Will and Dan's Excellent Journey Around the Circulation

The circulation is a CIRCLE!

And ENERGY drives it all!

Will (William Harvey)

Dan (Daniel Bernoulli)

A visual journey through CV Thermodynamics

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1. A CIRCLE—AND IT MUST STAY A CIRCLE!

I showed that the blood circulates continuously in a closed loop.

It has no beginning and no end—and it must be kept a CIRCLE!

CIRCULAR FLOW

Will (Harvey): The Circulation is a Circle!

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2. THE SOURCE: CARDIAC ATP

It all starts with energy from ATP, which powers cardiac contraction.

ATP

ATP (chemical energy) → Contraction (mechanical work) → Hydraulic Energy (to the blood)

The heart is a pump that adds hydraulic energy to the blood and makes it flow.

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3. RESISTANCE SPLITS THE ENERGY

Here's the key idea: RESISTANCE (R) splits the total hydraulic energy into two forms:

Hydraulic Energy (from heart) → R → PE (Potential Energy: Pressure) + KE (Kinetic Energy: Flow)

Dan (Bernoulli): Energy is the Currency of Circulation!

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4. PRESSURES, FLOW, AND RESISTANCE

MAP (arterial pressure) | PVP (venous pressure) | CVP (central venous pressure)

R_a (arterial resistance) | R_v (venous resistance)

Relative Resistance:

$$\frac{R_a}{R_v} = \frac{(MAP - PVP)}{(PVP - CVP)}$$

Waste Heat:

$P_{vout} - Pvin = MAP - 2PVP + CVP$

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5. HEAT PUMP AND HEAT ENGINE—TOGETHER

Heat Pump (establishes and maintains Pressure above P_{ms}) → PE (decreases entropy)

Cardiac Energy (ATP)

Circular Flow

Heat Engine (uses Pressure to drive Flow, which increases entropy) → KE

The cardiovascular system functions simultaneously as a heat pump and a heat engine.

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6. THE JOURNEY AT WORK

WASTE HEAT

R

- ✓ Circular flow
- ✓ Transports solutes
- ✓ Transports respiratory gases (O_2 and CO_2)
- ✓ Friction converts some energy to waste heat

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7. THE BIG PICTURE

- ✓ A closed hydraulic system (a circular flow)
- ✓ An open energetic system (ATP in, work out, waste heat out)

Keep the CIRCULATION a CIRCLE!

And remember—ENERGY drives, divides, and dissipates throughout the journey!

Together: A Dynamic, Energetic Circulation That Works—Because Energy Keeps It in Motion!

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Will and Dan's Excellent Journey Around the Energetics of the Circulation

Remember—the circulation is a **circle!** A closed loop that keeps the blood moving!

Will (William Harvey) — The Circulation is a Circle!

And it's all about **energy!** The heart gives energy to the blood in three forms: **pressure** (PE), flow (KE), and heat (HE) from losses!

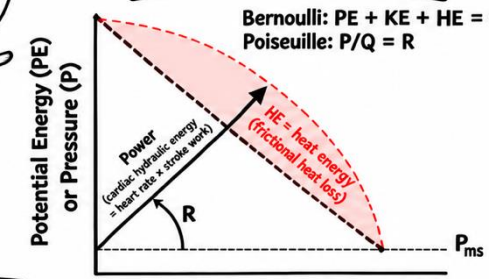
ENERGY

Dan (Daniel Bernoulli) — The Energy in the Flow!

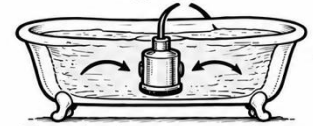
The P–Q (or REV) Diagram: Energy in the Circulation

Bernoulli: PE + KE + HE = C

Poiseuille: P/Q = R



"A Pump in a Tub" R = 0

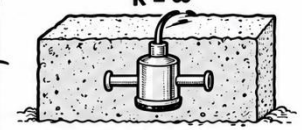


- Inlet and outlet pressures are the same
- Flow (KE) only, no pressure (PE)
- REV vector is horizontal

The Intermediate (Physiologic) Case

- REV vector (R) at an angle = a ratio of pressure (PE) to flow (KE) (P/Q = R)
- Vector length = constant total energy (PE + KE + HE = C)
- Shaded area between the straight line and the arc = energy lost to friction (heat, HE)

"A Pump in Concrete" R = ∞



- No flow (KE = 0)
- Pressure (PE) only
- REV vector is vertical

Key Takeaways

- Energy comes in three forms: pressure (PE), flow (KE), and heat loss (HE).
- The REV (or P–Q) vector shows how the heart partitions its energy.
- The vector's length is constant total energy at that operating level.
- The area between the straight line and arc represents frictional energy loss (heat).
- The two extremes—"pump in a tub" and "pump in concrete"—define the limits; real physiology is in between.