



Troubleshooting for Life

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Preventive Maintenance

Thinking about failure prevention.

Primary Goals of Preventive Maintenance

Safety:
Equipment
is safe for
patients
and clinical
users.

- Reduce or eliminate equipment malfunctions that may negatively affect patients and clinicians.

Reliability:
Equipment
is available
for use
whenever
needed.

- Enhance the reliability of equipment, thus improve patient care by making equipment available when needed.

Binseng Wang, 2018

Preventive
Maintenance
Applied

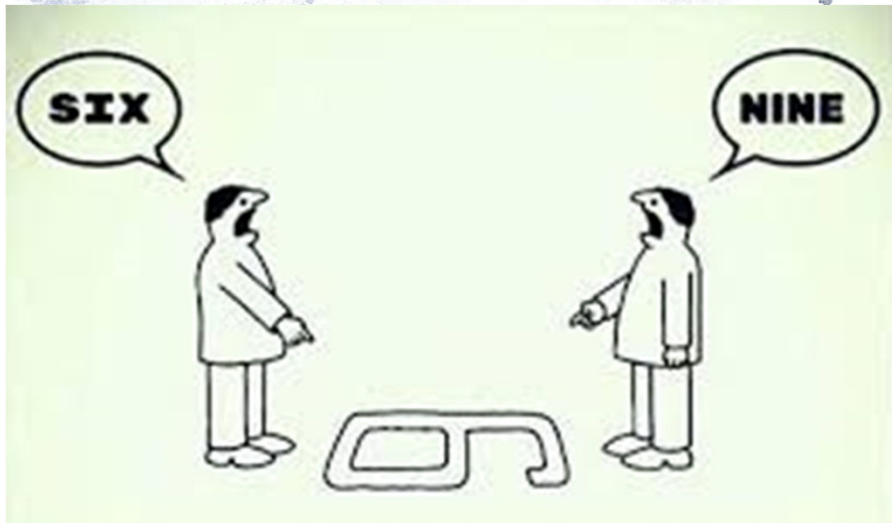




Framing

The world simply can't be made sense of...

Perspective Changes Everything...or does it?



- What is the message?
- Is that message correct?
- The answer might fool you. The number presented is factual. The question here is not about perspective or viewpoint.
- There is or was a correct answer. Investigate until you know the question or your results are questionable.

Framing our Thinking

Learning how to think?

Framing is a way of organizing what to think about.

Reframing is what you do when the facts don't fit.



Taxonomy and Hierarchy

- “A complex assembly is best described first in terms of its substances: its subassemblies and parts. Then, next, it is described in terms of its methods: its functions as they occur in sequence.”
— **Robert M. Pirsig**, [Zen and the Art of Motorcycle Maintenance](#)

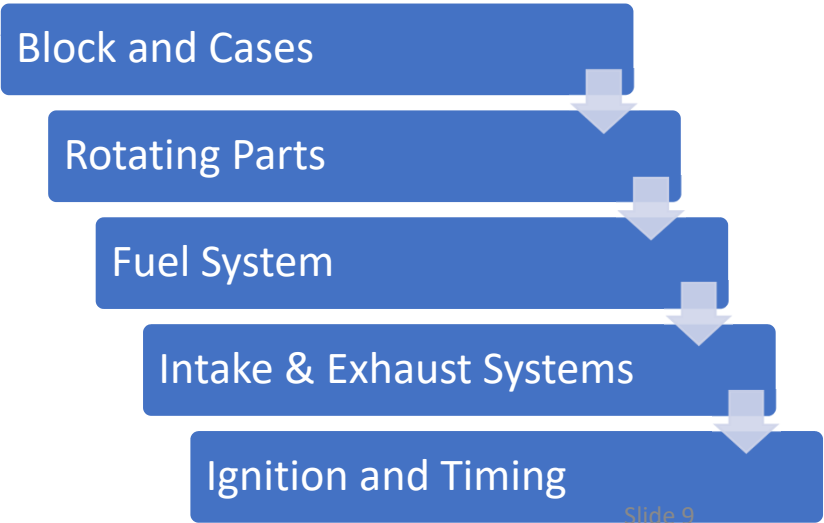
Breaking Down to Systems



Substances:
Useful?

- GO**
 - Engine
 - Clutch
 - Transmission
 - Chain/Sprockets or Drive Shaft
 - Rear Tire & Wheel
- STOP**
 - Master Cylinders
 - Fluid Reservoirs
 - Hoses and Lines
 - Calipers & Discs/Drums & Pads
- SAFETY**
 - Lights
 - Brakes
 - Engine Kill Switch

Subassemblies and Parts:
Useful?



Breaking Down Water Systems

1

- Pretreatment Array

2

- Principle Device (RO)

3

- Distribution System

4

- Monitoring & Records

Methods and functions as they appear in sequence:
Useful?

Trust but Verify

- Source 1 Says



- Source 2 Says



Data vs Information vs Knowledge



Knowledge

Information organized in order to understand and interpret. Used to make decisions

Information

Organized Data. Sorted, formatted, calculated.
Data that have been processed.

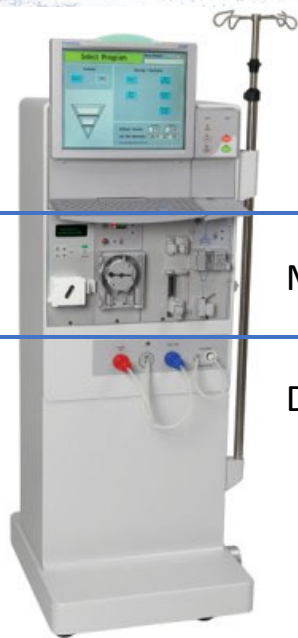
Data

Raw facts and figures; e.g. readings, values, test results
Generally have no meaning on their own.

Understanding Others (Perspective Again)

Operator

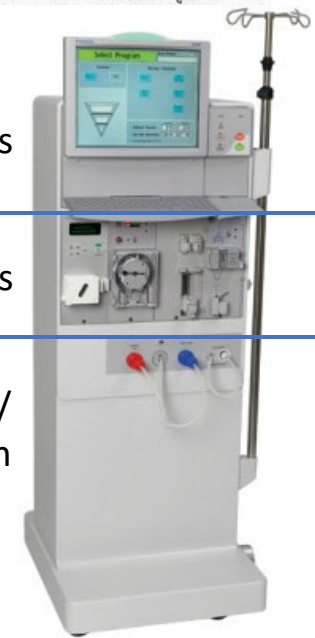
Nephrology Biomedical Technologist



Input/Output/Monitoring

Modules: Extracorporeal Circuit

Dialysate Connections



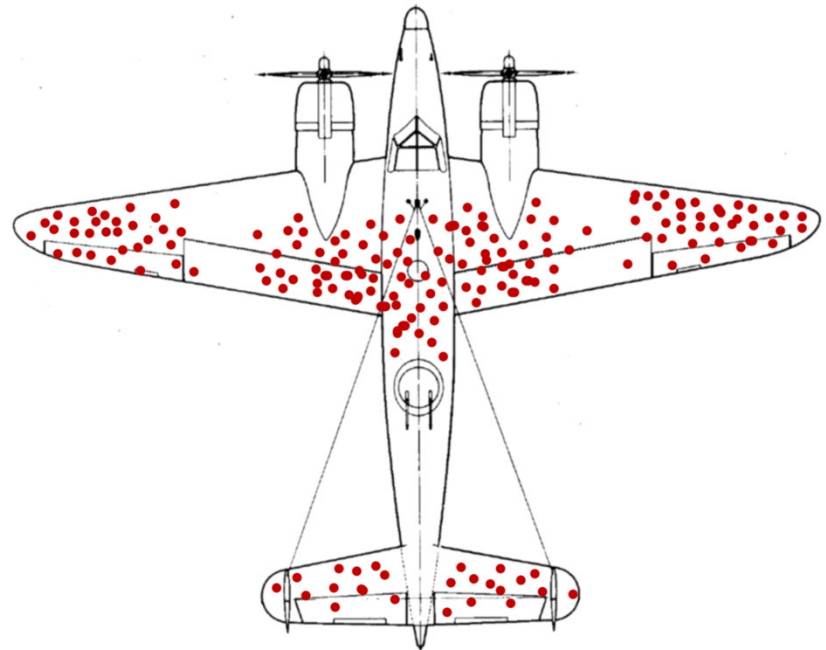
Electronics

Modules

Fluid Path/
Dialysate Preparation

Think Beyond the Obvious

Abraham Wald and Survivorship Bias



By McGeddon - Own work, CC BY-SA 4.0,
<https://commons.wikimedia.org/w/index.php?curid=53081927>

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Scientific Method

Investigation into cause

Scientific
Method

Be decisive.

Right or wrong,
make a decision.

The road of life
is paved with
flat squirrels
who couldn't
make a decision.

Be Methodical!

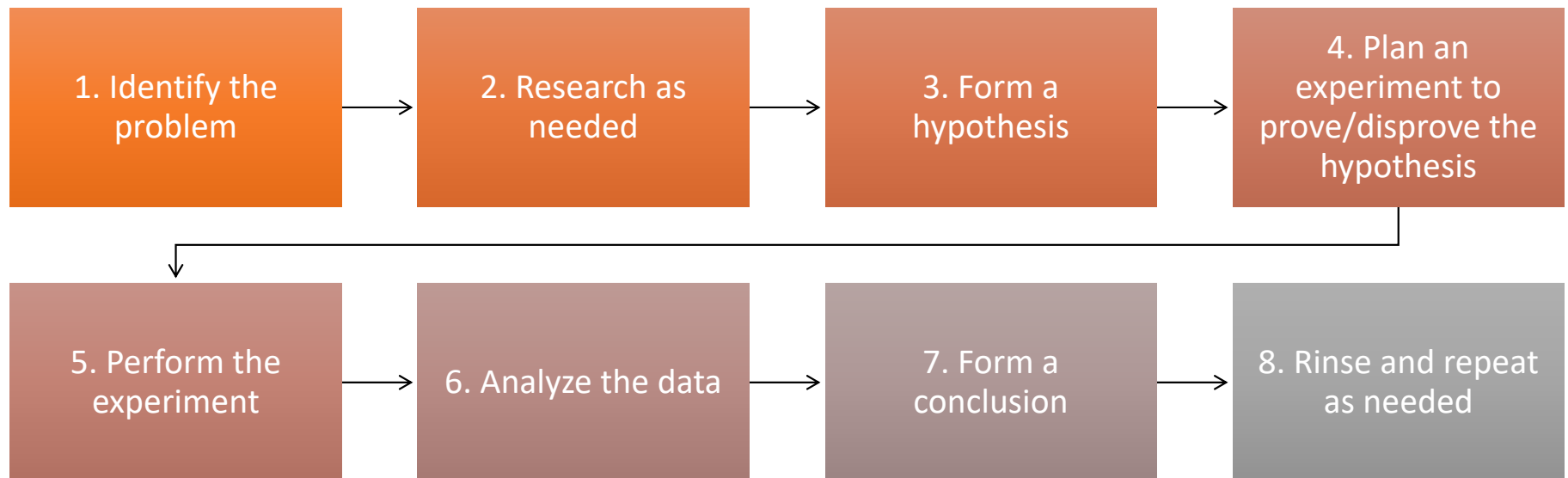


Scientific Method

“The real purpose of the scientific method is to make sure Nature hasn't misled you into thinking you know something you don't actually know. There's not a mechanic or scientist or technician alive who hasn't suffered from that one so much that he's not instinctively on guard.”

— Robert M. Pirsig, [Zen and the Art of Motorcycle Maintenance: An Inquiry Into Values](#)

Scientific Method



Scientific Method: Be Cautious and Careful

“One false deduction about the machine and you can get hung up indefinitely.”

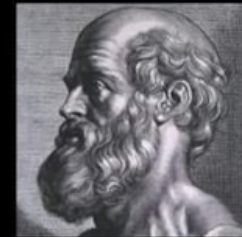
“The solutions all are simple—after you have arrived at them. But they're simple only when you know already what they are.”

“Motorcycle maintenance gets frustrating. Angering. Infuriating. That's what makes it interesting.”

— Robert M. Pirsig, [Zen and the Art of Motorcycle Maintenance: An Inquiry Into Values](#)

The Importance of Training

- Spoon feeding in the long run teaches us nothing but the shape of the spoon.
 - E.M. Forster
- *What is the message here?*



There are in fact two things, science and opinion; the former begets knowledge, the latter ignorance.

Hippocrates

The Importance of Training

Defining the
Systems

Understanding
Components

Understanding
Interactions

1. Define the Problem

- ~~I have a heater problem.~~
- The heater has failed to cold water.

Refine the problem statement as much as possible. Does the statement accurately define the problem presented?

Data: Our Friends

Conductivity Problem <input type="radio"/>	Other (describe below) <input type="radio"/>
Was the treatment Interrupted by the failure (Circle One)?	<u>YES</u> <u>NO</u>
Other and Detailed Problem Description (include location of machine when failure occurred and what the machine was doing when the failure occurred)	
tore up.	

2. Research (if needed)

What components are part of the heater circuit?

Do you know how they typically fail?

How are they connected to each other?

Past experience can be helpful here but is NOT conclusive.

The connection question applies to both physical connection (wiring, circuits, plugs) and understanding how the various parts interact.

2a. Results from Research

Typical Parts of Heater Circuit

- Heater Element
- Triac
- Temperature Sensor
- Circuit Board(s)
- Overtemp controls

Example: The triac acts something like a switch and uses a low voltage signal to turn the high voltage heater element on and off. Typical failures short the triac, which activates the heater rod and does not turn off when set temp is reached. The heater 'runs away' until the overtemp circuit shuts it down. When the temperature decreases to below the alarm value, the shorted triac again 'runs away' and again activates the overtemp circuit. To the observer, the machine is in and out of high temp alarm state.

3. Form a Hypothesis

1. *My research tells me that the heater rod often fails to cold water.*
2. *The heater rod is easy to test.*
3. *I have seen this in the past.*

Hypothesis: The problem is a failed heater rod.

4. Form a Test for the Hypothesis

1. *From my research, I know that heater rods are resistance heaters and can fail to either shorted or open conditions*
2. *I know the correct resistance range for a good heater.*
3. *I have the right tools to test the heater.*

Test: I will isolate the heater and test the resistance to the known standard.

5. Perform the Test

1. *Assure that the machine is unplugged (safety first!)*
2. *Disconnect the wires for the heater.*
3. *Measure the resistance of the heater rod.*

6. Analyze the Data

Compare the results to the known value for a good heater.

7. Form a Conclusion

*The resistance of the heater rod does not fit the range for a good heater so **I must conclude that the heater rod has failed and replace it.***

8. Rinse and Repeat as Needed

Had the heater rod passed the designed test, our conclusion would have been that the rod was good.

We would then move on to the next hypothesis regarding the remaining parts of the circuit.

Successive iterations of the process, testing each of the possible hypotheses, will resolve the issue provided you have done your part.

Scientific Method: Be Cautious, Careful, Thorough

“One false deduction about the machine and you can get hung up indefinitely.”

“The solutions all are simple—after you have arrived at them. But they're simple only when you know already what they are.”

Motorcycle Dialysis equipment maintenance gets frustrating. Angering. Infuriating. That's what makes it interesting.

— Robert M. Pirsig, [Zen and the Art of Motorcycle Maintenance: An Inquiry Into Values](#)

Discussion and Burning Questions

