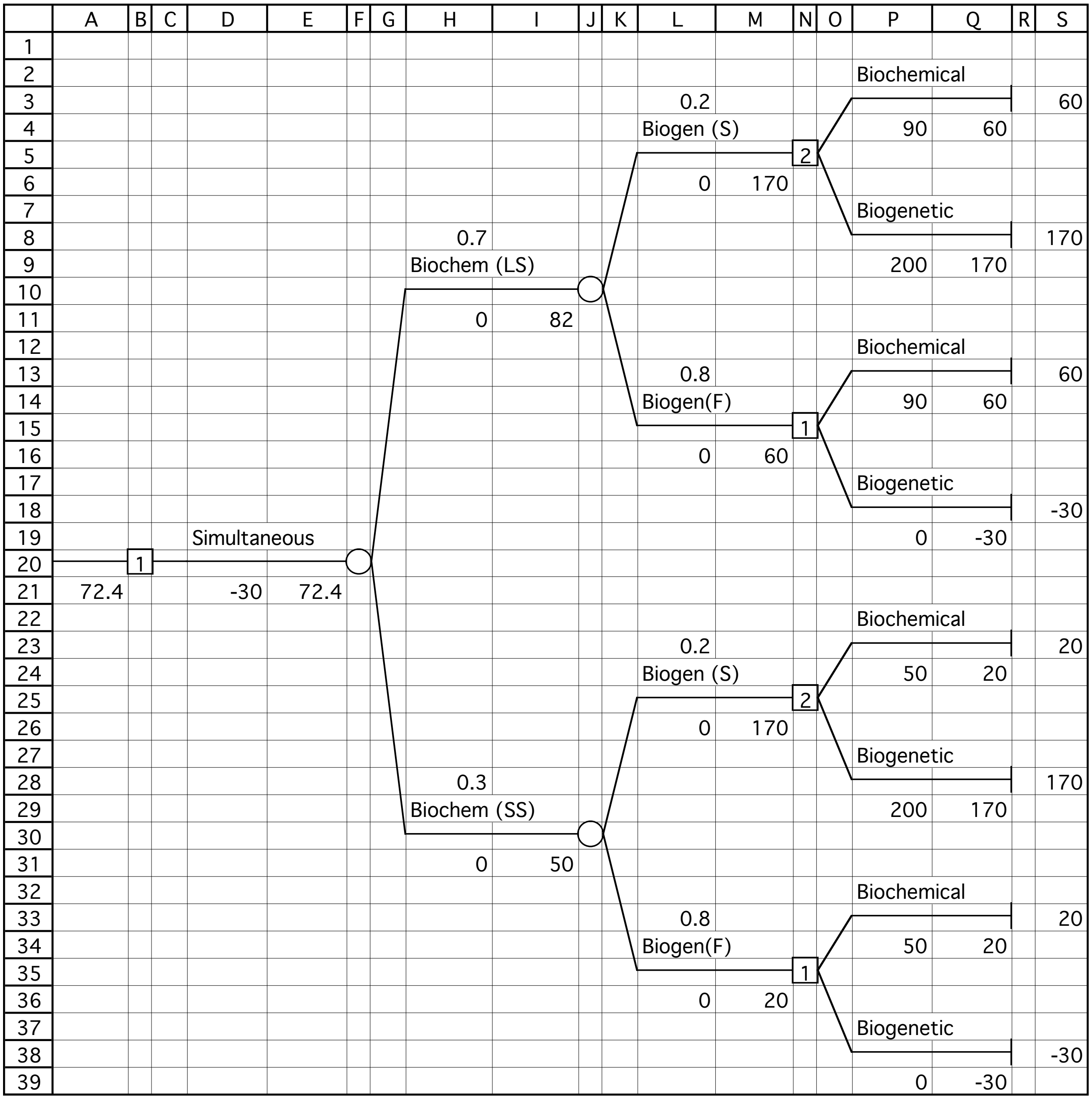
Consider a pharmaceutical company that is considering developing an anticlotting drug. They are considering two approaches. A biochemical approach would require less R&D and would be more likely to meet with at least some success. Some, however, are pushing for a more radical, biogenetic approach. The R&D would be higher, and the probability of success lower. However, if a biogenetic approach were to succeed, they would likely capture a much larger portion of the market, and generate much more profit. Some initial data estimates are given below.

R&D Choice	Investment	Outcomes	Profit (excluding R&D)	Probability
Biochemical	$10 million	Large success	$90 million	0.7
		Small success	$50 million	0.3
Biogenetic	$20 million	Success	$200 million	0.2
		Failure	$0 million	0.8



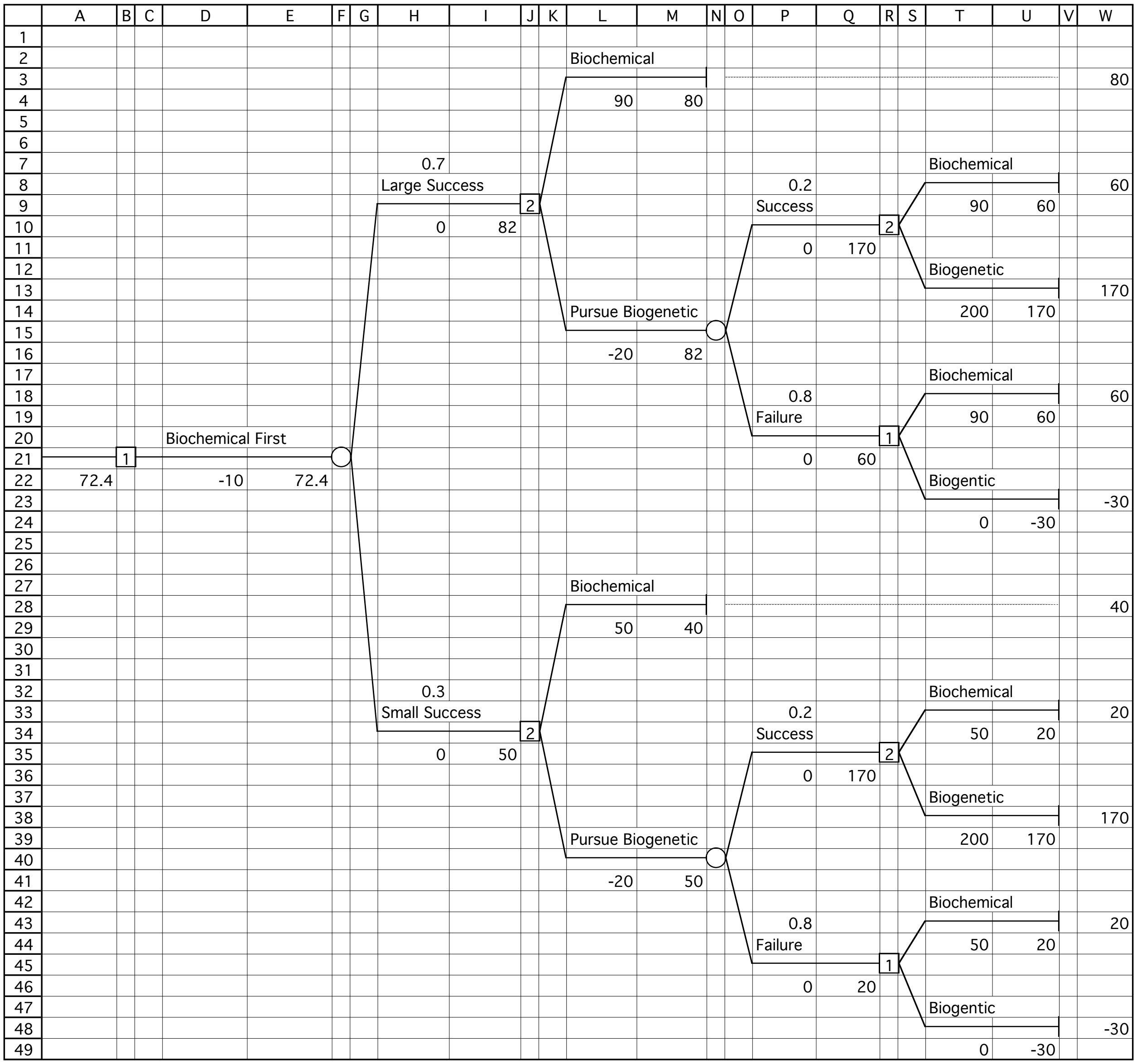
All monetary amounts in millions of dollars.

Simultaneous Development



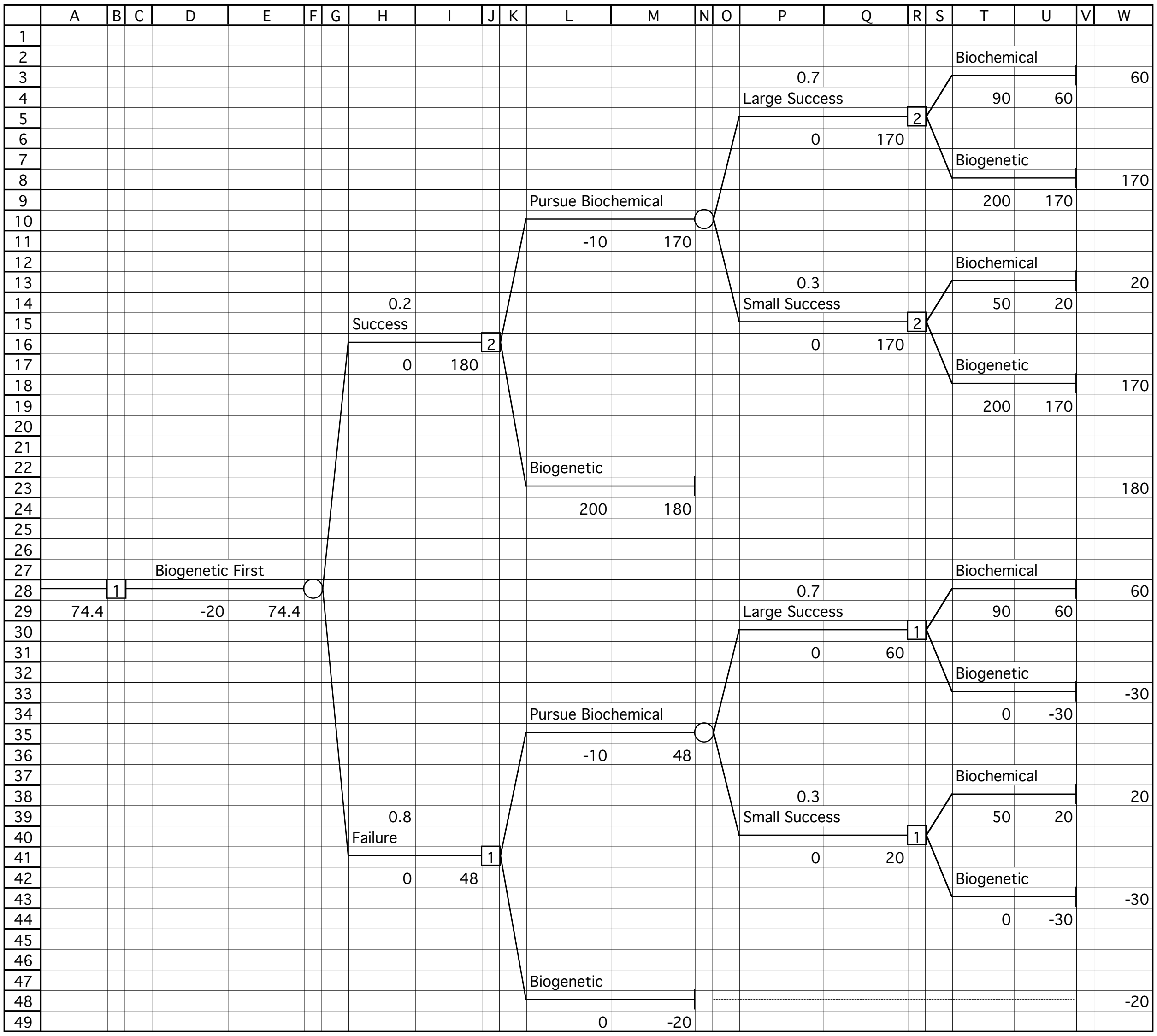
All monetary amounts in millions of dollars.

Biochemical First



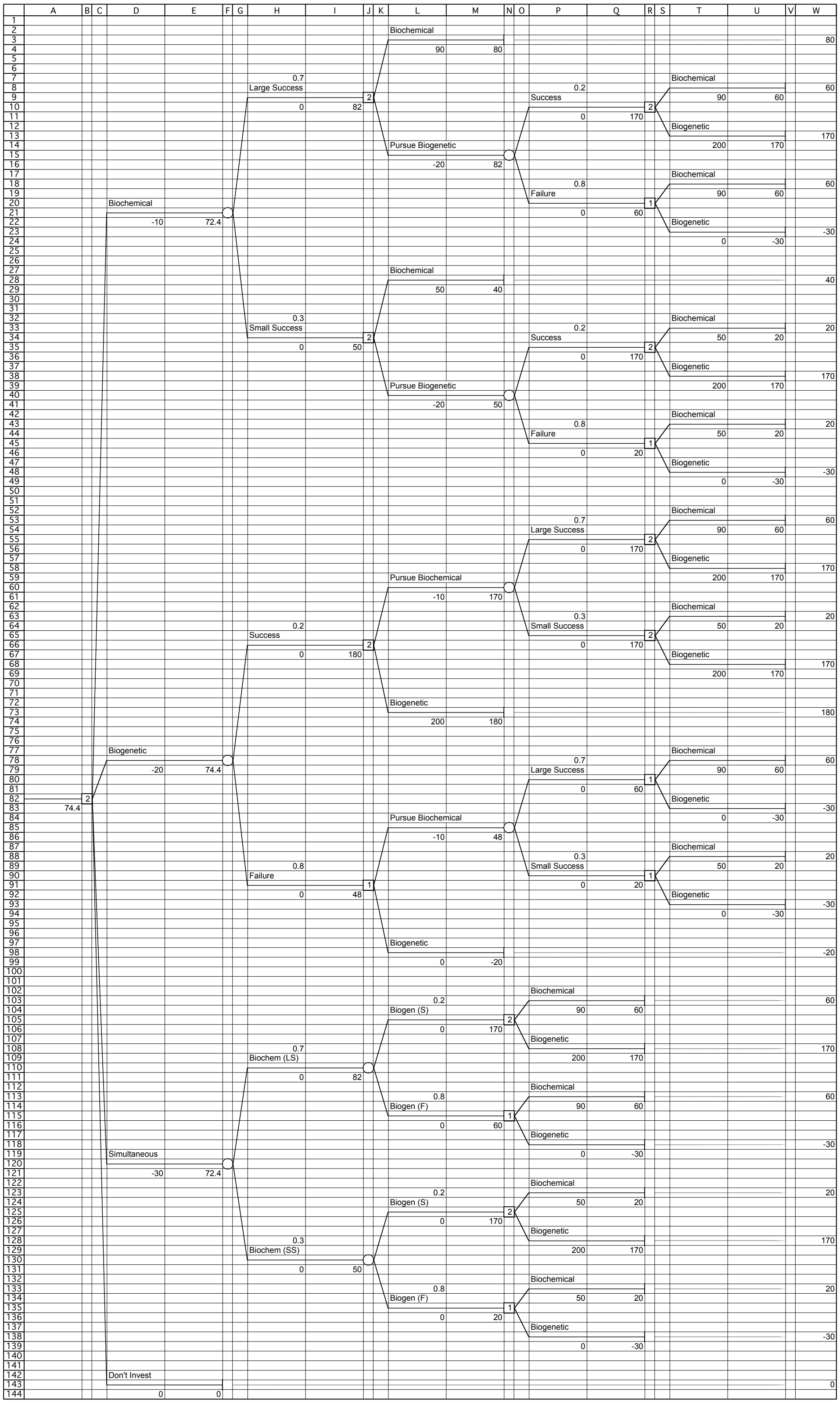
All monetary amounts in millions of dollars.

Biogenetic First



All monetary amounts in millions of dollars.

Whole Decision Tree



Decision Support System

	A	B	C	D	E
1	**Data**				
2		BC Investment	10		
3		BC Large Success Profit	90		
4		BC Small Success Profit	50		
5		BC Large Success Probability	0.7		
6		BG Investment	20		
7		BG Success Profit	200		
8		BG Failure Profit	0		
9		BG Probability of Success	0.2		
10					
11	**Results**				
12		Action:	Biogenetic First		
13			If Success Then Commercialize Biogenetic		
14			If Failure Then Pursue Biochemical		
15		Expected Payoff (millions):	$74.400		

- Data cells in "decision tree" spreadsheet (partial payoffs, probabilities) refer to data cells in "front end" spreadsheet.

- Results in "front end" spreadsheet refer to result cells in "decision tree" spreadsheet (decision node branch #'s, payoff values)

	B	C
12	Action:	=IF(Tree!B82=1,"Biochemical First",IF(Tree!B82=2,"Biogenetic First",IF(Tree!B82=3,"Simultaneous","Don't Invest")))
13		Biochemical"," If Large Success then Pursue Biogenetic"),IF(Tree!B82=2,IF(Tree!J66=1," If Success Then Pursue Biochemical"," If Success Then Commercialize Biogenetic")))
14		Biochemical"," If Small Success then Pursue Biogenetic"),IF(Tree!B82=2,IF(Tree!J91=1," If Failure Then Pursue Biochemical"," If Failure Then Don't Pursue Biochemical")))
15	Expected Payoff (millions):	=Tree!A83

Using Data Tables to Plot Payoff vs. Probability of BG Success

	A	B	C	D	E	F	G	H
1	Data							
2		BC Investment	10				BG Probability	Expected Payoff
3		BC Large Success Profit	90				of Success	($millions)
4		BC Small Success Profit	50					74.40
5		BC Large Success Probability	0.7				0.0	68.00
6		BG Investment	20				0.1	68.00
7		BG Success Profit	200				0.2	74.40
8		BG Failure Profit	0				0.3	87.60
9		BG Probability of Success	0.2				0.4	100.80
10							0.5	114.00
11	Results						0.6	127.20
12		Action:	Biogenetic First				0.7	140.40
13			If Success Then Commercialize Biogenetic				0.8	153.60
14			If Failure Then Pursue Biochemical				0.9	166.80
15		Expected Payoff (millions):	$74.400				1.0	180.00
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	H
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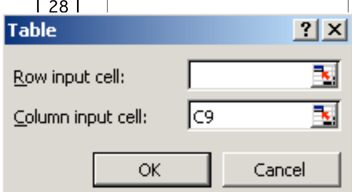

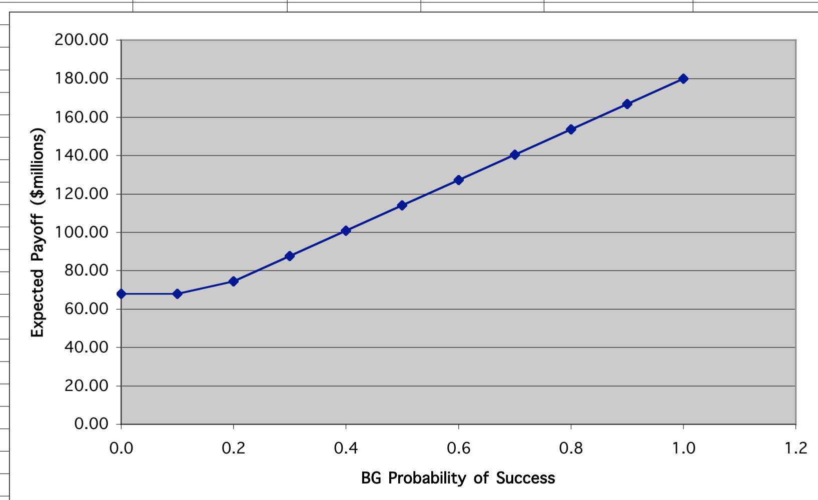

A “Data Table” can be used to generate Payoff vs. BG Success Probability.

In the first line of the table (H4), put an equation referring to the output cell of interest (in this case, =C15 for expected payoff).

In the first column of the table (G5:G15), enter the data for the input cells (in this case, the probabilities, ranging from 0 to 1).

Select the whole table (G4:H15), and then choose Table from the Data menu.

Specify the column input cell as the input cell in the spreadsheet that will be changing (as represented by the data in the first column of the table). In this case, this is the BG probability of success, in cell C9.