Figure 3.6a. STEMPLOTS: Rat Brain Weights

The data for this Figure 3.6a are given overleaf in the table at the upper right on page 3.14.

Rat Brain Cortex Weights (mg)
(*Unordered leaves*)

57	8	(1)
58	9	(1)
59	33	(2)
60	05332	(5)
61	22	(2)
62	3714	(4)
63	35528	(5)
64	76029 28777 42170 912	(18)
65	63724 82016 78162 533	(18)
66	80349 87521 08	(12)
67	96635 97080 0928	(14)
68	95092 7	(6)
69	49608 20636 4	(11)
70	78105	(5)
71	28881 10	(7)
72	08	(2)
73		(--)
74	0592	(4)
75	1	(1)
		(118)

Rat Brain Cortex Weights (mg)
(*Ordered leaves*)

57	8	(1)
58	9	(1)
59	33	(2)
60	02335	(5)
61	22	(2)
62	1347	(4)
63	23558	(5)
64	00112 22246 77777 889	(18)
65	01122 23334 56667 778	(18)
66	00123 45788 89	(12)
67	00023 56678 8999	(14)
68	02579 9	(6)
69	00234 46668 9	(11)
70	01578	(5)
71	01128 88	(7)
72	08	(2)
73		(--)
74	0259	(4)
75	1	(1)
		(118)

Enriched Environment
(ordered)

57		(–)
58		(–)
59		(–)
60		(–)
61		(–)
62	4	(1)
63	38	(2)
64	07779 9	(6)
65	12333 568	(8)
66	00348 8	(6)
67	06799 9	(6)
68	02579	(5)
69	00466 69	(7)
70	0178	(4)
71	01128 88	(7)
72	08	(2)
73		(–)
74	0259	(4)
75	1	(1)
		(59)

Impoverished Environment
(ordered)

57	8	(1)
58	9	(1)
59	33	(2)
60	02335	(5)
61	22	(2)
62	137	(3)
63	255	(3)
64	01122 22467 78	(12)
65	01224 66778	(10)
66	12578 9	(6)
67	00235 688	(8)
68	9	(1)
69	2348	(4)
70	5	(1)
71		(–)
72		(–)
73		(–)
74		(–)
75		(–)
		(59)

	Enriched (ordered)		**Impoverished** (ordered)	
		57	8	(1)
(–)		58	9	(1)
(–)		59	33	(2)
(–)		60	02335	(5)
(–)		61	22	(2)
(1)	4	62	137	(3)
(2)	83	63	255	(3)
(6)	9 97770	64	01122 22467 78	(12)
(8)	865 33321	65	01224 66778	(10)
(6)	8 84300	66	12578 9	(6)
(6)	9 99760	67	00235 688	(8)
(5)	97520	68	9	(1)
(7)	96 66400	69	2348	(4)
(4)	8710	70	5	(1)
(7)	88 82110	71		(–)
(2)	80	72		(–)
(–)		73		(–)
(4)	9520	74		(–)
(1)	1	75		(–)
(59)				(59)

DATA SOURCE: Freedman, D., Pisani, R. and Purves, R.: *Statistics.* W. W. Norton & Company, Inc., 1978, page 452.

Background: It has long been assumed that an animal's experience produces chemical or physical changes in its brain, but convincing evidence for such changes has been available only since the 1960s. Work in this area at the University of California, Berkeley, involved studying the brains of genetically pure strains of rats which had been exposed, usually from the time of weening onwards, to one of the following three environments:

(*continued overleaf*)

- *standard* – a few rats lived in a cage of adequate size with food and water always present;
- *enriched* – a few rats lived in a large cage furnished with a variety of objects they could play with; a new set of playthings, drawn out of a pool of 25 objects, was placed in the cage every day;
- *impoverished* – each rat lived alone in a cage.

In a typical experiment, a dozen sets of three male littermates were studied, with random assignment of the rats within each set to the three environments. Many such experiments were carried out over a period of years, involving several different strains of rats and also laboratory mice and gerbils; generally similar effects were observed throughout the investigation. Within each experiment, at the end of a predetermined experimental period (ranging from a few days to several months), the animals were sacrificed and their brains removed. The brain dissection and analysis of each set of three littermates were done in immediate succession but in random order; in addition, the specimens were identified only by a code number so that the person doing the dissection did not know which cage the rat came from. A small part of the data on brain cortex weights (in mg), involving rats from the enriched (**E**) and the impoverished (**I**) environments, are tabluated at the right.

Expt. #1		**Expt. #2**		**Expt. #3**		**Expt. #4**		**Expt. #5**	
E	**I**	**E**	**I**	**E**	**I**	**E**	**I**	**E**	**I**
689	657	707	669	690	668	700	662	640	641
656	623	740	650	701	667	718	705	655	589
668	652	745	651	685	647	679	656	624	603
660	654	652	627	751	693	742	652	682	642
679	658	649	656	647	635	728	578	687	612
663	646	676	642	647	644	677	678	653	603
664	600	699	698	720	665	696	670	653	593
647	640	696	648	718	689	711	647	660	672
694	605	712	676	718	642	670	632	668	612
633	635	708	657	696	673	651	661	679	678
653	642	749	692	658	675	711	670	638	593
		690	621	680	641	710	694	649	602

REFERENCE: Rosenzweig, M.R., Bennett, E.L. & Diamond, M.C.: Brain Changes in Response to Experience. *Scientific American* **226**(#2): 22-29 (1972). *See also*: Exercised brains. *Scientific American* **212**(#1): 52 (1965).

1 In the spaces provided on the lower half of page 3.13 overleaf, construct separate stemplots (with *ordered* leaves) of the brain cortex weight data for the groups of 'enriched' and 'impoverished' rats.
- Check your plots by confirming that each contains 59 leaves and that the total number of leaves in each pair of corresponding stems (*i.e.*, rows) agrees with the relevant number given in the upper two plots.
- On a separate sheet of paper, reformat your two *separate* plots as *back-to-back* plots.
  - Explain briefly which of the two types of stemplot (separate or back-to-back) is more effective in this context.

2 What *difference(s)* do your stemplots indicate between the brain cortex weights of the groups of 'enriched' and 'impoverished' rats.
- How can you account for your observations on the basis of the background information provided above?

3 In what sense, if any, do these data *prove* that the environment affects the anatomy of the brain:
- in rodents; • in humans? Give your reasons briefly.

4 As mentioned in the background information given above, the investigation included the following procedures:
- the rats in each set assigned to the three environments were *littermates*;
- within each set of littermates, the assignment to the three environments was made *equiprobably* ('*at random*');
- the brains from each set of three rats were dissected *in succession*;
- the brains were coded so that the person doing the dissection *did not know* from which environment a rat had come.

Explain briefly the importance of each procedure to the Plan for the investigation.

5 Suggest a reason why only 11 (instead of 12) pairs of observations came from Experiment #1.

6 On page 28 of the reference given above, the authors state: The effect of experimental environments on the brains of animals has sometimes been cited as bearing on problems of human education. We should like to sound a cautionary note in this regard. It is difficult to extrapolate from an experiment with rats under one set of conditions to the behaviour of rats under another set of conditions, and it is much riskier to extrapolate from a rat to a mouse to a monkey to a human. We have found generally similar brain changes as a result of experience in several species of rodents, and this appears to have fostered the assumption that similar results may be found with carnivores and with primates, including man. Only further research will show whether or not this is so. Animal research raises questions and allows us to test concepts and techniques, some of which may later prove useful in research with human subjects.
- Concerning the dangers of *extrapolation* which are raised in this excerpt from the reference:
  - Can you think of an example (*e.g.*, from drug testing in medicine) where an extrapolation from an *aminal* model to humans did not hold up and, as a result, serious harm ensued?
  - Can you think of a subject area where different extrapolations from *mathematical* models give rise to different predictions and, hence, to appreciably different regulatory legislation in different countries?
    - Explain, in simple terms, how differences in predictions, based on extrapolations from mathematical models, arise.